Volume 18
Number 2
July - Dec., 2012

ISSN 0972 – 6977

# Journal of Farming Systems Research & Development

RNI No. UP - ENG/2001/6732

Farming Systems Research and Development Association
Modipuram, Meerut – 250 110

# Farming Systems Research and Development Association
## Modipuram, Meerut
## (Regd. No. 2666)



The '**Journal of Farming Systems Research & Development**' is published bi-annually in June & December by the Farming Systems Research and Development Association, Modipuram, Meerut-250 110 (U.P.)

**Membership and Journal Subscription**

| Individual Membership | Indian | Foreign |
|---|---|---|
| Annual | Rs. 250/- | Us $ 40 |
| Life | Rs. 1500/- | Us $ 200 |
| Institutional | Rs. 500/- | Us $ 10 |

An admission fee of Rs. 10/- for Indian and US $ 5 for foreign membership will be charged extra at the time of enrolment.

The Life Membership fee may be paid either lumpsum or in two equal instalments within six months of enrolment. Paymentshould be made by Demand Draft only in favour of **Secretary, FSRDA,** payable at any branch of nationalised bank located in Meerut City. Outstation cheques are not acceptable in any case.

Limited space is available for insertion of advertisements.

Back volumes of the Journal are available for sale @ Rs. 200 per volume for individuals and Rs. 500 for institutions.

**NAAS Rating : 2.4**

*All correspondence may be addressed to :*

**The Secretary**
**FSRDA, C/o PDFSR, Modipuram, Meerut-250 110, U.P.**

# Journal of Farming Systems Research and Development

**Volume 18** **July - December 2012** **Number 2**

## CONTENTS

*J. Farming Systems Research & Development* **18** (2) : 187-195 (2012)

# IMPACT OF GROUND WATER TABLE ON ENERGY CONSUMPTION AND CROP ECONOMICS IN BUNDELKHAND REGION OF UTTAR PRADESH

N.D. Shukla[1], B. gangwar[2], B.K. Sharma[3] and Sunil Kumar[4]

*Project Directorate for Farming Systems Research, Modipuram. Meerut*

ABSTRACT

A survey of Jalaun and Hamirpur districts representing "water scarcity zone" of Bundelkhand region was conducted during 2009-10. The purpose was to assess the impact of water table dynamics on crop economics and energy consumption over the year. As per analysis of data, the average depth of water in bore well was 27.6 meter during (2009-10) while it was 29.7 and 17.9 meters during past five (2004-05) and ten years (1999-2000) respectively. The corresponding figures in Hamirpur were 30.8, 34.4 and 27.6 meters respectively. The wide disparity in water table was also observed with in the district. This has been proved with the fact that per hour diesel consumption for irrigation was recorded 2.02 and 2.10 liters in Jalaun and Hamirpur in 2009-10 compared to 2.39 and 2.65 liters during 2004-05 in these districts. The diesel consumption was of lower order during 1999-2000 because of normal rain fall in past ten years. The economics of wheat showed a net gain of Rs 7188/ha in Jalaun and Rs 4341/ha in Hamirpur during 2009-10 while the wheat growers of these districts incurred a loss of Rs 473 and 3071/ha in 2004-05 respectively. The contribution of irrigation in total operational cost was worked out 18.4 and 19.4 per cent in Jalaun and Hamirpur during 2009-10 as against 29.0 and 30.8 per cent in 2004-05. This indicates the effect dynamics of groundwater table on the crop economics. Further, the cropped area under cereal and millets declined from 40.1 to 38.3 per cent in Jalaun and 48.0 to 33.7 per cent in Hamirpur during 1984-85 to 2003-04 again showing the impact of scarcity of irrigation water and sharp depletion of ground water table in these districts. Rearing goat by majority of resource poor farmers with crop production and earning Rs 8.9/day per capita income by marginal and Rs 11,2/day/capita for small farm group further prove the scarcity of surface as well groundwater in Bundelkhand region including the districts included in the study.

**Key words:** Groundwater table, Dynamics, Disparity, recharge, Impact, Household, Gross Income, Net return, Variation, Operational cost. Extraction.

The people of Bundelkhand have remained both politically and economically separated from the rest of the country because of natural geography and harshness of the agro-climatic condition of the region. Most of the agriculture is subsistence and contribute little to the overall economy of the region. The per capita income which is the indicator for human development of a region or state, was Rs. 8114 as against national average of Rs. 13193 during 1997-98. Crippling poverty has therefore prevented many from improving their situation. Agriculture plays an important role in Bundekhand economy, however, poor soil and uncertain rainfall have made agriculture difficult in many parts of the region. Recent recorded history of Bundelkhand shows that entire region suffer from sever crop loss every three years or so either due to drought or flood. One fact which is generally not reflected in government assessment of drought is

Senior Scientists[1], Project Director[2], Senior Scientist[3], Scientist[4], Project Directorate for Farming Systems Research, Modipuram, Meerut (U.P.)

wide spatial and temporal variation in rainfall within a district during monsoon. For instance, data from state department of irrigation shows that in June-September 2009, rainfall is in Chitrakoot district varied from 576.5 mm at Karwi town to only 195 mm at Oham dam, in the rocky Patha area and both the location falling in the same block. Groundwater extraction from wells is the primary source of irrigation in most parts of the region. Because of rolling terrain and variable depth of soil, the groundwater table can be found at a depth anywhere between 3 to 22 meters or more. However, the relative accessibility of groundwater means that most farmers can obtain water from their own land regardless of their distance to a major source. Mechanized pumping using diesel power pumps has greatly increased the use of ground water for crop irrigation.

In Bundelkhand groundwater is main source of irrigation and rain water has little time to penetrate the soil which badly affects the groundwater recharge. Further, the groundwater recharge is aggravated by the substratum of impermeable rocks. Again rainfall is often in high bursts; of the total 850mm rain in a year in one place, 400mm may fall in just 20 hours, with intensity going up to 30 to 50 mm a hour. This also influence the groundwater recharge and cause sharp decline of groundwater table. The use of irrigation has improved in the region; however, widespread use in the region that often suffer from weak monsoon and drought, recharge of groundwater is limited and if under such situation, over extraction of groundwater is continued, there may be a serious threat to water scarcity in the region in coming future. As per National Committee on Development of Backward Areas Report (1981), five district viz Jalaun, Banda, Chitrakoot, Hamirpur, and Mohaba of Bundelkhand region falls under the category of “drought prone areas”.Out of these, two districts namely Jalaun and Hamirpur were included in the study to study the dynamics of groundwater table and their impact on crop economics and energy consumption. The study results will be helpful to the researchers and planners involved in the development of Bundelkhand region. The study findings will also focus the way of survival of farming community having limited resources in such a water scarcity zone.

## Materials and Methods

Jalaun and Hamirpur districts were purposely selected for the study. Further, three blocks from each of Jalaun and Hamirpur were selected following the multistage stratified random sampling method. There after, two villages from each block were chosen using same sampling procedure. Further, twenty farm families from each village were selected. Thus a total of 240 households were selected for the proposed study. Data with regard to operational holdings, area under various crops, quantity of input of used and their per unit price were gathered on well structured questionnaire developed for this purpose. Besides, data relating to depth of water in bore wells, per hour diesel consumption, during course of survey (2009-10) and past five (2004-05) and ten years (1999-2000), were recorded. The numbers of wells established, failed, dry and yielding water during course of survey was also noted. The information pertaining to fluctuation of water depth during summer, winter and rainy seasons which influence the cost of irrigation was also collected from the study districts. The sources of income other than cropping were also recorded to assess the socio-economic condition of the farm families settled in "water scarcity zone" of Bundelkhand region. Simple analytical tools like tabular analysis, percentage and average were used for processing the data.

## Results and Discussion

### Dynamics of ground water table

The average groundwater table governed by rainfall was recorded 27.6 meters during course of survey (2009-10) in district Jalaun Fig (I). As appraised by the farmers, the depth of water during past 5 and 10 years was 29.7 and 17.9 meters respectively. The corresponding figures in Hamirpur was 30.8, 34.4 and 27.6 meters respectively Fig-( 2).

The water table was little more during (2009-10) as the study districts received comparatively more rainfall during that with different magnitude while the rainfall was much below to normal before (2004-05) as apprised by the farmers during the course of survey. Farmers further informed that prior to 2004-05, these districts were receiving normal rains with different intensity. This has attributed to variation in water table over the years in the study districts. As evident from the data, the problem of groundwater was more in Hamirpur compared to Jalaun and this is because of disparity and intensity of rainfall at these locations. The variation in water table was not only observed between these districts, but a wide disparity in depth of water was also recorded with in the district. For instance, in Rampur block of Jalaun district, the average water table was measured 40.8 meters while in Dekore and Nandigaon blocks, it was 29.0 and 12.9 meters during course of survey ( 2009-10) respectively Fig. (3).

### Disparity in water table in different blocks of Jalaun district

This might be because of high bursts of rainfall at Nandigaon and low in Rampur during 2009-10. This showed a wide disparity in water table in Bundelkhand region. The results corroborate with the findings of National Geographic Society Report of India (1989). The similar variation in water table was also observed in the blocks of Hamirpur district with different magnitude. Besides, most of the bore wells were found yielding water only 5-6 hours at a time and there after they became empty and farmers left the wells for recharge for further 6-8 hours. Because of this, the farmer having bore wells were not able to sell the water to their neighbors for irrigating the crops. Since construction of well is a costly affairs, the marginal and small farmers are always depend on rainwater for crop production.

### Impact of ground water table

#### *Energy consumption*

Extraction of groundwater is the main source of irrigation for the farming community settled in Jalaun and Hamirpur districts. Change in water table over the period has made impact on diesel consumption and data presented in Table(1)has proved this facts.

As evident from the data, the consumption of diesel which was 1.54 lit/hrs in Jalaun and 1.59 lit/hrs in Hamirpur during 1999-2000 increased to 2.39 and 2.65 lit./hrs during 2004-05 in these districts. Sharp decline of groundwater table during a period of five years compelled the farmers to use high power diesel engine which increased the diesel consumption during 2004-05. However, due to improvement in rainfall, the per unit diesel use was marked marginally decreased during 2009-10 as

**Table 1 : Per unit diesel consumption and cost of irrigation (Rs/ha) at Jalaun and Hamirpur over the year**

| Details | 2009-10 | | 2004-05 | | 1999-2000 | |
|---|---|---|---|---|---|---|
| | Jalaun | Hamirpur | Jalaun | Hamirpur | Jalaun | Hamirpur |
| Per /hrs diesel consumption (lit) | 2.02 | 2.10 | 2.39 | 2.65 | 1.54 | 1.59 |
| Hours consumedPer/ha irrigation of wheat (2 irrig.) | 44.30 | 49.10 | 51.3 | 56.4 | 33.2 | 34.3 |
| Total cost ofirrigation (Rs/ha) | 3278 | 3815 | 4536 | 55.30 | 1892 | 2024 |

apparent from the data. Further, the fluctuation of water depth also influenced the number of hours consumed for irrigating per unit area of the respective crops. For example, 33.2 and 34.3 hours were being utilized for irrigating one hectare wheat during 1999-2000 in Jalaun and Hamirpur, increased to 53.1 and 56.4 hrs/ha during 2004-05 respectively. The growth in irrigation hours consequently increased the cost of irrigation which was recorded 133.7 and 173.2 per cent higher during 2004-05 compared to 1999-2000 in Jalaun and Hamirpur respectively. However, the corresponding growth in irrigation cost was observed declined to73.2 per cent in Jalaun and 88.5 per cent in Hamirpur during 2009-10 which is attributed to improvement in water table during the period. These figures clearly indicated the impact of fluctuation of ground water table on energy consumption and cost of wheat irrigation over the years.

**Economics of wheat cultivation**

In Bundelkhand region in general and study districts Jalaun and Hamirpur in particular wheat is the main cereal crop during *rabi* after sorghum. Gram is also grown on large scale after sorghum. Pigeon pea, black gram and sesamum are grown in kharif. Except wheat, other crops are generally depending on rainfall. The wheat grown by small and marginal farmers also do not receive irrigation due to lack of irrigation facility. However, the farmers who provided irrigation to wheat, the economics of wheat cultivation of such farm groups has been presented in Table-2.

Data in table clearly showed the impact of fluctuation of groundwater on wheat productivity and economic loss realized by wheat growers. As evident from the data, the speedy decline of groundwater attributed to irregular and erratic rainfall, brought down the groundwater table to the level of 29.7 meters in Jalaun and 34.4 meters in Hamirpur during 2004-05 and as a result the productivity of wheat in these districts was recorded 19 and 17q/ha during that year which was much below the national average of 26.2 q/ha. The low wheat productivity caused a loss of Rs 473/ha in Jalaun and Rs 3071/ha in Hamirpur during 2004-05 respectively. While comparing the wheat productivity, net return and contribution of irrigation from 2004-05 to 2009-10, the impact of groundwater table on wheat economics was more pronounced. For instance, the productivity of wheat harvested during 2009-10 was recorded 23 and 22q/ha in Jalaun and Hamirpur compared to 17 and 19 q/ha in 2004-05 in these districts

**Table 2 : Comparative economics of wheat cultivation during 2009-10 over 2004-05 of Jalaun and Hamirpur districts (In rupees)**

| Year/ districts | Variable cost | Intereston on working capital | Total cost | Cost of irrigation | Yield Q/ha | Gross income | Net return | Share of irrigation in total cost %) |
|---|---|---|---|---|---|---|---|---|
| **2009-10** | | | | | | | | |
| Jalaun | 16199 | 1620 | 17819 | 3218 | 23 | 25000 | 7181 | 18.4 |
| Hamirpur | 17872 | 1787 | 19659 | 3815 | 22 | 24000 | 4341 | 19.4 |
| **2004-05** | | | | | | | | |
| Jalaun | 14212 | 1421 | 15633 | 4536 | 19 | 15160 | - 473 | 29.0 |
| Hamirpur | 16319 | 1632 | 17951 | 5530 | 17 | 14880 | - 3071 | 30.8 |

*Note:* Support price of wheat Rs 1000/q for (2009-10) and Rs 640/q during (2004-05) was taken into account for calculating the gross income. Gross income includes income from wheat straw.

respectively. Similarly wheat producers of Jalaun and Hamirpur realized a profit of Rs 7181 and 4341/ha during 2009-10 while the wheat cultivators incurred a loss of Rs 473 and 3071/ha during 2004-05. The contribution of irrigation to the total operational cost was also observed declined from 29.0 and 30.8 per cent during 2004-05 to 18.4 and 19.4 per cent in 2009-10 in Jalaun and Hamirpur respectively. Good rains improved the water table as well as soil moisture during 2009-10 which caused improvement in productivity and profit margin. These figures clearly underline the effect of groundwater table on wheat economics in the study area.

## Effect of groundwater table on farming systems

Scarcity of irrigation water has also influenced the farming systems in Bundelkhand region. In general majority of the farming community in all parts of the country keeps milch animals like cow and buffaloes on the farm with cropping to meet the domestic requirement and enhance the farm income. However, due to non- availability of sufficient fodder and non-availability of drinking water for animals either in ponds or wells, the majority of resource poor farmers were observed keeping goats on the farm to supplement the household income. Further, while conducting the survey, farmers reported that during summer, the water table decline sharply and more than 60 per cent of wells become empty and under this situation farmers depend on Municipal Water Supply Systems for drinking purposes. The situation enforces the majority of the farming community to keep goats on the farm which require less water and depend on grazing. The other enterprises like horticulture, be-keeping, fisheries and vegetable farming were not observed to keep by any farm groups on the farm. However, the crop+ goat farming followed particularly by resource poor farmers in Hamirpur was observed remunerative Table (3).

As evident from Table (3), the marginal farmers cultivated 0.85 hectare gram with 7 goats, earned a net income of Rs 19,200 from crop+goat farming. The contribution of goats in total farm income was noticed 44.3 per cent which is

**Table 3 : Economics of goat based farming System.**

**(In rupees)**

| Farm group | Area (ha) | Crops | | | | Goats | | | | | | Crop+goats | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Cost of culti-vation (Rs.) | Produce (t) | Gross return (Rs.) | Net return (Rs.) | No. | Rearing cost | Pro-duction (No) | Gross return | Net gain | Total cost | Total income | Net return | (%) Share of goats |
| Marginal | 0.85 (Gram) | 6300 | 0.85 | 17000 | 10700 | 7 | 2500 | 12 | 11000 | 8500 | 8800 | 28000 | 19200 | 43.3 |
| Small | 0.75 Sorghum | 3800 | 0.50 | 8000 | 4200 | 5 | 2300 | 9 | 9000 | 6700 | 4300 | 17000 | 12700 | 32.6 |
| | 1.05 (Wheat) | 16350 | 2.60 | 26000 | 9650 | 0 | 0 | 0 | 0 | 0 | 16350 | 26000 | 9650 | |

marginally less than crop income. In case of small farm group, the share of goats to the total income was observed 32.6 per cent. As the non-vegetarian food habits is growing in all parts of the country and the price of meat is increasing day by day, rearing goats with crops was noted an income generating system for resource poor farmers in the study area.

## Impact of groundwater table on cropped area

The effect of groundwater table coupled with scarcity of rainfall was clearly apparent from shrinking of area under important cereals together with millet and oilseed crops over the year Table (4). Data presented in the table showed that the area under cereals and millets which was 40.1 per cent to the total cropped area in Jalaun and 48.0 per cent in Hamirpur during 1984-85 declined to 38.3 and 33.7 per cent during short span of nine years (2003-04) in these districts respectively. Similarly in oilseed, the area declined from 6.2 to 4.0 per cent in Jalaun and 6.7 to 3.0 per cent in Hamirpur during this period. The similar trend was observed in other neighboring districts like Lalitpur, Mahabo and Banda etc in respect of cereal and oilseed crops. This showed that due to poor and erratic rainfall which caused depletion of groundwater table and non-availability of other source of irrigation, farmers reduced the area under rice, wheat, barely and mustard which require irrigation during crop season.

However, the area under pulses was observed improving in all parts of Bundelkhand region and it needs appreciation keeping in view the hike of pulses price, its low production and high demand in the country. The share of area under pulses increased from 51.1 to54.9

**Table 4 : Per cent share of cropped area of important cereals in Bundelkhand during 2003- 04 over 1984-85**

| Districts | Cereal and Millets | | Pulses | | Oilseeds | |
|---|---|---|---|---|---|---|
| | 1984-85 | 2003-04 | 1984-85 | 2003-04 | 1984-85 | 2003-04 |
| Jhansi | 48.7 | 30.0 | 43.2 | 62.0 | 5.6 | 6.7 |
| Lalitpur | 61.7 | 38.4 | 24.0 | 56.8 | 10.0 | 3.9 |
| Jalaun | 40.1 | 38.3 | 51.1 | 54.9 | 6.4 | 4.0 |
| Hamirpur | 48.0 | 33.7 | 43.4 | 60.9 | 6.7 | 3.0 |
| Mohaba | — | 26.7 | — | 64.8 | — | 7.0 |
| Banda | 61.0 | 56.0 | 36.0 | 41.1 | 11.6 | 1.4 |
| Chitrakoot | — | 56.5 | — | 39.7 | — | 2.1 |
| BundelkhandRegion (UP) | 51.7 | 55.0 | 40.2 | 55.0 | 5.4 | 4.1 |

*Source:* Land Use Statistics, Ministry of Agriculture, Government of India, New Delhi.

per cent in Jalaun and 43.4 to 60.9 per cent in Hamirpur during 1984-85 to 2003-04. However, the negative impact of scarcity of irrigation water was neither observed on cropped area nor productivity of pulse crops. For instance, the average productivity of gram occupied substantial area in Jalaun and Hamirpur, was recorded 1200 and 970 kg/ha as against U.P average of 911 kg/ ha during 2003-04. This showed that the agro-climatic condition of Bundelkhand region including the study area are well suited for pulses production. However, declining area under cereals and oilseeds clearly showed the impact of scarcity of rainfall causing depletion of groundwater table in study area. Besides, if the shrinking of area under cereals are continued, a serious food crises may arise in the region in coming future.

**Scarcity of water and its impact on socio-economic condition and employment**

The annual farm income of marginal farm group having 6 family members was computed Rs 19200. The corresponding figure for small farm group keeping 5 family members was Rs 21500/annum Table (4). Considering the present increasing price trend of cereals, pulses, and edible oils, the income realized by these farm groups shown in the table, may not feed their family members through out the year. Further, per capita/day income of Rs 8.9 calculated for marginal farm and Rs 11.2 for small group again prove the burst economic situation of the resource poor farmers of the study districts .However, as apprised by the farmers, the male family members of these farm groups used to migrate in town and cities for employment during each year for survival of their families. The scope for earning wages from agricultural work either from their own village or from neighboring villages was observed very limited for resource poor farmers. The situation clearly indicate the impact of groundwater depletion caused by erratic and low rainfall coupled with drought on socio-economic condition of the farmers.

**Conclusion and future strategies**

The study inferred that the depletion of groundwater table is not only influencing the crop economics and energy consumption but it also compels the farmers to restrict the area under important food crops like rice, wheat and barley require irrigation and as such the area under these crops are shrinking in Bundelkhand including Jalaun and Hamirpur districts. The decline in water table to 29.7 meters in bore wells caused reduction in wheat productivity and incurred a loss of Rs 473/ha in Jalaun during 2004-04. However, increase in water depth attributed to improvement in the rainfall, raised the productivity to 4q/ha which in turn earned a net return of Rs7181/ha from wheat production during 2009-10. The similar variation in cost and return was also observed in Hamirpur wheat production during the period in question. Diesel consumption also decreased from 2.39 lit/hrs in 2004-05 to 2.02 lit/hrs in Jalaun and 2.65 to 2.10 lit/hrs in Hamirpur. These figures justify the impact of water table dynamics on crop economics and energy consumption.Rearing goats and sheep with cropping by resource poor farmers to enhance household income further indicate the scarcity of surface and groundwater which do not allow the farmers to grow fodder and keep milch animals like cow and buffaloes for milk production which is major source of income after crops to the farming community in all parts of the country. Cropping intensity which was recorded 125 and 117 per cent in Jalaun and Hamirpur again highlight the scarcity of irrigation water being utilized through groundwater sources by the farmers. Besides, migration of farmers to town and cities after harvesting the rabi crops further prove the uncertainty of kharif crops production and in turn, it badly influence the household income and as such farmers compelled to move cities and towns for employment. Keeping these results in view, following strategies has been developed to overcome the problems:

- Over dependence of groundwater utilization needs to be curtailed and for that, shift from current groundwater extraction to surface water utilization with management of rain water harvesting is essentially required.
- Integrated land and water development programme is required to be prepared.
- In water scarcity zone, only those crops which are drought tolerance, short duration and less water requiring crops are advised to be grown by the farmers and water intensive crops should not be promoted.
- Government and Communities must be partner in long term crises management in drinking as well as irrigation security.
- Establishment of canals and government tub-wells in each district of Bundelkhand is utmost essential to protect the crops.
- Establishment of watershed and effective implementation of water harvesting programme will benefit the farmers to make use of rain water for crop production.
- Development of small scale industries and food processing units will provide employment and supplement the household income to the various farm groups.

## References

National Geographic Society of India (1989) " Bundelkhand Region" India : A regional geography. R.L. Singh,Ed. UBS Publishers' Distributors Ltd: New Delhi,pp597-622.

Development Alternatives (1999) Reversing the downward Spiral: Understanding the influence of livelihood system of the resource base in Bundelkhand. Development Alternatives: New Delhi p118.

Center for Science and Environment (1999) The Citizens Fifth report: Part II Statistical Database CSE: New Delhi, p256.

*J. Farming Systems Research & Development* **18** (2) : 196-213 (2012)

# DESIGN AND DEVELOPMENT OF INTEGRATED FARMING SYSTEM MODELS FOR LIVELIHOOD IMPROVEMENT OF SMALL FARM HOLDERS OF WESTERN PLAIN ZONE OF UTTAR PRADESH

J.P. SINGH, B. GANGWAR, PREM SINGH AND D.K. PANDEY

*Project Directorate for Farming Systems Research, Modipuram, Meerut-250110, U.P.*

ABSTRACT

Studies conducted in India and abroad has recognized the utility and importance of IFS approach in livelihood improvement of small farm holders representing more than 86 percent of the total farm families of the country. Six years long IFS study conducted at PDFSR, Modipuram confirmed ( Singh and Gill 2010 ; Gill et al 2009) the findings and envisaged that from 1.5 hectare irrigated land besides fulfilling all the household food and fodder demand inclusive cost of production, created an additional average annual savings of Rs. 47000/- in first three years of its establishment and more than Rs.50, 000 in subsequent years. Singh 2004 also reported the similar results . Recycling of all the crop residues, animal and farm wastes and use of leguminous crops as green manure or dual purpose crops and biofertilizers could save more than 36% of plant nutrients. The analysis made on on-farm production and inter-relationship of different enterprises within the system envisage that more than 57 percent of the total cost on farm production Rs.1,97,883 per annum is met from the inputs (out- put of another enterprise/enterprises ) generated within the system itself. This shows the significance of IFS approach and advocate that farming can be made more sustainable and economic by adopting it under small farm conditions. The approach was found enhanced and regular income and employment generative and environment friendly too. The paper includes the concept, methodology and format of development a representative IFS model for the farmers of western plain zone of U.P. in particular and similar agro climatic conditions of Uttar Pradesh , Haryana, Punjab and other northern states of the country.

## Major concern

Indian economy depends primarily from rural & agricultural sectors. Contribution of Agriculture to GDP has gone down to 17.1% from 65% five decades ago. Two third of our population still depends on Agriculture for their livelihood. Small and marginal farmers constitute more than 86% of farming population and will reach to 95% in coming 30 years or so at present population growth rate. The major concern of coming era include unchecked population growth, shrinking land holding size, continuous fall in water table, decreasing factor productivity, stability in production and decreasing profit margins of small farm holder farmers. Agriculture to these categories of farmers is a subsistence type of farming and force to live farmers in poverty and constraints. These situations lead to large scale migration from villages to nearby towns and cities.

## Rout of enhanced and sustained livelihood of smallholder farmers

Looking in to the present agriculture scenario at small-holders, the single commodity / discipline based research efforts made in past are not sufficient to meet the future demands of small holders representing more than 4/5$^{th}$ of total farm families in India. Though, in isolation but concerted efforts made by several researchers in different parts of the country confirmed that Integrated Farming System Approach is the only way through which the livelihood of smallholders can be ensured and the production base soil and water can be sustained for a long

**Farming System Approach**

"Farming system" is a complex inter-related matrix of soil, plants, animals, implements, power, labour,capital and other inputs controlled in parts by farming families and influenced in varying degrees by political, economic, institutional and social forces that operate at many levels (Mahapatra, 1987). Farming system aims for increased productivity, profitability along with sustainability, balanced food, clean environment, exploring synergy among interacting enterprises through recycling farm wastes and by-products, generating family income & employment round the year, solving energy, fuel and fodder crises, increased input efficiency, enhanced opportunity for agriculture oriented industries and ultimately, improved standard of living of the farmers. In other words farming system management is the sound management of farm resources to enhance the farm productivity, reduce the environmental degradation, improve quality of life of resource poor farmers and to maintain sustainability.

**Aims of Integrated Farming System**

- Livelihood improvement
- Nutritional security
- Income growth
- Poverty alleviation
- Employment generation
- Judicious use of land and water resources
- Sustainable agricultural development
- Environmental improvement

**Possible output of Integrated Farming System**

To meet growing demand of human and animals and to provide gainful employment, IFS has several advantages over arable farming such as;

**a) Increased food supply:** Horticultural and vegetable crops can provide 2-3 times more calories than cereal crops on the same piece of land and will provide food and nutritional security. Similarly inclusion of Bee keeping, fisheries, sericulture, mushroom, cultivation under two or three tier system of integrated farming can give substantial additional high energy food without affecting production of food grains.

**b) Recycling of farm residues:** Proper collection & utilization of cowdung & urine of animals in the form of FYM and vermicompost alone can save about 50% of NPK requirements of the crops. Vermicompost containing 3 to 4 % more N content than FYM can be produced from crop residue mixed with cowdung for restoring soil fertility. Further, if we utilize even 1% of annually available 200 metric ton crop residue for mushroom cultivation then we can produce 2 lakh tons mushroom against only 40 tons of present day production.

**c) Use of marginal and wastelands:** Combination of forestry, fishery, poultry, dairying, mushroom and bee keeping can be combined with crop raising and all these activities can be undertaken on marginal to wastelands too.

**d) Increased employment:** Studies conducted in India and elsewhere, indicated 200 to 400 percent increase in gainful employment and additional income to farm families to increase their standard of living.

**e) Restoration of soil fertility and conserving environment:** With efficient recycling of crop and animal residue in crop-live stock- poultry-fishery system, at least half of the nutrient (if not more) can be saved along with restoration of soil fertility and cleaner environment be maintained. Preparation and large scale use of wormy compost will further help in decreasing dependence on chemical fertilizers and will also help in keeping clean and healthy environment.

## Farming System Research Methodology

### *Major steps in integrated farming system approach*

- Characterization of prevailing On-Farm Farming Systems of the region/area.
- Bridging yield gaps by minimizing production constraints through adoption of latest viable production technologies
- Maximization of farm production & profits by diversification of prevailing On-Farm Farming Systems through integration of economically viable but socially accepted low cost/ cost effective farm- enterprises

### *Way and means to achieve desired goal*

- To understand the farmer and his resources
- Estimation of family annual food and fodder demands
- Allocation of farm land and other resources for livelihood improvement
- Formulation of cost effective viable technological module/modules for different component enterprises to bridge the yield gaps
- Diversification of prevailing farming systems through integration of some additional need based socially accepted low cost enterprises which suits to his farm conditions

## PROJECT AREA AND PRESENT STATUS OF AGRICULTURE IN WESTERN PLAIN ZONE OF UTTAR PRADESH

### Location

The Project Directorate for Farming Systems Research Modipuram fall in Upper Gangetic Plain Region and is located on Delhi – Hardwar Highway No. 58, at a distance of about 10 K.M. from zero mile of Meerut city in the state of Uttar Pradesh. Modipuram is situated at an elevation of 237 meters above mean sea level, $29^{0}4^{/}$ N latitude and $77^{0}46^{/}$ E longitude.

### Soils and climate:

The project area falls under Agro-ecological Region No.4, i.e., "Northern Plain and Central Highlands, Hot Semi-Arid Eco-region" with alluvium derived soils. Soils of PDFSR, Modipuram research farm are representative of the region and are neutral to slightly alkaline in nature and belong to Typic Ustochrept group. Present fertility status of the soils in U.P. revealed that about 98% developmental blocks of the state are in low to very low in N & P and 57% blocks are medium in K content. Topography of the soil more or less is flat/leveled except few sand dunes and moderate slops near riverbanks. The climate of the region is broadly classified as semi-arid sub-tropical, characterized by very hot summers and cold winters. The hottest months are May-June, when maximum temperatures may shoot up as high as $45^{0}$C to $49^{0}$C, whereas during coldest months December- January, minimum temperature often goes below $5^{0}$C. The average annual rainfall is 862.7 mm, 75-

80% of which is received through southwest monsoons during July to September.

**Irrigation facilities**

More than 90% of the crops are grown under assured irrigation conditions propagated by the network of river canals (about 1/4th of the total irrigated area) and rest with diesel engine or electric operated deep bore wells.

**Farmers and farm conditions**

The marginal (76%) and small (14%) farmers constituting major part of the total farm families are owing only 58% of cultivated land with holding size ranging from 0.70 ha with marginal and 1.2 hectare land with small farmers. More than 31% of the farmers fall under below poverty line. Most of them are resource poor, illiterate, live in diverse, risk prone conditions. The problems faced by most of the farmers included high rates of agricultural loans, farming not secured by any financial /insurance institutions, no price support, poor marketing facilities and lack of technological know how and all these bother mainly to the poor of the poorest. The fields are yet scattered and divided in very small plots not suited for mechanization.

**SWOT analysis of small farm holders**

Before planning and start of any programme or project, SWOT analysis is must to get success. Our client in IFS are marginal and small farm holders and it is desirable to know the strength, weaknesses, opportunities and threats coming in the way of running the programme with these categories of farmers.

**Present Farming Systems Scenario**

- **Prevailing Farming System of the area-** Crops +Dairy.
- **Major crops -** Sugarcane, wheat, rice, mustard and fodder crops sorghum (Kh.) & berseem /oats.
- **Dominate cropping systems:** Sugarcane –wheat and Rice-wheat-summer sorghum.
- **Major dairy animals –** Buffaloes and cows (Buffaloes have an over edge on cows).

**Table 1 : General Status of Small land holders in the zone**

| Farmer | Farm Land | Institutions |
|---|---|---|
| Marginal -76% | Small Land Holdings | Lack of Technical Know How |
| (Owing 34% Land) | (0. 7 to 1.21 Ha) | High Rate of Gricultural Loans |
| And Small- 14% | Not Ideal for Mechanized Farming) | Lack of Market Facilities |
| (Owing 24% Land) | | No Price Support |
| Financially Weak | Low Soil Fertility | |
| (31% Below Poverty Line) | (In U.P. 98% Blocks are L to Vl in N&P and 57% Blocks are Medium in K Level) | |
| Resource Poor | | |
| (Depend on Others) | | |
| Most of them are Illiterate | Scattered Undulated Fields | |

**Table 2 : SWOT analysis of small farm holders.**

| Strengths | Weaknesses | Opportunities | Threats |
|---|---|---|---|
| Sufficient Man power | 1. Small & fragmented land holdings<br>2. Wide spread Poverty<br>3. Lack of resources<br>4. Illiteracy<br>5. Laggardness<br>6.Low risk bearing capacity<br>7.Poor technological know-how | 1. Loans on low interests<br>2. Subsidies on implements, milch animals and new enterprises like fish production, horticulture and a number of small scale industries.<br>3. Free trainings for agriculture related enterprises.<br>4. Research oriented technologies to increase the productivity and profitability of existing On-Farm farming Systems. | 1. Any type of technological and/ or methodological failures can affect the economic condition of the family.<br>2. Small farmers' works in risk prone diverse conditions.<br>1. Environmental factors such as climate and weather adversities are beyond the control of small farm holders who are economically handicapped.<br>3. High risk to introduce any new technology. |

- **Other options/enterprises**

  **a) Leading:-** Horticulture

  **b) Found Economical but not common:-** Bee keeping, Fishery, Piggery, Poultry & Mushroom.

The dominant on-farm farming system practiced by most of the farmers in western plain zone of Uttar Pradesh is **crops + dairy**. Some of the farmers owing large land holdings also integrate horticulture and or apiary with existing farming system as above. Under horticulture, fruit orchards of mango & guava mainly with large farmers and seasonal vegetables & marigold flowers mainly near vicinity of the towns and cities are becoming popular because of high income but with market risks. There are some other very promising but socially less accepted enterprises, including poultry, fishery, piggery, mushroom and vermiculture adopted by few farmers having zeal to get higher incomes

**Demand and supply**

The brief account of the present status of demand and supply under different components of various farming practices adopted by the farmers is described below;

**Crops:** The farmers grow selected crops (Rice, wheat, sugarcane and sorghum) and are dependent on local market mainly for pulses oilseeds and some times green fodder too. – *The annual minimum need of family for food, fodder and fuel are not met out.*

**Dairy:-**Rearing of indigenous & low yielding (4-6kg milk/day) breeds of buffaloes and cows. Fodders having very low nutrition value including wheat straw and sugarcane tops are fed as fodder for more than six months. Lack of leguminous and green fodders – *Raring of un- economical animals and poor nutrition are among the major constraints identified.*

**Fruit cultivation:-**Mango, guava, peach and pear are major fruit trees. The fruit orchards however are dominated by mango mixed in different ratios of peach/ pear or guava. Farmers grow any of the field crops even sugarcane or rice or wheat or sorghum in newly planted orchards. *Alternate bearing & blackheart disease in mango orchards are serious concern to the fruit grower – Lack of technological know-how.*

**Bee keeping:-**Bee keeping is practiced mainly by the orchard owners or the farmers residing near vicinity of the orchard owners , as this particular enterprise need constant flowering crops/trees. *Small holdings do not give room for fruit tree plantations and also inclusion of flowering crops like mustard and sunflower etc.*

**Fishery, piggery and poultry:-** Few farmers go for these three socially not accepted enterprises. Pounding and maintaining a certain depth of water in fishpond through out the year is the major constraint of fish farming. *Heavy loss due to diseases in piggery & poultry and social status& religion is the major hindrances in popularizing these areas of great potentialities.*

**Yield gaps**

The survey of existing farming system of western plain zone of Uttar Pradesh revealed that there is wide gap between farmer yield and achievable yield of different farm commodities (Table-3).

**Constraints responsible for yield gaps**

The constraints analysis is most important exercise in order to find out or suggest specific solutions to specific problems. With the help of survey following problems/constraints were analyzed which will help to identify researchable issues/interventions to make the different enterprises more profitable:

**A. Crop production**

- Late planting of crops, especially of sugarcane and wheat.
- Use of higher seed rates
- Poor seed management
- No seed treatment
- Improper sowing methods mainly broadcasting in wheat
- Excess use of N, imbalanced use of nutrients and improper application methods
- Use of poor quality FYM
- Lack of knowledge about disease and pests management in respect of application methods, time of

**Table 3 : Farmer yield, achievable yield and yield gap of some of the farm commodities**

| Farm commodities | Farm yield (Av.) q/ha | Achievable yield (Av.) q/ha | Gap (%) |
|---|---|---|---|
| Sugarcane (Plant crop) | 540 | 1100 | 103.0 |
| Sugarcane (Ratoon crop) | 740 | 1300 | 75.7 |
| Wheat | 46 | 65 | 41.3 |
| Rice | 42 | 65 | 54.8 |
| Buffaloes | 5.22kg/Animal/day | 12.0kg/Animal/day | 129.9 |
| Improved cows | 7.36kg/Animal/day | 18.0kg/Animal/day | 161.7 |

application, rates of pesticides and use of right pesticides.

**B. Animal husbandry**

- Rearing of Non-descript of animal
- Feeding of animals with poor quality feed and fodder
- Animals are not feed with balanced ration
- Incidence of diseases and other problems
- Fertility problem, anoestrus, repeat breeding, low conception rate, improper time of service, service by local and non-descriptive bull
- Little use of minerals, salts and vitamins

**C. Horticultural crops**

- Mango: The main problems of mango include alternate bearing, malformation, disease like bacterial blight and powdery mildew and pests like hopper and mealy bug, taking orchard by non-traditional farmers, grow unsuitable crops in orchards and lack of processing units.
- Vegetables: In vegetable main problems were non-availability of good quality seed, sowing of seed without proper treatment, lack of suitable variety and suitable techniques and pests and disease problems.
- Floriculture: In floriculture, there is no suitable variety of marigold, particularly for rainy season crop and disease and pest.

**D. Bee- keeping**

- Lack of technical know- how, adoption at small scale, non-availability of desired flower plants round the year for honey bees for feeding, lack of improved honeybees colonies and incidence of pests and diseases.

**E. Poultry**

- Lack of technical know-how, poor housing facility, non-availability of electricity, not taking regular batches of poultry are some of the problems of poultry.

**F. Fishery**

- Social factor, use of small size ponds, theft, poisoning, lack of technical no-how and un- awareness among farmers.

By solving above constraints/ problems we may improve inputs use efficiency, resulting in improved out put per unit area and time, the ultimate aim of farming system approach.

## ANNUAL FOOD AND FODDER DEMANDS OF AN INDIAN 7 MEMBERS' HOUSEHOLD

To reduce market dependency and allocation of farm resources, estimation of annual household food and fodder demand of the family is a pre – requisite. Several standards have been fixed for the purpose. However, in this project standard set by Dr. M.S.Swaminathan (1998) have been used and family annual requirements have been estimated (Table-4).

Based on the calculations as per standard given in above table the total annual requirement of different farm commodities is summarized in the table-5.

## DEVELOPMENT OF INTEGRATED FARMING SYSTEM MODEL

Characterization of On- Farm Farming Systems of an area if properly done give sufficient information on the

**Table 4 : Diet standards for different categories of farm workers (Average balanced diets for adult male and female- g/person/day)**

| Food Stuff | Male | | Female | |
|---|---|---|---|---|
| | Moderate work | Heavywork | Moderatework | Heavy work |
| Cereals | 450(450) | 630 (630) | 310 (310) | 440 (440) |
| Pulses | 80 (65) | 80 (65) | 60 (50) | 60 (50) |
| Green leaf vegetables | 125 (125) | 125 (125) | 100 (100) | 100 (100) |
| Other vegetables | 75 (75) | 100 (100) | 75 (75) | 75 (100) |
| Root and tubers | 100 (100) | 100 (100) | 75 (75) | 100 (100) |
| Fruits | 60 (60) | 60 (60) | 60 (60) | 60 (60) |
| Milk | 400 (250) | 400 (250) | 400 (250) | 400 (250) |
| Fats and oils | 40 (40) | 50 (50) | 35 (40) | 40 (45) |
| Sugar and Jaggery | 40 (40) | 55 (55) | 30 (30) | 40 (40) |
| Meat and fish | 0 (60) | 0 (60) | 0 (60) | 0 (60) |
| Eggs | 0 (30) | 0 (30) | 0 (30) | 0 (30) |
| Nuts | 50 (50) | 50 (50) | 40 (40) | 40 (40) |

(Figures given in parenthesis are for non vegetarian man/woman)

Source*:* Dr. M.S.Swaminathan,1998

**Table 5 : Total annual requirement of different farm commodities of 7 members' household**

| Farm commodities | Quantity (Kg/ton) |
|---|---|
| Cereals | 1550 Kg |
| Oilseeds | 130 Kg |
| Pulses | 200 Kg |
| Sugarcane | 1600 Kg |
| Green fodders | 40 Ton |
| Fruits | 200 Kg |
| Vegetables | 900 Kg |
| Milk | 1120 Kg |
| Honey | 20 Kg |
| Meat/Fish etc. | 160 Kg ** |

** Only for non-veg. families

prevailing farming systems, farm resources, yield gaps in different enterprises , constraints responsible for yield gaps and farmers' choices and priorities. Keeping all these aspects in mind, an Integrated Farming System Model and technological modules for each and every enterprise is prepared in consultation with the farmer and multi disciplinary team of scientists. Based on the information collected during diagnostic surveys conducted in the region and results of a six years (2004-05 to 2009-10) study on IFS at PDFSR, Modipuram, an ideal IFS model for one hectare cultivated irrigated land for small farm holders of western plain zone of Uttar Pradesh is hereby suggested for further dissemination of the technology.

**Components of IFS Model**

Prevailing Farming System (Crops + Dairy animals) +

Most accepted and profitable enterprise (Horticulture) +

Supplementary and most enterprising component (Fresh water fish production) + Value adding enterprise (Vermicompost) +

Safeguarding field crops and producing long term income (Boundary plantations)

**Allocation of farm land and other resources for livelihood improvement**

To meet at least the minimum essential annual requirements of food and fodder etc. of a household and reduced dependence on market for these commodities, it is must to allocate farm land and other resources including money in family purse, judiciously and accordingly. The remaining farm resources then should be/or may be allotted to some additional but few new enterprises already tested/proven beneficial and economical for further upliftment of the family. Based on the IFS study conducted at PDFSR, Modipuram, resource allocation for 1.0 ha irrigated land area representing marginal and small farmers both is given in table – 6 below.

**Formulation of enterprise modules**

As it is not possible to solve all the problems and constraints thereof, it is always advisable to prioritize the problems and related constraints causing much difference in yields if not solved. Then identify most viable and cost effective technologies which are feasible in operation and environment friendly too.

**Table 6 : Allocation of one hectare irrigated farm land for livelihood improvement**

| Farm commodities | Quantity (kg/ton) | Land allocation for basic commodities (ha) | Distribution of left out land area under suggested additional enterprise (ha) |
|---|---|---|---|
| Cereals | 1550 Kg | 0.35 | - |
| Oilseeds | 130 Kg | 0.11 | - |
| Pulses | 200 Kg | 0.17 | - |
| Sugarcane | 1600 Kg | 0.03 | 0.14 (Main cash crop of the region) |
| Green fodders | 40 Ton | 0.67 | A part of cropping systems followed |
| Fruits | 200 Kg | * | 0.22 (mango and guava ) |
| Vegetables | 900 Kg | ** | ** Will be met out from intercropping in fruit orchards and kitchen gardening |
| Milk | 1120 Kg | *** | *** Will be met out from dairy animals |
| Meat/Fish etc. | 160 Kg | **** | **** 0.10 (Under fish pond) |

*Note*: To meet minimum basic food and fodder requirements of the family a farmer need 1.33 ha gross cultivated area. Under irrigated conditions , more than two crops per year are taken from the same piece of land. Considering an average 250% cropping intensity the net cultivated area required comes to 5320 sq.m. or say 0.54 ha only. Now the remaining land area (0.46 ha) out of 10000 sq.m. (1.0 ha) is left available for diversification of the prevailing on – farm farming systems either with high value crops or by integrating some additional more paying enterprises to make the system holistic and also more profitable and sustainable.

## A) Crops

### Selection of crops and cropping systems

Select crops and cropping systems which satisfy household food and fodder requirements and are comparatively more paying. During last six years of studies on crops and cropping systems under IFS project at PDFSR, Modipuram, following cropping plan was found highly profitable as well helping in livelihood improvement. Farmers can choose and incorporate suitable crops in different crop rotations as per need of the family and farm resources.

### Technological package (Crops)

- Selection of season specific HYVs
- Use of RCTs (Zero tillage, BBF and residue recycling)
- SSNM
- INM –Increased use of organic sources of nutrients along with chemical fertilizers
- In situ and ex situ green manuring
- Use of Vermicompost in place of cow dung/FYM

## B. Dairy (Milk production)

### Size of the animal unit –

2 milch animals (1 buffaloes + 1 cow or 2 buffaloes as per choice of the family) & their young ones

### Economics of milk production

### 1. Production costs (Fixed + Recurring)

### a) Fixed cost

i) Purchase cost of the animals:

**One buffalo** @ 55,000/buffalo = Rs.60,000/-

**Table 7 : Productivity and profitability of different crop sequences at PDFSR (2004-2010)**

| S. N. | Crop sequences and technological interventions | Yield (SEY) (t/ha/ year) | Net returns (Rs./ha/ year) | B:C | Option/ Suitability |
|---|---|---|---|---|---|
| 1 | Sugarcane (Feb) + onion * –Ratoon (*Two year rotation)* | 95.94 | 63887 | 1.53 | More productivity / profitability from existing sugarcane based cropping systems |
| 2 | Sugarcane (May) +Cowpea (GM)*- ratoon-wheat *(Two year rotation)* | 86.98 | 53818 | 1.28 | More productivity / profitability from existing sugarcane based cropping systems |
| 3 | Rice – potato *- wheat – *Sesbania aculeate* * (GM) *(One year rotation)* | 131.01 | 67312 | 1.56 | Diversification of existing Rice-wheat cropping systems |
| 4 | Rice-berseem + mustad*-pearlmillet *(One year rotation* | 100.62 | 70162 | 1.73 | Better choice for animal based systems |
| 5 | Sorghum (SF) – rice (hybrid) *- berseem (One year rotation) | 146.42 | 166637 | 3.14 | Better choice for animal based systems |
| 6 | Rice (basmati) – potato *– marigold * (One year rotation) | 164.54 | 150812 | 1.57 | Most profitable cropping system for the farmers living in near vicinity of cities and towns |
| 7 | Maize (Dual purpose) *+ red gram *– wheat (One year rotation) | 82.23 | 123343 | 1.94 | A better cropping system with considerably higher net returns and B:C ratio. |
| 8 | Sorghum (SF) – rice (Hyb.) * - mustard *(One year rotation)* | 88.00 | 88380 | 2.40 | For the farmers living at far distances of cities |

* *Inclusion of high value crops for diversification and increased efficiency of prevailing cropping systems.*

**Crop module for livelihood security of small farm holder (6800 sq.m.**

| Major Farm commodities | Household Needs, Farm production and market value of produces (kg/q) | Crop sequences proposed and expenditure involved (Rs./seqence) | Net area alloted(Sq.m.) | Farm Commodities produced | Expected Production (kg/q) |
|---|---|---|---|---|---|
| Cereals (Rice, Maize, wheat) | 1550 Kg<br>(3340 kg)<br>Rs.40,080* | Rice (Hyb.) – potato - wheat – Sesbania aculeate (GM)<br>(Rs.16500)** | 1200 | Rice,<br>Wheat<br>Potato<br>G.M.(Fresh.wt.)<br>Dry fodders (Rice husk + Wheat straw) | 720 kg<br>660 kg<br>42.00 q<br>325.0 q<br>15.45 q |
| Oilseeds (Mustard) | 130 Kg<br>(216 kg)<br>Rs.6,480* | Sorghum-mustard- Maize+cowpea<br>(Rs.7320)** | 1200 | Mustard<br>Sorghum (GF)<br>Maize+cowpea | 216kg<br>84.0 q<br>66.00 q |
| Pulses (Red gram, black gram) | 200 Kg<br>(268 kg)<br>Rs.8,040* | Maize + red gram– wheat<br>Sorghum-blackgram-wheat<br>(Rs.10880)** | 800<br><br>800 | Maize<br>Red gram<br>Black gram<br>Wheat<br>Sorghum (GF)<br>Dry fodders (Wheat straw + Maize curvi) | 360 kg<br>148 kg<br>120 kg<br>880 kg<br>56.00 q<br>16.0 q |
| Sugar crops (Sugarcane) | 16.00 q<br>(128.0 q)<br>Rs.23,040* | Sugarcane (Feb) + onion –Ratoon<br>(Rs.20000)** | 1600 | Sugarcane<br>Onion<br>Green fodder (Sugarcane tops) | 128.0 quintal<br>10.0 quintal<br>51.0 q |

| | | | | | |
|---|---|---|---|---|---|
| Green fodders<br>Sorghum<br>Berseem<br>Oats<br>Sugarcane tops | 400.00 q<br>455.0 q<br>(Rs.34,125* | Sorghum (GF) – rice (hybrid) - berseem/oats<br>(Rs.8520)** | 1200 | Rice<br>Sorghum (GF)<br>Berseem (GF)<br>Oats (GF)<br>Dry fodder<br>(Rice husk) | 720 kg<br>84.0 quintal<br>66.0 quintal<br>48.0 quintal<br>7.20 q |
| Dry fodders (Wheat straw, Rice husk, maize curvi etc.) | 38.0 q<br>(38.6 q)<br>Rs.11,580* | | | | |
| Vegetables<br>Potato<br>Onion | 5.60 q<br>(42.0q)<br>Rs.42,000*<br>(10.0q)<br>Rs.10,000* | | | | |
| Net area<br>6800 sq.m. | Gross return<br>Rs. 1,65,345* | Cost of cultivation<br>Rs.63,220** | 6800 | Net profit<br>Rs.1,02,125/6800Sq.m. area | |

* Market value of the produce ** Cost of production

Yield levels

Rice; 60q/ha, Wheat;55q/ha, Maize ; 45q/ha, Mustard; 18 q/ha, Potato;350q/ha, Red gram;18.6q/ha, Onion;250q/ha

Green fodders: Sorghum; 700 q/ha, Maize + cowpea ; 550q/ha, Berseem;1100q/ha, Oats; 800q/ha

Prevailing market rates

Cereals; Rs.12/kg, Pulses and oilseeds ; Rs.30/kg, Potato;Rs10/kg, Onion

**One H F crossbred cow =** Rs.45,000/-

Total cost of animals = Rs.1, 05,000/-

ii) Miscellaneous expenditures including milking utensils and other petty items during initial establishing phase = Rs.5,000/-

Total (a) = Rs. 1,10,000/-

**b) Recurring expenditure**

1) Concentrate mixtures = Rs.36,160

   @ 4kg/day/animal x two animals x265 days @ Rs 18/kg

2) Dry period ration = Rs.7,200

   @2kg/day/animal x two animal x 100 days x Rs.18/kg

3) Dry fodder/straw = 38.0q x Rs.300/q = Rs.11,400

   *@ 5kg/day/animal x two animal x365 days*

4) Green fodder =Rs.19,875

   *@25kg/day/animal x two animals x365days x Rs.0.75/kg*

5) Mineral mixture = Rs.2375

   *@50 gm/day/animal x two animals x 365 days x Rs.65/kg*

6) Medicines and other miscellaneous = Rs.5, 000

7) Cost of vermicompost preparation = Rs.10,800

8) Labour - 4 hours daily @ Rs .150/day = Rs.27375

   **Total b) : = Rs.1,20,185**

Total cost of production = Rs.1,35,685

(Depreciation value of animals@10% of purchase value Rs.10,500+ Miscellaneous expenditure Rs.5000 + Recurring cost Rs.92,810)

**2. Production from dairy animals:**

i) Milk production

**Buffalo –** At an average milk production of 8.0 liter per day = 2120 liter

X 265 days milk period

Market value @ Rs.28.0 per liter = Rs.59, 360

**H.F.Cow -** At an average milk production of 12.0 liter per day = 3600 liter

X 300 days milk period

Market value @ Rs.25.0 per liter = Rs.90,000

**ii) Young ones of animals –**Two @ Rs.5000/calf = Rs.10,000

iii) Vermicompost 60.0 q @ Rs.500 per quintal = Rs.30,000

**Gross returns from dairy unit** = Rs.1,89,360

Net Profit

**Gross returns** Rs.1,89,360 **- Cost of production** Rs.1,35,685 = Rs.53,675

**C. Horticulture (Fruits and vegetables production)**

Total area under fruits = 2200 sq.m.

Fruit species

i) Mandarin var. kinnow (Papaya and vegetables as intercrops) = 1000 sq.m.

ii) Banana var. Grain Nain(Fodder / vegetables as intercrops) = 1200 sq.m

**Economic evaluation of horticultural unit**

1. Cost of cultivation: *(Considering average age of the orchard as 15 years)*

**a) Establishment year** *(Cost of pits, plants , plantation and input costs etc.)*

Banana plantations (280 plants) = Rs.11, 250

Kinnow plantations (66 plants) = Rs.8800

Guava plantations (50 plants) = Rs.3,000 (As *boundary plantation)*

Karonda plants (244) in between guava = Rs.3660

(As *boundary plantation)*

**Total cost** = Rs.26,710

Considering the average age of fruit plant as 15 years, the fixed cost = Rs.1,536

b) Recurring expenditures during subsequent years

@ Rs.50/tree/year for 396 tree/plants = Rs.19,800

@ Rs.9/tree/year for 244 Karonda plants = Rs.2196

(Pruning and harvesting etc)

**c) Labor cost –** 4 hours per day @ Rs.150/mandays of 8 hours = Rs.27,375

**d) Annual expenditure** (Fixed + running costs) = Rs.50,907

**Interest on borrowed money @7%** = Rs.3565

**e) Total expenditure / year to be incurred** = Rs.54472

**2. Annual production/income**

From banana unit (1st Year onward) Rs.35,000/year

From Kinnow (4th.year and onward) Rs.31,000/year

From guava ($4^{th}$. year and onward) Rs.22,000/year

From Karonda ($4^{th}$. year and onward) Rs.6000/year

Gross Returns/ year ***(Averaging production years of 14 for***

***banana, 12 each for kinnow and guavaand kinnow )*** Rs.94,000/year

**3. Net returns**

**( Gross returns** Rs.94,000 **– cost of cultivation** Rs.54,472) Rs. 39,528/year

**D. Fresh water fish production – Composite fish culture**

Under low lying and assured water supply conditions composite fish culture is an ideal enterprise giving higher income per unit area per unit time and that too with locally available recycled farm inputs (cow dung, rice bran, animal wash, vermicompost and fresh leaves of leguminous fodders) within the system itself. A small fish pond of 0.1 ha developed at PDFSR, Modipuram produced fish yield of 148 kg in first year of it's establishment to as high as 472 kg in fourth and 518 kg in fifth year with gross and net returns of Rs.25900 and Rs.16063, respectively.

Besides fish production, nutrient rich pond silt (de-silted once in every third year) and pond water (recycled as irrigation water for crop production twice a year in ***kharif*** rice and ***rabi*** wheat) were applied for productive use in crops. A total amount of 18.56 kg N, 6.21 kg P and 74.24 kg K was added by excavation of 15 cm deep ground soil surface of 800 $m^2$ pond area saving an amount of about rupees nine hundred fifty. The OC% of the soil was as high as 1.20 with an average value of 0.95. Addition of pond silt and water was found to increase the yield of rice and wheat by 3.48 q/ha and 2.41 q/ha, respectively.

In addition to this bund dykes was also utilized for raising fruits like banana citrus , guava and also many other crops including short duration vegetables and green manure crops *Sesbania aculeate* , *Lucenea lucocephala*. These crops not only add in to production but save bund slops from soil and water erosion.

Design and expenditure details of fish pond:

In 0.10 ha land area allotted to fish pond It is proposed to develop a small fish pond of 810 cu.m. volume. The design of the pond and it's specifications are given below;

i) Volume of the soil to be dug out = ½ (15+21) x 30x 1.5 =810 cu.m.

ii) Volume of cut and fill soil for making

embankments all around the fish pond = ½ (1+3) x 116x 0.5 =116 cu.m.

iii) Corner Work =4(1/2(1.45+0.45)x6.5 =12.35 cu.m.

iv) Total volume of soil for embankment = 116+12.35 =128.35 cu.m.

v) Surface area at the bottom of the pond = 15mx30m =450 sq.m.

vi) Surface area at the top of the pond = 21mx36m =756 sq.m.

vii) Total land area covered under fish pond = 28mx43m =1204 sq.m.

viii) Depth of standing water to be filled and maintained = 1.5 m

**Major fish species and number & ratio to be cultivated in the pond**

A composite mixed fish culture has been found ideal under fresh water fish production in small pond for optimum utilization of all the water depth layers. The farmers can choose the species as per market need and seed availability among the following fish species;

Local ***IMC*** fish species: Bhakur (Catla), Rehu (Rohu), Nain (Mrigal)

Exotic carps: Silver Carp or Grass Carp

**Seed rate (Number of fingerlings):** 1000

**Fish ratio:** Catla, Rohu, Mrigal and Grass carp (30:20:20:30)

**Cost of production**

**Fixed cost**

Cost of pond construction for an area of 1000 sq.m. = Rs. 45,000 (Approx.)

Considering total age of fish pond as 20 year, depreciation valueof fish pond = Rs.2250/-

(About 50% subsidy on pond construction and fish cultivation is given in most of the states)

**Recurring cost**

Average Cost of fish production/ha/year in a scientifically managed fish pond to get maximum production

| Sr. No. | Iteams Quantity Approx. cost | (Rs.) |
|---|---|---|
| 1. | Lime 250 kg 1 | 250/- |
| 2. | Cow dung 20 tonnes | 5000/- |
| 3. | Ammonium sulphate 450 kg | 3150/- |
| 4. | Single Super Phosphate 250 kg | 1750/- |
| 5. | Murrete of Potash 40 kg | 280/- |
| 6. | Broken rice (Kanni) 500 kg | 4000/- |
| 7. | Mustard cake 500 kg | 4000/- |
| 8. | Fish seed cost 10000 in Nos. | 4000/- |
| 9. | Water charges- Maintaining desired water level whole the year | 3000/- |
| 10. | Mahi /harvesting of fishes - | 2000/- |
| 11. | Miscellaneous expenditures - | 2000/- |
| | Total per hectare cost on fish production/year | 30430/- |

***Total running cost on fish production/ year from an area of 1000 sq.m= Rs.3043/-***

Depreciation cost of fish pond = Rs.2250/-

**Annual Fish Production:** Av. Fish yield 400 kg/year/1000 sq. m. pond area

Expected income from 1000 sq.m. fish pond:

Total income taking fish value@RsHYPERLINK "mailto:value@Rs25/-per"50HYPERLINK "mailto:value@Rs25/-per"/-per kilogram = Rs.20,000 per year

Net Profit per year ( Rs. 20,000 - (Rs.2250 + Rs.3043)=Rs.14707/1000 sq.m.

**Vermicompost**

Animal unit with two buffalos or one buffalo and one H.F. cow with two young ones produces more than 200 quintal of fresh cow dung. If 3/4th'of this cowdung is used for Vermicompost preparation and 1/4th' used for fish pond and FYM etc. than more than 60 quintal vermicompost can be prepared for fulfilling the need of field and plantation crops of the model. Vermicompost content of macro and micro nutrients N(%), P(%), K(%), Zn(ppm), Cu(ppm), Mn(ppm), Fe(ppm) is about 1.68, 0.23, 1.26, 112, 48, 397, 3323 as compared to respective values 0.70, 0.19, 1.37, 75, 34, 222, 3134 found in FYM.

**Method of Vermicompost preparation**

**Component of Vermicompost**

Pit size and depth of the pit : 1.5 to 3.0 meter length, 1.0 to 1.5 meter wide and 0.9 -1.5 feet deep pit size is ideal for Vermicompost preparation. Farmers can prepare as many as required such pits.

**Farm products:** Cow dung, Grain straw, Crop residues and other farm wastes

**Value addition:** Press mud from sugar mills, Spent Mushroom Substrates and or any other nutrient rich by products

**Earthworm species:** *Eisina faetida, Lumbricus rubellus and Perionyx excavator*

**Weight of earthworm:** For one quintal mixture of cowdung etc 250g to 500 gm

**Composition of different constituents of Vermicompost mixture**

50-75% cow dung + 25-30%% Crop residues/straw etc +SMS/Pressmud alone or in combinations

**Precautions**

- Proper shade on Vermicompost material is essential to save it from direct sunshine and rainy water
- The mixture should well moisten and loosen fortnightly for proper moisture (70-80%) and aeration which is a pre requisite for fat growth of the earthworms.
- Use neem cake time to time to save earthworm from ants etc.

**Application Rates in different field and plantation crops**

| S.N. | Crops | Quantity/ha |
|---|---|---|
| 1 | Cereals | 5t/ha |
| 2 | Pulses | 5t/ha |
| 3 | Oilseeds | 7-12 t/ha |
| 4 | Spices | 10t/ha |
| 5 | Vegetables | 10-12 t/ha |
| 6 | Fruit plants | 2-3 kg/plant |
| 7 | Cash crops | 12.5 t/ha |
| 8 | Flowers | 10 t/ha |
| 9 | Plantation crops | 5 kg/plant |

**Boundary Plantations**

All the field borders should invariably be planted with either perennial fruit tree species or grasses having little or no shade effect on companion crops and that will be a source of permanent income in long run. The plant and grass

| Farm produces under different farm enterprises | Expected annual prduction (kg) | Gross value of of the produce at prevailing market price (Rs.) | Estimated requirements of a family (7 members) (kg) | Product Value of home cunsumption (Rs.) |
|---|---|---|---|---|
| A.Crop production | | 1,00,305 | | |
| **i) Cereals** (Paddy, maize, wheat) | 3340 | 40,080 | 1550 | 18,600 |
| **ii) Pulses** (Green gram, pigeon pea, black gram | 268 | 8050 | 200 | 6000 |
| **iii) Oilseeds (**Mustard)**iv) Green fodders** (Sorghum, berseem, oats) | 216 | 6480 | 130 | 3900 |
| **v) Dry fodders** | 45500 | 34,125 | 21900 | 16425 |
| (Wheat straw, paddy husk, maize & sorghum curvi and pulses straw etc.) | 3860 | 11580 | 3800 | 11400 |
| **B. Dairy** | | **1,79,360** | | |
| Milk (Liters) | 5720 | 1,49,360 | 1575 | 40950 |
| Vermicompost | 6000 | 30,000 | 6000 | 30,000 |
| **C. Horticulture Unit** | | **1,23,300** | | |
| Fruits production& Vegetables (intercrop) | 94002930 | 9400029300 | 210560 | 21005600 |
| **D. Fishery** | 400 | **20,000** | 155** | 7750 |
| Total (A+B+C+D) | - | 4,22,965 | - | 1,42,725** 1,34,975 forIndian Non-veg |

** For non- veg. families

(All the figures included in the table are achievable and/or based on the yield levels achieved in an IFS model at PDFSR, Modipuram and prevailing market prices of (2010-11)

species tried at PDFSR, Modipuram for boundary plantations were jack fruit, bel, jamun, citrus species nimboo and karonda and aonla. *Cenchrus ciliaris* (Subabul) was also planted on pond dykes and field boundaries produced huge amount of green leguminous fodders and fuel wood. In addition to this guava and banana can also be planted on boundaries of crop fields as well as fruit orchards. They will save the crops from winds and hot waves besides income to the farmers.

## Livelihood security and economic viability of Integrated Farming System Model

Overall evaluation of the proposed IFS model based on averaged crop yields, prevailing market prices and estimated demand of a seven member Indian (Non-veg.) family has been summarised in the table below. The figures included in the table envisage the importance of IFS approach for livelihood improvement of small farm holder farmers. The approach not only fulfil the household food and fodder needs of a family but save a sizable cash for other liabilities of the family including education and health etc. Further, diversified nature of the approach extends possibilities of nutritional security along with round the year funds availability.

Total cost of production ( Rs.2,58,670)

Crops Rs. 63,220+ Dairy +Vermicompost Rs. 1,35,685 + Horticulture Rs. 54,472 + Fishery Rs.5,293

Gross returns (Rs.4,22,965)

Crops Rs. 1,00,305+ Dairy +Vermicompost Rs. 1,79,360 + Horticulture Rs. 1,23,300 + Fishery Rs.20,000

Net returns = Rs. 4,22,965 - Rs . 2, 58,670 = Rs.1,64,295

**Family consumption** = Rs. 1,34,975

**Net savings = Rs.**29, 320 (After meeting house hold food and fodder requirements)

**Note:** The project proposal submitted and production and economic values/ figures (achievable) included show the soundness of the IFS approach. However, it takes two to three years to achieve the targeted goals because the project involve enterprises like fruit plantations, boundary plantations etc. which start giving returns from third or more than third year of establishment of the project.

## CONCLUSION

IFS approach not only fulfils the household needs but enrich diet of human being and animals both and simultaneously keep the people away from the hazards of residual toxicity of the chemicals being used in agriculture on a large scale. Further, diversified nature of the project provides huge employment opportunity for unemployed rural youths. In addition, net saving of more than Rs.25,000/year or more than that will help to meet other liabilities of the family including education, health and social obligations and overall improvement in livelihood of small farm holders. The IFS model is a basket of options and farmers can choose appropriate combinations of enterprises as per their resources and family needs. Farmers having sufficient land and other farm resources can go for horticultural crops viz; fruits, vegetables and floriculture. Whereas, marginal farmers or land less farmers can integrate apiary and mushroom in to their existing farming systems. Farmers having sufficient irrigation water and / or living in low lying riverbed areas can choose fishery as an additional enterprise. Similarly, farmers living in near vicinity of the towns and cities can grow vegetables and green fodders as per market demand and availability.

## References

Gill, M.S., Singh, J.P. and Gangwar, K.S. (2009). Integrated Farming System and Agriculture Sustainability. Indian Journal of Agronomy 54 (2):128-139.

Mahaptra, B.S., Sharma, K.C. and Sharma, C.L. IRRI Newsletter 12(1):32. (1987).

Singh, J.P. and Gill, M.S. (2010). Livelihood Security and Resource Conservation through Integrated Farming System. Indian Farming, September, 2010 pp: 03-07.

Singh, Gurbachan.2004. Farming systems options in sustainable management of national resources. In: Proceedings of National Symposium on Alternative Farming Systems held at PDCSR, Modipuram, 16-18 September, 2004, pp. 80-94.

Swaminathan, M.S. (1998). In Hand book of Food and Nutrition.pp:185. The Bangalore Printing and Publishing Co. Ltd., Bangalore.

*J. Farming Systems Research & Development* **18** (2) : 214-223 (2012)

# EFFECT OF CROPPING SEQUENCE AND NUTRIENT MANAGEMENT ON THE PERFORMANCE OF WHEAT CROP

Rajeew Kumar[1], R.D. Misra[2], D.S. Pandey[3] and S.B. Bhardwaj[4]

*G.B. Pant University of Agriculture & Technology, Pantnagar-263145*

ABSTRACT

Many scientists have worked on rice-wheat cropping patterns by considering parameters like soil fertility, productivity, yield stability under different farming systems. In the present study an attempt has been made to study the effect of cropping sequence and nutrient management on the performance of wheat crop. The field experiments were conducted during 2001-03 at the Crop Research Center of G. B. Pant University of Agriculture and Technology, Pantnagar. All the morphological parameters like plant height at maturity, numbers of tillers at maximum tillering , ear bearing shoots at maturity , leaf area index and leaf nitrogen content with other physiological parameters viz. chlorophyll content , rate of photosynthesis and nitrate reeducates were measured, which was found to be significantly higher in rice–wheat cropping sequence than rice–lahi–wheat cropping sequence. The inferences have also showed that the yield and its contributing characters alongwith economic returns were significantly higher in rice-wheat cropping sequence. Farm Yard Manure (FYM) and crop residue management with starter dose at 100 % RDF had superior effect on morphological parameters, physiological parameters , yield attributing characters, grain yield and economic return over other nutrient levels. However, no apparent differences were observed between 100 % Recommended Dose of Fertilizer (RDF) and 150 % RDF.

**Key words:** Cropping Sequence, FYM, RDF, Green Manure, Crop Residue

Rice and wheat jointly contribute nearly three-fourth of the total food grain production of India covering an area of 10.5 mha and is the mainstay of food security system of the country. Continuously following this sequence led to the development of many problems related to soil fertility, physical health of soil and crop productivity which proven to be hazardous in long term. There are many reports of yield stagnation and declined in soil productivity (Yadav *et al.*, 1998). In a long term experiment on wheat crop at Pantnagar it was revealed that wheat yield declined when rotation was vogue from 7-9 years (Kulkarni *et al.*, 1987). The decline in crop yield can be minimized by the introduction of green manure in rice-wheat crop rotation for diversification of this system. So under such a situation, crop diversification and nutrient management may help in mitigating such problems. Low input sustainable agriculture (Grubinger, 1992) and reduced chemical inputs (Kirchner *et al* ., 1993) concepts which focus on green manuring, recycling crop residue in rotation are important for enhancing productivity in agriculture. However in the present scenario, adequate quantity of organic manures like FYM and compost are difficult to obtain due to mechanization of agriculture thus resulting considerable decrease in farm animal. Inclusion of short duration oil seed crop in rice-wheat

[1] JRO Agronomy, [2] Emeritus Scientist, Agronomy , [3]Professor, Agronomy and [4]JRO Statistics
[1]Corresponding author: Email: shuklarajeew@rediffmail.com

system has shown in augmenting productivity of the system and maintaining good soil health (Fang *et al.,*2000). Therefore a need to identify an alternative cropping system which retains higher and stable yield (Kumar *et al.*, 1999) is. So in light of above, this experiment was planned to find out the effect of cropping sequence and nutrients levels on performance of wheat crop in rice-wheat system .

## Materials and Methods

The present investigation was carried out during 2001-02 and 2002-03 at the Crop Research Centre of G. B. Pant University of Agriculture and Technology, Pantnagar . The soil of the experimental site falls in the sub-humid and sub-tropical climatic zone developed from calcareous, medium to moderately coarse textured materials under pre-dominant influence of tall vegetation. The experimental plot had silty clay loam in texture (Typic Hapludolls) with pH-7.2, organic carbon (0.81 %), total nitrogen (1723.8 kg/ha), available nitrogen (231.4 kg/ha), available phosphorus (19.7 kg/ ha), available potassium (269.8 kg/ha). The experiment was laid out in Split Plot Design, with four replications. The main plots contained two cropping sequence viz. rice-wheat cropping sequences ($C_1$) and rice-lahi-wheat sequence ($C_2$).The sub plot treatment contained nutrient scheduling in wheat viz. Recommended NPK for each crop ($N_1$), Recommended +10 t/ha FYM before wheat ($N_2$) , $N_1$ + Green manure before rice (INM) ($N_3$), $N_1$ + Straw incorporated without starter dose of N ($N_4$), $N_1$ + Straw incorporated with starter dose of N (20 kg N/ha) ($N_5$),150 %recommended for each crop ($N_6$), 150 % Recommended +10 t/ha FYM before wheat ($N_7$). The application of organic sources and their contribution in soil nutrient supply is depicted in table 1 followed by details of the crop are given in table 2. Urea, diammonium phosphate and muriate of potash were used as source of nitrogen , phosphorus and potassium respectively. Full doses of FYM, phosphorus, potassium and half doses of nitrogen were applied at the time of sowing. The remaining half dose of nitrogen was top dressed after first irrigation. Crop residue was retained after harvesting of rice crop. The experimental data obtained during the course of study was subjected to standard statistical analysis.

## Results and Discussion

**Morphological parameters:** All the morphological parameters viz. plant height at maturity, numbers of tillers at maximum tillering, ear bearing shoots at maturity, leaf area index, and leaf

**Table 1 : Particulars about FYM, Dhaincha (GM) and rice straw**

| Sl. No. | Organic source | Mean data of 2001-2002 and 2002-2003 | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | N (% ) | P ( %) | K (%) | O.C (%) | C:N | Fresh biomas ($t.ha^{-1}$) | Dry Biomass ($t\ ha^{-1}$) |
| 1. | FYM | 0.66 | 0.21 | 1.96 | 26.8 | 41:1 | 10.0 | 6.9 |
| 2 | Dhaincha | 2.27 | 0.36 | 2.03 | 38.6 | 17;1 | 21.0 | 4.4 |
| 3 | Rice straw | 0.54 | 0.09 | 1.38 | 39.2 | 73;1 | 5.0 | 3.9 |

**Table 2 : The details of crops**

| Crop | Variety | Seed rate (Kg ha) | Row spacing (Cm) | Sowing time | | Harvesting date | | Recommended dose of fertilizer (RDF) Kg ha | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2001-02 | 2002-03 | 2001-02 | 2002-03 | N | $P_2O_5$ | $K_2O$ |
| Rice | Pant Dhan-12 | 40 | 20 | 30.6.01 | 1.7.02 | 28.9.01 | 30.9.02 | 150 | 60 | 40 |
| Wheat | PBW-343 | 100 | 23 | * | * | 22.4.02 | 21.4.03 | 150 | 60 | 40 |
| Lahi | PT-507 | 6 | 30 | 4.10.01 | 1.10.02 | 27.12.01 | 26.12.02 | 90 | 40 | 20 |
| Dhaincha | Pant Ses.-1 | 50 | 20 | 13.5.01 | 14.5.02 | 28.6.01 | 30.6.02 | - | - | - |

*Wheat was sown on 27.11.01 and 26.11.02 in rice – wheat cropping sequence and 1.1.02 and 30.12.02 in rice –lahi wheat system.

nitrogen content, was significantly influenced by the cropping sequences (Table 3), except leaf nitrogen content at 60 DAS during 2001-02. All morphological parameters was significantly higher in rice – wheat cropping sequences ($C_1$) than rice-lahi-wheat sequences ($C_2$). Similar to cropping sequences, nutrient levels also showed significant differences on all morphological parameters except on plant height at maturity during 2002-03. FYM and crop residue with starter dose in 100 % RDF resulted significantly taller plant than crop residue without starter dose in 100 % RDF. Similar results were recorded in all morphological characters at 100 % RDF. There is no significant differences in morphological parameters were observed between 150 % RDF and 100 % RDF, when it applied alone. Even addition of FYM in 100 % RDF did not give significant differences in morphological characters over 150 % RDF applied alone. Significantly shorter plant in rice-lahi wheat system was might be due to the high temperature during mid and late vegetative growth which leads to significantly dwarfed plants (Radheyshyam,1986). Addition of FYM produced taller plant because of nutrient supplying through out the cropping season (Patra, 2000). Similar effect of cropping sequences and nutrient levels on morphological parameters were also reported by Singh (2001) and Misra (2002).

**Physiological parameters:** In physiological parameters, chlorophyll content, rate of photosynthesis and nitrate reductase studies were measured, which was significantly influenced by the cropping sequences and nutrient levels (Table 4). All physiological parameters was significantly higher in $C_1$ than $C_2$. At 100 % RDF, all the treatments had

**Table 3 : Effect of cropping sequences and nutrient management on morphological parameters of wheat crop**

| Treatments | Plant height at maturity | | Dry matter at harvest ($g/m^2$) | | Number of tillers at maximum tillering | | Ear bearing shoots at maturity | | Leaf Area Index at heading stage | | Leaf Nitrogen content at 60 DAS (%) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 |
| **Cropping sequences** | | | | | | | | | | | | |
| $C_1$ | 90.8 | 83.2 | 1022.1 | 1351.4 | 667.7 | 613.8 | 436.7 | 509.8 | 4.03 | 4.01 | 4.31 | 4.53 |
| $C_2$ | 74.8 | 64.2 | 1032.3 | 1362.5 | 550.8 | 504.0 | 379.0 | 425.4 | 3.55 | 2.88 | 4.24 | 3.63 |
| C.D (0.05) | 2.4 | 3.81 | 9.31 | 10.80 | 50.1 | 27.04 | 46.3 | 13.28 | 0.17 | 0.17 | NS | 0.07 |
| **Nutrients levels at 100 % RDF** | | | | | | | | | | | | |
| $N_1$ | 83.2 | 71.4 | 1105.8 | 1114.4 | 597 | 493 | 398.9 | 376.0 | 4.01 | 2.70 | 4.35 | 3.45 |
| $N_2$ | 85.5 | 73.4 | 1241.3 | 1251.1 | 634 | 595 | 408.1 | 483.3 | 3.61 | 3.38 | 4.45 | 4.05 |
| $N_3$ | 83.0 | 73.9 | 1129.3 | 1135.4 | 585 | 548 | 360.8 | 462.0 | 3.42 | 3.05 | 3.80 | 3.84 |
| $N_4$ | 77.5 | 72.6 | 1161.2 | 1173.5 | 539 | 520 | 381.6 | 403.0 | 3.57 | 2.78 | 4.17 | 3.65 |
| $N_5$ | 84.7 | 74.8 | 1196.2 | 1200.4 | 645 | 579 | 409.4 | 477.6 | 4.04 | 3.33 | 4.46 | 3.94 |
| **Nutrients levels at 150 % RDF** | | | | | | | | | | | | |
| $N_6$ | 82.3 | 72.9 | 1217.2 | 1222.4 | 606 | 534 | 382.8 | 431.0 | 3.31 | 2.99 | 4.24 | 3.68 |
| $N_7$ | 83.4 | 76.1 | 1262.7 | 1281.1 | 655 | 620 | 506.3 | 502.6 | 4.56 | 3.58 | 4.48 | 4.20 |
| C.D (0.05) | 3.55 | NS | 45.8 | 59.1 | 70 | 22.48 | 36.5 | 9.26 | 0.243 | 0.24 | 0.171 | 0.24 |

**Table 4 : Effect of cropping sequences and nutrient management on physiological parameters of wheat crop**

| Treatments | Chlorophyll content (SPAD reading) | | | | Rate of Photosynthesis (μ moles $cm^{-2}$ $s^{-1}$) | | | | Nitrate reductase activity (μ moles/g fresh weight/hr.) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | At heading | | 10 DAH* | | At heading | | 10 DAH* | | 5 DAA** | | 15 DAA** | |
| | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 |
| **Cropping sequences** | | | | | | | | | | | | |
| $C_1$ | 43.49 | 48.01 | 46.7 | 49.9 | 16.43 | 17.37 | 17.60 | 18.74 | 1.088 | 1.747 | 0.930 | 1.747 |
| $C_2$ | 39.96 | 37.99 | 40.08 | 38.86 | 13.71 | 15.34 | 14.75 | 16.43 | 0.723 | 1.091 | 0.653 | 1.091 |
| C.D (0.05) | 2.74 | 1.62 | 2.53 | 1.85 | 1.32 | 0.80 | 1.07 | 0.88 | 0.253 | 0.17 | 0.229 | 0.17 |
| **Nutrients levels at 100 % RDF** | | | | | | | | | | | | |
| $N_1$ | 43.43 | 34.13 | 42.86 | 35.30 | 14.67 | 13.93 | 15.74 | 14.73 | 0.760 | 0.999 | 0.690 | 0.627 |
| $N_2$ | 41.55 | 42.77 | 45.74 | 43.93 | 16.85 | 16.53 | 17.97 | 17.67 | 0.936 | 1.368 | 0.797 | 1.045 |
| $N_3$ | 40.00 | 40.03 | 43.03 | 40.63 | 13.92 | 15.67 | 15.12 | 16.73 | 0.764 | 1.212 | 0.659 | 0.922 |
| $N_4$ | 38.28 | 36.13 | 40.34 | 37.33 | 13.50 | 14.53 | 14.73 | 15.50 | 0.776 | 1.084 | 0.651 | 0.687 |
| $N_5$ | 42.75 | 42.30 | 44.51 | 43.50 | 15.02 | 16.30 | 16.22 | 17.47 | 0.906 | 1.305 | 0.734 | 0.997 |
| **Nutrients levels at 150 % RDF** | | | | | | | | | | | | |
| $N_6$ | 40.66 | 37.70 | 40.11 | 38.27 | 13.53 | 15.43 | 14.70 | 16.70 | 0.891 | 1.148 | 0.820 | 0.857 |
| $N_7$ | 45.39 | 44.70 | 47.39 | 46.13 | 18.02 | 17.80 | 18.72 | 18.53 | 1.301 | 1.540 | 1.189 | 1.215 |
| C.D (0.05) | 0.224 | 2.26 | 0.65 | 3.21 | 0.97 | 1.09 | 1.071 | 1.13 | 0.291 | 0.16 | 0.242 | 0.11 |

* Days after heading ** Days after anthesis

significantly higher chlorophyll content than the treatment contained crop residue without starter dose. When chlorophyll content was compared between 100 % RDF and 150 % RDF, the 100 % RDF had significantly higher chlorophyll content than 150 % RDF. Addition of FYM in both RDF increased the chlorophyll content however the cholorophyll content at FYM and crop residue with starter dose in 100 % RDF was statistically similar. Nutrients levels had similar effect on photo synthesis rate and nitrate reductase activities, as recorded in case of chlorophyll content. Chlorophyll content was higher in $C_1$ might be due to atmospheric temperature and plant age during cropping season which played important role in the synthesis of chlorophyll. Effect of FYM on chlorophyll content was similar as found by Misra (2002). Nitrate reductase activity in wheat was higher in $C_1$ because this system might be produced more amino acid and finally converted into the protein (Mahapatra, 2003). The similar effect of nutrients levels on nitrate reductase activities was also reported by Mishra (2002). Photo synthesis process depends on chlorophyll content, provides metabolic energy for crop growth and development. The effect of nutrient levels could be explained clearly by the report of Lawlor *et al.*, (1987).

**Yield contributing characters**

The table five depicted that the entire yield contributing characters was significantly affected by cropping sequences except spike length and 1000 grain weight during 2001-02. Cropping sequence of rice-wheat ($C_1$) contained significantly higher numbers of yield attributing characters than $C_2$. However nutrient levels showed significant differences only on number of grain per spike , grain weight per spike and 1000 garin weight. The yield contributing characters obtained at 100 % RDF with FYM, Crop Residue and 100 % RDF alone or with FYM were statistically similar . Green manuring before rice was also gave statistically similar yield contributing character s of wheat with 100 % RDF.

Grain yield of wheat was maximum in $C_1$ during both the years and it was significantly more over $C_2$. Interaction between cropping sequences and nutrient levels on grain yield was found significant (Table 5a). The maximum grain yield of wheat was recorded at in rice-wheat cropping sequences ($C_1$) with $N_7$ and the lowest grain yield at $C_2$ with $N_1$ during 2001-02 . At the same cropping sequence, nutrient levels did not give any significant differences between them but at the same levels of nutrients cropping sequences showed significant differences. The addition of FYM and Crop residue with starter dose gave higher yield contributing characters and finally yield. The reason behind this , the availability of nutrients for eg. nutrients available from FYM for longer period provides 30 per cent of nitrogen, 60-70 per cent phosphorus and 70 per cent of potassium are available to the first crop (Reddy and Reddy, 1997). Similar to this starter dose activate the flora and fauna in soils, which are responsible for decomposition and releasing of nutrients. In the present investigation FYM was evolved as superior amendment, but the rice straw with starter doses can be used under constraint availability of FYM . Similar observations were recorded by Katyal et al (2001) and Singh (2001)

**Economics:** Similar to other

**Table 5 : Effect of cropping sequences and nutrient management on yield contributing characters of wheat crop )**

| Treatments | Spike length (cm) | | No of fertile spikelets/ spike | | Number of fertile spike lets/ spike | | Number of grain/spike | | Grain weight/ spike (g) | | 1000 grain weight (g) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 |
| **Cropping sequences** | | | | | | | | | | | | |
| $C_1$ | 9.61 | 11.63 | 18.3 | 20.31 | 2.3 | 2.16 | 45.2 | 49.5 | 1.62 | 2.27 | 36.2 | 46.1 |
| $C_2$ | 9.55 | 9.49 | 16.9 | 16.68 | 2.9 | 2.57 | 35.2 | 33.21 | 1.09 | 1.07 | 36.5 | 33.2 |
| C.D (0.05) | | 0.38 | 0.95 | 0.81 | 0.31 | 0.29 | 8.3 | 4.05 | 0.22 | 0.03 | NS | 4.05 |
| **Nutrients levels at 150 % RDF** | | | | | | | | | | | | |
| $N_1$ | 9.59 | 10.35 | 17.3 | 17.2 | 2.6 | 2.6 | 38.9 | 34.7 | 1.39 | 1.26 | 32.5 | 35.7 |
| $N_2$ | 9.66 | 10.85 | 17.7 | 17.9 | 2.6 | 2.4 | 42.9 | 39.4 | 1.42 | 1.71 | 35.7 | 44.1 |
| $N_3$ | 9.76 | 10.72 | 17.4 | 17.31 | 2.6 | 2.5 | 42.8 | 37.6 | 1.20 | 1.58 | 31.4 | 41.8 |
| $N_4$ | 9.41 | 10.40 | 17.6 | 17.23 | 2.6 | 2.6 | 39.1 | 38.8 | 1.28 | 1.41 | 31.8 | 35.7 |
| $N_5$ | 9.57 | 10.76 | 17.7 | 17.76 | 2.7 | 2.5 | 41.4 | 39.1 | 1.40 | 1.64 | 33.8 | 42.4 |
| **Nutrients levels at 150 % RDF** | | | | | | | | | | | | |
| $N_6$ | 9.55 | 10.65 | 17.4 | 17.3 | 2.7 | 2.6 | 38.2 | 37.5 | 1.28 | 1.52 | 31.6 | 40.9 |
| $N_7$ | 9.55 | 10.85 | 17.8 | 18.0 | 2.4 | 2.4 | 40.1 | 36.9 | 1.51 | 1.84 | 36.7 | 49.6 |
| C.D (0.05) | NS | NS | NS | NS | NS | NS | NS | 4.03 | 0.19 | 0.05 | 4.5 | 4.9 |

**Table 5a : Interaction effect of cropping sequences and nutrient levels on wheat grain yield (q/ha)**

| Nutrient levels | 2001-2002 | | | 2002-03 | | |
|---|---|---|---|---|---|---|
| | $C_1$ | $C_2$ | Mean | $C_1$ | $C_2$ | Mean |
| | | | **Nutrients levels at 100 % RDF** | | | |
| $N_1$ | 43.2 | 29.1 | 36.2 | 39.1 | 27.9 | 30.8 |
| $N_2$ | 49.1 | 35.7 | 42.4 | 54.2 | 32.6 | 38.9 |
| $N_3$ | 45.8 | 29.8 | 37.8 | 40.8 | 30.4 | 35.8 |
| $N_4$ | 46.0 | 31.8 | 38.9 | 41.9 | 31.6 | 33.1 |
| $N_5$ | 50.7 | 32.1 | 41.4 | 50.0 | 31.2 | 37.6 |
| | | | **Nutrients levels at 150 % RDF** | | | |
| $N_6$ | 46.7 | 33.1 | 39.9 | 47.1 | 31.4 | 34.3 |
| $N_7$ | 51.3 | 36.8 | 43.7 | 57.7 | 38.0 | 41.2 |
| Mean | 47.6 | 32.5 | | 47.2 | 31.9 | |
| *CD $_1$ (0.05) | 9.11 | | | 1.73 | | |
| $CD_2$ (0.05) | 4.16 | | | 0.86 | | |
| $CD_3$ (0.05) | 19.86 | | | 12.50 | | |
| $CD_4$ (0.05) | 17.69 | | | 9.46 | | |

*$CD_1$ for cropping sequences, $CD_2$ for nutrient levels, $CD_3$ for comparison for cropping sequences at same level of nutrient, $CD_4$ for comparison for nutrient levels on same or different levels of cropping sequences.

**Table 6 : Effect of cropping sequences and nutrient levels on wheat profitability**

| Treatments | Cost of cultivation (Rs) | | Gross return (Rs) | | Net return (Rs) | | Benefit cost ratio (B:C) | |
|---|---|---|---|---|---|---|---|---|
| | 2001-2002 | 2002-03 | 2001-2002 | 2002-03 | 2001-02 | 2002-03 | 2001-2002 | 2002-03 |
| | | | | **Cropping sequences** | | | | |
| $C_1$ | 13496 | 13875 | 34400 | 35756 | 20904 | 21881 | 1.55 | 1.58 |
| $C_2$ | 13496 | 13875 | 23660 | 24685 | 10164 | 10810 | 0.75 | 0.77 |
| | | | | **Nutrients levels at 150 % RDF** | | | | |
| $N_1$ | 12610 | 12998 | 27432 | 23851 | 14822 | 10863 | 1.18 | 0.84 |
| $N_2$ | 12610 | 12998 | 30832 | 30289 | 18222 | 17301 | 1.45 | 1.33 |
| $N_3$ | 12610 | 12998 | 29322 | 26863 | 15774 | 12692 | 1.25 | 0.97 |
| $N_4$ | 12610 | 12998 | 31964 | 32132 | 17576 | 16443 | 1.39 | 1.27 |
| $N_5$ | 12610 | 12998 | 30186 | 29431 | 14434 | 15060 | 1.14 | 1.16 |
| | | | | **Nutrients levels at 150 % RDF** | | | | |
| $N_6$ | 12610 | 12998 | 27044 | 28048 | 16712 | 13875 | 1.33 | 1.06 |
| $N_7$ | 12610 | 12998 | 28394 | 25680 | 19354 | 19144 | 1.53 | 1.47 |

parameters , rice- wheat cropping sequences in more profitable than rice-lahi-wheat sequence but in the case of nutrient levels, addition of FYM with 150 % RDF was more economical. However the lowest economic return was found, crop residue applied with 100 % RDF without starter doses. (Table 6). Net return and benefit cost ratio was also higher under $C_1$. FYM, crop residue with starter dose in 100 % RDF were economic dose.

From the present investigation it was observed that thae rice- wheat cropping system was better cropping system in term of yield and benefits.The application of 150 % RDF gave statistically similar results on grain yield obtained at 100 % RDF. Thus it can be concluded that in *tarai* soils there is no need to increase the RDF. FYM and Crop residue with 100 % RDF gave statically similar garin yield , pay to attention that , in case of limted FYM availability crop residue will be viable option.

## REFERENCES

Fang, Z. Lu, SH., Zhang, F.S. 2000. A study of the differences of wheat and oilseed rape in tolerance to Mn deficiency in field. J. of Hebei Agril. Unversity, China. **23** (3):1-4

Grubinger, V.P. 1992. Organic vegetable production and how it related to LISA. Horticulture Science. **27:** 759-760.

Katyal, V., Gangwar, K.S., Gangwar, B. 2001. Conservation of organic carbon, in relation to crop productivity , yield stability and soil fertility under rice-wheat cropping system. Indian J. of Agron. **46** (1):1-4

Kirchner, MJ., Wollum II, G., King, LD. 1993. Soil microbial population and activities in reduced chemical input agroecosystem. Soil Science Society of America Journal. 57:1289-1295.

Kulkarni, KR., Devi, LS., Jagannath, HK. Setty, TPK. 1987. Studies in rice farming system in India. In report of the Asian rice farming systems working group, IRRI, Philippines.357-368.

Kumar, V., Ghosh, BC., Bhatt, R. 1999. recycling of crop wastes and green manure and their impact on grain yield and nutrient uptake of wetland rice. *J. Agric. Sci.* **132:**149-154.

Lawlor, D.W., Boyle, FA., Young, AT., Keys, AJ., Kendall, AC. 1987. Nitrate nutrition and temperature effect on wheat photosynthesis and photo respiration of leaves. *J. Experimental Botany.* **38:** 393-408

Mahapatra, Subash. 2003. Production, profit and Energy potential of wheat (Triticum aestivum L) through integrated nutrient management in wheat based cropping systems. Ph.D Agronomy thesis submitted to G.B. Pant University of Agriculture & Technology, Pantnagar.

Mishra, V.K. 2002. Studies on physiology of heat tolerance in different genotypes of wheat . Ph.D Agronomy thesis submitted to G.B.Pant University of Agriculture & Technology, Pantnagar.

Patra, A.K., Nayak, B.C., Mishra., M.M. 2000. Integrated nutrient management system in rice-wheat cropping sequences. *Indian J. Agron.* **45** (3):453-457.

Radheyshyam.1986.Responce of wheat varieties to defoliation under varying sowing dates. Ph.D Agronomy thesis submitted to G.B.Pant University of Agriculture & Technology, Pantnagar.

Reddy, T.Y. and Reddi, G.H.S. 1997. Principles of Agronomy. Kalyani Publishers, Ludhiana. 515pp.

Singh Adesh. 2001. Integrated use of nitrogen phosphorus and potassium and their effect on growth and yield of wheat. MSc Agronomy thesis submitted to G.B.Pant University of Agriculture & Technology, Pantnagar.

Yadav, D.S., Singh, R.M., Kumar, A., Achal, R. 2000. Divrsification of sustainable cropping system for sustainable production. *Indian J. of Agron.* **45** (1):37-40.

*J. Farming Systems Research & Development* **18** (2) : 224-232 (2012)

# SOCIO-PERSONNEL, FARM RESOURCE CHARACTERIZATION AND PRODUCTION CONSTRAINTS IN AGRA CANAL COMMAND AREA

M.P. Singh, V.K. Singh and S.A. Kochewad

*Project Directorate for Farming System Research, Modipuram, Meerut.*

## Abstract

The present study was conducted in Mathura and Agra districts of Uttar Pradesh to characterize the socio-personnel characteristic of farmers, soil characters, major crops and cropping system of the region, irrigation water availability and to find out the production constraints perceived by villagers in various farming situations. Survey revealed that majority of small farmers were young and middle age group (60%) followed by medium (57%) and large (51.5%) farmers. Literacy among the medium farmers was more as compared to small and large categories of farmers. More than (80%) of farmers from all the categories having 17 years for farming experience. Majority of small farmers belongs to lower income group. The soils were of clay loam (40%), loamy sand (38%) and sandy loam (22%) in texture. Soil pH ranged between 7.35 and 9.21 (mean 8.16). The soil was saline to sodic in nature. Averaged across the village, water table depth was noted (91 to 104 ft). Nitrogen use was common and its application rates were much more than the recommended. The frequency of FYM use by the farmers was at the 3-4 years interval. The productivity of rice, sorghum, wheat, potato and pulses varied from 3.4 to 3.8 t/ha, 10.3 to 12.4 t/ha, 3.1 to 3.8 t/ha, 22.2 to 26. 8 t/ha and 0.7 to 0.9 t/ha, respectively. The average milk production of indigenous cow and buffalo was 3.0 and 6.0 liter respectively during the lactation period. High salinity in ground water, mixing of industrial effluents in irrigation canal, wild animals problems such Nilgai, monkeys and wild pigs and non availability of agriculture labour at the critical stage of crop are some of the important production constraints in the study area.

**Keywords**: Constraints, Livestock, Socio-economic, Soil, Water table

The availability of water from the *Tehri* dam will certainly help in improving the productivity of the concerned area and will advocate the shifting of cropping pattern in the command area. In addition with availability of water and enhancement of present water use will definitely affect the ecology of the area and make the environment more favorable for crop production. Under such circumstances, not only crop production will improve but also the farming systems concept will emerge as a key component to increase the farmers house hold income and livelihood. It will also have impact on all component of farming system viz., livestock, horticulture, vegetable and high value crops etc. Taking these factors into consideration, it is time to formulate and pursue those policies, which contribute to higher productivity, profitability and prosperity. Therefore, the present study was under taken to characterize the socio- economic conditions, soil characters, major components of farming system (crop, livestock and horticulture) of the region, irrigation water availability and find out the production constraints perceived by villagers in various components of farming system in Agra canal command area.

## Materials and Methods

Survey was conducted by adopting stratified random sampling. Sampling was done by randomly in Mathura and

Agra districts of Uttar Pradesh. 50 farmers (ten in each) from five villages of Gobardhan block (Mathura district) and 50 farmers (ten in each) from five villages of Achhanera and Fatehpur Sikri block (Agra district) in Agra canal command area were selected for the study. Thus total 100 farmers were selected from the Agra canal command area. The selected framers were interviewed personally and information of different aspects of farm resources (socio-personnel characters, soil characters, water table depth, irrigation sources, livestock and machineries etc), input use in different enterprises was obtained and production constraints of different enterprises were identified.

## Results and Discussion

### Socio- personnel characteristics of the farmers

It was found that majority of small farmers were young and middle age group (60%) followed by medium (57%) and large (51.5%) framers (Table 1). The descriptive analysis of educational status revealed that 6.3% of large farmer and 13.5% respondents of small farmer categories were found to be illiterate. Literacy among the medium farmers was more as compared to small and large categories of farmers. However; percentages of graduate and postgraduate level of education among large farmers were more in comparison to small and medium farmers. With regard to irrigation facilities, (100%) large farmers have irrigation facilities followed by medium (94.5%) and small (90%) farmers. More than 80% farmers from all the categories engaged in agriculture and animal husbandry. More than 75% farmers of all categories are rearing milch animals, v.z. cow and buffaloes. It was observed that 25% large farmers had joint family system; it is very high in small (82%) and medium (60%) categories of farmers. More than 80% of farmers from all the categories having 17 years for farming experience and as regards to farm powers/tractor and other implements, 78 % of large, 29 % of medium and 14 % of small farmers are having their own tractor and farm implements. It is because large farmers having bigger size of holding as well as much farm resources as compared to small and medium farmers. Majority of small farmers belongs to lower income group having income up to Rs. 30000/ annum and only 12% small farmers were having income more than Rs. 60000/ annum income from various sources.

### Psychological characteristics of farmers

It was found that only (38%) farmers had low attitude and (9%) high attitude in small farmers respondents towards to various cropping technologies in Agra canal command (Table 2). However 12.5% had low knowledge, 45% had medium and 34.5 had high knowledge in small farmer category. As regards to risk bearing ability is concerned, majority (53 to 78%) of all the categories of respondents taking medium to high level of risk.

### Communicational characteristics of the farmers

Regarding utilization of communicational resources, it was found (Table-3) that social participation (30%), informal sources (33%) govt. and non govt. organization (25%) and mass media communication e.g. T.V., Radio, Kisan mela/Krishak Gosthi (12%) in small farmers category were using together the information related to new innovation in various farming systems. However, it was observed that more utilization of communication resources in medium to

**Table 1 : Socio economic characteristics of respondents**

| Sr.No. | Particulars | Small(%) | Medium(%) | Large(%) |
|---|---|---|---|---|
| **A. Age groups** | | | | |
| 1 | 0-18 years | 25.6 | 12 | 18.5 |
| 2 | 18-35 years | 24 | 22 | 21.5 |
| 3 | 35-55 years | 36.3 | 28 | 27 |
| 4 | >55 years | 10.4 | 22 | 24 |
| **B. Education class family** | | | | |
| 1 | Primary | 26 | 27 | 26.2 |
| 2 | Secondary | 30.5 | 29 | 28.5 |
| 3 | Senior secondary | 16 | 28.5 | 10.2 |
| 4 | Graduate & post graduate | 7.3 | 26.0 | 4.5 |
| 5 | Illiterate | 13.5 | 9.5 | 6.3 |
| **C. Caste category** | | | | |
| 1 | General | 38 | 41 | 39 |
| 2 | OBC | 30.5 | 32 | 32 |
| 3 | SC | 16 | 29 | 33 |
| 4 | Others | 7.3 | 8 | 6 |
| **D. Size of land holding** | | | | |
| 1 | Marginal and small | 76.4 | 69 | 61 |
| 2 | Medium | 13.5 | 12.5 | 24 |
| 3 | Larger | 10.1 | 17.5 | 15 |
| **E. Irrigation facilities** | | | | |
| | Canal water | 52 | 30.0 | 14.5 |
| | Tube well | 38 | 64.5 | 85.5 |
| | Rainfed | 10 | 5.5 | 0.00 |
| **F** | **Occupation** | | | |
| | Service | 10 | 13 | 80 |
| | Farming | 90 | 87 | 92 |
| **G** | **Livestock production** | | | |
| | Milch animal | 75 | 80 | 85.4 |
| | Draft animals | 25 | 20 | 14.5 |
| **H** | **Type of family** | | | |
| | Joint | 82.3 | 60 | 25 |
| | Single | 15.7 | 40 | 75 |
| **I** | **Experience in farming** | | | |
| | 0-17 year | 24 | 19 | 11.5 |
| | 18-29 year | 31.5 | 32 | 29 |
| | >30 year | 49.5 | 47 | 59.5 |
| **J** | **Farm machineries** | | | |
| | No | 86 | 73 | 2 |
| | Yes | 14 | 29 | 78 |
| **K** | **Annual income** | | | |
| | <30000 | 33 | 20.5 | 4.5 |
| | 30-60000 | 56 | 41 | 28.5 |
| | >60000 | 12 | 59.5 | 67 |

**Table 2 : Psychological characteristics of respondents**

| Particulars | Small (%) | Medium (%) | Large (%) |
|---|---|---|---|
| **Attitude** | | | |
| Low | 38 | 31 | 13 |
| Medium | 53 | 57 | 39 |
| High | 9 | 13 | 48 |
| **Knowledge** | | | |
| Low | 12.5 | 28 | 39 |
| Medium | 45 | 59 | 36 |
| High | 34.5 | 33 | 25 |
| **Risk taking ability** | | | |
| Low | 47 | 30 | 22 |
| Medium | 40 | 34 | 42 |
| High | 13 | 36 | 36 |

**Table 3 : Communicational characteristics of respondents in Agra canal command area**

| Sources | Small (%) | Medium (%) | Large (%) |
|---|---|---|---|
| Social participation | 30 | 27 | 17 |
| Informal Sources | 33 | 35 | 36 |
| Formal sources | 25 | 20 | 25 |
| Mass media | 12 | 18 | 22 |

larger farmers through social participation (17-27%), informal sources (35-36%), formal sources govt. and non govt. organization (20-25%) and mass media communication, v.z. T.V., Radio, Kisan mela /Krishak Gosthi (18 to 22%).

## Soil characteristics

20 soil samples (0-15 and 15-30 cm depth) were collected from each village exclusively from fields, which were under dominant cropping system of the village for two or more consecutive years. From each field four sub-samples were drawn at 0-15 cm and 15-30 cm layer and analyzed. The soils were of clay loam (40%), loamy sand (38%) and sandy loam (22%) in texture. Soil pH ranged between 7.35 and 9.21 (mean 8.16). The soil was saline to sodic in nature. The electrical conductivity of soil varied from 0.15 to 4.37 $dsm^{-1}$ (mean 0.70 $dsm^{-1}$). The soil organic carbon ranged between 0.11 to 0.76 %. However, range values of Olsen P and available K (13 to 82 kg/ha and 96 to 431 kg/ha, respectively) were found under 0-15 cm soil depth. Increasing soil depth had increased values of EC and pH and decreased organic carbon percent and Olsen P and available K. The below soil profile depth (15-30 cm) pH ranged between 7.46 to 8.95 (mean 9.04). The

electrical conductivity ranged from 0.18 to 4.88 dsm$^{-1}$ (mean 0.85 dsm$^{-1}$).

**Water table**

Water table depth (ft) is directly linked with the cropping systems adopted. The rice based cropping system requires more number of irrigation as compared to the pearl millet /maize based cropping system. Further water table is directly limited with use of under ground water through centrifugal pumps and added recharge through canal water. Averaged across the village, water table depth was recorded between (91 to 104 ft). In general, water table depth was maximum during summer season and lowest during kharif season in both the locations. The lowest water table depth under study area may be ascribed in terms of low frequency of canal water release through canal /pumps in the region. Study reveals that water table depth has improved during last three years study area of Gobardhan, Achhnera and Fatehpur Sikri blocks. It is clear that water table depth is directly linked with the canal water availability and adoption of cropping systems in the study area.

**Fertilizer use by the farmers**

Nitrogen (N), Phosphorus (P), Potash (K) and micronutrients use was related to crop grown, farmer's economic situation and availability of nutrients in this region. Nitrogen use was common and its application rates were much more than the recommended. Averaged use of N was more in case of *rabi* (117 kg /ha) than *kharif* (103 kg/ ha). The total N use in a year per hectare cropped area was 244 kg /ha, which ranges from 50-640 kg/ha. The smaller nitrogen use in *kharif* season may be ascribed in relation with crop grown during the season. Villages having Pearl millet / sorghum are pre dominant crops had smaller N use (45 kg/ha) compared to other villages where rice based cropping system was a pre-dominant. None of the farmers reported N use during zaid (summer) season. The lower crop productivity in these villages may also be visualized in terms of smaller N use caused by irrigation water constraints.

Phosphorus usage ranged between 10 to 161 kg/ha during *Kharif* (monsoon) season with a mean of 46 kg/ha and 10 to 172 kg/ha with a mean of 63 kg/ha during *Rabi* (winter) season. Over all, per hectare Phosphorus use was 110 kg/ha, and it is more practiced during rabi season crops like wheat, potato and mustard etc than the *Kharif* season. Such fake qualities of fertilizers are also major constraints in achieving maximum economic production in this region. Use of Potassium was very meager in study area and restricted to some selected crops only. On an average, farmers apply 11.4 kg $K_2O$ /ha. Since zinc was emerging problems in all these location particularly in rice based cropping system farmers apply 20-30 kg/ha zinc sulphate (21%) to rice crops. Although its application rate depends upon its magnitude of deficiency. Average use of micronutrients was 9 kg/ha. Lack of awareness regarding significance of micronutrients among the villagers and availability of poor quality of micro-nutrients/complex fertilizers also creating a major obstacle in knowledge promotion regarding significance of balanced nutrition.

**Use of organic manure and residue by the farmers**

The major organic manures used by the farmers were farmyard manure (FYM). Farmers use FYM once in 3-4 years interval. Mahander Singh *et.al* (2004) also reported similar finding. The total organic manure use in kharif season crops receive almost 70% FYM with an average rate of 18-30 tonne/ hectare Among *Rabi* crops, only potato crops receive FYM, other crops do not have any organic input during *Rabi* season. Only 8-10% farmers were applying FYM to rice crop and none of the farmers reported use of farmyard manure in other crops. The average rate of application of FYM (15 t/ha) to rice was apparently much smaller. Further, survey revealed that use of FYM is mostly preferred in vegetable crops like potato, onion, chillies and cucurbits in all the canal command area. About 25-30% farmers are practicing residue burning in rice field in all the locations.

***Productivity of major cropping systems adopted by the farmers***

The information pertaining to cropping system being adopted in study area was collected and very interesting observation has been made in Table 4. Rice-wheat cropping is the pre-dominant cropping system covering about 30% area followed by pearl millet-mustard (20%), jowar-wheat (5%), cotton-wheat (3%) and pearl millet-wheat (14%). The cropping patterns of different villages varied depending upon the geophysical characteristics, socio-economic situation of the farmers, market and post harvest processing facility and other infrastructures available with the farmers. The farmers are raising the crop successfully using their tube well water. But the water table is shallow and all farmers are using pump/submersible tube wells.

Average productivity and production gap of various crops is presented in (Table-5).The productivity of rice, jowar, wheat, potato and pulses varied from 3.4 to 3.8 t/ha, 10.3 to 12.4 t/ha, and 3.1 to 3.8 t/ha, 22.2 to 26. 8 t/ha and 0.7 to 0.9 t/ha, respectively. However, if the data is examined critically it is very clear that still there is scope to enhance the per unit productivity level to harvest near the optimum yield. The average cropping intensity was 119%.

**Table 4 : Details of major cropping systems coverage**

| Sr. No. | Cropping systems | (%) covered area |
|---|---|---|
| 1 | Rice- wheat | 30 |
| 2 | Jowar- wheat | 5 |
| 3 | Cotton- wheat | 3 |
| 4 | Pearl millet- wheat | 14 |
| 5 | Pearl millet- mustard | 20 |
| 6 | Fallow- mustard | 13 |
| 7 | Dhaincha- mustard | 7 |
| 8 | Rice- rice- wheat | 0.5 |
| 9 | Pearl millet- Pearl millet- wheat | 0.5 |
| 10 | Maize- potato- wheat | 2.5 |
| 11 | Dhaincha- potato- wheat | 3.5 |
| 12 | Jowar-rice- wheat | 1 |

**Table 5 : Average productivity (t/ha) and production gap (%) of various crops**

| Sr. No. | Crops | Average productivity (t/ha) | Production gap% |
|---|---|---|---|
| 1 | Rice | 3.6 | 20 |
| 2 | Bajara | 2.4 | 14.3 |
| 3 | Jowar | 12.4 | 31.1 |
| 4 | Wheat | 3.8 | 9.5 |
| 5 | Mustard | 1.9 | 13.6 |
| 6 | Potato | 26.8 | 8.3 |
| 7 | Pulses | 0.7 | 20 |
| 8 | Cotton | 1.2 | 19 |

## Livestock

The major populations of animals in the surveyed villages were of buffaloes, cow, male buffaloes and bullocks. Among these buffaloes population was apparently more in Agra canal command area. Of the total animal population, milch animals population accounted for 96%. It is pertinent to mention that increasing demand of milk due to burgeoning population and cost effective use of agricultural by products led to popularize the dairy enterprise in this region. Dairy animals in this region are dominated by buffaloes (80 to 93%) as against to cow population (7 to 20%). The average milk production of indigenous cow and buffalo was 3.0 and 6.0 liter respectively during the lactation period. The reasons assigned for low milk productivity of these animals were poor health, imbalanced nutrition and poor management. Low conception in animals is also major hindrance in milk production. The major buffalo breeds in these locations were Murrah, Bhadawari and Surati. Haryana and Holstein Friesian-crossbred were cattle breeds found in these sampled villages.

## Major production constraints

The technological and infrastructural constraint analysis given (Table 6-7) is of great significance, which is related to the administrative and allied agricultural departments to invite their serious attention. High salinity in ground water, mixing of Industrial effluents in irrigation canal, imbalanced supply of plant nutrients, low conception in buffaloes and the availability of poor quality agro-inputs (seed, fertilizers insecticides and weedicide) were important technological constraints in production. Mahander Singh *et.al* (2004) also reported non-availability of inputs at the time of sowing as constraint in production. Among the infrastructural constraints wild animals problems such Nilgai, monkeys and wild pigs was serious constraint. Non availability of agriculture labour at the critical stage of crop was second important constraint. Singh *et. al* (2009) reported similar finding. Poor participation in the extension programmes was third constraint. Balasubramani *et.al* (2005) also reported low participation of farmers in extension programme Poor credit

**Table 6 : Technological constraints perceived by the farmers**

| Sr. No. | Constraints for sustainable production system | (% respondent) | Rank |
|---|---|---|---|
| 1 | Mixing of Industrial effluents in irrigation canal | 90 | II |
| 2 | Imbalanced supply of plant nutrients | 82 | III |
| 3 | The availability of poor quality agro-inputs (seed, fertilizers insecticides and weedicide ) | 78 | IV |
| 4 | Increasing white grub infestation | 74 | V |
| 5 | High salinity in ground water | 94 | I |
| 6 | Imbalance feeding of milch animals | 71 | VII |
| 7 | Dissemination of weed flora through canal water | 58 | IX |
| 8 | Health hazard for animals with human beings due to poor quality of canal water | 72 | VI |
| 9 | Ground water pollution | 62 | VIII |
| 10 | Low conception in buffaloes | 82 | III |

**Table 7 : Infrastructural constraints perceived by the farmers**

| Sr. No. | Constraints for sustainable production system | (% respondent) | Rank |
|---|---|---|---|
| 1 | Irregular canal water supply | 60 | IX |
| 2 | High cost of tubewell installation | 25 | XII |
| 3 | Poor participation in the extension programmes | 80 | III |
| 4 | Non-availability of surface water at critical time particularly at the critical growth stages of crops. | 64 | VII |
| 5 | Poor drainage in canal command area | 55 | X |
| 6 | The canal basement is at lower alleviation than the irrigated fields | 61 | VIII |
| 7 | Depth of water table is more than 75 feet | 41 | XI |
| 8 | Poor credit facilities | 79 | IV |
| 9 | Wild animals problems such blue bulls, monkeys and wild pigs | 84 | I |
| 10 | Remunerative price of agriculture produce | 76 | V |
| 11 | Poor market infrastructure for final agro-produce | 70 | VI |
| 12 | Non availability of agriculture labour at the critical stage of crop | 82 | II |

facilities, low remunerative price of agriculture produce are some of the other infrastructural constraints. These constraints should be addressed in holistic manner as early as possible to increase the agriculture production in this area.

## REFERENCES

Balasubramani, N., Swathilekshmi, P.S.and Chandrakandan, K. (2005).A study on the yield gap analysis in paddy in the Erode district of Tamilnadu. *Asian Journal of Extension Education*. *XXIV*. 44-51.

Mahander Singh, Singh, S.P.and Singh, J.P. (2004).Farming systems characterization problems and prospects. Extended summaries 2nd *National Symposium* on alternative farming system. September 16-18, 2004, Modipuram.

Singh, S.P., B.Gangwar, Singh, M.P. and Satyapal Singh. (2009).Constraints inintegrated farming system in Western U.P. *Prog. Agric* **9**(1):12-18.

*J. Farming Systems Research & Development* **18** (2) : 233-240 (2012)

# EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON SOIL FERTILITY STATUS AND PRODUCTIVITY OF RICE-MAIZE SEQUENCE UNDER PERMANENT PLOT EXPERIMENT

A. Sathish, H. Chandrappa, A.Y. Hugar and Nagaraja Kusagur

*Agricultural Research Station, Kathalagere, Davanagere District,*
*University of Agricultural Sciences (Bengaluru), Karnataka*

## Abstract

Long term experiment (1988-2008) was carried out at Agricultural Research Station, Kathalagere, Karnataka to study the effect of integrated nutrient management on soil fertility status and productivity of rice-maize cropping sequence. The treatments which received organic sources of nutrients in combination with inorganic fertilizers as showed improvement in organic carbon content from 0.68 per cent to 0.73 per cent, available phosphorus from 12.3 kg/ha to 22.01 kg/ha and maintained available potassium content. In general there was decrease in available potassium content among all the treatments due to crop removal as a result of continuous cropping. Significant increase in rice yield were noticed in treatments receiving paddy straw as source of nitrogen (25 to 50 %). Higher maize yield was observed in treatments applied with organic and inorganic fertilizers in kharif followed by 100 per cent NPK in summer season. Thus showing the beneficial effect of organic sources of nutrients on the succeeding crop and also improving the soil fertility levels.

**Keywords**: Rice – maize, INM, Soil fertility, productivity, organic and inorganic sources of nutrients.

Rice and maize are the two major crops grown in maximum area in Bhadra command area of Karnakata. Rice is grown in an area 10.67 lakh ha in *kharif* season and 2.85 lakh ha in the summer season with total production of 36.46 lakh tonnes in Karnataka. Similarly maize is also grown in an area of 9.61 lakh ha with production of 26.42 lakh tonnes. Major contribution to total rice as well as maize production comes from Bhadra command area. Among the various production constraints, shortage of canal water and development of salinity in some patches are the major considerations for lower productivity in rice-rice system. Hence there is a need to replace the summer rice by some light irrigated crops like maize, which is profitable interms of its economic value as well as reducing the development of salinity due to continuous submergence (Newaj and Yadav, 1992). In addition to this, due to imbalance in application of fertilizers and continuous cropping, deficiency of some of the nutrients has been observed in some areas. In order to overcome this problem, alternative strategies are needed so that soil degradation as well as soil fertility level can be managed for sustainable productivity. Hence the present study was initiated at Agricultural Research Station, Kathalagere, Davanagere District, Karnataka to study the effect of integrated nutrient management practices on soil fertility changes and productivity of rice –maize cropping sequence.

## Materials and Methods

A long term field experiment was conducted from 1988 to 2008 at Agricultural Research Station, Kathalagere under canal irrigation from Bhadra right canal to study the effect of integrated nutrient management on soil fertility status and productivity of rice-maize sequence under permanent plot experiment in moderately shallow, dark reddish brown, sandy clay soils. The initial soil fertility levels were (pH - 6.40, EC - 0.13 $dSm^{-1}$, organic carbon - 0.68 % , available phosphorus - 12.3 kg/ha, available potash - 211.4 kg/ha) taken as reference. The experiment was laidout in a randomized block design with twelve treatments with different organic sources of nutrients (Treatment details are given in Table 1) and replicated four times.

The organic sources of nitrogen used were FYM (Farm yard manure), paddy straw and glyricidia with nitrogen content of 0.5 per cent, 0.4 per cent and 0.8 per cent on dry weight basis respectively. Nutrient equivalent basis of organic sources to meet the required quantity of N were incorporated in the soil 15 days before planting of kharif paddy. Entire dose of P and K and 50 per cent of inorganic N were applied at the time of planting in the form of Single Super Phosphate, Murate of Potash and Urea respectively. The remaining dose of nitrogenous fertilizer was top dressed in equal splits at 30 and 60 days after transplanting in the form of Urea. Twenty-five days old seedlings were transplanted in rows of 20cm apart with 10cm spacing between hills. For the summer crop of maize, 50 per cent N and full dose of P and K were applied at different levels based on the treatments at the time of sowing and remaining 50 per cent N was applied at 30 days after sowing. Seeding was done in rows of 60cm apart with 30cm spacing between

**Table 1 : Treatment details of permanent plot experiment on integrated nutrient supply in Rice- Maize cropping system**

| Sl. No. | Nutrient Source | |
|---|---|---|
| | ***Kharif* (rice)** | **Summer (maize)** |
| 1. | Control | Control |
| 2. | 50% NPK | 50% NPK |
| 3. | 50% NPK | 100% NPK |
| 4. | 75% NPK | 75% NPK |
| 5. | 100% NPK | 100% NPK |
| 6. | 50% NPK + 50% N(FYM) | 100% NPK |
| 7. | 75% NPK + 25% N (FYM) | 75% NPK |
| 8. | 50% NPK + 50% N (Paddy Straw) | 100% NPK |
| 9. | 75% NPK + 25% N (Paddy Straw) | 75% NPK |
| 10. | 50% NPK + 50% N (Glyricidia) | 100% NPK |
| 11. | 75% NPK + 25% N (Glyricidia) | 75% NPK |
| 12. | Farmers Practice<br>(85:50:30 kg NPK/ha & FYM 2 t/ha) | Farmers Practice<br>(75:37.5:38.75 kg NPK/ha ) |

seeds. Intercultural operations were done before top dressing of nitrogen. Plant protection measures were adopted for both the crops as and when pest and diseases were noticed. Yield data on paddy crop during kharif followed by maize crop during summer has been considered for the statistical analysis. Soil samples were collected after the harvest of summer maize crop and analyzed for different parameters like pH, electrical conductivity, organic carbon, available phosphorus and available potash content by following the standard methods to study the changes in the soil fertility levels. All the results were then analyzed statistically for drawing conclusion using standard statistical analysis tools.

## Results and Discussion

### Soil pH and Electrical conductivity

Both soil pH and EC values varied significantly among various treatments (Table 2). There was decrease in soil pH in all the treatments when compared to the initial values, where as EC values have increased. The values were fluctuating among the treatments may be because of the dissolved salts contribution from soil, water and release of ionic species due to reduction process as observed by Nambiar (1985).

### Organic carbon

Organic carbon content has increased from 0.68 per cent to 0.73 per cent over initial level and from 0.62 per cent to

**Table 2 : Soil properties and available nutrients as influenced by different cropping systems at the end of season, 2007-08.**

| Treatment | pH(1:2) | EC(1:2) | OC(%) | Available Phosphorus (Kg/ha) | Available Potassium (Kg/ha) |
|---|---|---|---|---|---|
| $T_1$ | 5.28 | 0.16 | 0.62 | 10.97 | 125.80 |
| $T_2$ | 5.56 | 0.22 | 0.65 | 18.06 | 163.05 |
| $T_3$ | 5.42 | 0.21 | 0.65 | 18.85 | 183.80 |
| $T_4$ | 5.43 | 0.22 | 0.62 | 17.84 | 187.26 |
| $T_5$ | 5.51 | 0.24 | 0.67 | 21.92 | 185.67 |
| $T_6$ | 5.81 | 0.22 | 0.72 | 22.01 | 188.81 |
| $T_7$ | 5.62 | 0.16 | 0.70 | 20.55 | 184.41 |
| $T_8$ | 5.38 | 0.17 | 0.72 | 20.60 | 181.30 |
| $T_9$ | 5.61 | 0.15 | 0.73 | 21.96 | 187.79 |
| $T_{10}$ | 5.49 | 0.22 | 0.72 | 21.62 | 184.15 |
| $T_{11}$ | 5.72 | 0.19 | 0.70 | 21.40 | 182.64 |
| $T_{12}$ | 5.95 | 0.22 | 0.64 | 18.90 | 141.75 |
| Initial status | 6.4 | 0.13 | 0.68 | 12.3 | 211.4 |
| SEm± | 0.015 | 0.012 | 0.014 | 0.13 | 0.84 |
| CD @ 5% | 0.042 | 0.04 | 0.04 | 0.38 | 2.43 |

0.73 per cent over control over the years in the treatments receiving organic sources of nutrients in addition to inorganic fertilizers (Table-2). The increase in organic carbon content in treatments receiving combination of both organic and inorganic sources may be attributed to higher biomass addition to soil through crop residues as per the observation of Sharma and Sharma (2002).

Lowering of organic carbon content of soil was common in control and in treatments which received only inorganic fertilizers (Singh *et al.*, 2001). This type of lowering of organic carbon content of soil may be due to its rapid mineralization resulting from intensive cropping and also as a result of attaining stable equilibrium with the changing soil crop environment (Singh *et al.*, 2008)

**Available phosphorus**

It is well known fact that the crop uses 25 to 30 per cent of applied phosphorus and remaining part is not readily available so which remains in the soil. There was gradual increase in available phosphorus content of soil over the years and when compared to initial status of soil, increase was more under organic combination treatments (12.3 kg/ha to 20.55-22.01 kg/ha). Treatment receiving 25 per cent N through FYM recorded significantly higher available P than control as well as other treatments (Table 2). Increase in available phosphorus with addition of organic sources might be due to additional application of phosphorus and mobilization of phosphorus from lower layers of the soil. Tolanur and Badanur (2003) also reported that FYM and Green manure addition with inorganic fertilizers had the beneficial effect on increasing the availability of phosphorus.

**Available potassium**

The data on available potassium content of soils shows that there was depletion in available potassium content over the years when compared to initial level (211.4 kg/ha) due to continuous cropping (Table 2). The decrease in available potassium is more evident in control plot as well as farmers practice mainly because of lack of application of balanced dose of fertilizers, especially potassium fertilizer application. The treatments supplied with organic sources have maintained relatively higher available potassium content similar to the observations made by Singh *et al* (2008). The declining trend of available potassium among all the treatments may be attributed to crop removal due to continuous cropping (Laxminarayana, 2006).

**Grain and straw yield**

Grain and straw yields were significantly influenced by the application of fertilizer in combination with organic sources. The data of rice and maize yield has been give**n in Table 3 and 4 re**spectively.

**Rice grain and straw yield**

Rice yields increased significantly with the increase in nitrogen levels up to 100 kg/ha. Rice yields further increased with 100 per cent application of N, P and K and in treatments receiving part of N through various organic sources. Among all the treatments, application of 25 per cent and 50 per cent N through paddy straw gave significantly higher grain and straw yields, respectively. The increase in yields are attributed to contribution of nitrogen from paddy straw which also helps in saving in terms of application of fertilizer N, similar results were also observed by Gill *et. al.*(1994).

**Table 3 : Yield of Rice (Kg/ha.) as influenced by integrated nutrient management in rice-maize cropping sequence (2003-2008).**

| Treatments | 2003-04 | | 2004-05 | | 2005-06 | | 2006-07 | | 2007-08 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) |
| $T_1$ | 1901 | 2962 | 2338 | 2745 | 3137 | 3485 | 2442 | 2237 | | | 2455 | 2857 |
| $T_2$ | 4003 | 4904 | 3476 | 5683 | 5198 | 5926 | 4130 | 3922 | | | 4202 | 5109 |
| $T_3$ | 4364 | 5570 | 3761 | 6129 | 5350 | 5900 | 4415 | 4393 | Due to non availability of canal water, crop was not established | | 4473 | 5498 |
| $T_4$ | 4832 | 6155 | 3832 | 6265 | 5979 | 6739 | 5058 | 5106 | | | 4925 | 6066 |
| $T_5$ | 5643 | 6871 | 5851 | 7044 | 6505 | 7529 | 5504 | 5680 | | | 5876 | 6781 |
| $T_6$ | 6060 | 8260 | 6263 | 7121 | 6353 | 7600 | 4722 | 4693 | | | 5850 | 6919 |
| $T_7$ | 5609 | 7339 | 6166 | 6680 | 6578 | 7757 | 5409 | 5358 | | | 5941 | 6784 |
| $T_8$ | 6543 | 9540 | 5791 | 7140 | 6644 | 7660 | 4620 | 4642 | | | 5900 | 7246 |
| $T_9$ | 5671 | 7003 | 6171 | 7337 | 7017 | 7383 | 5329 | 5596 | | | 6047 | 6830 |
| $T_{10}$ | 5921 | 7406 | 5838 | 6647 | 6557 | 7441 | 4985 | 5080 | | | 5825 | 6644 |
| $T_{11}$ | 5680 | 7376 | 5941 | 7529 | 6966 | 7084 | 5738 | 5885 | | | 6081 | 6969 |
| $T_{12}$ | 4569 | 6579 | 4381 | 6411 | 5811 | 7514 | 5234 | 5369 | | | 4999 | 6468 |
| S Em± | 240 | - | 206 | 399 | 268.30 | 231.32 | 101.36 | 124.80 | | | | |
| CD @ 5 % | 691 | - | 593 | 1148 | 773.0 | 666.0 | 305.44 | 376.04 | | | | |

**Table 4 : Yield of Maize (Kg/ha.) as influenced by integrated nutrient management in rice-maize cropping sequence (2003-2008).**

| Treatments | 2003-04 | | 2004-05 | | 2005-06 | | 2006-07 | | 2007-08 | | Mean | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) | Grain (Kg/ha.) | Straw (Kg/ha.) |
| $T_1$ | Due to non availability of canal water, crop was not established | | 782 | 1750 | 988.30 | 1725.15 | 2387 | 3918 | 1263.5 | 3997.5 | 1355 | 2848 |
| $T_2$ | | | 2040 | 2273 | 2065.79 | 1988.30 | 3186 | 4218 | 3556.8 | 4454.0 | 2712 | 3233 |
| $T_3$ | | | 3559 | 5073 | 2722.22 | 2229.53 | 4049 | 4869 | 4329.3 | 6567.8 | 3665 | 4685 |
| $T_4$ | | | 3353 | 3578 | 2463.45 | 2214.91 | 3893 | 4949 | 4189.0 | 7097.3 | 3475 | 4460 |
| $T_5$ | | | 3798 | 6847 | 3260.23 | 3033.63 | 4740 | 5512 | 4362.3 | 6402.8 | 4040 | 5449 |
| $T_6$ | | | 4000 | 7086 | 3748.54 | 3596.49 | 4915 | 5600 | 4943.0 | 7269.5 | 4402 | 5888 |
| $T_7$ | | | 3581 | 5309 | 2878.65 | 2456.14 | 4014 | 5534 | 4040.5 | 6586.5 | 3629 | 4971 |
| $T_8$ | | | 3819 | 6928 | 3630.12 | 3399.12 | 4360 | 5717 | 4535.0 | 6702.3 | 4086 | 5687 |
| $T_9$ | | | 3641 | 5618 | 3012.43 | 2536.55 | 3837 | 5285 | 4710.8 | 6353.8 | 3800 | 4948 |
| $T_{10}$ | | | 3793 | 6535 | 3187.87 | 2967.84 | 4334 | 5454 | 4223.8 | 6653.3 | 3885 | 5403 |
| $T_{11}$ | | | 3581 | 5087 | 2783.63 | 2258.77 | 3706 | 5051 | 4038.0 | 6429.3 | 3527 | 4707 |
| $T_{12}$ | | | 3490 | 4416 | 2467.84 | 2222.22 | 3278 | 5314 | 3775.3 | 4889.8 | 3253 | 4211 |
| S Em± | | | 123 | 268 | 173.57 | 224.29 | 321.37 | 209.48 | 321.86 | 335.4 | | |
| CD @ 5 % | | | 353 | 770 | 499.78 | 646.0 | 918.52 | 603.16 | 926.7 | 965.9 | | |

Significantly lowest productivity was observed in control and in the treatments receiving only inorganic fertilizers. Thus use of organic sources in combination with inorganic fertilizers helps in maintaining the yield levels of rice.

***Maize grain and straw yield***

Significantly higher grain and straw yields were recorded in treatments receiving 100 per cent N, P and K through inorganic fertilizers in summer preceded by application of either 100 per cent N, P, K or in combination of organic and inorganic fertilizers, during kharif season. The higher yields could be possible due to the effect of improvement in soil fertility levels as a result of addition of balanced dose of fertilizers in the previous season (Hegde and Dwivedi, 1993). Lowest grain and straw yields were observed in control. Treatment receiving 80, 50 and 30 kg/ha N, P and K and 2 tons /ha FYM (Farmers practice) also showed lower yields, necessitating the use of both organic and inorganic sources for achieving better yields in the long run. Though treatment T3 and T5 received 100 per cent NPK during summer, yields were relatively low when compared to the treatments receiving combination of organic and inorganic sources during kharif season.

Thus application of organic sources of nitrogen in rice crop has beneficial effect on succeeding crop *i.e* maize in the summer season. Though the green manures are good source of both nitrogen and organic matter, they can not meet the total crop nutrient requirement in the present day agriculture (Ladha *et al.*, 1996). The availability of only green manure is also a limiting factor. Hence to meet the demand of nutrients we need to use the integrated approach by utilizing the available resources. The use of paddy straw to meet 25-50 per cent N requirement which other wise goes as a waste in some places can be effectively used during kharif season, so that the rice productivity can be enhanced. In the summer season maize productivity can be enhanced through application of 100 per cent NPK by utilizing the nutrients derived in treatments receiving organic sources in the previous season.

Among various treatments, where ever combination of both organic and inorganic fertilizers are used during kharif season and 75 to 100 per cent NPK through inorganic fertilizer during summer season as significantly improved the fertility levels when compared to all other treatments. Highest yield of rice was observed in treatment receiving 25 per cent N through paddy straw and 75 per cent NPK through inorganic fertilizer. In case of maize, treatments receiving 50 per cent of N through inorganic, 100 per cent P, K and 50 per cent N through FYM during kharif season and 100 per cent NPK through inorganic fertilizer during summer season gave highest yield indicating the importance of balanced nutrition and availability of nutrients for better crop growth. The decline in soil fertility and resultant productivity in treatments receiving only inorganic fertilizers was mainly because of imbalance in nutrient supply. In general depending on the availability at least 25 per cent of nutrients need to be supplied through various organic sources including green manure, paddy straw and FYM. Thus in addition to providing nutrients, it also improves the soil physical properties and microbial population leading to higher fertilizer use efficiency and better productivity of rice and maize.

REFERENCES

Gill, M.S., Tarloksingh and Ran, S.D., 1994. Integrated nutrient management in rice-wheat cropping sequence in semi arid tropics. *Indian Journal of Agronomy,* **39**(4): 606-608.

Hedge, D.M. and Dwivedi, S.S., 1993. Integrated nutrient supply and management as a strategy to meet nutrient demand. *Fertilizer news,* **38**: 49-59.

Ladha, J.K., Kundu, D.K., Angelo Van Coppenole, N.G., Peoples, M.B., Carangal, V.R. and Dart, P.J., 1996. Legume productivity and soil nitrogen dynamics in low land rice based cropping systems. *Soil Science Society of American Journal*, **60**:183-192.

Laxminarayana, K., 2006. Effect of integrated use of inorganic and organic manures on soil properties, yield and nutrient uptake of rice in Ultisols of Mizoram. *Journal of the Indian Society of Soil Science,* **54** (1): 120-123.

Nambiar, K.K.M., 1985. All India coordinated project on long term fertilizer experiments and its research achievements. *Fertilizer news,* **30**(4): 56-66.

Newaj, R., and Yadhav, D.S., 1992. Production potential and labour employment under different cropping systems under upland conditions of Eastern UP. *Indian Journal of Agronomy*, **37**(3): 401-406.

Sharma, S.K. and Sharma, S.N., 2002. Integrated nutrient management for sustainability of rice-wheat cropping system. *Indian Journal of Agricultural Science,* **72**:573-576.

Singh, A.P., Mahapatra, B.S., Singh, R.K., Bhadadhwaj, A.K., Chaubey, A.K., and Vishwakarma, V.K., 2008. Productivity and fertility status in rice –wheat crop sequence as influenced by integrated nutrient supply under permanent plot experiment. *Journal of Farming Systems Research and Development,* **14**(1): 6-11.

Singh, Muneshwar, Singh, V.P., and Reddy, K., Sammi, 2001. Effect of integrated use of fertilizer nitrogen and farm yard manure or green manure on transformation of N, K and S and productivity of rice-wheat system on vertisol. *Journal of the Indian Society of Soil Science,* **49**: 430-435.

Tolanur , S.I and Badanur, V.P., 2003. Effect of integrated use of organic manure, green manure and fertilizer nitrogen on sustaining productivity of rabi sorghum – chickpea system and fertility of a vertisol. *Journal of the Indian Society of Soil Science,* **51**: 41-45.

*J. Farming Systems Research & Development* **18** (2) : 241-246 (2012)

# EFFECT OF PLANT GROWTH PROMOTERS ON GROWTH, YIELD ATTRIBUTES AND YIELD OF BLACK GRAM (*VIGNA MUNGO*)

A.K. Katiyar*, and Arjun Singh Jat**

*Krishi Vigyan Kendra, Budaun*
*(Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, UP)*

Abstract

The field experiments were conducted in kharif 2009 and 2010 on Black gram (Urd) to asses' contribution of growth promoters commercially available in market for the farmers. For this purpose Aminos, Biozyme, Tracel and Planofix were sprayed on standing crop at 45 days after sowing. The seed of black gram was inoculated prior to sowing for all the treatments except control. Growth promoters were applied as alone in different treatments and also their dual combinations. Observations on plant growth were taken at 40and 60 days after sowing and yield attributing character were taken at harvest. Rhizobium inoculation was better than control both the years. Aminos followed biozyme, tracel and planofix was contributed more trifoliate, nodule number, plant height and yield characters among alone application of growth promoters. Application of growth promoters in combination, highest grain yield (12.65 & 13.45 q/ ha.) were obtained from combined application of aminos+ tracel followed by aminos+ biozyme (12.43 & 13.12 q/ ha) and biozyme+ tracel (12.32 & 12.89 q/ha), aminos+ planofix (11.98 & 12.45 q/ha). Among single applied growth promoters highest yield (11.52 & 11.85 q/ ha) were found from aminos and followed by biozyme, tracel and planofix were obtained from both the years of experiments.

**Key words:** Black gram, Aminos, Biozyme, Tracel, Planofix, Rhizobium.

Productivity in Agriculture is a very important to produce better quality and yield leads to profitability. Every farmer wants to achieve maximum productivity from their unit area. However, to achieve this goal with advancement of technology, use of excess fertilizer and pesticides, now the time is to look at Bio-technological tools to achieve the goal of farmers. For this purpose plants growth promoters may become a new tools to increase productivity. The requirement of amino acids in essential qualities is well know as a means to increase yield and overall quality of crops. The application of amino acids for foliar use is based on its requirement by plants. The plant absorbs amino acids, micronutrients, hormones and enzymes through stomata and used as ingredients in the process of Protein Synthesis. Most of the Indian farmers traditionally using recommended seed and fertilizers practices to produce their crops with their limited resources. There are many growth promoters available in the market which can increase productivity with minimum cost. For this purpose experiments were planned to assess the contribution of Aminos, Tracel, Biozyme and Planofix on legume Black gram (Urd). Palaniappan and Balasubramaniyam (1989) reported the yield of rice, maize, soybean, maximized by increasing plant density by increasing application of NPK fertilizers and growth regulators.

*Associate Director (Soil Science), **Assistant Professor (Agronomy)

## MATERIALS AND METHODS

The field experiments were conducted in kharif 2009 and 2010 at Tarai of Uttar Pradesh by using commercial growth promoters available in market on sprayed on standing crop of Black gram (Urd) at just before flowering. Before sowing seeds were inoculated with rhizobium culture except control uniformly. The growth promoters were used in separate treatment and also with their combinations. The experiments were conducted in RBD with three replication, data were recorded at 40 and 60 days after sowing (DAS) growth stage and at crop harvest. The growth promoter's descriptions as follows:

**Aminos**- It is an amino acid based Bio-stimulants, used 500 ml/ hectare at flower initiation stage.

**Bio-zyme-** It contains plant growth regulators as cytokinin, auxin precursors, enzyme and amino acids specially blended to retain their stability over long periods. Used 400 ml/ hect.spray at flowering stage.

**Planofix-** It is a Nephaline acetic acid (NAA) used 100 ml/ hectare. Black gram it sprayed two times, first at flower initiation stage and second at two weeks after flowering. Spray was done at evening time to protect from sunlight. Lakshmamma and Rao (1996) recommended spray of 20 ppm NAA twice at 50 % flowering stage, decrease flower drop and increased seed yield in *V. mungo*.

**Tracel-** It is a mixture of micronutrient available in powder form and used 4 kg tracel dissolved in 500 liter of water spray at flower initiation stage.

The experimental site having soil loam soil with 7.6 pH and sowing was done in the last week of July in both the years.

## RESULTS AND DISCUSSION

The effects of different treatments were recorded at three times during crop season in both the years. Number of leaves and plant height were recorded at 40 days after sowing. The growth promoters were applied at 45 days after sowing and data were recorded after 15 days after spray as at 60 days after sowing and nodule number, nodule dry weight and plant dry weight were recorded. The yield attributes number of pods per plant, number of grain per plant, plant dry weight per plant, grain yield q/ha and thousand grain weight calculated at harvest time.

It is reveled from the data (Table-1) that at 40 DAS no much difference were observed except control due to effect of rhizobium inoculation were observed. Lowest trifoliate (9.66 and 9.87/ plant) and plant height (31.00 and 31.56cm.) recorded from control plot during 2009 & 2010, respectively. It is also supported by Sarmah and Day (1986) that application of tracel- 2 @ 5g/ litre at 50 % flowering reported that plant height and branches were unaffected, but number of pods and seed yield were increased, highest yield were obtained from with spray of planofix. Among single application of growth promoters higher numbers of nodules were recorded with the aminos compared to tracel, biozyme and planofix during both the years. Maximum nodule numbers (67.33 and 67.89/plant) were recorded (Table-1) by the spray of aminos along with tracel followed by biozyme + tracel, aminos+ biozyme in respective years. Nodule dry weight (88.33 and 87.56 mg/plant) and plant dry weight (4.93 and 5.25g/plant) at 60 days after sowing were recorded maximum by the use of aminos and tracel followed by

**Table 2 : Effect of growth promoters on yield attributes and yields of Blackgram.**

| Treatments | Trifoliate/ plant at 40 DAS | | Plant height cm) 40 DAS | | Nodule no./ plant 60 DAS 15 day after spray | | Nod dry weight (mg/pl.) | | Plant dry wt. (gm) 60 DAS | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 |
| Control | 9.66 | 9.87 | 31.00 | 31.56 | 40.33 | 41.45 | 47.00 | 47.75 | 2.03 | 2.49 |
| Rhizobium | 11.00 | 10.86 | 32.66 | 33.12 | 49.66 | 50.23 | 50.66 | 51.32 | 2.43 | 2.76 |
| Rhizobium + Aminos | 11.20 | 11.95 | 33.66 | 33.22 | 63.66 | 63.90 | 75.66 | 76.56 | 3.60 | 3.42 |
| Rhizobium+Biozyme | 11.40 | 11.12 | 33.66 | 33.96 | 55.66 | 56.42 | 56.00 | 56,98 | 2.63 | 2.75 |
| Rhizobium+Planofix | 11.33 | 11.45 | 34.00 | 34.75 | 54.00 | 55.15 | 49.00 | 50.65 | 2.56 | 2.73 |
| Rhizobium+Tracel | 11.66 | 11.37 | 34.66 | 33.98 | 58.00 | 58.75 | 68.66 | 70.12 | 3.20 | 3.67 |
| Rhizobium+ Aminos+ Biozyme | 10.92 | 10.85 | 34.33 | 34.08 | 66.00 | 66.90 | 88.00 | 87.45 | 4.00 | 4.35 |
| Rhizobium+ Biozyme+ Planofix | 11.33 | 11.67 | 34.66 | 33.08 | 56.33 | 57.12 | 56.66 | 58.25 | 3.46 | 3.87 |
| Rhizobium+ Planofix+ Tracel | 11.33 | 11.98 | 34.66 | 32.92 | 57.66 | 58.22 | 71.00 | 71.55 | 3.26 | 3.65 |
| Rhizobium+Biozyme +Tracel | 11.66 | 11.35 | 34.66 | 33.21 | 66.00 | 66.87 | 85.33 | 84.42 | 3.90 | 4.18 |
| Rhizobium+ Aminos+ Tracel | 11.66 | 11.87 | 33.33 | 33.76 | 67.33 | 67.89 | 88.33 | 87.56 | 4.93 | 5.25 |
| Rhizobium+ Aminos +Planofix | 10.66 | 11.78 | 34.33 | 33.82 | 65.00 | 65.87 | 76.66 | 77.36 | 3.56 | 3.87 |
| | NS | NS | NS | NS | * | NS | ** | ** | ** | ** |
| SEM | 0.904 | 0.925 | 1.989 | 1.872 | 4.925 | 4.721 | 4.548 | 4.234 | 0.277 | 0.314 |
| CD 5% | 2.652 | 2.686 | 5.835 | 4.675 | 14.444 | 10.32 | 13.33 | 11.21 | 0.814 | 2.24 |

**Table 2 : Effect of growth promoters on yield attributes and yields of Blackgram.**

| Treatments | Pods/plant | | Number of grains/ plant | | Plant dry weight (gm/plant) | | Thousand Grain wt. (gm) | | Grain yield (q/ ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 | 2009 | 2010 |
| Control | 11.46 | 11.85 | 33.66 | 34.89 | 1.60 | 1.75 | 35.52 | 36.63 | 10.65 | 11.20 |
| Rhizobium | 12.00 | 12.46 | 47.33 | 48.45 | 1.76 | 1.98 | 39.04 | 40.23 | 11.47 | 11.98 |
| Rhizobium + Aminos | 15.33 | 15.87 | 64.00 | 65.20 | 2.73 | 2.75 | 40.44 | 41.34 | 11.52 | 11.85 |
| Rhizobium+ Biozyme | 13.66 | 14.10 | 57.66 | 58.74 | 2.30 | 2.54 | 35.37 | 37.48 | 11.30 | 11.55 |
| Rhizobium+ Planofix | 12.33 | 12.78 | 48.00 | 49.23 | 2.23 | 2.67 | 39.61 | 40.76 | 10.96 | 11.14 |
| Rhizobium+ Tracel | 13.66 | 13.86 | 59.66 | 60.78 | 2.60 | 2.67 | 38.64 | 39.75 | 11.15 | 11.24 |
| Rhizobium+ Aminos+ Biozyme | 17.33 | 17.86 | 69.00 | 71.20 | 4.36 | 4.43 | 43.48 | 44.35 | 12.43 | 13.12 |
| Rhizobium+ Biozyme+ Planofix | 13.66 | 14.45 | 58.00 | 59.32 | 2.40 | 2.68 | 36.10 | 37.23 | 11.73 | 12.27 |
| Rhizobium+ Planofix+ Tracel | 14.00 | 14.55 | 60.66 | 61.23 | 2.66 | 2.96 | 40.57 | 41.25 | 11.85 | 11.40 |
| Rhizobium+ Biozyme + Tracel | 16.66 | 17.20 | 65.33 | 65.95 | 3.30 | 3.40 | 43.21 | 44.31 | 12.32 | 12.89 |
| Rhizobium+ Aminos+ Tracel | 19.00 | 20.25 | 78.00 | 79.45 | 4.76 | 4.98 | 44.53 | 45.65 | 12.65 | 13.45 |
| Rhizobium+ Aminos + Planofix | 16.00 | 17.36 | 65.00 | 66.65 | 2.76 | 3.20 | 41.38 | 42.35 | 11.98 | 12.45 |
| | ** | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| SEM | 0.671 | 0.87 | 1.548 | 1.67 | 0.118 | 0.23 | 0.989 | 1.254 | 0.104 | 0.215 |
| CD 5% | 1.969 | 2.23 | 4.541 | 3.89 | 2.901 | 3.56 | 2.901 | 3.452 | 2.850 | 3.56 |

aminos and biozyme among all sprayed growth promoters single and with their combination during both the years of experimentation. Lowest nodule number, dry weight plant dry weight was observed from rhizobium inoculation followed by control treatment during both the years. Singh and Uttam (1994) concluded from a field trial that application of planofix at tillering and booting stage increased plant height, grain and straw yield.

The yield contributing characters (Table-2) were concern, lowest pods per plant (12.00 and 12.46) observed from rhizobium inoculation alone followed by control (11.46 and 11.85) during 2009 & 2010, respectively. Spray of alone growth promoters was consider, aminos contributed more pod yield followed by tracel, biozyme and planofix. Maximum pods per plant (19.00 and 20.25) were obtained from spray of aminos + tracel treatment followed by aminos+ biozyme (17.33 and 17.86), biozyme + tracel (16.66 and 17.20), and aminos + planofix (16.00 and 17.36) among used growth promoters in combinations in respective years. Similar trends were found in case of number of grains per plant as related to pods per plant (Table-2). Maximum plant dry weight (4.76 gm. per plant) was recorded by combined spray of aminos + tracel treatment followed by aminos+ biozyme, biozyme +tracel, aminos+ planofix and planofix + tracel. Among single application maximum plant dry wt. (2.73gm. per plant)) was found with application of aminos followed by tracel, biozyme and planofix.

Thousand grain weight were almost same from biozyme+ tracel and aminos+ tracel, lowest from biozyme application alone which was near to control treatment. Highest thousand grain weights (44.53 and 45.65 g) were recorded with the combined application of aminos+ tracel followed by aminos+ biozyme (43.48 and 44.35g) and biozyme+ tracel (43.21 and 44.31g), aminos+ planofix (41.38 and 42.35 g) in the respective years. Among single applied growth promoters highest thousand grain weight (40.44 and 41.34 g) were found with aminos followed by planofix (39.61 and 40.76 g), biozyme and tracel during both the years of investigation (Table-2).

Highest grain yield (12.65 and 13.45 q/ ha.) were obtained from combined application of aminos+ tracel followed by aminos+ biozyme (12.43 and 13.12 q/ ha) and biozyme+ tracel (12.32 and 12.89 q/ ha), aminos + planofix (11.98 and 12.45 q/ha). Among single applied growth promoters highest yield (11.52 and 11.85 q/ ha) were found from aminos and followed by biozyme, tracel and planofix (Table-2). Subbain *et. al.* (1989) also reported that planofix (NAA) two foliar sprays 20 and 40 ppm to black gram at flower initiation stage on black gram increased yield 10-15 % over control. Baghel and Yadava (1994) reported seed yield of black gram were highest with application of 30 ppm planofix (NAA). Singh and Chandel (2005) reported on pooled basis, highest grain, straw and biological yields and protein content were recorded under Biozyme crop' spray 400 ml/ha + half of recommended NPK.

It was concluded that rhizobium inoculation increased yield compared to control treatment. Also concluded that all growth promoters increased yield parameters when applied singly are different combinations.

## References

S.C. Sarmah and S.C. Day (1986) Response of soybean to foliar application of some growth regulators. Soybean Genetics News Letter, **13:** 71-74.

P. Lakshmamma; I.V.S.Rao (1996) Influence of shading and NAA on yield and yield component in Black gram. Annals of Agricultural Research; **17** (30) 320-321.

P. Subbian; N. Ashokaraja; S.P. Palaniappan (1989) Response of black gram to growth regulators. Journal of Maharashtra Agricultural University, **14**(3) 372-73.

S.P. Palaniappan; P. Balasubramaniyam (1989) Maximum yield research Tamil Nadu. Proceeding of Symposium on maximum yield 16-18 Nov. 1988, New Delhi, 43-56.

M.S. Baghel; H.S Yadava (1994) Response of black gram to dates of sowing and growth regulators on seed yield and attributes. Bhartiya Krishi AnusandhanPatrika, **9**(1)38-42.

V.P.N. Singh and S.K. Uttam (1994) Effect of plant growth regulators and fertility levels on yield of wheat. Bhartiya Krishi Anusandhan Patrica, **9**(1) 56-62.

P.K. Singh and A.S.Chandel (2005) Effect of biozyme on yield and quality of wheat (*Triticum aestivum*). Indian Journal of Agronomy (India). 50(1) p. 58-60.

*J. Farming Systems Research & Development* **18** (2) : 247-254 (2012)

# PRODUCTIVITY AND N USE EFFICIENCY OF WHEAT UNDER DIFFERENT RICE RESIDUE, TILLAGE AND NITROGEN MANAGEMENT IN RICE-WHEAT CROPPING SYSTEM

ARVIND TOMAR[1], SUDHIR KUMAR[1], M.L. JAT[2], VIPIN KUMAR[3] AND SUDHIR KUMAR[3]

[1]*Janta Vedic (P.G.) College, Baraut, Baghpat (U.P.)*
[2]*CIMMYT- India, NASC Complex, Pusa, New Delhi - 110012*
[3]*Project Directorate for Farming Systems Research, Modipuram Meerut-250 110*

## SUMMARY

A field experiment on sandy loam was conducted during rabi 2005-06 and 2006-07 at the Research Farm of the Janta Vedic (P.G.) College, Baraut, District–Baghpat (U.P.) to study the productivity and nitrogen use efficiency and economics of wheat (Triticum aestivum L.) under different rice residue and zero and conventional tillage practices in main plots and four nitrogen levels (0, 50 kg, 100 kg and 150 kg N/ha) in sub plots replicated crops. Residue retained with zero tillage recorded yield attributes as well as grain and straw yield significantly higher over the other residue and tillage management. Residue retained with zero tillage also recorded significantly higher uptake of nitrogen by wheat plants as compared to residue incorporated with conventional tillage. Nitrogen use efficiency was positively higher in residue burned with zero tillage than residue incorporated under conventional tillage. The increasing rate of nitrogen at higher dose (150 kg N/ha and 100 kg N/ha) produced significantly higher number of grains/spike, more spike length and more test weight of grains as compared to 50 kg N/ha application. The higher rates of nitrogen application showed significantly better grain and straw yield as compared to middle and lower level of nitrogen application. The amount of nitrogen removal was significantly influenced by various levels of nitrogen application. Maximum uptake of nitrogen was observed in 150 kg N/ha which was significantly higher than 100 and 50 kg N/ha. The N use efficiency was higher with 100 kg N/ha. It might be because of operation of low diminishing return. Nitrogen use efficiency did not increased due to excessive nitrogen, which did not show further any response. Net return was found to be maximum (Rs. 40805 and 38848 /ha) under residue retained with zero tillage under 150 kg N/ha and maximum benefit: cost ratio of 2.29 and 2.10 during 2005-06 and 2006-07, was obtained from residue retained with zero tillage under 100 kg N/ha. A high grain yield and reduced cost of cultivation per hectare and greater water saving were noted in zero tilled wheat sowings compared with conventional practices.

**Key words :** Residue retained, zero tillage, residue burning, conventional tillage, grain yield, N use efficiency

Rice-wheat is the most commonly employed cropping system on around 14 million hectares of land extending across the Indo-Gangetic Plain (IGP). Wheat (*Triticum aestivum* L.) is a predominant *rabi* crop of North- Western Plain Zone and Central Zone of India which occupy about 28.52 million ha area. Wheat production technology has systematically changed with the adoption of high yielding dwarf varieties. The tillage, residue management and nitrogen application were markedly different for tall varieties from the presently grown dwarf ones. The major challenge facing the IGP's rice-wheat cropping system is to sustain long-term productivity. This system has a pivotal role in the food security and livelihoods of millions of farmers and workers of populous countries such as India, particularly in central Uttar Pradesh. The system's productivity and economic gains have been consistently decreasing, mainly because of the delayed sowing of wheat after the rice harvest and the fatigued soil condition. The adoption of resource conservation technologies, such as zero tilled wheat sowing, is considered essential to maintain the productivity of the rice-wheat cropping system (Singh *et al.*, 2010). Zero tillage with previous crop residue retention results in water saving. It also saves the soil from formation of large cracks and also avoids sub-soil compaction (Jat *et al.*, 2008). The zero-tillage technology is widely maintained as an integrated approach that can tackle the problem of wheat yield stagnation in the rice-wheat zone by timely sowing, reducing cost of production, improved input use efficiency and saving irrigation water (15-20%), build-up in SOC due to reduced burning of crop residues (Gupta *et al.* 2010 and Saharawat *et al.* 2010). Conventional tillage practices followed by farmers for raising wheat after rice, involve higher use of machines, labour and energy as it is done to change the low permeability soil structure created for rice to well aerated structure for wheat.

Rice residue management is important in rice-wheat cropping system. Several management options available to farmers for the management of rice residues are burning incorporation, surface retention and mulching and baling and removing the straw. Crop residues may be incorporated partially or completely into the soil depending upon methods of cultivation (Dormaar and Carefoot, 1996). Residue retain on the soil surface, serve as physical barrier to emergence of weeds, moderate the soil temperature, conserve soil moisture, add organic matter and improve the nutrient-water interactions. In addition, decomposing residues kept on soil surface possibly release allele-chemicals which further strengthen the inhibitory effects on wedd seed germination and early growth (Gupta et al., 2010).

## Materials and Methods

An investigation was conducted on sandy loam (67.50 % coarse sand, 16.80% silt and 13.70% clay) soils and a pH of 7.1 at at the Research Farm of the Janta Vedic (P.G.) College, Baraut, District–Baghpat (U.P.) at winter rabi 2005-06 and 2006-07. The soils was low in available N (161.57 kg N/ha) and medium in available P (18.1 kg/ha) and rich in K (216.45 kg/ha). The experimental layout accommodated 24 treatments combinations imposed to wheat crop, comprising 6 tillage methods (Residue burned - Conventional tillage, Residue removed - Conventional tillage, Residue incorporated - Conventional tillage, Residue burned – Zero tillage, Residue removed – Zero tillage and Residue retained – Zero tillage) in main plots and four nitrogen levels (0, 50 kg, 100 kg and 150 kg N/ha) in sub plots, replicated trice. The wheat variety 'PBW 343' was sown at a distance of 20 cm between lines under all the conventional and zero tillage with a seed rate of 100 kg/ha. Rice variety Pusa-1121 was transplanted on 5 July 2005 and 26 June 2006 for residue treatments. Conventional plots were prepared for sowing wheat after giving pre sowing irrigation and sowing was accomplished on Dec, 8 and 5 of 2005-06 and 2006-07, respectively, whereas, sowing in zero tilled plots was taken directly after harvesting Rice variety Pusa-1121 on same dates on residual moisture. Residue of rice was removed and burned after harvesting of rice according by treatments. Full dose of P and K was applied basel under all tillage methods, whereas, N (0, 50, 100 and 150 kg N/ha) was applied in splits as per the treatment at basal, crown root initiation (CRI) and earing stage of the wheat crop. Data on various yield attributes, grain and straw yields of wheat and economic return were calculated as per the standard procedures.

**Yield performance**

Data recorded on yield attributes, viz. spike length, number of grains/spike, 1000 seed weight as well as grain and straw yield of wheat crop (Table 1) exhibited significant differences under different tillage and residue management. The longest spike length under residue retained with zero tillage, which was significantly superior over the other residue and tillage management. Significantly more number of grains/spike and higher test weight were recorded under residue retained with zero tillage as compared to residue incorporated with conventional tillage. Perhaps this might have been possible due to the fact that residue retained under zero tillage eliminated the crop weed and adds more nutrients which benefited the plants in utilizing higher amount of inputs. Similar results were reported by Singh *et al.* (2007), Zamir *et al.* (2010) and Meena (2010).

Different residue and tillage management on grain and straw yield was quite appreciable. Highest yields of grain and straw were recorded under residue retained with zero tillage followed by residue burned with zero tillage over residue incorporated with conventional tillage. The increase in grains and straw yield may be attributed mainly to higher number of effective tillers and the production of grains per spike, which was highly favored under residue retained with zero tillage. These results confirm the findings of Sharma and Mittra (1992), Singh *et al.* (2007), Zamir *et al.* (2010).

The application nitrogen at higher dose (150 kg N/ha and 100 kg N/ha) produced significantly higher number of grains/spike, more spike length and more test weight of grains as compared to 50 kg N/ha application. The increase in yield attributing characters under 150 and 100 kg N/ha may be due to ever availability of nutrients even during later reproductive and grain filling stage, which resulted in increased rate of photosynthesis, which has direct bearing on yield components and yield. Increase in the earhead length may be due to better assimilation of carbohydrates. This find support the observations of Chanda and Gunri (2004), Kumar *et al.* (2007) and Deshmukh *et al.* (2007).

The higher rates of nitrogen application showed significantly better grain and straw yield as compared to middle and lower level of nitrogen application. The response to nitrogen application was almost identical in both the years of experimentation. Application of nitrogen 100 kg N/ha registered significantly higher grain and straw yield over 50 kg N/ha and no nitrogen. This could be ascribed to more number of productive tillers and higher number of grains/spike, the production of which was highly favored under higher supply of nitrogen. These results are in accordance to the finding of Maqsood *et al.* (2002), Jakhar *et al.* (2005), Allam *et al.* (2007).

**Nitrogen uptake (kg/ha)**

The uptake of nitrogen in wheat crop was significantly influenced by residue and tillage management (Table 2). Residue retained with zero tillage

**Table 1 : Yield attributes and yields as influenced by rice residue, tillage and nitrogen management**

| Residue and tillage management | Spike length (cm) | | No of grains/spike | | 1000-grain weight (g) | | Grain yield (q/ha) | | Straw yield (q/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2005-06 | 2006-07 | 2005-06 | 2006-07 | 2005-06‘ | 2006-07 | 2005-06 | 2006-07 | 2005-06 | 2006-07 |
| Residue burned-Con. tillage | 9.39 | 9.18 | 43.61 | 42.94 | 39.21 | 39.14 | 39.23 | 38.81 | 47.08 | 47.20 |
| Residue removed-Con. tillage | 9.59 | 9.42 | 45.86 | 45.04 | 39.49 | 39.30 | 40.60 | 39.85 | 51.72 | 50.85 |
| Residue incorporated-Con. tillage | 8.81 | 8.90 | 42.35 | 41.25 | 38.09 | 37.56 | 36.99 | 36.44 | 45.08 | 44.17 |
| Residue burned-Zero tillage | 10.05 | 9.93 | 47.59 | 46.66 | 41.48 | 40.98 | 42.70 | 42.02 | 53.67 | 52.72 |
| Residue removed-Zero tillage | 9.82 | 9.80 | 46.69 | 46.31 | 40.38 | 40.10 | 42.62 | 41.74 | 52.29 | 51.49 |
| Residue retained-Zero tillage | 10.36 | 10.21 | 49.22 | 48.34 | 41.94 | 41.34 | 44.43 | 43.54 | 58.00 | 56.82 |
| SEm± | 0.11 | 0.06 | 0.56 | 0.39 | 0.40 | 0.45 | 0.38 | 0.44 | 0.62 | 0.39 |
| CD at 5% | 0.33 | 0.18 | 1.76 | 1.23 | 1.26 | 1.42 | 1.20 | 1.37 | 1.94 | 1.24 |
| **Nitrogen levels (kg/ha)** | | | | | | | | | | |
| 0 kg/ha | 9.02 | 8.84 | 39.73 | 38.84 | 37.81 | 37.60 | 28.65 | 28.17 | 39.21 | 38.20 |
| 50 kg/ha | 9.57 | 9.57 | 44.88 | 44.13 | 38.77 | 38.47 | 36.88 | 36.21 | 49.14 | 48.37 |
| 100 kg/ha | 9.81 | 9.73 | 47.83 | 47.16 | 40.70 | 40.08 | 47.98 | 47.02 | 56.85 | 56.42 |
| 150 kg/ha | 10.27 | 10.14 | 49.43 | 48.56 | 43.10 | 42.80 | 50.87 | 50.19 | 60.03 | 59.18 |
| SEm± | 0.11 | 0.14 | 0.51 | 0.59 | 0.47 | 0.49 | 0.41 | 0.49 | 0.58 | 0.69 |
| CD at 5% | 0.32 | 0.41 | 1.46 | 1.70 | 1.35 | 1.42 | 1.18 | 1.41 | 1.67 | 2.00 |

**Table 2. Effect of rice residue, tillage and nitrogen management on nitrogen uptake, N use efficiency and economics of wheat**

| Residue and tillage management | Total N uptake (kg/ha) | | Nitrogen use efficiency (kg grain/kg N) | | Net return | | B:C ratio | |
|---|---|---|---|---|---|---|---|---|
| | 2005-06 | 2006-07 | 2005-06 | 2006-07 | 2005-06 | 2006-07 | 2005-06 | 2006-07 |
| Residue burned-Con. tillage | 80.85 | 80.30 | 12.91 | 12.82 | 24442 | 23119 | 1.37 | 1.23 |
| Residue removed-Con. tillage | 85.11 | 85.12 | 12.40 | 11.62 | 25622 | 23828 | 1.39 | 1.22 |
| Residue incorporated-Con. tillage | 76.40 | 73.22 | 12.44 | 12.08 | 22000 | 20459 | 1.22 | 1.08 |
| Residue burned-Zero tillage | 92.17 | 91.51 | 12.57 | 12.15 | 29938 | 28419 | 1.84 | 1.67 |
| Residue removed-Zero tillage | 90.31 | 86.99 | 12.60 | 12.40 | 29121 | 27369 | 1.73 | 1.54 |
| Residue retained-Zero tillage | 98.56 | 95.13 | 13.01 | 13.33 | 31865 | 30126 | 1.94 | 1.75 |
| SEm± | 1.08 | 0.89 | 0.15 | 0.20 | 274 | 253 | 0.023 | 0.15 |
| CD at 5% | 3.39 | 2.82 | 0.41 | 0.62 | 862 | 797 | 0.074 | 0.046 |
| **Nitrogen levels (kg/ha)** | | | | | | | | |
| 0 kg/ha | 56.27 | 55.24 | - | - | 16367 | 15009 | 1.12 | 0.98 |
| 50 kg/ha | 77.30 | 75.25 | 16.46 | 16.07 | 23693 | 22132 | 1.47 | 1.31 |
| 100 kg/ha | 100.85 | 98.67 | 19.33 | 18.85 | 33328 | 31469 | 1.87 | 1.68 |
| 150 kg/ha | 114.52 | 112.35 | 14.82 | 14.68 | 35272 | 33604 | 1.86 | 1.69 |
| SEm± | 1.01 | 1.25 | 0.23 | 0.15 | 293 | 362 | 0.024 | 0.017 |
| CD at 5% | 2.89 | 3.59 | 0.66 | 0.44 | 841 | 1039 | 0.068 | 0.050 |

recorded significantly higher uptake of nitrogen by wheat plants as compared to residue incorporated with conventional tillage. Higher nitrogen uptake was also recorded under residue burned with zero tillage, which was significantly superior over the other treatments of residue and tillage management. The trend was found similar in both the years of study. Increase in uptake under zero tillage may be due to an increased grain and straw yield of wheat and increasing nitrogen content. The similar result was reported by Kumar *et al.* (2004).

The amount of nitrogen removal was significantly influenced by various levels of nitrogen application. Maximum uptake of nitrogen was observed in 150 kg N/ha which was significantly higher than 100 and 50 kg N/ha. This is obvious because the biomass production increased due to these nitrogen rates over no nitrogen. Nitrogen uptake increased with its successive level of fertilizer dose. The higher nitrogen uptake by wheat crop at higher rate of nitrogen was also reported by Jakhar *et al.* (2005), Bhat *et al.* (2006), Pandey *et al.* (2008).

**N use efficiency**

Nitrogen use efficiency was positively influenced by rice residue and tillage management. Residue burned with zero tillage led to higher efficiency than residue incorporated under conventional tillage. Application of nitrogen increased N use efficiency up to 100 kg N/ha. The N use efficiency was higher with 100 kg N/ha. It might be because of operation of low diminishing return. Nitrogen use efficiency did not increase due to excessive nitrogen, which did not show further any response. Pannu *et al.* (2010) also reported similar findings.

**EconomicS**

In the present study residue incorporation with conventional tillage under no nitrogen resulted in lower total return as compared to zero tillage. Net return was found to be maximum (Rs. 40805 and 38848 /ha) under residue retained with zero tillage under 150 kg N/ha followed by residue burned with zero tillage under 150 kg N/ha (Table 2). The maximum benefit: cost ratio of 2.29 and 2.10 during 2005-06 and 2006-07, was obtained from residue retained with zero tillage under 100 kg N/ha. Singh *et al.* (2010) showed that the zero tillage method of wheat cultivation is the most economical and attractive option for the farming community of central Uttar Pradesh. A high grain yield and reduced cost of cultivation per hectare and greater water saving were noted in zero tilled wheat sowings compared with conventional practices.

REFERENCES

Alam, M.S., Nesa, M.N., Khan, S.K., Hossain, M.B. and Hoque, A. (2007). Varietal differences on yield and yield contributing characters of wheat under different levels of nitrogen and planting methods. *J. Applied Sci. Res.,* : 1388-1392.

Bhat, M.A., Mahal, S.S., Kumar, K. and Mahey, R.K. (2006). Effect of nitrogen levels, irrigation regimes and weed control methods on competitiveness of bed planted Durum wheat (*Triticum durum* Desf.) with *Phalaris minor* Retz. *Indian J. Weed Sci.,* **38**(3/4): 233-236.

Chanda, K. and Gunri, S.K. (2004). Response of hybrid and high yielding wheat genotypes (*Triticum aestivum* L.) to nitrogen levels under terai zone of West Bengal. *Crop Res. Hisar,* **28**(1/3): 34-38.

Deshmukh, P.H., Andhale, R.P., Sinare, B.T. and Shinde, S.H. (2007). Effect of nitrogen levels and seed rates on growth and yield of wheat under Furrow Irrigated Reduced-till Bed planting system. *Annals Plant Physiol.,* **21**(1): 67-70.

Dormaar, J.F. and Carefoot, J.M. (1996). Implications of crop residue management and conservation tillage on soil organic matter. *Can. J. Plant Sci.,* **76**: 627-634.

Jakhar, P., Singh, J. and Nanwal, R.K. (2005). Nutrient content and uptake in wheat (*Triticum aestivum* L.) as influenced by planting methods, biofertilizers and nitrogen levels. *Haryana J. Agron.,* **21**(1): 75-77.

Jat, M.L., Gathala, M.K., Singh, K.K., Ladha, J.K., Gupta, R.K., Singh, S., Sharma, S.K., Saharawat, Y.S. and Tetarwal, J.P. (2008). Experiences with permanent beds in the rice-wheat systems of the western Indo-Gangetic Plain. *ACIAR Proc. Series,* **127**: 98-107.

Kumar, S., Pandey, D.S. and Rana, N.S. (2004). Effect of tillage, rice residue and nitrogen-management practice on yield of wheat (*Triticum aestivum*) and chemical properties of soil under rice (*Oryza sativa*) wheat system. *Indian J. Agron.,* **49**(4): 223-225.

Kumar, S., Singh, K. and Jatav, A.L. (2007). Effect of nitrogen levels on growth and yield of recently released wheat variety Malviya 468 under late sown condition. *Prog. Agric.,* **7**(1/2): 25-27.

Kumar, V., Singh, S., Yadav, A., Malik, R.K. and Hobbs, P.R. (2002). Studies on the effect of zero tillage in wheat on physio-chemical properties of soil in comparison to conventional tillage. *In Proc.* March, 4-6, CCS, Haryana Agric., Hisar, pp. 178-182.

Maqsood, M., Aslam, A., Saeed, Z., and Ahmad, M., S (2002). Effect of irrigation and nitrogen levels on grain yield and quality of wheat (*Triticum aestivum*). *Int. J. Agric. Biol.,* **4**(1): 164-165.

Noorka, I.R., Afzal, M., Ahmad, T., Ullah, S. and Bashir, S. (2009). Validity of zero tillage system for energy conservation and insurance of satisfactory growth and yield in wheat. *African Crop Sci. Conf. Proc.,* **9.** pp. 23 – 26

Pal, S.S and Jat, ML. (2004). Enhanced decomposition of rice straw and its effect on soil health and crop yields in rice-wheat cropping system in an ustochrept of Indo-Gangetic Plain. *Indian J Agric. Sci.,* **74** (8): 409-414.

Pal, S.S., Jat M.L., Sharma S.K. and Yadav R.L. (2002). Managing crop residues in rice-wheat system. *Technical Bulletin,* PDCSR. Modipuram, India pp. 40,

Pandey, I. B., Paswan, S., Sinha, N. K. and Pandey, R. K. (2008). Response of late-sown wheat (*Triticum aestivum*) varieties to nitrogen levels. *Indian J. Agric. Sci.*. **78**: 6, 537-539.

Pannu, A.K. and R. K. Buttar, G. S. (2010). Impact of nitrogen application on the performance of wheat (*Triticum aestivum*) and nitrogen use efficiency under different dates of sowing. Indian J. Agron.. **55**: 1, 40-45.

Sharma, A.R. and Mittra, B.N. (1992). Integrated nitrogen management in rice (*Oryza sativa*) wheat (*Triticum aestivum* ) cropping system. *Indian J. Garic. Sci.* **62**:70-72.

Singh, I., Sangwan, N., Singh, H., Rinwa, R.S., Singh, S. and Kumar, V. (2007). Effect of different tillage and rice residue management practices on wheat crop in rice-wheat cropping system. *Haryana J. Agron.*, **23**(1/2): 6-9.

Singh, P., Singh, P., Singh, K. N., Singh, R., Aga, F. A., Bahar, F. and Raja, W. (2010). Evaluation of wheat (*Triticum aestivum*) genotypes for productivity and economics under graded levels of nitrogen in temperate Kashmir. *Indian J. Agric. Sci.* **80**: 5, 380-384.

Singh, Y., Gupta, R. K., Singh, G. Singh, J., Sidhu, H. S. and Singh, B. (2009). Nitrogen and residue management effects on agronomic productivity and nitrogen use efficiency in rice-wheat system in Indian Punjab. *Nut. Cyc. Agroeco.* **84** (2 ): 141-154.

Zamir, M. S. I., Ahmad, A.U.H. and Javeed. H. M. R. (2010). Comparative performance of various wheat (*Triticum aestivum* L.) cultivars to different tillage practices under tropical conditions. *African J. Agric Res.* **5**(14), pp. 1799-1803.

*J. Farming Systems Research & Development* **18** (2) : 255-262 (2012)

# HIGHER SUGAR RECOVERY THROUGH SELECTION OF PLANTING TIME AND VARIETY IN SUGARCANE (*SACCHARUM OFFICINARUM*)

B.L. Manjunath

*ICAR Research Complex for Goa*
*Old Goa-403 402, GOA*

## Abstract

Field experiments were conducted for three years during 2006-2009, at ICAR Research Complex for Goa, Goa to identify a high yielding variety of sugarcane (*Saccharum officinarum L.*) and optimum time of planting / harvesting for enhanced recovery of sugar. The experiment was conducted in a Factorial RBD with three replications, five sugarcane varieties and three planting / harvesting dates.

The cane yield was significantly higher with early planting and decreased with delay in planting time (from 113.3 t / ha in February planting to 89.3 t/ha with April planting) clearly suggesting its advantage of to harness higher yield potential of the crop. February planting also recorded higher cane sugar yield (8.88 t/ha) significantly differing from March and April plantings / harvestings and among the varieties, Co-8014 recorded higher cane sugar yield (8.92 t/ha). However, the brix and Pol content of cane juice was highest (22.6 and 20.1 %, respectively) with variety SNK-707 under April planting / harvesting. The variety also recorded highest sugar recovery (11.4 %). Considering both cane yield and recovery, maximum cane sugar yield of 11.22 t/ha could be obtained in variety Co-8014 with early (February) planting in the region.

**Key words:** cane sugar yield, early planting, sugar recovery, sugarcane yield, time of planting.

Sugarcane is a commercial crop in the West coast region of India with relatively poor yields and low recovery of sugar leading to lesser returns. Although the crop has a better potential, lack of a suitable high yielding variety with proper package is limiting the cane productivity in the region. Further, the sugar recovery is a problem owing to climatic situations prevailing in the region.

The sugar production depends mainly on cane yield and percent sugar recovery, hence this objective requires combined attention on cane yield and its sugar contents. Sucrose yields in sugarcane could be improved by increasing the efficiency of biomass production and /or by increasing the fraction of total biomass partitioned to stalk sucrose, or both. This could be achieved by optimally matching the physiology of genotypes to the driving environmental conditions (Singels *et al.,* 2005).

The crop requires fairly high temperature, low relative humidity, sunny weather with no rainfall in its germination and tillering stage, moderate temperature and high relative humidity and well distributed rainfall for fast growth and cool weather, moderate dry and sunny period for ripening. Early and continuous rain from May to July also influence the development of sugarcane growth, tillering, millable canes and thickness of canes. Further, this also has bearing on intercultural operations and fertilizer application in time (Narendra Singh *et al.*, 2008). Heavy rainfall and water–logging at the time of grand growth period delays the growth and development of sugarcane crop and thereby, the sugar accumulation will also be delayed. Further, heavy rainfall and water logging during sugar accumulation period in cane reduces the rate of dry matter production per plant. Re-growth in crop instead of sugar accumulation during the period may also be the possible reason for lower sugar recovery (Tiwari, 2005).

Sucrose accumulation begins in leaves and subsequently translocated into stalks. The ripening of cane occurs because stalk elongation is more sensitive to low temperature, restricted soil moisture and low nutrition. Consequently, the photosynthates which normally support the growth of plant and stalk elongation get redirected into sugar storage.

Relative temperature disparity is important factor which helps in cane maturity.

Dry conditions or low relative humidity 21-30 days prior to harvest has direct positive impact on sucrose accumulation in cane. The cool and dry climate during ripening period is conducive to higher accumulation of sucrose. For the process of physiological maturity to occur, where a seasonal reduction of air temperature does not occur, the crop must be subjected to a moderate drought, inducing sugar accumulation in plant tissues.

Sugarcane productivity can be improved by identifying a suitable variety with an improved package of practices using sound management techniques. The crop is normally planted during February in the region. Earlier and /or delayed planting might influence the cane productivity and sugar recovery owing to changing weather parameters during different period of year. Thus, there is a need for proper planting and harvesting schedule so as to overcome the losses in cane yield and sugar recovery.

Keeping these points in view, an experiment was planned and conducted to identify an elite genotype with optimum time for planting / harvesting of sugarcane so as to obtain higher cane yield with better sugar recovery in the region.

## Materials and Methods

Field investigations were carried out for three years in one plant and two ratoon crops during 2006 to 2009 at ICAR Research Complex for Goa, Goa. The study involved the selection of productive sugarcane genotype from among the resistant lines developed for white wooly aphid tolerance along with the earlier identified high yielding varieties and the ruling variety of the region. Further the study also included identifying an optimum time for planting /harvesting so as to obtain higher cane yield with better sugar recovery. The field trial was conducted under Factorial RBD with three planting times and five varieties in three replications (Table 2).

The soil of the experimental site was lateritic, slightly acidic in reaction, low in available N (197 kg/ha) and P (10.6 kg/ ha) and medium in available K (168 kg/ ha). Different varieties were planted during second week of each month from February to April as per the treatments schedule. Similarly, harvesting of both plant cane and the first ratoon were scheduled as per the treatments in different varieties. Recommended standard package of practices were followed for all the genotypes. All the growth and yield attributes were assessed periodically and quality parameters viz., Pol. Purity, brix and recovery were estimated during maturity using standard procedures. The commercial cane sugar was worked out based on the cane yield and recovery obtained in each of the variety. All the results were statistically analysed as per the standard procedure and treatments were compared at 5 per cent probability level.

## Results and Discussion

The monthly mean weather parameters recorded during the period of experimentation is presented in Table 1. It was observed that maximum diurnal variation ranging from 13.54°C to 15.02°C prevailed during December to February period in the West coast region. Incidentally, the humidity during the period is lowest with more bright sunshine hours. Relative temperature disparity at 50 per cent with dry spell is most suitable for crop maturity. As such, coinciding the early ripening phase of the crop with the period December to February is ideal for more sucrose accumulation in cane in the region. Kambar *et al* (2000) also inferred that long hours of sunshine, cool nights with clear skies are highly favourable for sugar accumulation.

### 1. Growth and yield parameters

Salient pooled mean results of investigations of plant cane and two ratoons are presented in Tables 2 to 4. The cane yield is known to be significantly and positively correlated with number of millable canes, cane height, cane girth and single cane weight. Further, maximum direct effect on cane yield depends on number of millable canes followed by single cane weight (Krishnakumar *et al.,* 2004). Sugarcane yield is the function of final

**Table 1 : Weather parameters recorded during the experimental period (Mean of 2006 to 2008)**

| Month | Temperature(°C) | | | Relative humidity (%) | | Mean sunshine hours/ day | Rainfall (mm) |
|---|---|---|---|---|---|---|---|
| | Mean maximum | Mean minimum | Diurnal variation | Morning | Afternoon | | |
| January | 34.13 | 19.11 | 15.02 | 77.9 | 34.4 | 9.60 | 0 |
| February | 34.29 | 19.48 | 14.81 | 85.0 | 40.5 | 9.93 | 1.4 |
| March | 34.31 | 22.43 | 11.88 | 89.1 | 49.7 | 8.87 | 42.5 |
| April | 34.74 | 24.72 | 10.02 | 86.1 | 56.0 | 9.17 | 9.9 |
| May | 34.90 | 25.55 | 9.35 | 84.3 | 57.0 | 8.43 | 121.2 |
| June | 30.82 | 23.92 | 6.90 | 93.5 | 80.7 | 2.57 | 856.0 |
| July | 29.79 | 23.83 | 5.96 | 91.7 | 81.3 | 2.03 | 565.8 |
| August | 29.18 | 23.43 | 5.75 | 94.5 | 82.4 | 2.57 | 829.2 |
| September | 29.86 | 23.30 | 6.56 | 94.8 | 78.8 | 4.00 | 672.5 |
| October | 32.91 | 23.34 | 9.57 | 89.4 | 62.8 | 6.50 | 103.4 |
| November | 34.31 | 21.63 | 12.68 | 80.9 | 46.5 | 8.10 | 10.9 |
| December | 33.98 | 20.44 | 13.54 | 74.0 | 37.1 | 8.70 | 0 |

stalk population density and cane weight. Cane weight, in turn depends on length and thickness of millable cane (Yadava and Sharma, 1978).

The pooled mean growth and yield parameters of sugarcane were significantly influenced by the time of planting. The millable canes were significantly higher with early planting and decreased with delay in planting from February to April (94,173/ha to 52,347/ha) clearly suggesting the advantage of early planting as a consequence of more tillering. Higher sprouting in the February started ratoons may be due to availability of

**Table 2. Pooled mean growth and yield parameters of sugarcane varieties as influenced by dates of planting (mean of 2006 to 2009)**

| Planting month/Variety | Millable canes (000'/ha) | Cane height (m) | Cane girth (cm) | Inter-nodal length (cm) |
|---|---|---|---|---|
| **February** | | | | |
| CO-86032 | 99.01 | 3.17 | 2.31 | 12.05 |
| SNK-632 | 82.96 | 3.24 | 2.79 | 11.89 |
| SNK-49 | 92.59 | 2.92 | 2.38 | 13.81 |
| SNK-707 | 98.15 | 2.84 | 2.37 | 11.52 |
| CO-8014 | 98.15 | 3.13 | 2.46 | 10.07 |
| Mean | 94.17 | 3.06 | 2.46 | 11.87 |
| **March** | | | | |
| CO-86032 | 85.56 | 3.12 | 2.39 | 12.33 |
| SNK-632 | 82.59 | 3.07 | 2.63 | 11.48 |
| SNK-49 | 52.84 | 2.95 | 2.39 | 13.54 |
| SNK-707 | 74.08 | 2.71 | 2.12 | 11.54 |
| CO-8014 | 77.41 | 2.87 | 2.36 | 10.71 |
| Mean | 74.50 | 2.94 | 2.38 | 11.92 |
| **April** | | | | |
| CO-86032 | 55.43 | 2.98 | 2.28 | 11.88 |
| SNK-632 | 57.66 | 3.10 | 2.74 | 11.63 |
| SNK-49 | 54.20 | 2.99 | 2.35 | 13.34 |
| SNK-707 | 43.21 | 2.61 | 2.11 | 11.32 |
| CO-8014 | 51.23 | 2.95 | 2.53 | 12.32 |
| Mean | 52.35 | 2.93 | 2.40 | 12.10 |
| C.D (P=0.05) Planting Time | 10.9 | 0.139 | 0.139 | 0.481 |
| Variety | NS | 0.179 | 0.107 | 0.620 |
| Planting time x Variety | NS | 0.311 | 0.185 | 1.075 |

more reducing sugars for respiration (Shrivastava *et al.,* 1984). The cane stature was also found higher with February planting and found to reduce from 3.06 m to 2.92 m with delayed planting in April. Although no definite trend was observed as regards cane girth (2.46 to 2.40 cm), the delay in planting was found to significantly enhance the inter-nodal length in all the varieties (11.9 to 12.1cm). In general, early planting in February was found to favour more number of inter-nodes in cane (27.3) as compared to late planting (26.3). Similarly, weight of the cane was also found to enhance with early planting

**Table 3. Pooled mean yield parameters and yield of sugarcane varieties as influenced by dates of planting/ harvesting (mean of plant cane and two ratoons)**

| Planting month/Variety | No. of internodes/ cane | Mean cane weight (kg) | Cane yield (t/ha) | Cane sugar yield(t/ha) |
|---|---|---|---|---|
| **February** | | | | |
| CO-86032 | 26.8 | 1.70 | 103.70 | 9.26 |
| SNK-632 | 27.9 | 2.08 | 115.90 | 8.01 |
| SNK-49 | 23.8 | 1.64 | 113.40 | 8.24 |
| SNK-707 | 25.3 | 1.39 | 98.70 | 7.70 |
| CO-8014 | 32.7 | 1.67 | 134.60 | 11.22 |
| Mean | 27.3 | 1.70 | 113.26 | 8.88 |
| **March** | | | | |
| CO-86032 | 27.2 | 1.59 | 106.00 | 8.43 |
| SNK-632 | 27.7 | 1.80 | 103.30 | 8.17 |
| SNK-49 | 22.8 | 1.36 | 74.85 | 7.20 |
| SNK-707 | 24.0 | 1.13 | 104.80 | 7.64 |
| CO-8014 | 30.0 | 1.47 | 94.95 | 8.16 |
| Mean | 26.3 | 1.47 | 96.78 | 7.92 |
| **April** | | | | |
| CO-86032 | 25.3 | 1.60 | 76.58 | 7.59 |
| SNK-632 | 27.5 | 2.05 | 115.52 | 8.35 |
| SNK-49 | 23.2 | 1.56 | 90.58 | 5.92 |
| SNK-707 | 24.1 | 1.27 | 75.96 | 9.64 |
| CO-8014 | 31.3 | 1.74 | 87.98 | 7.39 |
| Mean | 26.3 | 1.64 | 89.32 | 7.78 |
| C.D (P=0.05)Planting Time | 1.68 | 3.36 | 1.08 | 1.57 |
| Variety | 2.17 | 4.33 | 1.40 | 2.03 |
| Planting time x Variety | 3.76 | 7.50 | 2.42 | 3.52 |

**Table 4. Pooled mean quality parameters of sugarcane varieties as affected by time of planting/harvesting (mean of plant cane and two ratoons)**

| Planting month/ Variety | Brix (%) | Pol (%) | Purity (%) | Recovery (%) |
|---|---|---|---|---|
| **February** | | | | |
| CO-86032 | 21.2 | 16.6 | 87.4 | 8.91 |
| SNK-632 | 16.1 | 13.4 | 79.6 | 6.63 |
| SNK-49 | 18.6 | 14.4 | 86.6 | 7.35 |
| SNK-707 | 21.1 | 14.9 | 85.2 | 7.70 |
| CO-8014 | 19.8 | 16.0 | 85.5 | 8.45 |
| Mean | 19.4 | 15.0 | 84.9 | 7.81 |
| **March** | | | | |
| CO-86032 | 21.1 | 15.2 | 84.3 | 8.43 |
| SNK-632 | 19.4 | 14.9 | 84.1 | 7.47 |
| SNK-49 | 18.2 | 15.4 | 85.2 | 7.99 |
| SNK-707 | 22.1 | 14.6 | 79.6 | 8.24 |
| CO-8014 | 20.6 | 16.1 | 88.4 | 8.92 |
| Mean | 20.3 | 15.2 | 84.3 | 8.21 |
| **April** | | | | |
| CO-86032 | 21.2 | 17.8 | 88.9 | 9.51 |
| SNK-632 | 18.2 | 14.8 | 82.8 | 6.96 |
| SNK-49 | 18.2 | 13.1 | 82.7 | 6.09 |
| SNK-707 | 22.3 | 17.7 | 87.6 | 9.72 |
| CO-8014 | 20.1 | 15.9 | 85.5 | 8.58 |
| Mean | 20.0 | 15.9 | 85.5 | 8.17 |
| C.D (P=0.05) Planting Time | 1.57 | 1.68 | 3.36 | 1.08 |
| Variety | 2.03 | 2.17 | 4.33 | 1.40 |
| Planting time x Variety | 3.52 | 3.76 | 7.50 | 2.42 |

(1.70 kg/cane). Alexander and Mathew (2003) also observed that early planting (15$^{th}$ January) resulted in the higher cane length, millable cane count and cane yield.

Further, the pooled mean growth and yield parameters of sugarcane were found to be significantly affected due to varieties as well except for the cane number. Among the varieties, SNK-632 recorded significantly higher cane stature (3.13 m) and cane girth (2.72 cm) followed by Co-86032 (3.09 m and 2.33 cm, respectively). The ruling variety Co-8014 recorded significantly more number of internodes (31.2 /cane), although the inter-nodal length of the variety was significantly lower (10.3 cm). Further, the variety SNK-632 was significantly superior in individual cane weight (1.97 kg) (Table 2).

The interaction between varieties and planting dates was also significant for different growth and yield parameters of sugarcane studied except for the millable canes. The variety SNK-632 when planted during February recorded significantly higher cane height (3.24 m), cane girth (2.79cm) as well as cane weight (2.08 kg). Another variety SNK-49 recorded significantly longer inter-nodal length (13.81 cm) while the ruling variety Co-8014 recorded significantly more number of internodes (32.7/cane) under February planting.

**2. Cane yield and cane sugar yield**

The cane yield was significantly higher with early planting and decreased with delay in planting time (from 113.3 t /ha with February planting to 88.5 t/ha with April planting) clearly suggesting the advantage of early planting to harness higher yield potential of the crop. Among the varieties, significantly higher cane yield of 111 t/ha was recorded in variety SNK-632. Further, under February planting/harvesting, the ruling variety Co-8014 recorded the highest cane yield (134.6 t/ha).

The sugar yield has a positive correlation with the stalk yield, and the stalk yield has a positive correlation with number of stalks, one stalk weight, retention of one stalk weight and stalk length. Therefore as the number of stalks increases and one stalk weight is retained, the stalk yield increases. The cane sugar yield followed a similar trend as that of cane yield with February planting recording 8.88 t/ha, being significantly higher and differing from March and April plantings. Among the varieties, Co-8014 recorded higher cane sugar yield (8.92 t/ha). Further, the variety under February planting/harvesting, recorded the highest cane sugar yield (11.22 t/ha) as a consequence of higher cane yield coupled with moderate sugar recovery. The higher cane and sugar yield with February planting in different varieties was a consequence of higher cane length and individual cane weight. Rajibdas *et al*, (2007) also observed highly positive association of cane length, single cane weight and cane diameter with both cane and sugar yield.

**3. Quality parameters**

The brix and Pol content of cane juice was found to improve with delay in cane planting / harvesting from February to April while among the varieties evaluated, higher values were observed with the variety SNK-707. Highest brix content of 22.3 per cent was observed with the variety SNK-707 under April planting which also recorded higher Pol content (17.7 %). The purity of cane juice was found to improve with delay in planting especially with April planting and further, the recovery per cent was found to improve with delay in the planting upto March and constant thereafter. Chaturvedi and Dubey (2001) observed that each unit purity drop is responsible for direct loss of 0.11 per cent recoverable sugar. The purity drop can be a combined effect of dextran, amino acids and higher glucose component than fructose. Further, higher the dextran, higher will be the drop in recovery due to Pol reading inflation. The better recovery in March and April planted crop may be due to better solar radiation use efficiency during summer months. Singels *et al.*, (2005) also observed that sugarcane crop planted in April and May seem to have higher radiation use efficiencies than other periods thereby compensating for lower interception of radiation during other part of the year.

Sugarcane variety Co-86032 recorded significantly higher recovery (8.95 % over the planting dates) and was followed by Co-8014 (8.65 % recovery). Nevase et al., (2003) also observed that the sucrose content in Co-8014 was consistently superior to other varieties at all stages. Further, the highest recovery of 9.70 per cent was observed in variety SNK-707 when the crop was planted or harvested for ratoon during April. It was followed by variety Co-86032 which recorded a recovery of 9.51 per cent during April planting.

Thus, it may be concluded that early planting of sugarcane during February is beneficial to get higher yield potential over late plantings. Although, the sugar recovery per cent could be substantially enhanced by selecting varieties like SNK-707 with late plantings, still maximum cane sugar yield could be obtained in variety Co-8014 with February planting.

## REFERENCES

Alexander, D and Mathew T, 2003. Effect of planting dates, varieties and mineral nutrition on juice quality and cane productivity. *Co-operative Sugar*, **34**(10): 793-795.

Chaturvedi P.P. and Dubey, 2001. Study on loss of recoverable sugar as compared to calculated POL based recovery, *Bharatiya Sugar*, May 2001, 9-14.

Das Rajib, Ghoshal S.K., Ray Bikash Ranjan and Mazumdar, D. 2007. Study of correlation and path analysis in relation to cane and sugar yield of sugarcane, *Sugar Tech*, **9**(4) : 293-299.

Kambar, N.S., Matiwade, P.S., Yadahalli, K.B., Thippannawar, P.S. and Patil, S.B. 2000. Use of organics for high cane and sugar production - A review, *Bharatiya Sugar*, February 2000, 23-26.

Krishnakumar, Singh, P.K. and Singh, J.R.P., 2004. Genetic variability and character association in sub-tropical clones of sugarcane, *Indian Sugar*, **54** (3): 189-198.

Nevase, V.B., Thorat, S.T. and Patil, B.P. 2003. Effect of sugarcane genotypes and potassium levels on sucrose content in juice at different crop growth phases and cane yield, *Journal of Indian Society for Coastal Agricultural Research,* **21**(1): 9-13.

Singh Narendra, Singh, K.P and Bachloo, S. 2008. Reasons of low recovery trend in sugarcane during current season 2008-09 in North India, *Indian Sugar*, 59-63.

Tiwari T. N. 2005. Adverse effect of heavy rainfall and water–logging during growth period of sugarcane, *Indian Sugar*: 17-20.

Shrivastava, A.K. Kacker, N.K., and Singh, M., 1984. Partitioning of assimilates in sugarcane, *Indian Journal of Plant Physiology*, **27**: 97-103.

Singels, A., Donaldson, R.A. and Smith, M.A. 2005. Improving biomass production and partitioning in sugarcane : theory and practice, *Field Crops Research*, **92**(2/3) : 291-303.

Yadava, R.L. and Sharma, R.K., 1978. Correlation and regression studies between yield and its attributes in sugarcane varieties, *Indian Journal of Sugarcane Technology*, **1**:17-22.

*J. Farming Systems Research & Development* **18** (2) : 263-271 (2012)

# ATTITUDE OF FARMERS TOWARDS ZERO-TILLAGE IN WHEAT UNDER RICE- WHEAT CROPPING SYSTEM

B.K. SHARMA[1], G.C. SHARMA AND PREM SINGH

*Project Directorate for Farming Systems Research, Modipuram, Meerut-250 110 (U.P.)*

ABSTRACT

A study was carried out in Saharanpur, Muzaffarnagar and Bagpat districts of Western Uttar Pradesh during 2004-05, to study the attitude of farmers towards zero tillage in rice-wheat cropping system. The villages were selected where farmers were adopting zero-tillage in sowing of wheat after rice or where PDCSR and SBVPUA&T Modipuram laid out their experiments/demonstrations on zero-tillage in wheat after rice under RCT (NATP) project. The sampling design used was simple random sampling for the selection of the respondents and only those farmers adopting zero-tillage in wheat were selected. A total sample size was 66 comprising 2 marginal (less than 1 ha), 15 small (1 to 2 ha), 31 medium (2-5 ha) and 18 large (5 ha and above) holding were selected for the study purpose. Out of which 20 farmers were using only zero- tillage and 46 farmers were adopting zero-tillage as well conventional tillage to make the comparison. The information on different parameters viz., socio-economic status, attitude towards zero-tillage, farmers perception about zero-tillage, cost of cultivation, input use and yields were collected from sampled farmers through personnel interview using structured pre-tested questionnaires. The results revealed that the independent variables like knowledge and attitude of farmers was found to be positively and significantly associated with adoption of zero tillage technology. The results revealed that the 71.21 percent respondents were recordedhaving positive attitude including most favourable (12.12%) to favourable (59.09 %) towards zero tillage technology. The zero order correlation between the independent variables like education, adoption and knowledge of zero-tillage technology of the sample farmers was found to be significant at 5% level of significant. The preference to adopt zero tillage in the rice-wheat system was mainly due to less operational cost to the extent of 15 % mainly due to reduction in the cost of land preparation. The benefit cost ratio under the zero tillage practice was 1:1.60 compared to conventional method (1:1.39). In addition to saving money for land preparation, the farmers were also benefited by getting yield as they are getting through the conventional method. Further, it was observed that there were less or no lodging, less infestation of weed, less seed rate as well proper placement of fertilizer.

**Key words:** Rice-wheat system, Zero tillage, Attitude towards zero-tillage

## INTRODUCTION

In the Indo-gangetic Plains (IGP), rice and wheat have replaced the less remunerative coarse cereals and more risk-prone oilseed and pulse crops from the cropping system. In pre-green revolution era of 1960-61, these two crops contributed less than 55% of total food grains production in the country but their contribution has increased over the years with current contribution of over 79%. Although, average rice and wheat yields have increased over the years, evidence were accumulated during 1990's which suggested that the impressive rates of yield growth achieved earlier are no longer being sustained. Evidence were put forward to stagnation or even decline in yield frontier, some of them were attributed to imperfect adoption to local environments insufficient provision of nutrients and improper exploitation of water, infestation of pest and disease. To maintain the yield more inputs are needed. Diagnostic surveys of farmers' practices in rice wheat cropping systems clearly brought out late sowing of wheat as the first ranking problem affecting wheat yield. Evidence suggested that delayed wheat sowing after middle of November in trans IGP and late November in Middle IGP, had resulted into loss of wheat grain yield by about 1%/ha/day (Hobbs et al., 1997 and Singh, et.al. 2003). To address these problems the use of zero-tillage fertilizer seed drill was advocated for timely sowing of wheat after rice harvest. It has been practiced for over four decades in one form or another in the U.K. and many parts of the USA. In India too, this technique has been practiced in eastern U.P. and Bihar for sowing of pulses and mixed crops, in Imphal sowing of rapeseed-mustard Variety Pusambum yella particularly and in Nagaland foot hills sowing of linseed are common practice..

Rice-wheat cropping system is practiced in Indo-Gangetic plains (IGP) region of India in about 12 million ha area. The study carried out by Kumar, et al.(1998) revealed that growth in the total factor productivity of rice-wheat cropping system has either declined or stagnated. Besides, it caused damage to agro-eco system by multiplying the problems of insect-pests and diseases, declining soil fertility and infestation of weed flora. It has also been recognized that the output per unit of individual inputs, are of limited use as indicators of real productivity change. Further, the increasing input cost and non-remunerative prices of food grain produce has become the major concern of Scientists and Policy makers (Timsina and Connor, 2001). In this regard, reduced or zero tillage technologies at farmer fields has played a major role in sustaining the yield level, reducing the production costs, and also improving the soil health.

Farmers of the region are psychologically in favour of conventional tillage (CT) for almost all the crops. This philosophy has been passed on from one generation to the next. Most growers and more specifically the older ones still believe that "the more you till the more you eat". And it is obvious that if you grow in much, you can lead a comparatively more comfortable and prosperous life. A similarly, other local saying is that moneylender can refuse you any time but tillage won't disappoint you. These are often used to support age-old perceptions and to convince their children to opt more preparations before any crop is sown. This mind-set still holds so firmly that it looks like you are betraying the public when you even suggest such radical techniques like zero or no-tillage.

Zero tillage technology involves direct seeding of wheat after rice without tilling the field by using zero-tillage drill and maintains good soil structure by keeping the soil capillary and pore transportation system intact. This zero-tillage permits early sowing of wheat by7-10 days, saving of energy and reduction in the cost of cultivation. With the changing scenario of increasing cost of inputs, i.e. cost of fertilizers, diesel, non-availability of labour and over exploitation of underground water, the alternate tillage technologies other than conventional tillage in rice-wheat, a pre-dominant cropping system of Indo-Gangetic plain region needs to be evaluated at farmers' field. The adoption of new technology is measured through its technical efficiency. Therefore, an analysis at the farm level is desirable to get a clear understanding of impact of tillage technologies. The zero tillage uses direct seeding of wheat crop just after harvest of rice with the help of zero seed-drill without any preparatory tillage. The zero tillage ensures early advancement of wheat sowing, seed saving, conservation of irrigation water and reduction in cost of cultivation (Hobbs, 2001 and Pandey *et al.*, 2003)). It helps to conserve resources by enhancing profitability and sustainability, improves soils health and prevents health degradation .

In the present paper, an attempt has been made to study the attitude of farmers towards zero tillage and resource use efficiency. Also, the distributions of respondents towards its adoption and their socio-economic characteristics, such as, attitude, knowledge, proneness, adoption, education level and occupation etc., have been examined.

## Material and Methods

This study was conducted in Saharanpur, Muzaffarnagar and Bagpat district of Western Uttar Pradesh during 2004-05. It was carried out in villages where farmers were adopting zero-tillage in sowing of wheat after rice or where PDCSR and SBVPUA&T Modipuram laid out their experiments/demonstrations on zero-tillage in wheat after rice under RCT (NATP) project. The sampling design used was simple random sampling for the selection of the respondents and only those farmers adopting zero-tillage in wheat were selected. A total sample size was 66 comprising 2 marginal (less than 1 ha), 15 small (1 to 2 ha), 31 medium (2-5 ha) and 18 large (5 ha and above) holding farmers were selected. Out of which 20 farmers were using only zero-tillage and 46 farmers were selected those who were adopting zero-tillage as well as conventional tillage to make the comparison. The sampling frame of cultivators was prepared by complete enumeration for all the selected villages. The detail information of practicing zero-tillage and conventional tillage, knowledge about zero tillage technology, cost of cultivation, input use, yield, socioeconomic characteristics, attitude of farmers towards zero-tillage technologies etc. were collected from sampled farmers through personal interview using pre-tested interview schedule. The data were averaged to get the information on economics gains in field preparation in sowing of wheat. Besides, distribution of respondents according to land holding size, socio-economic status and their occupation, perception and constrain analysis while practicing zero tillage technology, were also computed and analyzed.

In order to identify the level of attitude towards adoption of zero-tillage technology, a summary rating scale as proposed by Likert (1932) was used and tested for reliability and validity of results. Standardized scale classified into 16 items (7 negative and 11 positive) was applied to know the attitude of farmers. The response was obtained on a five point attributes, viz ‘strongly agree’, ‘agree’, ‘undecided’, ‘disagree’, and ‘strongly disagree’ with weightage of 5,4,3,2 and 1 for positive statements and reverse for negative statements respectively. The total attitude score for each respondent was computed. Based on the score obtained, the respondents were categorized into three categories (least favourable, favourable and most favourable) taking mean and half standard deviation as measurement check. Similarly, knowledge was assessed through 10 point questions with possible alternates. Thereafter, level of knowledge was calculated which was categorized into three categories, viz. less knowledgeable, knowledgeable and most knowledgeable. Likewise, source of information pertaining to zero-tillage of wheat after rice were obtained on four points variants, i.e. most often, often, some times and never with corresponding weightage of 4,3,2 & 1 respectively. Based on respondents' total score of each source were ranked and ranged to the category of 0-5, 6-10 and >10 and proneness attributes were scored and categorized into three categories. Further, the adoption index (A.I.) of individual farmers was developed to identify the level of adoption of new technology, viz. low, medium and high adopters. Other variables such as age, education, occupation, source of information, proneness, experience in agriculture, social participation, material possession and holding size were measured with the help of instruments developed and some ready made instruments were used with some modification developed by different authors.

## Result and Discussion

Attitude score (Table-1) reveals that the most of the farmers were either strongly agreed or agreed by the profitability gained monetarily and saving in diesel consumption, and found to it high profitable technologies. It also gives water saving in Ist irrigation due to its adoption. Mostly farmers were convinced about increase in yield of wheat and were prone to its promotion. But the few of the farmers were disagreed about the increase in wheat yield and were prone to infer that it is a risky proposition in their state. However they could not support their statement with any reason. Hence, on the basis of the farmers' favorable attitude , it may be inferred that such programme helps in increasing their knowledge about the zero-tillage which enhances its greater adoption.

A perusal of data reveals that majority (51.51%) of the respondents practicing zero-tillage (ZT) were in the age group of 40-60 years, had middle and intermediate (77.27%) level of education and only 4.55 per cent were having graduate and above education, having agriculture (69.70%) as their main occupation and remaining 10.60 per cent and 19.70 per cent engaged in Agriculture + Service and Agriculture+ Business, respectively. As regards to the knowledge level, 21.21 per cent participants were well acquainted, while 69.7 per cent were having medium level and only 9.09 per cent had little knowledge about zero-tillage technology of wheat. Similar findings were also reported by Singh et.al. (2003) in their study conducted at Western Uttar Pradesh. The data revealed that 78.79 per cent respondents were well acquainted with the technology through various sources of media. The proneness of farmers was rated more than 4 in case of more than 90 per cent of farmers, medium (53.03%) to low (37.88%) level of experience in agriculture and possessed medium (53.03%) to high (25.76%) level of material possession. The farmers adoption level of zero tillage in wheat was medium as is evident from the fact that 42.42 per cent farmers fell into this category, 34.85 per cent into high and remaining 22.73 percent into low category.

The households of the selected villages practicing zero tillage were stratified into marginal (<1 ha), small (1-2 ha), medium (2-5 ha) and large (>5 ha). Out of sixty six sampled farmers (Table-2), only 3.03 per cent were marginal, 22.73 per cent small, 46.97 percent medium and 27.27 percent were large. Marginal and small farmers having very limited land did not want to take more risk even though more than 58 percent put their whole rice land into zero tillage of wheat. As regards to the medium and large categories of farmers, only 19.35 and 22.22 per cent farmers respectively

**Table 1 : Distribution of respondents (N=66) based on attitude score towards zero-tillage technology**

| S.No. | Statements | SA | Agree | Undecided | DA | SDA |
|---|---|---|---|---|---|---|
| 1. | ZT is a highly profitable technology | 51.52 | 31.82 | 10.61 | 3.03 | 3.03 |
| 2. | I would not advise any one to adopt ZT | 4.55 | 13.64 | 18.18 | 48.48 | 15.15 |
| 3. | ZT increase yield from wheat | 7.58 | 10.61 | 21.21 | 39.39 | 21.21 |
| 4. | I earned a lot of money from my self and my family due to adoption of ZT | 28.79 | 46.97 | 10.61 | 9.09 | 4.55 |
| 5. | Government is supply wasting money on popularizing ZT | 6.06 | 4.55 | 7.58 | 50.00 | 31.82 |
| 6. | ZT technology is a risky proposition | 10.61 | 12.12 | 6.06 | 46.97 | 24.24 |
| 7. | I would suggest that Government should strongly promote ZT | 43.94 | 37.88 | 4.55 | 10.61 | 3.03 |
| 8. | ZT will never be successful in our state. | 6.06 | 13.64 | 16.67 | 40.91 | 22.73 |
| 9 | I feel all the farmers should adopt ZT technology | 27.27 | 43.94 | 16.67 | 9.09 | 3.03 |
| 10. | ZT saves diesel | 42.42 | 48.48 | 4.55 | 3.03 | 1.52 |
| 11. | ZT saves money | 33.33 | 53.03 | 6.06 | 6.06 | 1.52 |
| 12. | ZT saves water in the first irrigation | 25.76 | 42.42 | 24.24 | 6.06 | 1.52 |
| 13. | ZT saves water in the subsequent irrigation | 7.58 | 10.61 | 25.76 | 31.82 | 24.24 |
| 14. | The crop turns yellow after first irrigation in CT | 16.67 | 54.55 | 13.64 | 10.61 | 4.55 |
| 15. | The crop does not turn yellow after first irrigation in ZT | 4.55 | 7.58 | 15.15 | 48.48 | 24.24 |
| 16. | ZT technology is very simple and does not require any special skill | 45.45 | 36.36 | 12.12 | 4.55 | 1.52 |

** SA= Strongly Agreed; A = Agreed ; DA= Disagreed ; SDA= Strongly Disagreed

put their total rice land into zero-tillage of wheat, remaining all categories of farmers put their rice land into zero-tillage and conventional tillage both. Altogether, only 30.30 per cent farmers put their whole rice land into zero-tillage, remaining 69.70 per cent converted part area into zero-tillage (56.48%) and part area under conventional cultivation (43.52%) of wheat (Table-3).

Study revealed that 71.21 percent respondents were recorded positive attitude including most favourable (12.12%) to favourable (59.09 %) towards

**Table 2 : Distribution of respondents adopting zero-tillage and conventional tillage of wheat**

| Categories of farmers | Wheat in zero tillage | | Wheat in Conventional tillage | |
|---|---|---|---|---|
| | Respondents | % | Respondents | % |
| Margianl | 2 | 3.03 | 1 | 2.17 |
| Small | 15 | 22.73 | 6 | 13.04 |
| Medium | 31 | 46.97 | 25 | 54.35 |
| Large | 18 | 27.27 | 14 | 30.44 |

**Table-3: Area of rice used under zero-tillage ZT) and conventional tillage (CT) of wheat**

| Area under rice (ha) | Area under ZT of wheat (ha) | Percentage | Area under CT of wheat (ha) | Percentage |
|---|---|---|---|---|
| 169.96 | 96.00 | 56.48 | 73.96 | 43.52 |

zero tillage technology. This findings is in conformity with results obtained by Sharma & Sharma (2006). The zero order correlation between education, adoption and knowledge of zero-tillage technology of the sample farmers was found to be significant at 5% level of significant (Table-4). Age, experience in agriculture

**Table 4 : Zero order correlation of coefficient of independent variables with attitude towards zero tillage technology.**

| Independent variables | r Values | t value |
|---|---|---|
| Age | -0.0297 | -0.69 |
| Caste | 0.2208 | 0.29 |
| Education | 0.1163 | 2.24** |
| Occupation | 0.1820 | 0.25 |
| Experience in Agri. | 0.0612 | -0.95 |
| Type of family | 0.0943 | 0.73 |
| Social participation | -0.0765 | 1.39 |
| Material possession | 0.0512 | 1.04 |
| Source of information | 0.1209 | 1.54 |
| Adoption | 0.2963 | 2.48** |
| Knowledge | 0.2815 | 7.75** |
| Land holding | 0.2896 | -0.65 |
| Proneness | 0.1123 | 1.25 |

** Significant at 5% level of significance.

and land holding of participants shows negative and non significance relationship with attitude towards zero-tillage technology. The favourable attitude towards zero-tillage of large proportion of farmers is mainly due to no land preparation cost and no significant difference in the zero tillage and conventional tillage wheat yield. This finding is in conformity with the results obtained by Singh et. al (2003) and Sharma and Sharma (2006).

As regards to the perception of the farmers of zero-tillage and conventional tillage technologies like seed rate, 84 per cent farmers opined that seed rate in conventional tillage is very high due to broadcasting and 76 farmers opined that in zero-tillage seed rate is comparatively low. Similarly, in case of water requirement, it is high in CT and medium to low in ZT (Table-5). As regards to weed infestation in CT is concerned; it is more as compared to ZT. The germination in CT is little late as compared to ZT, the physical appearance of the crop in CT at the time of germination is light green because of broadcasting application of fertilizer and in ZT dark green because of proper/deep placement of fertilizer. The 92 per cent farmers opined that in conventional tillage lodging is high to very high, but in zero-tillage 98 percent farmers practicing zero-tillage opined that lodging is low to nil.

A critical analysis of the data presented in table-6 indicated that there was clear saving of land preparation in cultivation of wheat under zero-tillage that comes about 15 per cent of the total cost. Other benefits like proper

**Table 5 : Perception of farmers towards zero-tillage in wheat**

| Particulars | Nature of impact | CT | Respondent % | ZT | Respondent % |
|---|---|---|---|---|---|
| Seed rate | Increased | High to | 84 | | |
| | Reduced | very high | | Medium | 76 |
| Water requirement | Increased | High | 82 | | |
| | Reduced | | | Medium to low | 52 |
| Weed infestation | Increased | More | 65 | | |
| | Reduced | | | Comparatively less | 48 |
| Germination | Normal | Little late | 48 | | |
| | Normal | | | Little early | 37 |
| Physical appearance | Normal | Light green at the time of germination | 45 | | |
| | Normal | | | Dark green at the time of germination | 65 |
| Lodging of crop | Increased | High to very high | 92 | | |
| | Decreased | | | Low to nil | 98 |

**Table 6 : Input use, cost and return per hectare of zero-tillage and conventional tillage of wheat**

| Items | Unit | Conventional tillage | | Zero tillage | | Percentage |
|---|---|---|---|---|---|---|
| | | Per ha | % of cost | Per ha | % of cost | change |
| Inputs cost (Seed, Fertilizers & chemicals) | Rs | 4904.00 | 21.34 | 4883.00 | 24.94 | 2.93 |
| Land preparation | Rs | 3527.00 | 15.35 | - | - | - |
| Sowing & irrigations | Rs. | 2389.00 | 10.39 | 2564 | 13.10 | 27.46 |
| Harvesting , Threshing & Miscellaneous | Rs. | 6153.00 | 26.79 | 6129.00 | 31.31 | 4.36 |
| Rental value | Rs | 6000.00 | 26.13 | 6000.00 | 30.65 | 0 |
| Cost of cultivation | Rs | 22972.00 | 100.00 | 19576.00 | 100.00 | -14.78 |
| Av.yield | q/ha | 41.70 | - | 40.81 | - | -2.13 |
| Gross return | Rs | 31913.00 | - | 31220.00 | - | -2.17 |
| Net return | Rs | 8941.00 | - | 11644.00 | - | 30.23 |
| B C ratio | | 1 : 1.39 | - | 1 : 1.60 | - | |

placement of fertilizer, saving irrigation water, no or very less lodging of crops, weed infestation were also comparatively low, saving of time by 7-10 days. As regards to the yield under zero-tillage is concerned, it was found to be 41.70 qt / ha, little higher as compared to conventional practice ( 40.81q./ha.). It indicates that there was no significant difference in the yield but there are other advantages in practicing zero-tillage technology. The finding corroborated the result obtained by Singh et al (2003). The BC ratio was found to be higher under wheat in case of zero-tillage cultivation (1:1.60), as compared to conventional method (1:1.39).

## CONCLUSION

It can be concluded that more than 71 percent of the sampled farmers had favourable and most favourable attitude towards zero-tillage technology. The correlation coefficient between education, adoption and knowledge of zero-tillage technology of the sample farmers were positively and significantly associated with the attitude of the farmers towards zero-tillage technology. In addition to saving money for land preparation, the farmers were also benefited for getting yield equivalent as they are getting through the conventional method. Besides, those were less or no lodging, less infestation of weed, less seed rate and proper placement of fertilizer. Therefore, the technology had their own benefits which can be popularized among the farmers.

## REFERENCES

Hobbs P.R., Giri GS. and Grace p. 1997. Reduced and zero-tillage options for the establishment of wheat after rice in south Asia. Paper Series 2. Rice – Wheat Consortium. CIMMYT, Mexico DF, 18.

Hobbs P.R. 2001. Tillage and crop establishment in South Asian rice-wheat systems: present practices and future options.(in) The Rice-

Wheat Cropping System of South Asia: Efficient Production Management . Kataki P K (Ed). The Haworth Press, New York.

Kumar,P., Joshi,P.K., Johansen,C. and Asokan, M. 1998. Sustainability of rice-wheat based cropping systems in India, Economics and Politicak Weekly, XXXIII, 152-158.

Likert,R. 1932. A technique for the measurement of ttitudes, Arch. Psychol. of Edwards, A . L. 1969. Techniques of attitude scale construction. Vakils, Feffer & Simon Pvt. Ltd. Bombay.

Pandey L.M., Pal s. and Mruthyunjaya 2003. Impact of zero tillage technology in the rice(*Oryza sativa*) –wheat (*Triticum aestivum*) system of foothills of Uttaranchal State, *India. Indian Journal Agril. Sci.* 73(8):432-437.

Sharma, G.C. and Sharma, B.K.(2006) Allocative efficiency of zero tillage technology in rice-wheat system of Haryana .*Journal Fmg.Sys.Res.& Dvp* 12(1&2): 93-100.

Singh,A.K.,Sharma,G.C.,Sharma,S., Kumar,S. and Singh,S.P.2003. Study on knowledge, attitude and constraints in adoption of zero tillage technology in wheat after rice. J. Fmg, Systems Res.& Dev. 9(2): 261-263.

Timsina J. and Connor, D.J. 2001. Productivity and management of rice-wheat cropping systems: issues and challenges. Field Crops Research 69: 93-132.

*J. Farming Systems Research & Development* **18** (2) : 272-277 (2012)

# KNOWLEDGE AND ADOPTION OF IMPROVED ANIMAL MANAGEMENT PRACTICES IN NORTHERN MAHARASHTRA

D.U. Mane, M.V. Dhumal, M.F. Siddiqui and S.A. Kochewad

*Department of Livestock Production and Management*
*College of Veterinary and Animal Sciences, Parbhani, Maharashtra -413517*

## Abstract

The investigation was carried out with dairy farmers of Jalgaon district of Maharashtra. The dairy farmers were interviewed with the structured interview schedule and information about knowledge level and adoption of management practices were collected. Age of dairy farmers, family size, and annual income was positive but non-significantly correlated with level of knowledge, education level, land holding, social participation and source of information of dairy farmers was positively and significantly correlated. Herd size of the farmer had very weak and non-significant correlation. Risk orientation attitude had negatively and non-significant correlation with level of knowledge of improved dairy cattle management practice. The correlation coefficient of socio-economic status with adoption of dairy animal managemental practices were Age, Education, Family size, Herd size, Land holding, Annual income, Social participation , Source of information and Risk orientation. The negative significant correlation of age with adoption of dairy farm animal practices may lead to conclusion that age advances it may lead to decrease the adoption. The positive non-significant correlation of family size indicate non-significant role of family size in the adoption process. The multiple regression analysis reveals that the share of social participation was major in overall variability of knowledge level and education plays important role in overall variability in level of adoption of improved practices.

**Key words**: Adoption, Improved Animal husbandry practices, Independent variables Knowledge,

## Introduction

Livestock plays an important role in providing house hold nutritional security, increased income, employment especially of women and in rural area. Livestock provide economic security and social status to the rural families. About 21 per cent of households owning milch animals are landless and some 30 per cent are marginal farmers with land holding of less than one hectare. Thus cattle and buffaloes are not just the source of income for the majority; they are in fact, the major investment of their livelihood. Majority of these animals are reared under sub-optimal conditions due to low economic status of livestock owners. Livestock sector is directly related to a more balanced development of rural economy and upliftment of poorer sections of the society.

Milk production in India is in the hand of small rural producer and 70 per cent of production scattered all over the country. The larger proportion of milk continues to be marketed by unorganized sector. The qualitative aspects relating to handling need to be given due importance, small milk producers need to be encouraged to come into the organised sector with support to use the latest technology available to produce

Present address: [1]Veterinary Officer, Sulepeth, Gulbarga, Karnataka, [2 & 3] Associate Professor, College of Veterinary and Animal Sciences, Parbhani, Maharashtra.

[4] Scientist, PDFSR, Modipuram, Meerut. (sanjiv_kochewad@yahoo.com)

product which are of high quality. Animal Husbandry sector provides large self employment opportunities as per. According to National Sample Survey Organizations (1999) estimate the Animal Husbandry sector has provided employment to 11 million in principal status, 8 million in subsidiary status, which is 5 per cent of the total working population of India (Mudgal, 2000).

## Materials and Methods

The present study was conducted on the 200 farmers of Jalgaon district of Maharashtra. Ten villages of Jalgaon district of Maharashtra in India were selected and from each village 20 respondents with the help of random sampling test were selected. Jalgaon district is located in the North West region of the state of Maharashtra. Jalgaon is located between 21°C North latitude and 75.45° East longitude. Jalgaon district receives an average rainfall of about 750 mm and the maximum temperature 34.9°C and minimum 19.9°C with an area of about 11765 Sq.km. The basic instrument used for the study was structured interview schedule. The data collected through personal interviews of the respondents, so as to get valid and complete responses. The tabulated data was subjected to statistical analysis. Ex-post facto research design was used for the present study. Kerlinger (1964) stated that ex-post facto research design is worthy to apply when the independent variable has already acted upon.

## Results and Discussion

Correlation of personal and socio-economic characteristic of dairy farmers with level of knowledge and adoption.

It was found that age of dairy farmers was positive but non-significantly correlated with level of knowledge of dairy animal management practices (Table.1). These findings were in agreement with Chang and Chand (1996). Education level of dairy farmers was significant and positively significantly with level of knowledge about management practice. Education is directly and proportionately correlated with knowledge and education must have been working as a driving force in increasing the knowledge. The similar findings were reported by Kadian and Ram Kumar (1999) .Family size of farmers and level of knowledge were positive and non-significantly correlated .Herd size of the farmer had very weak and non-significant correlation with level of knowledge of management of dairy animal practices. Which indicate little relationship with herd size and knowledge. Land holding of dairy farmer has highly significant and positive correlation. The increased land holding will increase income, which in turn lead to increased social participation and gain in knowledge. These observations are in

**Table 1 : Correlation coefficient of different Independent variable with knowledge of dairy farmers**

| Independent variable | Correlation Coefficient |
|---|---|
| Age | 0.070 NS |
| Education | 0.148* |
| Family Size | 0.091 NS |
| Herd Size | -0.009 NS |
| Land Holding | 0.180 ** |
| Annual Income | 0.186** |
| Social participation | 0.285** |
| Source of Information | 0.161* |
| Risk Orientation | - 0.029 NS |

**P<0.01 * P<0.05 N S = Non Significant

agreement with the findings of Narwale (1991) and Kadian and Ramkumar (1999).There were positive but non-significant correlation. Social participation of dairy farmer had highly significant and positive correlation. Panchbhai *et. al* (2009) reported similar findings. It was observed that the source of information was positive and significantly correlated. Risk orientation attitude had negatively and non-significant correlation

There was negative and significant correlation of age with adoption (Table.2.) of dairy farm animal practices which leads to the conclusion that age advances may lead to decrease in the adoption. Deshmukh (1996) also reported similar findings. Positive and significant to highly significant correlation of education with adoption was observed which reveals that increase in education may lead to increase in adoption of improved animal husbandry practices. Musaba (2010) also reported similar finding. There was positive and non-significant correlation of adoption with family size, which indicates the non-significant role of family size in the adoption process. Gautam *et.al* (2007) reported similar findings. Correlation of herd size with adoption was positive and highly significant. There was positive and highly significant correlation of land holding, which indicates that increase in land holding will leads to increase in the adoption. It means that the bigger the farm size, the more will be the adoption of scientific practices. Positive and highly significant correlation of annual income with adoption was found. There was positive and significant correlation of social participation with adoption. Social participation provided an opportunity to the farmers to widen their scope of interactions. These interactions might have helped the farmers in understanding new innovations and strengthen the already established opinion/notion. Shinde *et.al*. (1998) and Yadav *et.al* (1997) reported the same findings. There was positive and significant correlation of use of source of information with adoption which conforms to the findings of Shinde *et al*. (1998). There was negative and non-significant correlation of risk orientation with adoption process.

**Table 2 : Correlation coefficient of different independent variable with adoption of dairy farmers**

| Independent variable | Correlation Coefficient |
|---|---|
| Age | -0.155* |
| Education | 0.161* |
| Family Size | 0.026 NS |
| Herd Size | 0.206** |
| Land Holding | 0.280** |
| Annual Income | 0.395** |
| Social participation | 0.152* |
| Source of Information | 0.139* |
| Risk Orientation | -0.120 NS |

** P<0.01 * P<0.05 NS = Non Significant.

## Multiple regression analysis of selected independent variable with knowledge and adoption

Multiple regression technique was used to determine the individual and overall influence of selected independent variables on the knowledge of improved animal husbandry practices by the farmers. All the selected independent variables were put with knowledge of improved animal husbandry practices in the multiple regression equation. The multiple regression analysis of all the independent variables with respect to adoption of improved managemental practices is 13%. The multiple regression analysis has shown that there is variability of minimum 3 percent to a maximum of 21.7 per cent. The share of social participation was highest i.e. 21.7 percent in gaining the knowledge level. It was observed from (Table 3) that the calculated't' value has shown positive and highly significant multiple regression between age, education, land holding, annual income and social participation whereas, it had positive and significant multiple regression with source of information. The positive non-significant multiple regression of family size, herd size and risk orientation are found.

The multiple regression coefficients of all the independent variables with respect to adoption of improved managemental practices are 26 percent (Table 4). The multiple regression analysis has shown that there is variability of minimum 6 per cent to a maximum of 41 percent. The calculated't' value has shown positive and highly significant multiple regression of education, annual income and social participation which may lead to conclusion that the three independent variables played major role in the level of adoption of dairy animal management practices by the farmers. The share of education is highest i.e. 41.5 percent in deciding the level of adoption. The negative and highly significant multiple regression of age and family size is indicative of the fact that the age and family size had important and negative role in the overall variability of the level of adoption of dairy management practices. The negative and significant multiple regression of risk orientation with adoption may lead to the conclusion that the dairy farmers were most optimistic and they would not take risk and challenges in adoption of unproved dairy management practices.

**Table 3 : Multiple Regression analysis of independent variables with knowledge of dairy farmers**

| Independent Variable | Regression of Coefficient (B1) | Standard error | t- value |
|---|---|---|---|
| Age | 0.155 | 0.024 | 6.359** |
| Education | 0.105 | 0.018 | 5.633** |
| Family size | 0.078 | 0.105 | 0.746NS |
| Herd Size | 0.140 | 0.110 | 1.265NS |
| Land Holding | 0.172 | 0.069 | 2.472** |
| Annual Income | 0.104 | 0.027 | 3.851** |
| Social participation | 0.217 | 0.054 | 3.974** |
| Source of information | 0.074 | 0.048 | 1.541* |
| Risk orientation | 0.031 | 0.087 | 0.356NS |

** P<0.01 * P<0.05 NS=Non-significant $R^2$=0.134 N=200

**Table 4 : Multiple Regression analysis with adoption of dairy farmers**

| Independent Variable | Regression of Coefficient (B1) | Standard error | t- value |
|---|---|---|---|
| Age | -0.127 | 0.058 | -2.5133** |
| Education | 0.415 | 0.176 | 2.357** |
| Family size | -0.046 | 0.021 | -2.190** |
| Herd Size | 0.249 | 0.228 | 1.093NS |
| Land Holding | 0.192 | 0.131 | 1.465* |
| Annual Income | 0.350 | 0.178 | 1.966** |
| Social participation | 0.067 | 0.033 | 2.030** |
| Source of information | 0.081 | 0.055 | 1.472* |
| Risk orientation | -0.265 | 0.179 | -1.477* |

** P<0.01 * P<0.05 NS=Non-significant $R^2$=0.269 N=200

## Conclusion

Knowledge and adoption of improved managemental practices at a larger scale is an important step towards increasing milk production in the country. Hence understanding the factors that lead farmers to knowledge and adoption are key component of policy design. The positive significant correlation of education and source of information and positive highly significant correlation of land holding, annual income and social participation with knowledge level of dairy animal management practices indicates that increase in the selected characteristics will increase the knowledge level. The selected characteristic such as education, social participation, source of information herd size, land holding and annual income will increase the adoption of dairy animal management practices and improve the milk production in the country.

## References

Chang, M. and Chand, R. (1996). Adoption of scientific and dairy farming practices by ex-serviceman. *Indian J. Dairy Sci.*, 49 (8): 507-510.

Deshmukh, G.N. (1996).A study of farmer's preferential behaviour regarding management of crossbred cow over buffaloes. M.Sc. (Agri.) Thesis, M.P.K.V., Rahuri (M.S.).

Gautam,U.S., Ram Chand and Singh, D.K (2007). Socio-Personal Correlation for Decision -Making and Adoption of Dairy practices. *Indian Res. J. Ext. Edu.* 7 (2-3)

Kaidan, K.S. and Ram Kumar (1999). Factor associated with knowledge level of dairy farmers. *Mah. J. Extn. Educ.*, 18:33-37.

Kerlinger, F.N. (1964). Foundation of behavioral research, educational and psychological inquiry, New York. Holt. Rinehort and Winston, Inc.

Mudgal,V.D., Singhal, K. K. and Sharma, D.D. (2000).Advances in dairy animal production. International book distributor (Pvt) Ltd. New Delhi.

Musaba, .E .C (2010) Analysis of factors influencing adoption of cattle management technologies by communal farmers in Northern Namibia. *Livestock Research for Rural Development* 22 (6) 2010

Narwal, R.S., Dixit, V.B and Dahiya, S.S. (1991). Correlates of farmers attitude towards buffalo management practices. *Ind. J. Extn. Educ.*, 27 (1) : 97-100.

Panchbhai, G. J., Siddiqui, M. F., Dhumal, M. V., Siddiqui,M. B. A., Channa,G. R., Shisode, M. G., Kharwadkar, M. D., Jondhle, V. M., Surjuse, P. D., and Suryavanshi, P. R.(2009).Correlation between socio-economic characteristic of dairy farmers with knowledge and adoption of dairy management practices in Akluj area of Solapur, Maharashtra. *ISPAM, National Symposium*, 26-28 Feb 2009.

Shinde, V.G., Sangle, G.K. and Dikle, R.N. (1998). Adoption of improved dairy

practices by dairy farmers. *Maharashtra J. Extn. Edn*, XV (11): 144.

Yadav, B.L. and Yadav, M.C. (1997). Different levels of adoption of buffalo

husbandry practices among farmers of different level of social participation. *Indian J. Animal Sci.*, 67 (5): 445-449.

*J. Farming Systems Research & Development* **18** (2) : 278-284 (2012)

# DIVERSIFICATION AND INTENSIFICATION OF RICE-WHEAT CROPPING SYSTEM UNDER GARHWAL HIMALAYAS

DINESH KUMAR SINGH[1], PURUSHOTTAM KUMAR[2] AND A.K. BHARDWAJ[3]

[1]*Govind Ballabh Pant University of Agriculture & Technology Horticulture Research & Extension Centre-Jeolikote-263 127 Uttarakhand*
[2]*Govind Ballabh Pant University of Agriculture & Technology—Horticulture Research & Extension Centre, Srinagar-246 174, Nainital, Uttarakhand*
[3]*Department of Agronomy, Govind Ballabh Pant University of Agriculture & Technology, Pantnagar, Uttarakhand*

ABSTRACT

A field experiment was conducted at farmers' fields during 2008-09 in the districts of Dehradun and Pauri of Uttarakhand to diversify and intensify the existing rice-wheat cropping system. Eighteen farmers were selected from the six blocks of above mentioned districts. Every farmer was taken as a replication. Treatments consisted of five cropping systems including the traditional rice-wheat system. Rice-vegetable pea-vegetable frenchbean cropping system recorded highest paddy equivalent yield (22085 kg/ha) and highest net returns (Rs. 164645 $ha^{-1}$). The net returns under this cropping system were statistically higher than the net returns under remaining cropping systems. Second highest net returns (Rs. 91143 $ha^{-1}$) were recorded from rice-mustard-mungbean cropping system and it was followed by rice-wheat+mustard (Rs. 86589 $ha^{-1}$), rice-wheat (Rs. 83961 $ha^{-1}$) and rice-toria-urdbean (Rs. 74969 $ha^{-1}$). The paddy equivalent yield of different cropping systems were in the following order rice-vegetable pea-vegetable frenchbean (22085 kg/ha)> rice-mustard-mungbean (13119 kg/ha)>rice-toria-urdbean (12153 kg/ha)> rice-wheat+mustard (10420 kg/ha)> rice-wheat (9604 kg/ha).

**Keywords:** Rice-wheat, cropping system, diversification, economics

The rice-wheat is the predominant cropping system of northern India covering about 10.5 million hectare area and contributing about 38% food grains to the national food basket (Gangwar, B. 2009). In Uttarakhand rice and wheat crops are being grown on area of 295 and 398 thousand hectares, respectively. In the state of Uttarakhand majority of holdings fall in the category of small and marginal farms as the average size of holding in the hilly areas is around 0.4 ha and for the state as a whole, it is 0.8 ha. The average productivity of rice and wheat in the state was 19.66 and 20.02 q/ha, respectively during the year 2008-09 (Anonymous, 2010).

Rice-wheat system is considered as backbone of food grain security. This system is likely to play its important role in sustaining the food grains self sufficiency in future too. The system production can be increased up to the level of 9.1 to 21.5 tons/ha/year depending upon the choice of high value crops for diversification of existing rice-wheat cropping system.

Continuous cultivation of rice and wheat in sequence during the last three decades is causing many second generation problems like decline in water table, emergence of multi nutrient deficiencies, formation of hard pan and

Present address: Training Organizer/Agronomist GBPUA&T-Krishi Vigyan Kendra, Dhanauri-247667, Haridwar, Uttarakhand

build up of weeds like *Phalaris minor* in wheat. Moreover, the stagnation in system productivity and profitability is experienced in recent years. As a result system sustainability is under threat. There is need to consider partial substitution of rice-wheat system through efficient alternatives as diversification and intensification approach.

With the overflow of cereal production, need is being felt to diversify and intensify the existing rice-wheat system with remunerative and efficient crops like pulses, oilseeds and vegetables. Under Garhwal Himalayan conditions, where majority of holdings fall in the range of marginal and small, viable alternative is selection of suitable cropping systems that generate maximum net profit per unit investment per unit time to farmers. Therefore, the present study was undertaken to find out the productivity and economics of various possible cropping systems by incorporating pulses, oilseeds and vegetable crops that can replace rice-wheat system.

## Materials and Methods

The experiment was carried out on farmers' fields taking single farmer as a replication. Eighteen farmers were selected from the six blocks of the districts of Pauri and Dehradun namely, Pauri, Khirsu, Dugadda in district Pauri and Kalsi, Vikasnagar, Doiwala in district Dehradun, during the year 2008-09. Treatments comprised of five crop sequences (Table 2) including the traditional rice-wheat system. Recommended package of practices were followed for all the crops in different sequences. The varieties grown of rice, wheat, mustard, toria, urdbean, mungbean, pea and frenchbean were Pusa Sugandha 5, PBW 502, Pusa Bold, PT 507, PU 31, Pant Mung 5, Arkel and VL Boni, respectively. Fertilizer doses applied as per the recommendation were as follows: rice: 100, 60 and 40 kg $ha^{1}$ of N, $P_2O_5$ and $K_2O$, respectively, wheat: 150, 60 and 40 kg $ha^{1}$ of N, $P_2O_5$ and $K_2O$, respectively, mustard and toria: 100, 40 and 40 kg $ha^{1}$ of N, $P_2O_5$ and $K_2O$, respectively, urdbean and mungbean: 15 and 45 kg $ha^{1}$ of N, and $P_2O_5$, respectively, pea: 30, 70 and 50 kg $ha^{1}$ of N, $P_2O_5$ and $K_2O$, respectively, frenchbean: 120, 70 and 50 kg $ha^{1}$ of N, $P_2O_5$ and $K_2O$, respectively. When the mustard was intercropped with wheat, the fertilizer doses were applied as recommended for the wheat crop only. Intercropping of wheat and mustard was done as per the recommendation (9 rows of wheat to 1 row of mustard). The soils of the experimental sites were in general low in available nitrogen (200.1 kg/ha), medium in available phosphorus (14.4 kg/ha) and available potassium (168.7 kg), medium to high in organic carbon (0.73 %), neutal in pH (6.8) and the mean electrical conductivity was 1.0 dS/m (Table 1).

## Results and Discussions

The data on grain and straw yield of different crops in sequence has been summarized and depicted in Table 2. Grain yield of crops in different crop sequences were converted to the paddy equivalent yield on price basis and summed together to get the paddy equivalent yield of the system. Highest paddy equivalent yield (22085 kg/ha/year) was recorded with rice-vegetable pea-vegetable frenchbean crop sequence, and it was follwed by rice-mustard-mungbean (13119 kg/ha/year), rice-toria-urdbean (12153 kg/ha/year), rice-wheat+mustard (10420 kg/ha/year) and rice-wheat (9604 kg/ha/year). System

**Table 1 : Soil fertility status before sowing of *kharif* crops of different cropping systems (18 locations)**

| Parameters | Minimum | Maximum | Mean | Details |
|---|---|---|---|---|
| Available N kg/ha | 160 | 225 | 200.1 | Low |
| Available $P_2O_5$ kg/ha | 12.1 | 17.2 | 14.4 | Medium |
| Available $K_2O$ kg/ha | 145 | 190 | 168.7 | Medium |
| Organic carbon (%) | 0.6 | 0.82 | 0.73 | Medium to high |
| pH | 6 | 7.8 | 6.8 | Neutral |
| Electrical conductivity (dS/m) | 0.75 | 1.7 | 1.0 | - |

**Table 2 : Grain and straw yield and other parameters of different crops in different cropping systems**

| Treatment | Grain/pod/tuber yield (kg/ha) | | | Straw yield (kg/ha) | | | Duration | Paddy equivalent yield of the system (kg/ha) |
|---|---|---|---|---|---|---|---|---|
| | ***Kharif*** | ***Rabi*** | ***Zayad*** | ***Kharif*** | ***Rabi*** | ***Zayad*** | **days** | |
| Rice-Wheat | 5053 | 4659 | - | 6945 | 5771 | - | 274 | 9604 |
| Rice-Wheat+Mustard | 5383 | 4410 (wheat) 321 (mustard) | - | 6695 | 5618 | - | 273 | 10420 |
| Rice-Toria-Urdbean | 6065 | 1216 | 1060 | 7153 | 3442 | 1040 | 326 | 12153 |
| Rice-Mustard-Mungbean | 5385 | 1710 | 1162 | 6495 | 4544 | 953 | 342 | 13119 |
| Rice-Pea-Frenchbean | 5138 | 7283 | 4745 | 6330 | - | 5003 | 318 | 22085 |

productivity also followed the same trend as of paddy equivalent yield of the system. It was recorded highest (60.5 kg/ha/day) with rice-vegetable pea-vegetable frenchbean system followed by rice-mustard-mungbean (35.9 kg/ha/day), rice-toria-urdbean (33.3 kg/ha/day), rice-wheat+mustard (28.5 kg/ha/day) and rice-wheat (26.3 kg/ha/day) (Figure 1).

When the wheat was intercropped with mustard, the grain yield reduced from 4659 kg $ha^{-1}$ to 4410 kg $ha^{-1}$ and additional 321 kg $ha^{-1}$ mustard yield was achieved. Rice-mustard-mungbean crop sequence had the maximum duration (342 days) followed by rice-toria-urdbean (326 days) and rice-vegetable pea-vegetable frenchbean (318 days). Rice-wheat and rice-wheat+mustard sequences were almost same in duration (274 and 273 days, respectively).

Cost of cultivation, gross returns and net returns of different crop sequences were calculated and depicted in Table 3. All the crop sequences had rice crop during the *kharif* season so the cost of cultivation has been the same (Rs. 24237 $ha^{-1}$) for all the treatments. During the *rabi* season highest cost of cultivation

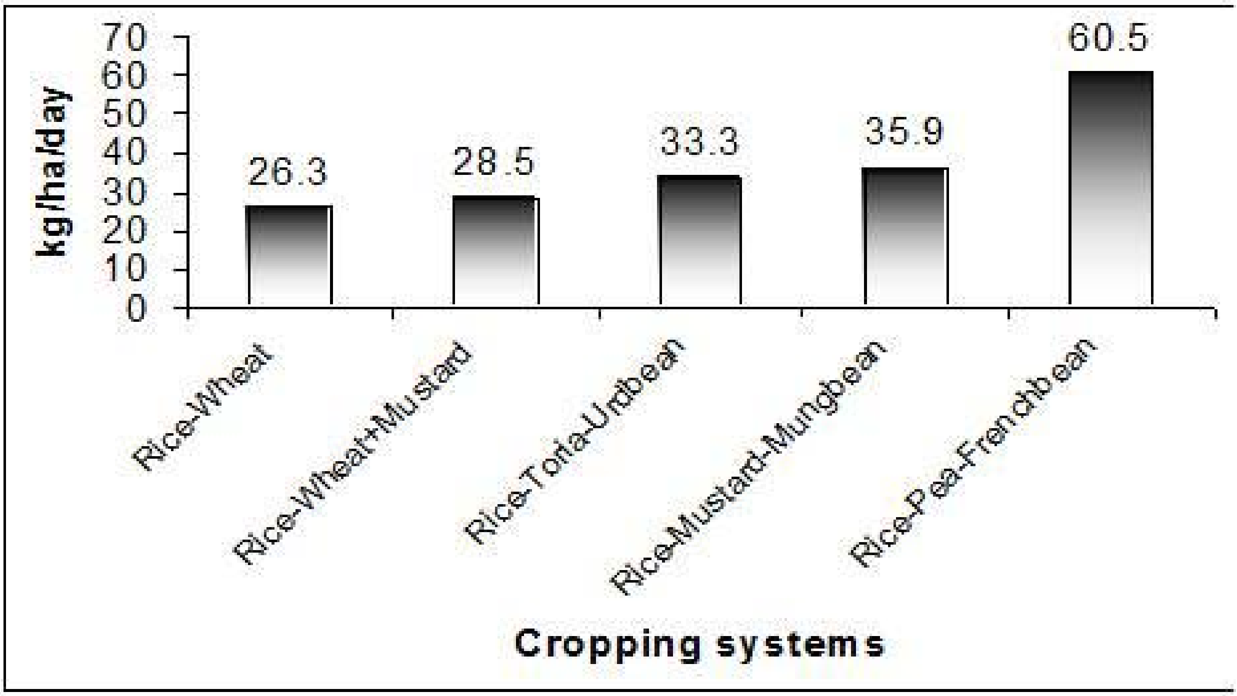



**Figure 1.System productivity of different cropping systems**

was recorded with wheat crop sown alone under rice-wheat crop sequence (Rs. 21427 $ha^{-1}$), and it was followed by the rice-wheat+mustard crop sequence (Rs. 21409 $ha^{-1}$). Vegetable pea crop sown under rice-vegetable pea-vegetable frenchbean crop sequence also had at par cost of cultivation (Rs. 20816 $ha^{-1}$) with the wheat crop. Lowest cost of cultivation was recorded with toria crop (Rs. 14799 $ha^{-1}$) while it was Rs. 15669 $ha^{-1}$ for the mustard crop. During *zayad* season highest cost of cultivation was recorded with the frenchbean crop (Rs. 26737 $ha^{-1}$), while it was only Rs. 14143 $ha^{-1}$ and Rs. 14087 $ha^{-1}$ for the urdbean and mungbean crops, respectively. Rice-vegetable pea-vegetable frenchbean crop sequence recorded highest total cost of cultivation (Rs. 71790 $ha^{-1}$) and it was statistically higher than those of remaining crop sequences. Rice-toria-urdbean and rice-mustard-mungbean had at par total cost of cultivation (Rs. 53180 $ha^{-1}$ and Rs. 53993 $ha^{-1}$ , respectively). Lowest total cost of cultivation (Rs. 45664 $ha^{-1}$) was recorded with rice-wheat and rice-wheat+mustard crop sequences, which was statistically lower than the remaining crop sequences.

Gross returns for different crop sequences were calculated as per the prevailing market prices of the produce and depicted in Table No. 3. During the *kharif* season there was rice crop in every crop sequence and from this crop gross returns varied from Rs. 61281 to Rs 66283 per hectare. During *rabi* season highest gross returns were recorded with vegetable crop (Rs. 108502 $ha^{-1}$) and it was significantly higher than those from the remining crops in sequence during *rabi*. Pea crop was followed by wheat+mustard intercrops having gross returns of Rs. 67889 $ha^{-1}$. Toria and mustard crops fetched gross

**Table 3 : Economics of different cropping systems**

| Treatment | Cost of cultivation (Rs./ha) | | | Total cost of cultivation (Rs./ha) | Gross returns (Rs./ha) | | | Total gross returns (Rs./ha) | Net returns (Rs./ha) | | | Net returns from system (Rs./ha) | B:C Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Kharif* | *Rabi* | *Zayad* | - | *Kharif* | *Rabi* | *Zayad* | - | *Kharif* | *Rabi* | *Zayad* | - | - |
| Rice-Wheat | 24237 | 21427 | - | 45664 | 64396 | 65229 | - | 129625 | 40159 | 43802 | - | 83961 | 1.84 |
| Rice-Wheat+Mustard | 24237 | 21409 | - | 45646 | 64346 | 67889 | - | 132235 | 40109 | 46480 | - | 86589 | 1.90 |
| Rice-Toria-Urdbean | 24237 | 14799 | 14143 | 53180 | 66283 | 26763 | 35102 | 128148 | 42047 | 11964 | 20959 | 74969 | 1.41 |
| Rice-Mustard-Mungbean | 24237 | 15669 | 14087 | 53993 | 65141 | 41229 | 38766 | 145136 | 40904 | 25560 | 24679 | 91143 | 1.69 |
| Rice-Pea-Frenchbean | 24237 | 20816 | 26737 | 71790 | 61281 | 108502 | 66652 | 236435 | 46562 | 87686 | 39916 | 164645 | 2.29 |
| C.D. 5 % | NS | 984.4 | 299.5 | 1396.8 | 4412.9 | 11868.5 | 9818.8 | 19173.9 | 12564.8 | 12025.2 | 9944.3 | 19683.2 | - |

returns of Rs. 26763 $ha^{-1}$ and Rs. 41229 $ha^{-1}$ , respectively as compared to Rs. 65229 $ha^{-1}$ obtained from the wheat crop sown alone. Duing zayad season, highest gross returns of Rs 66652 were obtained from the vegetable frenchbean crop and it was statistically higher than those obtained from urd bean and mungbean crops (Rs. 35102 $ha^{-1}$ and Rs. 38766 $ha^{-1}$, respectively. Gross returns from the crops in sequence were summed together to get the total gross returns. Highest total gross returns were recorded with rice-vegetable pea-vegetable frenchbean crop sequence (Rs. 236435 $ha^{-1}$) and it was statistically higher than those from rest of the crop sequences. Rice-mustard-mungbean crop sequence produced second highest gross returns of Rs. 145136 $ha^{-1}$ and it was followed by rice-wheat+mustard (Rs. 132235 $ha^{-1}$), rice-wheat (Rs. 129625 $ha^{-1}$) and rice-toria-urdbean (Rs. 128148 $ha^{-1}$). All the crop sequences except rice-vegetable pea-vegetable frenchbean were at par among themselves for the total gross returns. Minimum total gross returns were recorded with rice-toria-urdbean crop sequence (Rs. 128148 $ha^{-1}$).

Rice crop was common to all the crop sequences during *kharif* season but the net returns from this crop varied from Rs. 37044 $ha^{-1}$ to Rs. 42047 $ha^{-1}$. During rabi season net returns varied from Rs 11964 to Rs 87686 $ha^{-1}$ . The highest net returns (Rs. 87686 $ha^{-1}$) were obtained from the vegetable pea crop and it was followed by wheat+mustard intercropping (Rs. 46480 $ha^{-1}$), wheat crop sown alone (Rs. 43802 $ha^{-1}$), mustard (Rs. 25560 $ha^{-1}$) and toria (Rs. 11964 $ha^{-1}$). Net returns recorded with vegetable pea (Rs. 87686 $ha^{-1}$) were statistically higher than those from the remaining crops in the sequence during *rabi* season. During zayad, vegetable frenchbean provided the highest net returns of Rs 39916 $ha^{-1}$ , which is statistically higher than those from mungbean (Rs. 24679 ha$^{-1}$) and urdbean (Rs. 20959 ha$^{-1}$).

Net returns from the individual crops in the crop sequence were summed up to get the net returns from the system and termed as net returns from the system. Highest net returns (Rs. 164645 ha$^{-1}$) were obtained from rice-vegetable pea-vegetable frenchbean cropping system, and it was statistically higher than the remaining cropping systems. Second highest net returns (Rs. 91143 ha$^{-1}$) were recorded from rice-mustard-mungbean cropping system and it was followed by rice-wheat+mustard (Rs. 86589 ha$^{-1}$), rice-wheat (Rs. 83961 ha$^{-1}$) and rice-toria-urdbean (Rs. 74969 ha$^{-1}$). Kumar *et al*. (2007) and Suri and Tiwari (2007) also reported the beneficial effects of diversification of existing cropping system. Net returns from rice-toria-urdbean cropping system (Rs. 74969 ha$^{-1}$) were lower than the traditional rice-wheat system (Rs. 83961 ha$^{-1}$), however the difference was not significant.

Highest B:C ratio (2.29) was recorded with rice-vegetable pea-vegetable frenchbean cropping system due to high returns from vegetable pea (Rs. 108502 ha$^{-1}$) and vegetable frenchbean (Rs. 66652 ha$^{-1}$). Next to this cropping system rice-wheat+mustard and rice-wheat systems had almost equal B:C ratio (1.90 and 1.84, respectively), however, rice-wheat+mustard cropping system was slightly superior to rice-wheat system. Lowest B:C ratio was recorded with rice-toria-urdbean (1.41), it was followed by rice-mustard-mungbean (1.69). Lower B:C ratio under these two cropping systems were mainly due to less returns with the toria (Rs. 26763 ha$^{-1}$)and mustard (Rs. 41229 ha$^{-1}$) crops.

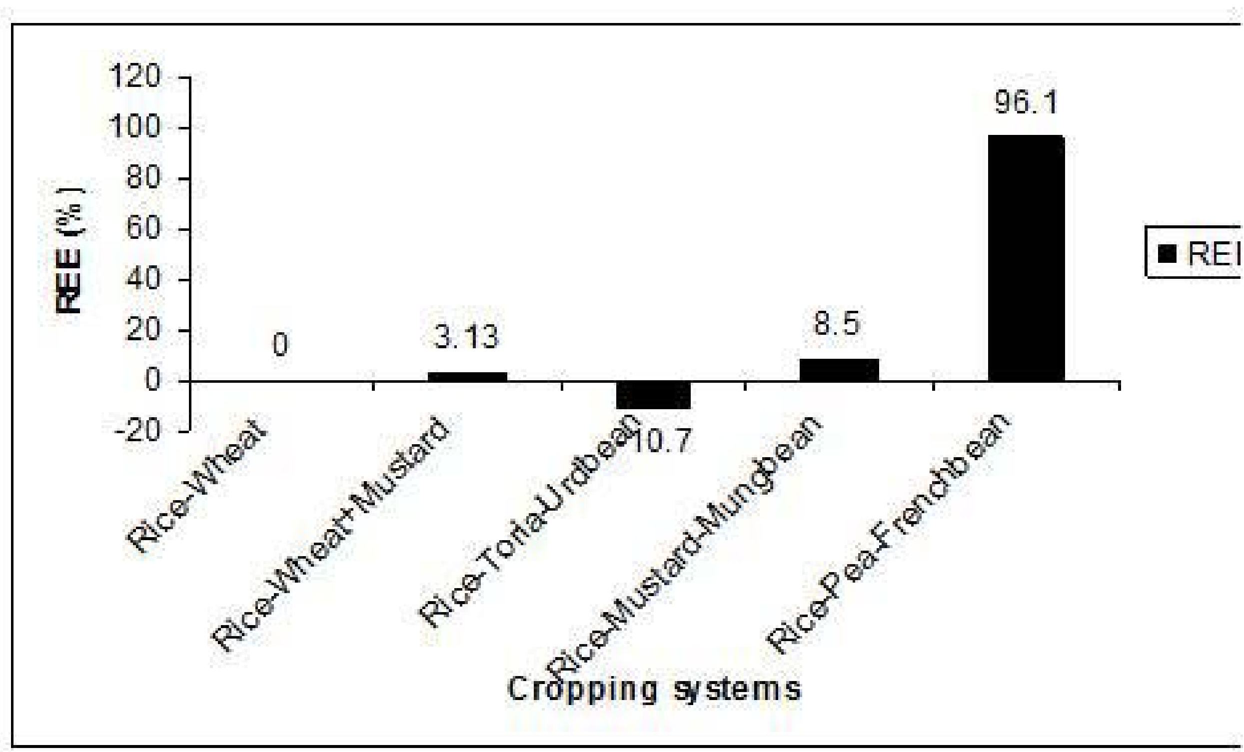



**Figure 2. Relative economic efficiency of different cropping systems**

Relative economic efficiency (REE) is the comparative measure of economic gains over the existing rice-wheat system. Rice-vegetable pea- vegetable frenchbean system had 96.1 per cent REE i.e. 96.1 per cent more net returns under this system as compared to the traditional rice-wheat system. Rice-wheat+mustard and rice-mustard-mungbean cropping systems received 3.13 and 8.5 per cent relative economic efficiencies. Negative relative economic efficiency (- 10.7 %) was recorded with the rice-toria-urdbean system, due to very low net returns from toria crop (Rs. 11964 $ha^{-1}$) against wheat crop (Rs. 43802 $ha^{-1}$) (Figure 2).

Highest net returns (Rs. 164645/ ha), B: C ratio (2.29), system productivity (60.5 kg/ha/day) and relative economic efficiency (+%) was recorded with rice-vegetable pea- vegetable frenchbean cropping system, hence this cropping system proves to be the best cropping system among all the cropping systems tested. This cropping system recorded 130 per cent higher paddy equivalent yield and 96 per cent higher net returns over the traditional rice-wheat system. So this cropping system can also be recommended over the conventional rice-wheat cropping system in irrigated situations of Garhwal Himalayas.

## REFERENCES

Anonymous. 2010. Statistical Diary Uttarakhand 2008-09. *Arth avam sankhya nideshalaya, Niyojan Vibhag, Uttarakhand Shashan, Neshvilla Road, Dehradun*

Gangwar, B. 2009. Efficient cropping systems for commercialization in selected zones of India. Proceedings of 22$^{nd}$ training course on Advances in Commercial Agriculture. March, 18-April, 07, 2009. CAS Agronomy, GBPUAT, Pantnagar.

Kumar, Purushottam, Singh, D.K. and Sharma, Mohit. 2007. Intensification of exhisting Maize-Sugarcane-Raton-Wheat cropping system. Journal of Farming Research & Devlopment **13**(2) : 229-233.

Suri, V.K. and Tiwari, A.N. 2007. Ensuring livelihood security of low resource poor farmers of Uttar Pradesh through appropriate technology interventions. Journal of Farming Research & Devlopment **13**(2):151-161.

*J. Farming Systems Research & Development* **18** (2) : 285-289 (2012)

# PERFORMANCE EVALUATION OF WHEEL HAND FOR WEEDING IN ROW VEGETABLE CROP

HARI RAJ SINGH AND DR. RAKESH TIWARI

*1. Lecturer, department of Ag. Engg. SCRie&T, CCS University, Meerut.*
*2. SMS/Astt. Prof (Soil Science) KVK, Hastinapur, S.V.B.P.U of Ag. & Tech.*

ABSTRACT

There weeding tools C.I.A.E Wheel hand hoe, A.A.I wheel hand hoe with sweep blade and rake with 3 forks were tested for their working performances conducted on farmers' fields to find out the performance in terms of weeding index, field efficiency, man-h/ha, field capacity and ratio of man-h in three crops viz; chilli, brinjal and tomato were tested under three weeding conditions. Average weeding efficiency for khurpi was maximum 97.74% with respect to other implements because it covers more area near to the plants roots but for hoes it was max. 94.41% for C.I.A.E wheel hand hoe. Average field efficiency was max. 85.46% for C.I.A.E wheel hand hoe where as the average field capacity was max. $8.36 \times 10^{-3}$ ha/hr and average ratio of man-h was mim. 1:2.28 for A.A.I wheel hand hoe with 3-froks. It was found that average cost of weeding per ha for A.A.I wheel hand hue with rake with 3 forks was minimum Rs. 687,.30 and max. Rs. 1473.33 for khurpi

## INTRODUCTION

The production of food grains has increased more than four fold from 50 million tones at the time of independence to more than 200 million tines today. Weed control is one of the most expensive operations in crop production. The losses due to weeds, which are unwanted plants, were assessed as 33.8% of the total production. In India, about 4.2 billion rupees are lost every year due to weeds in raising major crops. The reduction in yield of the main crop is around 20% to 45% depending on the crop and location. Weed control is a problem in the production of the crops and it considerably affects the yield of crops by lowering the quantity and quality of the crop production. It saves 70-75% on labour & operating time; 80% on cost of operation and also results in 5-8% increase in yield compared to convention method of weeding using khurpi. An experiment was conducted during rainy season to study various mechanical weeding methods i.e by using blade hoe, 3 tyne wheel hoe, hand hoe, sweet hoe etc. (singh, 1976). In low land rice khupi had very low field capacity of 0.0033 ha/h (Haq and Islam, 1983). Performance of a power weeder (1.7 h.p RT 35 engine) was compared whit conventional method of manual weeding with hoe and manually operated dry land weeder. The field capacity of the power weeder was 0.04 ha/h with weeding efficiency of 93% and performance index of 453. The cost of operation of power weeder was Rs. 250.00 against dry land weeders Rs. 490 only snd Rs. 720.00 by manual with hoes. The weeding by the power weeder saves time by 93% and saves 65% cost in comparison to the manual weeding (Rangasamy et. al. , 1993). For soybean crop the unit cost of production and benefit cost ratio was obtained maximum by wheel hoe, i.e 6.03:1 in comparison to other mechanical and chemical weeding methods. The area covered by one man-hour for chemical spraying, mechanical by C.I.A.E wheel hoe, flat blade weeder, V-shap wheel hoe and hand weeding by khurpi were 0.00597, 0.0056, 0.0041, 0.0049 and 0.0021 respectively but wheel hoe was recommended for weeding in soybean (Shrivastava, 1997). For soybean crop and pegion pea crops average weeding percentage was 93.14% under wheel hoe operation but It was 96.43% for local practices and showed that manual weeding was costlier upto 3.66 times than wheel hoe weeding under same field conditions. The average weeding percentage for vegetables were 87-95% for wheel hoe and 97-98% for manual weeding. It was found that manual weeding was nearly four and half times costlier then wheel hoe weeding under same field condition (patel, 1998). The present study has been undertaken at farmers filed under tow vegetable cultivation in Champatpur village near Allahabad Agricultural institute, Allahabad with the objective to evaluate the working performance and comparison fo C.I.A.E (Center institute of Agriculture Engineering) and A.A.I (Allahabad Agricultural institute) wheel hand hoes whit local practice for weeding row vegetable crops in different weed density for corps viz., chilli, brinjal and tomato.

## MATERIALS AND METHODS

In the present study C.I.A.E. wheel hand hoe with V-shape sweep blade, A.A.I. wheel hand hoe with sweep blade and rank with three forks and khurpi were Tested under selected farmer's field for Chilli, Brinjal and Tomato vegetables in the different weeding conditions. Major weed under three crops were Doob grass, Bhangarai, Motha, Bathua, Stgatthia, Congress grass, krishneel etc. chilli crop was grown at the sandy loam soil of average moisture content 5.92% on dry basis (d.b.) and the average spacing between the rows was 67 cm. Brinjal crop was grown at the sandy loam soil of the average moisture content 8.01% (d.b) and the average spacing between the rows was 107 cm. tomato crop was grown at the loamy sand soil of average moisture content 4.26% (d.b) and the average spacing between thw rows was 48 cm.

### Parameter used to Judge Performance

#### *Weeding percentage or weeding Index*

It is the ratio between the number of weeds removed by weeder to the number if weeds presents in a unit area before weeding and is expressed as percentage. The spots, where such counts are taken randomly, and a ring covering an area of I square meter were used for sampling.

$$\text{Weeding index} = \frac{\text{weeds before weeding} - \text{weeds after weeding}}{\text{weeds before weeding}} \times 100$$

### Man-h/ha

It is the required labour time per hectare of land for weeding.

$$\text{Man-h/ha} = \frac{\text{number of labour engaged} \times \text{time taken to perform the operation hr}}{\text{Area of land ha}}$$

### Field Capacity

It is defined as the area covered per unit time.

$$\text{Field capacity, ha/h} = \frac{\text{Area covered ha}}{\text{time taken to cover the area hr}}$$

### Ratio of Man-h

It is define as the ratio of man-h per ha for wheel hoe weeding to that for local weeding practice.

$$\text{Ratio of man-h} = \frac{man-h\ per\ for\ wheel\ weeding}{man-h\ per\ ha\ for\ local\ paractice\ weeding}$$

### Time loss

It is total time lost during operation e.g rest or turnig etc.

### Soil moisture Content (S.M.C)

It is the percentage weight of water present in unit dry weight of soil. This is calculated on dry weight basis (d.b) this is the calculated because force required to operate the implement is different at different moisture content. This is expressed as percentage.

$$\text{Soil moisture content (d.b)} = \frac{\text{weight of wet soil} - \text{weght of dry soil}}{\text{weight of dry soil}} \times 100$$

**Field efficiency**

It is defined as the ratio of actual time for weeding to the total time taken weeding including time of rest or turning in different operations.

$$\text{Field efficiency} = \frac{\textit{Actual time}}{\textit{Total time}} \times 100$$

**Specifications of twin wheel hand hoe (CIAE)**

| | | |
|---|---|---|
| 1. Total length, m | : | 1.68 |
| 2. Length if handle, m | : | 1.45 |
| 3. Handle width, m | : | 0.58 |
| 4. Wheel width, m | : | 0.20 |
| 5. Wheel width, m | : | 0.12 |
| 6. Length if blade, m | : | 0.20 |
| 7. Width of blade, m | : | 3.00 |
| 8. Angle of blade $^0$ | : | $140^0$ |
| 9. Diameter of conduct pipe, cm | : | 2.50 |
| 10. Depth adjustment, cm | : | 15.00 |
| 11. Total weight, kg | : | 4.00 |

**Specification of A.A.I wheel hand hoe**

| | | |
|---|---|---|
| 1. Total length, m | : | 1.53 |
| 2. Length of handle, m | : | 1.48 |
| 3. Handle width, m | : | 0.60 |
| 4. Wheel diameter, m | : | 0.60 |
| 5. Wheel width, m | : | 0.03 |
| 6. Length of blade, m | : | 0.20 |
| 7. Width of blade, m | : | 0.22 |
| 8. Angle of blade, $^0$ | : | $60^0$ |
| 9. Diameter of conduct pipe, cm | : | 2.6 |
| 10. Depth adjustment, cm | : | 15 |
| 11. Total weight, kg | : | 6.5 |

**Specification of khurpi**

| | | |
|---|---|---|
| 1. Working width of blade, cm | : | 8.00 to 10.00 |
| 2. Length of blade, cm | : | 12.00 to 20.00 |
| 3. Length if Handle, ck | : | 15.00 to 20.00 |

Three experiments were conduct in village Champatpur village near Allhabad to find out the performance of wheel hand hoes in comparison to local practices for weeding in vegetable crops e.g chilli, brinjal and tomato. These vegetables were transplanted in lines after uprooting performed during the favorable condition of soil which depends mostly in soil moisture content and number of weeds in that field.

**Procedure**

- three plots of three different crops were selected for performance evolution of the selected implements.
- Three experiments. Plots of size 40 m × 10 m for four different working tools.
- Six soil sample were taken randomly from the three plots from different depths. Three were at the depth of 5 cm. and 3 at the depth of 10 cm and this procedure were performed for all three different vegetables.

- Weeds were counted of size 1m   1m for three different plots, before and after weeding. This procedure has been done for all three different vegetables.
- Weeds are picked out after operating the hoes from the weeded plots and remaining unaffected weeds are also counted.
- Total time of weeding and time losses in turning and for rest etc. were recorded separately for each plot.
- The soil moisture content in dry weight basis of the field was calculated by gravimetric method.
- Weeding efficiency, field efficiency, man h/ha, field capacity and ratio of man-h were calculated for all possible combinations.

## RESULTS AND DISCUSSION

Average weeding index for C.I.A.E wheel hand doe with sweep blade, A.A.I wheel hand hoe with sweep blade and rake with 3-froks and khurpi average weeding indexes found 91.32%, 87.41%, and 95.88% respectively for chilli crop (Table: 1) 93.73%, 94.33%, 93.07%, and 98.13% for brinjal crop (Table: 2) and 98.2%, 97.0%, 97.9%, and 99.2% for tomato crop (Table: 3) Which shows that the average weeding index for I.C.A.E wheel hand hoe is better than A.A.I wheel hand hoe with both types of blades but it is lower than khurpi.

Average field efficiency for respective implement were recorded as 83.67%, 78.5%, 77.09% and 95.88% in chill crop; 86.93%, 82.67%, 78.27% and 81.03% in brinjal crop 85.77%, 81.43%, 80.6% snd 76% in tomato crop. Respectively. Results shows that for same field condition average field efficiency for C.I.A.E wheel hand is better than any other weeding implements, but varies from crop to crop.

Average man –h/ha were found for C.I.A.E wheel hand hoe with sweep blade A.A.I wheel hand hoe with sweep blade and rake with 3-frocks and khurpi as 280] 192] 178 and 428 in chilli crop; 119, 129, 93 and 223 in brinjal cropp and 148, 135, 124 and 253 in tomato crop, respectively and ratio of man-h were calculated for C.I.A.E wheel hand hoe with sweep blade A.A.I wheel hand hoe with sweep blade and rake with 3-froks as 1:2.06, 1:2.23 and 1:2.40 in chilli crop; 1:1.87, 1:2.73 and 1:2.40 in brinjal and 1:1.71, 1:1.87 and 1:2.04 in tomato crop , respectably. Result state that ratio of man-h for C.I.A.E wheel hand hoe is lower than A.A.I wheel hand hoe with both tools but is better than khurpi. Generally that was the highest × for A.A.I wheel hand hoe with rake with 3-forks.

Average field capacity for respective implement were as 5.22  $10^{-3}$ ha/ h, $5.63\times10^{-3}$ ha/h, 5.93$10^{-3}$ ha/h and 2.24$10^{-3}$ ha/h in chilli crop; 8.47$10^{-3}$ ha/ h, 7.83$10^{-3}$ ha/h, 10.9$10^{-3}$ ha/h and 4.54$10^{-3}$ ha/h ha/ha in brinjal crop and 6.911$10^{-3}$ ha/h, 7.58$10^{-3}$ ha/h, 8.25$10^{-3}$ ha/h and 4.02$10^{-3}$ ha/h in tomato crop in respectively. Result that average field capacity for C.I.A.E. wheel hand hoe with sweep blade is lower than A.A.I. wheel hand hoe with any type of tools. Generally, that was the highest for A.A.I wheel hand hoe with rake with 3 froks.

Average cost of weeding per ha was calculated as Rs. 813.33 for C.I.AE. wheel hand hoe with sweep blade, Rs. 793.44 for A.A.I. wheel hand hoe with sweep blade RS. 687.30 for A.A.I. wheel hand hoe with rake with 3-froks and Rs. 1473.33 for khurpi

## Conclusions

The result of the tests conducted in the actual fields of the farmers for C.I.A.E wheel hand hoe, A.A.I. wheel hand hoe with sweep blade and rake with three forks and khurpi were concluded as follows:

1. All wheel hand hoes perform satisfactory weeding operation.

2. Average weeding efficiency for C.I.A.E wheel hand hoe was 94.41% where as 93.40%, 92.75% and 97.74% A.A.I. wheel hand hoe with sweep blade and rake with three forks and khurpi, respectively.

3. Average field efficiency for C.I.A.E wheel hand hoe was 85.46% where as that of A.A.I wheel hand hoe with sweep blade and rake with three forks and khurpi was 80.90%, 78.65% and 80.20% respectively.

4. Average field capacity for C.IA.E. whell hand hoe was $6.8510^{-3}$ ha/h, were as it was $7.0110^{-3}$ ha/h, $8.3610^{-3}$ ha/h and $3.6010^{-3}$ ha/h for A.A.I. wheel hand hoe with sweep blade and rake with three forks and khurpi, respectively.

5. Average ratio of man-h for C.I.A.E. wheel hand hoe was 1:1.88 where as 1:1.94 and 1:2.28 for A.A.I wheel hand hoe with sweep blade and rake with three forks, respectively.

The above results show that mechanical weeding gave beeter performance than local practice. In hoes; C.I.A.E. whell hand hoe gave better performance for weedin index and field efficiency and A.A.I wheel hand hoe with rake with three forks gave better performance for field capacity and ratio of man-h.

## Refrences

Haq, K.A and Islam, M.S. 1983 performance of indigenous hand in Bangladesh vol. XVI; No. 4 AMA pp. 47-50.

Patel. As. 1998. Demonstration and popularization of twin wheel hand hoe for weeding of crops and vegetables. Investigation no. 5. CAE/FIM/JNKVV/94-4, Annual report of AH India coordinated scheme on farm implements and machines CAE, Jabalpur center, India.

Rangasamy, k.m. Subrammaniam, Bala and Swaminathan, K.R. 1993. Evaluation of power weeder performance, AMA 24 (4): 16-18.

Singh, S.R 1976. Mechanical weeding in direct sown rice. Indian J, Agril. Sci. 46(11): 507-509.

Srivastava, A.K 1997. performance evaluation of different weeding methods and economic viability for soybean crop. Agriculture Engineering Today. Vol. 21(1-4): 90-15.

*J. Farming Systems Research & Development* **18** (2) : 290-295 (2012)

# PERFORMANCE OF POTATO BASED CROPPING SYSTEM UNDER ORGANIC MODE DURING INITIAL YEARS OF CONVERSION IN RELATION TO NUTRIENT MANAGEMENT PRACTICES

MANOJ RAGHAV, NARENDRA KUMAR* AND DHASHI KAMAL

*Department of Vegetable Science, Department of Soil Science*, College of Agriculture, G. B. Pant University of Agriculture & Technology, Pantnagar-263 145, U.S.Nagar, Uttarakhand*

## ABSTRACT

The study compares the performance of potato, cowpea and okra crop system during initial three years of conversion (2003-04 to 2005-06) from conventional cultivation to organic cultivation. The experiment was conducted at Organic Farming Centre, G.B. Pant University of Agriculture and Technology, Pantnagar for three consecutive years revealed that the crop yield as well as available nitrogen, phosphorus and potassium content of soil improved with organic management and time after the harvesting of each crop. The effect of different organic manures and their doses showed significant influence on yield and chemical properties of soil. The highest yield during last year in each crop was obtained by the application of FYM@ 40 t/ha. While the continuous use of inorganic fertilizers showed no increase in yield and this was almost same in all the years. The soil health was also improved in terms of organic carbon, available nitrogen, phosphorous and potassium content with treatment having FYM @ 40t/ha.

**Key words**: Potato, cowpea, okra, organic mode, nutrient management

Organic farming is an alternative agriculture system, which has been proposed as a solution to the problem of soil health, sustainable yield and pollution associated with inputs of fertilizers and pesticides. A crop like cowpea has greater prospects of growing organically due to its low nutritional requirement, probable cultural practices to control weeds and Integrated Pest Management module to control diseases and pest to great extent. Crop rotation is a central tool that integrates the maintenance and development of soil health with different aspects of crop under organic system heavily reliant on organic sources. Nutrients supply to crops under organic systems mainly depends on organic sources such as manures, legumes and biofertilizers. The development and implementation of well designed crop rotation is the basis of success of organic production system (Chhabra and Chhabra, 2003). The present study has been conducted on okra-potato-cowpea cropping system to evaluate their potential yields from first year to third year of conversion of land from conventional to organic mode. The study also involved evaluation of soil health in terms of organic matter, available N, P and K after harvest the crop.

## MATERIALS AND METHODS

The field experiment was conducted at the Organic Farming Centre, G.B. Pant University of Agriculture and Technology, Pantnagar. It lies in the narrow belt of foot hills of Shivalik range of Himalayas known as *tarai*. Soil of the experiment site had 6.9 pH, high in organic carbon, medium in total and available N and P and high in total and available K. The *kharif* crop okra was sown in the month of June. After harvest of okra, potato has been planted in the month of October then cowpea was sown in March after harvest of potato every year. The experiment was laid out in Randomized Block Design with three replications. Treatments consisted of nine combinations *i.e.* $T_1$- FYM @ 20t/ha, $T_2$-FYM @ 25t/ha, $T_3$- FYM @ 30t/ha, $T_4$- FYM @ 35t/ha, $T_5$- FYM @ 40t/ha, $T_6$-Poultry Manure (PM) @ 5t/ha, $T_7$- PM @7.5t/ha, $T_8$- FYM @ 20t/ha+ Biofertilisers (Azotobacter + Phosphorus Solubilising Bacteria) and $T_9$- Recommended Dose of Fertilizers (RDF). Recommended dose of fertilizers were applied for okra, potato and cowpea (80:60:40, 160:100:120 and 30:60:50 kg N, $P_2O_5$ and $K_2O$ per hectare, respectively). The sources of chemical fertilizers were urea, single super phosphate and muraite of potash for N, $P_2O_5$ and $K_2O$, respectively. According to the need of crop, regular cultural operations were done to raise a healthy crop. To control weeds hand weeding was done according to the need. Neem formulated insecticides and bio-control agents have been used to control insects and disease. The yield was recorded on plot basis and the same was converted into quintal per hectare. The soil samples were analyzed using standard procedure for nitrogen (Subbiah and Asija, 1956), phosphorus (Olsen *et al.,* 1954) and potassium (Hanway and Heidel, 1952).

## Results and Discussion

During initial years of conversion from conventional to organic mode of cultivation yield and available nutrients showed an increasing trend from first year onward in all the crops *viz.* okra, potato and cowpea.

### Impact on Crop Yield

*Okra-* The data pertaining to yield (Table-1) from 2003-04 to 2005-06 showed increasing trend in all the treatments having organic sources of nutrition except $T_9$ *i.e.* recommended dose of fertilizers. During first year highest yield (67.6 q/ha) was obtained in treatment $T_5$- FYM@40t/ha and same trend was found during next two years 77.2 q and 86.9 q, respectively. In all there was about 22.21% increase in the yield of okra crop. Contrary to this the treatment $T_9$ (recommended dose of fertilizers) have not shown any increase in yield during experimental period. The increase in yield was in line with the findings of Somkumar *et al.* (1997).

*Potato-* Organic manures *i.e.* FYM and poultry manure applied to the crop influenced tuber yield during all the three years (Table-1). Tuber yields of potato were recorded significantly higher in treatment $T_5$ (FYM@40t/ha) during all the three consecutive years (225.0 q/ha, 243.8q/ha and 268.1q/ha, respectively). Rainys and Rudokas (2005) also reported that application of FYM @ 40 t/ha gave better yield than the application of lower dose of FYM and recommended dose of chemical fertilizers.

*Cowpea-* Like okra and potato, pod yield in cowpea also increased due to organic treatments applied in the crop from initial year to third year of the experiment but in case of the inorganic fertilizers ($T_9$), the yield was stable from first to third year. The highest yield (55.2q/ha) was observed in treatment $T_9$. In organic treated plots lowest yield (44.7 q) has been recorded in treatment $T_1$ (200q FYM/ha) in third year. The levels of FYM and poultry manure had significant effect on yield in all three years. A similar result of higher pod yield in cowpea by application of FYM was reported by Sharma *et al.,* (2002).

Such increase in yields of okra, potato and cowpea due to FYM has been

**Table 1: Effect of organic manure on crop yield**

| Treatment | Okra (q/ha) | | | Potato (q/ha) | | | Cowpea (q/ha) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2003-04 | 04-05 | 05-06 | 2003-04 | 04-05 | 05-06 | 2003-04 | 04-05 | 05-06 |
| T1 | 56.1 | 62.7 | 67.3 | 172.6 | 197.6 | 218.3 | 35.6 | 39.9 | 44.7 |
| T2 | 58.5 | 64.8 | 70.2 | 186.5 | 202.5 | 227.1 | 37.7 | 41.2 | 46.7 |
| T3 | 60.3 | 67.3 | 74.8 | 194.0 | 216.8 | 230.9 | 40.8 | 45.6 | 51.8 |
| T4 | 62.1 | 69.9 | 77.3 | 212.0 | 236.3 | 251.8 | 44.8 | 50.4 | 56.8 |
| T5 | 67.6 | 77.2 | 86.9 | 225.0 | 243.8 | 268.1 | 50.6 | 56.7 | 62.9 |
| T6 | 62.6 | 65.1 | 69.2 | 177.0 | 193.0 | 208.9 | 39.7 | 42.7 | 44.1 |
| T7 | 65.7 | 69.7 | 74.7 | 188.0 | 205.7 | 211.7 | 43.2 | 47.8 | 49.2 |
| T8 | 70.1 | 73.2 | 77.3 | 201.3 | 214.2 | 231.8 | 43.1 | 47.6 | 50.8 |
| T9 | 80.7 | 81.2 | 80.3 | 230.8 | 228.3 | 225.9 | 55.2 | 54.1 | 55.6 |
| CD at 5% | 6.2 | 5.3 | 6.1 | 8.6 | 7.9 | 7.4 | 2.8 | 2.9 | 2.3 |

reported to be associated with the release of macro and micronutrients during the course of microbial decomposition. Organic matter also functions as source of energy for soil micro flora which brings about the transformation of inorganic nutrients held in soil, manure or applied through fertilizers in a form that is readily utilized by growing plants. The beneficial effects of FYM application are also related to improvement in soil physical properties and availability of sufficient amount of plant nutrients throughout the growth period and especially at critical growth periods of crops resulting superior yield (Sharma *et al.,* 2002).

**Impact on Soil Health**

The results presented in Table-2, 3 and 4 showed that the application of farm yard manure, poultry manure and biofertilizers *viz.*, *Azotobacter* and phosphorus solublising bacteria were useful in maintaining the soil fertility. During the initial year of organic farming, the fertility level of soil *i.e.* organic carbon, available nitrogen, phosphosphorus and potassium content was 0.69-0.72%, 228.0-232.07, 13.0-15.2 and 120.61-123.27 kg per hectare but after three years of experiment, the fertility level in all the organic treatments was improved. But in case of inorganic fertilizers ($T_9$) *i.e.* recommended dose of fertilizers; there was no increase in fertility level. The highest increase in fertility level *i.e.* organic carbon, available nitrogen, phosphosphorus and potassium content have been recorded in treatment $T_5$ (FYM@ 40t/ha) from initial 0.69%, 228 kg/ha, 13.0 kg/ha and 123.02kg/ha, respectively to last year 0.76%, 241.07 kg/ha, 18.03 kg/ha and 128.43 kg/ha, respectively of experiment. The added organic manure *i.e.* FYM has resulted in a substantial increase in organic carbon in post harvest soil, which was clear from the soil analysis (Table-4). Similar increase in organic carbon content due to application of organic manure was reported by Chellamuthu *et al.,* (1988). Organic matter added through FYM, poultry

**Table 2 : Status of nutrients in soil before sowing of okra crop**

| Treatment | 2003-04 | | | | 2004-05 | | | | 2005-06 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) |
| T1 | 0.72 | 230.12 | 14.50 | 121.81 | 0.76 | 243.70 | 17.38 | 126.99 | 0.77 | 250.79 | 22.87 | 132.61 |
| T2 | 0.70 | 232.07 | 15.20 | 123.27 | 0.75 | 245.06 | 18.49 | 128.82 | 0.77 | 250.18 | 22.21 | 134.19 |
| T3 | 0.71 | 228.17 | 14.00 | 120.61 | 0.76 | 243.00 | 18.56 | 128.93 | 0.77 | 255.67 | 22.88 | 135.61 |
| T4 | 0.69 | 229.01 | 13.50 | 122.32 | 0.75 | 245.07 | 18.73 | 129.62 | 0.79 | 256.17 | 23.01 | 136.32 |
| T5 | 0.69 | 228.00 | 13.00 | 123.02 | 0.78 | 247.09 | 19.78 | 130.87 | 0.83 | 260.08 | 24.91 | 139.81 |
| T6 | 0.70 | 231.06 | 14.62 | 122.47 | 0.73 | 242.52 | 19.56 | 128.21 | 0.74 | 249.98 | 20.96 | 132.96 |
| T7 | 0.71 | 232.00 | 14.92 | 120.97 | 0.74 | 243.89 | 17.93 | 128.79 | 0.75 | 251.20 | 21.68 | 133.83 |
| T8 | 0.72 | 228.16 | 14.00 | 122.81 | 0.75 | 242.53 | 17.47 | 128.61 | 0.77 | 249.07 | 21.38 | 132.41 |
| T9 | 0.71 | 229.07 | 15.00 | 121.92 | 0.69 | 246.70 | 17.96 | 126.01 | 0.70 | 257.02 | 20.19 | 130.09 |
| CD at 5% | 0.002 | 1.217 | 0.986 | 0.087 | 0.101 | 1.672 | 0.896 | 0.732 | 0.001 | 1.312 | 1.001 | 1.123 |

**Table 3 : Status of nutrients in soil before sowing of potato**

| Treatment | 2003-04 | | | | 2004-05 | | | | 2005-06 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) |
| T1 | 0.73 | 235.16 | 15.25 | 123.21 | 0.76 | 245.16 | 18.43 | 128.43 | 0.77 | 252.67 | 22.13 | 134.18 |
| T2 | 0.72 | 237.06 | 16.29 | 125.34 | 0.76 | 248.16 | 19.37 | 130.11 | 0.77 | 256.70 | 23.61 | 136.82 |
| T3 | 0.73 | 232.07 | 15.92 | 123.81 | 0.76 | 247.07 | 19.92 | 130.51 | 0.78 | 258.19 | 24.57 | 138.61 |
| T4 | 0.72 | 234.16 | 15.96 | 124.63 | 0.76 | 248.07 | 20.03 | 131.22 | 0.80 | 260.00 | 24.87 | 139.72 |
| T5 | 0.73 | 233.07 | 16.07 | 125.97 | 0.80 | 252.96 | 21.71 | 133.19 | 0.83 | 262.47 | 26.73 | 143.17 |
| T6 | 0.71 | 236.10 | 15.92 | 124.13 | 0.73 | 244.17 | 18.77 | 129.98 | 0.74 | 252.21 | 22.27 | 134.17 |
| T7 | 0.72 | 237.06 | 15.98 | 123.81 | 0.74 | 246.86 | 19.03 | 130.34 | 0.75 | 253.61 | 23.44 | 135.62 |
| T8 | 0.73 | 235.00 | 15.15 | 124.20 | 0.76 | 244.16 | 18.59 | 129.17 | 0.78 | 252.18 | 23.37 | 134.29 |
| T9 | 0.71 | 236.16 | 16.00 | 123.18 | 0.69 | 250.01 | 18.90 | 127.41 | 0.70 | 259.81 | 21.87 | 132.00 |
| CD at 5% | 0.003 | 1.341 | 1.624 | 1.112 | 0.003 | 2.816 | 1.776 | 2.176 | 0.003 | 1.861 | 1.712 | 2.543 |

**Table 4 : Status of nutrients in soil before sowing of cowpea**

| Treatment | 2003-04 | | | | 2004-05 | | | | 2005-06 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) | O.C% | Available N(kg/ha) | Available $P_2O_5$ (kg/ha) | Available $K_2O$ (kg/ha) |
| T1 | 0.74 | 240.10 | 16.07 | 125.69 | 0.76 | 247.62 | 19.67 | 130.14 | 0.77 | 255.11 | 23.81 | 135.96 |
| T2 | 0.73 | 242.07 | 17.09 | 127.13 | 0.76 | 250.72 | 20.92 | 131.77 | 0.77 | 259.37 | 24.89 | 138.27 |
| T3 | 0.75 | 238.00 | 16.83 | 127.18 | 0.76 | 251.00 | 21.13 | 132.43 | 0.79 | 262.12 | 26.08 | 140.21 |
| T4 | 0.73 | 240.01 | 16.92 | 127.34 | 0.77 | 251.72 | 21.67 | 133.01 | 0.81 | 263.14 | 26.89 | 142.46 |
| T5 | 0.76 | 241.07 | 18.03 | 128.43 | 0.81 | 255.16 | 23.16 | 136.01 | 0.85 | 266.81 | 28.57 | 146.53 |
| T6 | 0.72 | 239.20 | 16.40 | 126.18 | 0.73 | 246.14 | 19.81 | 131.23 | 0.74 | 255.44 | 23.61 | 136.53 |
| T7 | 0.73 | 240.00 | 16.67 | 126.83 | 0.74 | 247.16 | 20.33 | 132.17 | 0.75 | 256.91 | 23.98 | 138.03 |
| T8 | 0.74 | 239.10 | 16.12 | 127.18 | 0.76 | 246.19 | 20.01 | 130.62 | 0.78 | 254.81 | 24.81 | 136.08 |
| T9 | 0.70 | 241.00 | 17.28 | 124.81 | 0.69 | 254.17 | 19.68 | 129.30 | 0.69 | 261.34 | 23.86 | 133.63 |
| CD at 5% | 0.002 | 1.214 | 1.516 | 0.896 | 0.003 | 1.752 | 1.300 | 1.789 | 0.003 | 1.081 | 1.001 | 2.610 |

manure and crop residue incorporation improves soil physical, chemical and biological properties for better growth and yield of the crop (Pasricha, 1988). Availability of N, P and K in soil increased substantially when FYM was added in soil. FYM is a good source of nutrients such as NPK and nutrient availability is increased with FYM application which is thought to be due to the action of organic acids released from the organic matter complex. Some of which in addition to influencing pH, form stable complexes or chelated compounds with cations responsible for phosphate fixation (Staford and Pierre, 1953). The use of organic manures increased soil organic carbon by 5.33 to 18.82 per cent, available nitrogen by 9.69 to 14.55 per cent, phosphorus 37.78 to 54.54 per cent and potassium 9.75 to 16.04 per cent. In case of yield, 11.19 to 20.93 per cent, 9.31 to 22.21 per cent and 9.98-21.23 per cent higher yields were recorded under organic mode in potato, okra and cowpea, respectively. From the experimental results it could be concluded that shifting okra-potato-cowpea cultivation from conventional mode to organic mode can increase yield potential by third year. But growing of legume crops in the cropping sequence would be beneficial for accumulating nitrogen and improving the quality of soil.

## REFERENCES

Chhabra, R. and Chhabra, A. 2003. Concept and feasibility of organic farming in Indian Agriculture. *Indian Journal of Ecology*, **30** (2):135:151.

Chellamuthu, S., Kothandaraman G.V. and Duraisamy P. (1988). Effect of farmyard manure and Ammonium Sulphate on the available nutrients of soil. *Madras Agriculture Journal,* **75**:196-199.

Hanway, J.J. and Heidel, H. 1952. Soil analysis methods as used in Lowa State College Soil Testing Laboratory. *Lowa Agriculture*, **57**:131.

Olsen, S.R., Cole, C.V., Waterable, F.S. and Dean, L.A. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. Cric. U.S. Department of Agriculture, 939-941.

Pasricha, N.S. 1998. Integrated nutrient and water management for sustainable crop production In: G.S. Dhaliwal, N.S. Randhawa, R. Arora and A.K. Dhawan (Eds). Ecological Agriculture and sustainable Development, vol I. Indian Ecology society and CRPID. Chandigarh, 321-535.

Rainys, K. and Rudokar, V. (2005). Potato tuber yield and quality as affected by growing conditions and varietals peculiarities. *Zemdirbyste Mokslo Darbai*, **89**:67-80.

Subbiah, B.V. and Asija, G.L. 1956. A rapid procedure for the determination of available nitrogen in soils. *Current Science*, **25**:259-260.

Stanford, G. and W.H. Pierre (1953). In soil and fertilizer phosphorus (Eds). Pieree, W.H. and A.C. Norman Academic Press, New York.

Sharma, S.R., Bhendari, S.C. and Purohit, H.S. (2002). Effect of organic manure and mineral nutrients on nutrient uptake and yield of cowpea. *Environment and Ecology*, **50** (4): 475-480.

Somkumar, R.G., K.G. Mahakal and P.B. Kale (1997). Effect of different levels of nitrogen on growth and yield in okra varieties. *PKV Research Journal*, **21**(1):22-24.

*J. Farming Systems Research & Development* **18** (2) : 296-305 (2012)

# EXPERT SYSTEM: A OUTREACH TOOL FOR AGRICULTURAL EXTENSION

[1]Meenakshi Malik, [2]B. Gangwar, [2]Sunil kumar, [2]Harbir Singh, [2]V.P. Choudhary and [2]Vipin Kumar

[1]*National Centre for Integrated Pest Management (NCIPM), PUSA, New Delhi*
[2] *Project Directorate for Farming systems Research, Modipuram, Meerut*

## Abstract

An expert system uses knowledge specific to a problem domain to provide "expert quality" performance in that application area. An expert system is software that uses a knowledge base of human expertise for problem solving, or to clarify uncertainties where normally one or more human experts would need to be consulted. In agriculture, expert system unite the accumulated expertise of individual disciplines e.g., agronomy, soil science, plant pathology, crop physiology, entomology, horticulture and agricultural meteorology or on various crops such as rice, wheat, maize into a framework that best addresses the specific, on-site needs of farmers. Expert systems combine the experimental and experiential knowledge with the intuitive reasoning skills of a multitude of specialists to aid farmers in making the best decisions for their crops. This paper deals with the concept and importance of expert system in general and web enabled expert system in Agricultural domain in particular and also problems and prospects of its development.

**Keywords:** "Expert System, Agricultural Technology, Knowledge dissemination, System diagnosis, Extension, System design"

## Introduction

Agriculture is one of the important sectors determining economy of any country. The dynamics of agriculture in 21$^{st}$ century is very much realized. Through the improved cultivars, improved resistant/tolerant genotypes to biotic and abiotic stresses, improved resource efficiency and better quality characteristics. With advancement in crop biology the other spheres of agriculture has also advanced. Use of advanced information technology and telecommunication has eased the way of information gathering and dissemination and has direct relevance to agriculture extension.

Many specializations of agriculture *viz.*, includes crop improvement, crop production, crop protection, natural resource management and social sciences aced to be amalgamated for an effective and efficient practice of technological innovations at farm level[1]. Expertise in each field is necessary for a profitable agriculture enterprise. For a farmer agriculture is profitable if he makes the right decision at right time. The availability of information at right time, on weather, inputs and marketing, is as important as the inputs. There is a need to make a flow of information and knowledge from all sources to farmer to make appropriate decision[2]. Expert system is a powerful tool and viable solution for accelerated information dissemination.

Expert system provides expert advice to farmers on various crop production operations *viz.* variety selection, field preparation, fertilizer application, schedule of irrigation and crop protection. It can provide solution to the problems faced by the farmers through online queries. The inbuilt information in the expert system will help farmers to choose production practices and in identifying insect/pest infestation and recommend the best suited crop protection measure. The expert system delivers expert advice and directions based on the information available from experts. Expert systems are most valuable to organizations that have a high-level of know-how experience and expertise that cannot be easily transferred to other members[3]. They are designed to carry the intelligence and information found in the intellect of experts and provide this knowledge to other members of the organization for problem-solving purpose[4].

The expert system can be used as a stand alone advisory system for the specific knowledge domain perhaps with monitoring by a human expert. It also can provide decision support for a high-level human expert. The agriculture expert system allows a high-level expert to be replaced by a subordinate expert aided by the expert system. The expert system made accessible by extension machinery aids in dissemination of seed based actions to the farmers and can produce a high quality product benefitting themselves and other subsidiary stakeholders.

## Structure of Expert Systems

Expert systems typically have several components and it uses all these components to solve a specific problem. The knowledge base is the component that contains the knowledge obtained from the domain expert. Normally the way of representing knowledge is using rules. The inference engine is the component that manipulates the knowledge found in the knowledge base as needed to arrive at a result or solution. The user interface is the component that allows the user to query the system and receive the results of those queries [5]. Many ES's also have an explanation. Various components and interconnection in an expert system are (figure 1)

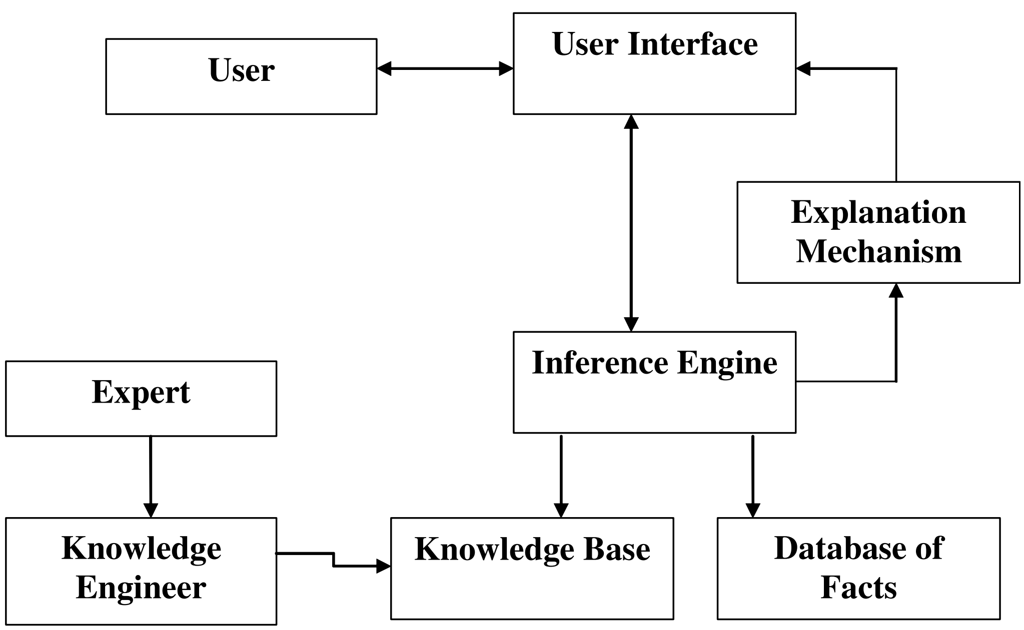



**Fig.1.The diagram shows how these components interact to provide solutions for problems requiring a high level of expertise in a specific domain.**

- **Database of Facts**

A knowledge base contains information relating to specific problem or about how to solve a particular problem, in the form of facts and rules. This component of expert system is developed with assistance from at least one human domain expert[6]. Facts of the domain are the information widely and generally available within the domain.

- **Knowledge base**

That part of the program in which the knowledge is stored, using some method of representation, such as rules. It consists of facts, theorems, cases, forms, texts, graphics, spreadsheets, principles and rules that experts use to solve a problem. The information in a knowledge base comes from many sources such as human experts, books, journals, database & others. Managers also can gain knowledge from observation, formal and informal interviews & questionnaires. This is known as knowledge acquisition.

- **Inference Engine**

The inference engine is similar to the reasoning of the human brain. Also known as the "Inference Mechanism," this controls the reasoning operations of the expert system. This is the part of the program that deals with making assertions, hypotheses, and conclusions[7]. It is through the inference mechanism that the reasoning strategy (or method of solution) is controlled.

- **Explanation Mechanism**

Explanation module provides explanation of expert system reasoning and decision. This is important for validation and understanding of the solution and reasoning process of the expert system.

- **Forward and Backward Chaining**

The two popular reasoning possesses that an expert system uses are forward and backward chaining. In forward chaining, the inference engine begins with a set of known facts, analyze the data and looks for solution that match the data set[8]. In backward chaining the inference engine begins with a goal and search for data facts and other evidence and support in goal.

## DESIGN TECHNIQUE / METHODOLOGY

The general methodology for expert system is depicted in fig.2. The main elements in the design techniques are identification phase, conceptualization phase, formalization, system design & development, testing/evaluation and prototype revision phase[9].

- **Identification phase**

It is the definition phase which identifies the problem. To identify, characterize and define the problem is the objective of Identification phase. After defining the problem the necessary resources, goals and objectives are identified.

- **Conceptualization phase**

The second stage of ES development, conceptualization, involves designing the proposed program to ensure that specific interactions and relationships in the problem domain are understood and defined [10]. Relationships between objects and processes and control mechanisms are determined as key concepts. This is the initial stage of knowledge acquisition. It involves the specific characterization of the situation and determines the expertise needed for the solution of problem.

• **Formalization Phase**

The formalization phase involves organizing the concepts, subproblems and information flow into the formal representations. To identify a domain with a collection of all possible solutions, the hypothetical solution space, the underlying model, and the characteristics of the data are the key objectives. It is difficult to separate the conceptualization phase from the formalization phase and, in reality, knowledge-base design proceeds almost in parallel with knowledge acquisition [11]. The two items that are the most important in the formalization stage are: (1) refinement of the knowledge pieces into their specific relationships and hierarchy and (2) more accurate determination of the expected user interaction with the system.

• **System design phase**

Identification of design blocks, determination of storage devices, detail design block specifications are the three phases in the system design phase. During the system design phase, the designer specifies how the system will meet the requirements identified during the previous three phases of the development [12].

• **System development phase**

The expert system is created during the system development stage with the design created during the System design phase.

• **Testing and evaluation phase**

Testing is the most important part of the expert system. During this phase, the prototype system is evaluated. Whether the Expert System is meeting the requirements of the designer/user is evaluated in the phase [13]. Perhaps the most difficult aspect of testing is accurately handling the uncertainty that is incorporated in most ES in one way or another.

• **Prototype revision phase**

An expert system evolves over time, calling for almost constant revision, a trait expert systems share with most prototypes. Based on the results of the testing/evaluation phase, concepts and relations are refined, the solution space, the model, and the data characteristics are renormalized, and the system is redesigned.

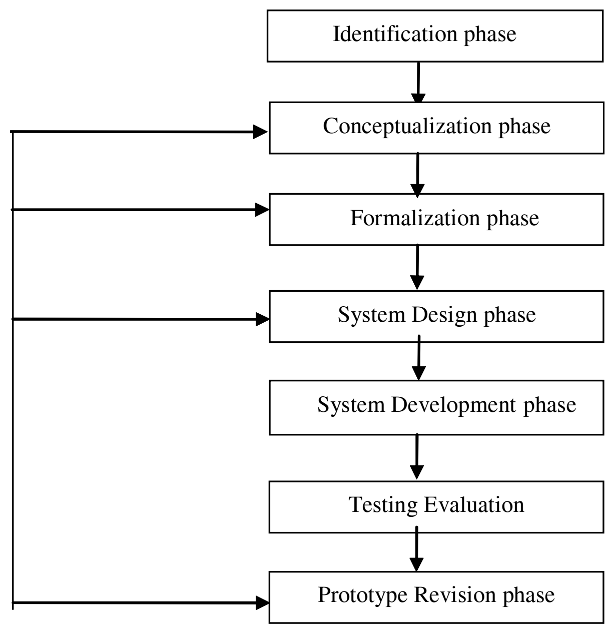



**Figure 2. The steps in a typical expert systems analysis and design methodology.**

## Characteristics of Agricultural Expert System

Expert systems technologies have bewildered many outsiders (such as engineers and technical specialists who do not specialize in artificial intelligence). This is, in part, because of the use of complex terminology and unclear definitions [14]. To establish a common base of understanding, some definitions are suggested here (Finn,1989)

- It simulates human reasoning about a problem domain, rather than simulating the domain itself.
- It solves the problem by heuristic or approximate methods.
- Expert system unlike Decision support system can replace the decision maker.
- An expert system is a software program that captures the knowledge and problem solving skills of a human expert.

BENEFITS & LIMITATIONS OF AN EXPERT

Expert system provides a great deal of advantages to research organization involved in technology development and extension. The technology developers will know the real time problems faced by farmers which will lead to continuous improvement of technology. The expert system is the bridge between the researchers and farmers. The expert system is not a substitute for extension workers rather it will facilitate extension to target the technology to be transferred or improved [15]. The system acts online hence every time presence of human expert is not required. This is an added advantage because in absence of expert still the expertise is available for service. The queries can be saved which will act as a database to asses the impact of any technology. The results are replicable which will enable the stakeholder to review the results many a time. The systematized system will be of great help to the end user in finding relevant information.

Compared to traditional programming techniques, expert-system approaches provide the added flexibility (and hence easier modifiability) with the ability to model rules as data rather than as code. In situations where an organization's IT department is overwhelmed by a software-development backlog, rule-engines, by facilitating turnaround, provide a means that can allow organizations to adapt more readily to changing needs.

In practice, modern expert-system technology is employed as an adjunct to traditional programming techniques, and this hybrid approach allows the combination of the strengths of both approaches [16]. Thus, rule engines allow control through programs (and user interfaces) written in a traditional language, and also incorporate necessary functionality such as inter-operability with existing database technology.

The system however has many theoretical benefits but still a small number of expert systems are available [17]. This system has few limitations which are follows. An integrated and targeted high level of effort is required to build knowledge base, rule base, and or geographical setting within the expert system. There is need to customize expert systems for each organization which is more cumbersome. The expert system team needs computer hardware and skilled personnel to handle hardware and software. There is need to develop system for performing algorithmic problem solving tasks. The other problems associated with are technical and are very important with respect to user and developer.

- Garbage In, Garbage Out: The Garbage In, Garbage Out (GIGO) phenomenon: A system that uses expert-system technology provides no guarantee about the quality of the rules on which it operates [18]. All self-designated "experts" are not necessarily so, and one notable challenge in expert system design is in getting a system to recognize the limits to its knowledge.

- Errors in making logical decision making: Expert systems are notoriously narrow in their domain of knowledge. They sometimes repeatedly give the same results whereas the real time problem may be more complex. Additionally, once some of the mystique had worn off, most programmers realized that simple expert systems were essentially just slightly more elaborate versions of the decision logic they had already been using. Therefore, some of the techniques of expert systems can now be found in most complex programs without drawing much recognition.
- Considerable knowledge is required for an expert system as rule-based approach is not optimal for all problems
- Ease of rule creation and rule modification can be double-edged. A system can be sabotaged by a non-knowledgeable user who can easily add worthless rules or rules that conflict with existing ones [19]. Reasons for the failure of many systems include the absence of facilities for system audit, detection of possible conflict, testing before deployment.

### Challenges Related to Sharing, Exchanging and Disseminating Knowledge and Technologies

The first challenge is the poor mechanisms and infrastructure for sharing and exchanging agriculture knowledge generated from research at national and regional levels. In this regard initiatives are taken up to develop information system. P3is-2 is an information system developed by NCIPM which is aimed to make database of all plant protection personnel under NARS (ICAR), State Agriculture Universities, State Agriculture Departments, Krishi Vighyan Kendras. This will bring all plant protection personnel on one platform. But still, such information systems are in their infancy. Then, it is very difficult to reach the farmers. Many research activities are repeated due to the lack of such mechanisms and infrastructure at the national level[21]. The second challenge is inefficient mechanisms and infrastructure for transferring technologies, produced as the result of research. Knowledge and technologies fostering agricultural production and environment conservation are examples. The third challenge is the recording and maintaining indigenous as a heritage for new generation. It is accumulated knowledge of ages remained with the very few practicing them. The fourth challenge is to integrate economic and social knowledge to different stakeholders at operational, management and decision-making levels.

### Possibilities of Expert System in Agriculture

Amongst the difficulties of applying scientifically obtained research results to practical problems is the emphasis on representing those results in a standard scientific form (i.e. as a process model) rather than in a form suited to managers. Recent products from research into artificial intelligence have provided an alternative approach to representing knowledge suitable for management purposes; these products, expert systems, consist essentially of two parts, a knowledge base and an inference engine. The former contains accumulated knowledge about a particular management problem, whilst the latter consists of an inferencing mechanism used to search for relevant knowledge in order to suggest solutions [22]. Expert systems have now been applied in a number of fields, including agriculture, and guidelines on the problem types to which they are well-suited are now emerging from the applications.

It is no different with other Expert System, the Expert System for Agriculture is same as others knowledge based system, its use the rule based which the experience and knowledge of a human expert is captured in the form of IF-THEN rules and facts which are used to solve problems by answering questions typed at a keyboard attached to a computer on such diversified topics, for example, in pest control, the need to spray, selection of a chemical to spray, mixing and application, optimal machinery management practices, weather damage recovery such as freeze, frost or drought, etc. It gives results for the key words used in the search string [23]. The expert system in agriculture for various crops can be developed. Various Expert systems have been developed by the institutes of ICAR.

**1. Expert system on wheat crop management (EXOWHEM)**

Indian Agricultural Statistics Research Institute (IASRI) has developed an Expert System on Wheat Crop Management System (EXOWHEM) to solve the problems faced by a farmer at remote places where the services of the expert is not always available. It is an integrated system that addresses all aspects of wheat crop management and to diagnose pests and diseases for wheat crop and suggest preventive/curative measures as Wheat is a major cereal crop and India is one of the main wheat producing and consuming countries of the world.

**2. Expert System on Pulses (PulsExpert)**

PulsExpert is a web based expert system developed by IIPR, Kanpur for the four major pulse crops namely Chickpea, Pigeonpea, Mungbean and Urdbean. It is available at *(http://www.iipr.res.in/pulseexpert/home_page.asp).* The PulsExpert emulates the interaction a user might have with a human expert to solve a problem and incorporates all the modern features like knowledge acquisition from multiple experts, knowledge retrieval, feedback from users and farmers. The PulsExpert contains up to date information related to diagnosis the disease and to identify insects affecting the crops and suggesting preventive and control measures.

**3. Grape Cultivation**

Indian Institute of Horticultural Research Institute, Bangalore developed an expert system for the grape cultivators to help the Agricultural field personnel to give timely and correct advice to the farmers [24]. It determines the best strategy for required at certain times by the farmer.

**4. Expert System on Seed Spices (EXPSS)**

EXPSS is a web based Expert System developed on Seed Spices by IASRI(). The EXPSS covers 10 Seed Spices namely Ajwain, Anise, Caraway, Cumin, Celery, Coriander, Dil, Fennel, Fenugreek, Nigella and provides complete information about about seed management. It guides farmers to diagnose pests and diseases for Seed Species and suggest preventive/curative measures. Solving online Query is one most important feature of EXPSS.

**5. Expert System on Maize (AgriDaksh)**

AgriDaksh is available online through

IASRI web site http://www.iasri.res.in or through a direct link http://expert.iasri.res.in/agridaksh/. AgriDaksh is created by DMR. Basically it has five parameters i.e. Variety Selection, Cultural Practices, Disease Diagnosis, Insect Identification, and Post Harvest Technology. AgriDaksh find extensive use in the areas of fertilizer application, crop protection, irrigation scheduling and diagnosis of diseases in Maize.

### 6. Expert System on Extension (ESE)

ESE is developed by IASRI and can be accessed through link (*http://iasri.res.in:8081/krishisamadhan/index.html*) ESE is helpful when the extension workers is unable to advice the farmer at several times then there is a great need for an knowledge based system, which may provide suitable information looking some basic needs and resources of the farmers.

## Conclusion

The agriculture expert system helps the farmers to do single point decisions, which to have a well planning for before start to do anything on their land. Expert system can also be helpful in suggesting a sequence of tactical decisions throughout a production cycle such as plant protection and nutrition decisions, livestock feeding etc[25]. The main purposes for the rise of the expert system are as a delivery system for extension information, to provide management education for decision makers (farmers), and for dissemination of up-to-date scientific information in a readily accessible and easily understood form, to agricultural researchers, advisers and farmers [26]. By the help of the expert system, the farmers can produce a more high quality product to the citizen. Expert system in agriculture, education, environmental management and medicine had been through a tremendous phases from simple expert system to the complex multipurpose systems. Implementation of expert system in such fields is greatly influenced by techniques and methods from adaptive hypertext and hypermedia [27]. Focus on expert system would prove to be a boon to Indian agriculture.

## References

Islam S. N., Farooqi M. S., Agarwal H. O. Expert Systems: A boon for farming community. Agricultural Extension Review. Jan-Feb, 2005, 3-6

Brian G Leib, Todd V Elliott, Gary Matthews; 2001; WISE: A web-linked and producer oriented program for irrigation scheduling; Computer and Electronics in Agriculture, Elsevier; 33 (2001) 1-6

Salah K, Rafea M, Rafea A; 1998; KROL: A Knowledge Representation Object Lunguage on Top of Prolog; Expert Systems with Applications – An International Journal; Vol 14(4); Elsevier Science Ltd

Lemmon, H. (1986). COMAX: An expert system for cotton crop management. Science 233:29-33.

Jones, E., Roydhouse, A. (1995). Intelligent Retrieval of Archived Meteorological Data, IEEE Expert, 10(6): 50-57.

Schulthess,U. et.al. (1996). NEPER-Weed: A Picture-Based Expert System for Weed Identification. Agron. J. 88: 423-427.

Gillard, P.: PCAI magazine. Expert System used to disseminate Complex Information in Agriculture and Horticulture, Knowledge Technology Inc. July/August, 1998.

[8] Kamel, A., Schroeder, K., Sticklen, J., Rafea,A., Salah,A., Schulthess,U., Ward, R. and Ritchie, J. (1994). Integrated Wheat Crop Management System Based on Generic Task Knowledge Based Systems and CERES Numerical Simulation. AI Applications.

Jay Liebowitz (1989) Expert systems technology for training applications, Educational Technology Volume 29 , Issue 7 Pages: 43 – 47.

Hayes-Roth, F., Waterman, D. A., and Lenat, D. B., Building Expert Systems, Addison-Wesley, Reading, MA, 1983.

Waterman, D. A., A Guide to Expert Systems, Addison-Wesley, Reading, MA, 1986.

Shaalan Khaled, El-Badry Mona, Rafea Ahmed; 2004; A multiagent approach for diagnostic expert systems via the internet; Expert Systems with Applications 2 (2004) 1-10

Harmon, P. and King, D., Expert Systems: Artificial Intelligence in Business, John Wiley & Sons, Inc., New York, 1985.

Dorn Jurgen, Frenz Mitterbock; Acquisition and Representation of Knowledge for the FOREX Expert System; Institut for Informations systeme, Technische Universitat Wien, Paniglgasse

Rafea A, Edrees S, El-Azhari S, Mahmoud M; 1994; A Development Methodology for Agricultural Expert Systems based on KADS; Proceedings of the Second World Congress on Expert Systems; January, 1994

Rafea A, Shaalan K; 1996; Using Expert Systems as a Training Tool in the Agriculture Sector in Egypt; Expert Systems with Applications – An International Journal; Vol 12(12) Pergamon

Weis, S.M. and Kulikowasaki,C.A.,A practical guide to designing expert system:, Rowman and Allanheld NJ, USA 1984.

http://en.wikipedia.org/wiki/Expert_system

http://en.wikipedia.org/wiki/Expert_system

Rafea Mahmoud; A Case-based Collaborative Knowledge acquisition Tool; Central Laboratory for Agricultural Expert System, Egypt

Mohan, S., Arumugam, N. (1995). An intelligent front-end for selecting evapotranspiration estimation methods. Computers and electronics in agriculture 12(4): 295-309.

Chandrasekaran B; 1998; Generic tasks as building blocks for knowledge-based system: the diagnosis and routine design examples, The Knowledge Engineering Review; 3(3), 183-210

Rafea, A., El-Azhari, S., Ibramim, I., Edrees, S., Mahmoud, M.; 1995; Experience with the Development and Deployment of Expert Systems in Agriculture; Proceedings of IAAI-95 conference, Montreal- Canada

Goyal R.C. Priorities in Computer Application in Agriculture Research. Proceedings of the XV National Conference on National Priorities in Agricultural Statistics and Computer Application, Birsa Agricultural University, Kanke, Ranchi, Jharkhand.2007

Gerevini, A., Perini, A., Ricci, F., Forti, D., Ioratti, C., Mattedi, l.(1992). POMI: An Expert System for Integrated Pest Management of Apple Orchards, AI Applications, 6(3):

Rafea A, El-Azhari S, Hassan E; Integrating Multimedia with Expert Systems for Crop Production Management; Central Laboratory for Agricultural Expert System, Egypt

Wielinga B J, Velde W Van de, Schreiber A Th, Akkermans J M, Simmons Reid; Second Generation Expert Systems, pages 299-335; Springer-Verlag, Berlin- Heidelberg, Germany 1993.

*J. Farming Systems Research & Development* **18** (2) : 306-313 (2012)

# STUDIES ON YIELD AND ECONOMICS IN SUGARCANE BASED INTER CROPPING SYSTEMS

N. Ramesh[1] and A. Sundari[2]

*Department of Agronomy, Faculty of Agriculture*
*Annamalai University, Annamalai Nagar – 608 002.*

## Abstract

Field experiment was conducted at Annamalai University Experimental Farm, Annamalai Nagar to investigate the suitable intercrops in sugarcane.The growth, yield components and yield of intercrops were high in all intercropping system except sunflower. The least observation was recorded under sugarcane + sunflower. However among pulses sugarcane + blackgram intercropping system produced the highest sugarcane equivalent yield of 132.66 t $ha^{-1}$ and among oilseeds sugarcane + sesame produced sugarcane equivalent yield of 112.61 t $ha^{-1}$. The least sugarcane equivalent yield of 92.72 t $ha^{-1}$ was registered under sugarcane + sunflower intercropping system. The highest land equivalent ratio of 1.32 and income equivalent ratio of 1.41 was recorded under sugarcane + blackgram intercropping system in case of pulses. Among oilseeds the highest LER and IER was registered under sugarcane + sesame intercropping system. The highest net income of Rs. 80,481 and cost benefit ratio of 2.45 was recorded by sugarcane + blackgram intercropping system, this was followed by sugarcane + cowpea and among oil seeds sugarcane + sesame recorded the highest net return and cost benefit ratio of Rs. 60,330 and cost benefit ratio of 2.09.

**Keywords**: Intercrop, yield, sugarcane equivalent yield, land equivalent ratio and Income equivalent ratio

## Introduction

In worldwide sugarcane occupies an area of 20.1 million hectares with a total production of 1318.1 million tonnes and productivity of 65.5 tonnes per hectare (Yadav *et al.,* 2005). Sugarcane is the leading cash crop of India, with an area of 4.20 million hectares and cane production of 281.17 million tonnes. It covers 4.20 per cent of the total gross cropped area. In Tamilnadu, it is cultivated over an area of 0.34 million hectares with an annual production of 35.11 million tonnes (Agricultural Statistics, 2011). Since sugarcane is cultivated in row-planting with a minimum spacing of 90 cm between rows, there is adequate interspacing available for easy intercropping. Further during the initial period of 90-100 days, the rate of growth of cane is slow and the foliar canopy does not cover the interspace fully. Under this situation, the crop-weed competition is very acute, necessitating frequent manual weeding or application of large doses of chemical herbicides at high costs which in the long run may impair environment and soil health very badly. Intercropping not only given additional yield and economizes sugarcane cultivation but also suppress weed growth and their interaction. Intercropping can go a long way in economizing sugarcane cultivation with additional yields and their smothering effect on weeds though it invites careful selection of weed management option (Sundara, 2004). Pulses and oil seeds may be suitably intercropped with sugarcane when the growth of main crop is slow, resulted in the higher return. The intercrops

[1] Assistant Professor [2]Professor

economically and efficiently utilize the nutrients and radiant light energy till the initiation of vigour and grand growth of sugarcane. Therefore, the present investigation was carried out to assess the performance of intercrops in sugarcane.

## Materials and Methods

Field experiment was conducted to study intercrop for sugarcane for higher production and profit. The experiment was laid out in Randomized Block Design with seven treatments and replicated thrice. The treatments details were $T_{1:}$ Sole sugarcane, $T_{2:}$ sugarcane+ black gram, $T_{3:}$ sugarcane+ cow pea, $T_{4:}$ sugarcane+ green gram, $T_{5:}$ sugarcane+ sunflower, $T_{6:}$ sugarcane+ sesamum and $T_{7:}$ sugarcane+ groundnut. The field was divided into three strips of which one was left without any disturbance after sugarcane planting (control). In sole sugarcane crop, sugarcane was allowed to grow without any control measure. Whereas in intercropping treatments, two rows of intercrops *viz.*, blackgram, cowpea, greengram, sunflower, sesame and groundnut were dibbled three days after planting in between sugarcane inter rows after proper spacing. Disease free seven months old two budded sugarcane setts were selected from the nursery and planted at the rate of 75,000 setts $ha^{-1}$.

Blackgram, greengram, sunflower, groundnut, cowpea and sesame were dibbled in row by hand at 2 seeds per hill at a spacing of 30 × 10, 30 × 10, 30 × 10, 30 × 10 and 30 × 15 and 30 × 30 cm, respectively three days after planting at a depth of 3 cm in between sugarcane inter rows. Fertilizer application was done as per the recommended dose of 275, 62.50 and 112.5 kg $ha^{-1}$ of N, $P_2O_5$ and $K_2O$, respectively

The sugarcane equivalent yield was calculated with the help of formula for each plot (Thakur, 1994).

$$\text{Sugarcane equivalent yield} = \frac{\text{Yield of intercrop}}{\text{Market price of sugarcane (Rs/q)}} \times \text{Market price of intercrop (Rs/q)}$$

The land equivalent ratio was calculated with the help of the formula (Balasubramaniyan and Palaniappan, 2001).

$$\text{LER} = \sum_{i=1}^{n} \frac{Y_{ab}}{Y_{aa}} + \frac{Y_{ba}}{Y_{bb}}$$

where,

$Y_{ab}$ - Yield of crop 'a' in intercropping

$Y_{ba}$ - Yield of crop 'b' in intercropping

$Y_{aa}$ - Yield of crop 'a' in pure stand

$Y_{bb}$ - Yield of crop 'b' in pure stand

**Income equivalent ratio (IER):** It was worked out as suggested by Reddy (1986)

$$\text{IER} = \frac{\text{Income from intercropping ha}^{-1}}{\text{Income from sole cropping ha}^{-1}}$$

## Result and Discussion

### Sugarcane growth as influenced by intercropping systems

All the sugarcane intercropping systems had significant impact on Germination percentage, Number of tillers at 90 DAP, economic shoot count (Table 1) at 210 DAP. With respect to pulses as intercrop, the sugarcane + blackgram recorded the highest number of 57 percent of germination,1,84,700 tillers $ha^{-1}$ and1,56,600 $ha^{-1}$ economic shoot count. It was followed by sugarcane + cowpea. This was closely followed by sugarcane + greengram. Among oilseeds sugarcane + sesame

**Table1 : Effect of intercropping systems on Germination (Per cent), No of tillers 90DAP ('000 $ha^{-1}$) Economic shoot count ('000 $ha^{-1}$) at 210 DAP cane length (cm), cane diameter (cm), number of internodes $cane^{-1}$, number of millable cane ('000 $ha^{-1}$) and individual cane weight (kg)**

| Treatments | Germination (Per cent) | No of tillers 90DAP ('000 $ha^{-1}$) | Economic shoot count ('000 $ha^{-1}$) at 210 DAP | Cane length (cm) | Cane diameter (cm) | No of internodes $cane^{-1}$ | Number of millable cane ('000 $ha^{-1}$) | Individual cane weight (kg) |
|---|---|---|---|---|---|---|---|---|
| $T_1$ - Sole sugarcane | 55.66 | 132.70 | 117.20 | 206.80 | 1.82 | 21.60 | 85.30 | 0.86 |
| $T_2$ - Sugarcane + blackgram | 57.00 | 184.70 | 156.60 | 288.50 | 2.99 | 29.10 | 132.80 | 1.52 |
| $T_3$ - Sugarcane + cowpea | 57.00 | 174.10 | 148.20 | 272.41 | 2.78 | 27.50 | 124.80 | 1.40 |
| $T_4$ - Sugarcane + greengram | 57.00 | 165.30 | 140.30 | 257.10 | 2.54 | 26.20 | 113.60 | 1.25 |
| $T_5$ - Sugarcane + sunflower | 55.66 | 123.40 | 107.70 | 190.60 | 1.58 | 20.20 | 73.50 | 0.72 |
| $T_6$ - Sugarcane + sesame | 57.00 | 154.30 | 132.20 | 240.25 | 2.31 | 24.80 | 104.50 | 1.12 |
| $T_7$ - Sugarcane + groundnut | 56.00 | 143.70 | 124.60 | 224.80 | 2.07 | 23.20 | 94.50 | 1.00 |
| General mean | 56.47 | 154.03 | 132.40 | 240.07 | 2.30 | 24.66 | 104.04 | 1.12 |
| $SE_D$ | 1.20 | 3.46 | 2.91 | 6.47 | 0.08 | 0.50 | 3.29 | 0.05 |
| CD (p = 0.05) | NS | 8.07 | 6.66 | 14.95 | 0.18 | 1.11 | 7.92 | 0.11 |

produced the highest number of 57 percent of germination,1,84,700 tillers $ha^{-1}$ and1,56,600 $ha^{-1}$ economic shoot count and the lowest values was recorded by sugarcane + sunflower. Taller plants of sugarcane was obtained in association with blackgram due to complementary interaction between base crop of sugarcane This is in conformity with the findings of Kannappan and Ramaswami (1995).Sugarcane + blackgram enhanced the tiller production by 49.67 per cent over the sole sugarcane and this may be due to the additive effect of reduced competition of weeds in the plant crop for moisture, nutrient, light and an encouraged higher uptake of the nutrients by the crop to produce more tillers and this has increased economic shoot count. Also similar results are reported by Roodagi *et al.* (2001a) and Marimuthu *et al.* (2003).

**Crop yield parameters and yield influenced by intercropping systems**

The sugarcane yield parameters *viz.,* cane length, cane diameter, number of internodes, number of millable cane and individual cane weight (Table 1) were significantly influenced by the various intercropping systems. Among the intercropping system, sugarcane + blackgram significantly increased all the yield parameters. The reason attributed for the increase in these characters in the above treatments may be effective control of weeds there by increased LAI, plant height, DMP, number of tillers and economic shoot count which were directly involved in increasing yield attributes. Finally number of millable cane, which is one of the important yield attributes in determining the final yield of sugarcane.The imposition of the tillage practices mainly altered the NMC to an appreciable level. The increased NMC as well as higher number of tiller production and ESC might be due to effective control of weeds. Similar results were also obtained by Kannappan and Ramaswami (1995).This was followed by sugarcane + cowpea and next in order was sugarcane + greengram and sugarcane + sesame. The sugarcane + sunflower remained to be for behind than the other treatments by recording the least number of NMC.

**Table 2 : Effect of intercropping systems on cane ,sugar yield and intercrop yield (t $ha^{-1}$)**

| Treatments | Cane yield (t $ha^{-1}$) | Sugar yield (t $ha^{-1}$) | Yield kg $ha^{-1}$ (intercrop) |
|---|---|---|---|
| $T_1$ - Sole sugarcane | 92.5 | 11.19 | - |
| $T_2$ - Sugarcane + blackgram | 121.8 | 15.02 | 348 |
| $T_3$ - Sugarcane + cowpea | 116.3 | 14.27 | 301 |
| $T_4$ - Sugarcane + greengram | 110.1 | 13.43 | 326 |
| $T_5$ - Sugarcane + sunflower | 86.5 | 10.41 | 354 |
| $T_6$ - Sugarcane + sesame | 104.7 | 12.71 | 312 |
| $T_7$ - Sugarcane + groundnut | 98.5 | 11.92 | 447 |
| General mean | 104.34 | 12.71 | - |
| $SE_D$ | 2.05 | 0.28 | - |
| CD (p = 0.05) | 4.74 | 0.66 | - |

**Yield**

The cane yield and sugar yield (Table 2) were significantly altered by various intercropping systems. The sugarcane + blackgram proved its superiority by recording 121.8 and 15.02 t $ha^{-1}$ of cane and sugar yield, respectively. This increased yield may be attributed to the reduced weed population, weed dry matter production, nutrient uptake and there by minimizing the deleterious effect of weeds resulted to the higher LAI, DMP, yield attributes and finally the yield. The results are in corroboration with the findings of Marimuthu *et al.* (2003). This was followed by sugarcane + cowpea. Similar results were obtained by Roodagi *et al.* (2001a and b).

Next in order was sugarcane + greengram and sugarcane + sesame and similar results were obtained by Sinha *et al.* (1994) and Kamruzzaman .M and Hasanuzzaman.M (2007)

The lowest yield was recorded in sugarcane + sunflower intercropping system. The reduction in cane yield with sunflower intercropping might be due to detrimental effect that is high molecular weight allelopathic compounds excreted by sunflower roots which immobilized nutrients and resulted in poor plant growth. These results are corroborate with the findings of Kathiresan and Rajasekaran (1990); Ahmed *et al.* (1990); Singh and Chauhan (1998).

**Performance of intercrops in intercropping situation**

The intercrops *viz.,* blackgram, cowpea, greengram, sunflower, sesame and groundnut recorded the grain yield of 348, 301, 326, 354, 312 and 447 kg $ha^{-1}$, respectively. Among the intercrops higher blackgram yield was recorded by Sanjay Kumar *et al.* (2005) lend to support the present findings.

**Sugarcane equivalent yield, land equivalent ratio and Income equivalent ratio (Table 3)**

Regarding pulses as intercrop, the increased sugarcane equivalent yield of 132.66 t $ha^{-1}$ was recorded in sugarcane + blackgram intercropping system. This was followed by sugarcane + cowpea

**Table 3 : Effect of intercropping systems on sugarcane equivalent yield, land equivalent ratio and income equivalent ratio**

| Treatments | Sugarcane yield (t $ha^{-1}$) | Intercrop yield (t $ha^{-1}$) | Sugarcane equivalent yield (t $ha^{-1}$) | Land equivalent ratio | Income equivalent ratio |
|---|---|---|---|---|---|
| $T_1$ - Sole sugarcane | 92.50 | - | - | 1.00 | - |
| $T_2$ - Sugarcane + blackgram | 121.8 | 0.348 | 132.66 | 1.45 | 1.32 |
| $T_3$ - Sugarcane + cowpea | 116.3 | 0.301 | 122.17 | 1.42 | 1.26 |
| $T_4$ - Sugarcane + greengram | 110.1 | 0.326 | 117.10 | 1.40 | 1.19 |
| $T_5$ - Sugarcane + sunflower | 86.50 | 0.354 | 92.72 | 1.24 | 0.94 |
| $T_6$ - Sugarcane + sesame | 104.7 | 0.312 | 112.61 | 1.44 | 1.13 |
| $T_7$ - Sugarcane + groundnut | 98.5 | 0.447 | 105.48 | 1.38 | 1.06 |

which recorded sugarcane equivalent yield of 122.17 t $ha^{-1}$. Whereas among oilseeds as intercrop, sugarcane + sesame recorded the highest sugarcane equivalent yield of 112.61 t $ha^{-1}$. The lowest sugarcane equivalent yield of 92.72 t $ha^{-1}$ was recorded in sugarcane + sunflower intercropping system. Land equivalent ratio (LER) was calculated for assessing the intercropping advantages. Among the pulses intercropping system, the highest LER was recorded in sugarcane + blackgram intercropping system (1.45). This was followed by sugarcane + cowpea which recorded LER of 1.42. Sugarcane + sesame recorded the highest LER of 1.44 and the least LER of 1.24 was recorded in sugarcane + sunflower intercropping system. Gulshan Mahajan *et al.* (2004) and Naik *et al.* (2008) recorded higher sugarcane equivalent yield in sugarcane + blackgram intercropping system.With respect to pulses as intercrop, sugarcane + blackgram recorded the highest IER of 1.32. The sugarcane + cowpea was the next best in order. Among oilseeds as intercrop, sugarcane + sesame recorded the highest IER of 1.13. The least IER of 1.06 was recorded in sugarcane + sunflower intercropping system.

## Economics

Among the various sugarcane intercropping systems, sugarcane + blackgram(Table 4) registered the highest gross income of Rs. 1,35,981, the highest net income of Rs. 80,481 and the highest cost benefit ratio (2.45). This was followed by sugarcane + cowpea which recorded the gross income of Rs. 1,25,228, net income of Rs. 70,128 and cost benefit ratio of 2.27. Sugarcane + sesame recorded the CBR of 2.09. The sugarcane + sunflower treatment. This might be due to increasing magnitude of competition by unrestricted weed growth affecting the performance of the crop. Kathiresan and Ramadoss (2005)and Namadeva Shinde, *et al.*,(2009) observed that blackgram intercropped cane recorded the highest economic value thereby increasing the total value and cost benefit ratio lend to support the present findings. Among the intercrops, sunflower recorded the lowest net returns and this result is in accordance with the results of Sharma *et al.* (1997).

**Table 4 : Effect of intercropping systems on economics of weed management**

| Treatments | Cost of cultivation (Rs.) | Gross income (Rs.) | Net income (Rs.) | Cost benefit ratio |
|---|---|---|---|---|
| $T_1$ - Sole sugarcane | 54000 | 94813 | 40813 | 1.76 |
| $T_2$ - Sugarcane + blackgram | 55500 | 135981 | 80481 | 2.45 |
| $T_3$ - Sugarcane + cowpea | 55100 | 125228 | 70128 | 2.27 |
| $T_4$ - Sugarcane + greengram | 55100 | 120025 | 64925 | 2.18 |
| $T_5$ - Sugarcane + sunflower | 55200 | 95035 | 39835 | 1.72 |
| $T_6$ - Sugarcane + sesame | 55100 | 115430 | 60330 | 2.09 |
| $T_7$ - Sugarcane + groundnut | 55500 | 108115 | 52615 | 1.95 |

REFERENCES

Agricultural Statistics. 2011, Directorate of Economics and Statistics, Department of Agriculture and Co-operation, Ministry of Agriculture, Govt. of India, p. 88

Ahmed, M.S., M.S. Cheema and G. Muhammad. 1990. Feasibility of intercropping rabi crops in autumn crop of sugarcane. *Pakistan Sugar J.,* **5(2):** 10-14.

Balasubramaniyan, P. and SP. Palaniappan. 2001. Principles and practices of agronomy. Agrobios (India), Jodhpur, pp. 498-499.

Chauhan, R.S. and F.C. Das. 1990. Effect of weed control measures on sugarcane field. *Indian Sug.,* **XL(4):** 231-33.

Gulshan Mahajan, L.S. Brar, M.S. Bhullar, B.S. Boparai and V. Sardana. 2004. Weed management in sugarcane and mash intercropping system. *Indian J. Weed. Sci.,* **36(3&4):** 297-299.

Kannappan, K. and C. Ramaswami. 1995. Studies on weed management in sugarcane based intercropping systems. *Co-op. Sug.,* **27(4):** 275-278.

Kamruzzaman .M and Hasanuzzaman.M (2007) Factors affecting profitability of sugarcane production as monoculture and as intercrop in selected areas of bangladesh Bangladesh J. Agril. Res. 32(3): 433-444.

Kathiresan, G. and S. Rajasekaran. 1990. Influence of pulses on short crop cane yield of short duration variety. *Co-op. Sug.,* **21(8):** 575-576

Kathiresan, G. and G. Ramadoss. 2005. Choice of intercrop for sustaining the ratoon sugarcane yield, quality and soil fertility under clay soil. *Co-op. Sug.,* **36(12):** 989-998.

Marimuthu, R.S., Nasir Ahmed and S. Giridharan. 2003. Intercropping in ratoon sugarcane. *Indian Sug.,* **LIII(1):** 27-29.

Namadeva Shinde, B. L. Patil, C. Murthy and Mamle Desai.N.R(2009) Profitability analysis of sugarcane based inter cropping systems in Belgaum district of Karnataka. Karnataka J. Agric. Sci., **22 (4)** : (820-823)

Naik R. Balaji, Rao Ch. Mukunda, Ramanjaneyulu A.V., Sekhar D(2008) Agro-Economic Feasibility of Kamsali Sugarcane (*Saccharum Officinarum* L.) Based Paired Row Intercropping System in Northern Telangana Zone of Andhra Pradesh. Progressive Agriculture.**8**(2)pp 240

Reddy, Y.V.R. 1986. Economics of increasing cropping intensity in dry land agriculture in India. *Andhra Agric. J.,* **33:** 303-313

Roodagi, L.I., C.J. Itanal and M.B. Chetti. 2001a. Impact of intercropping and planting methods on growth and yield of sugarcane. *Karnataka J. Agrl. Sci.,* **14(2):** 305-310.

Roodagi, L.I., C.J. Itnal, D.P. Biradar and S.A. Angadi. 2001b. Leaf area index, light transmission ratio and sugar yield of sugarcane as influenced by planting methods and intercropping systems. *Bharathiya Sug.,* **26(10):** 39-45.

Sanjay Kumar, N.S. Rana and P.K. Tomar. 2005. Effect of intercrops and weed management practices on weed suppression and productivity in spring planted sugarcane. National Biennial Conferences, ISWS, PAU, April 6-9, pp. 68-69.

Sharma, R.K., G.K. Nema and H.D. Verma. 1997. Intercropping of different crops in autumn-planted sugarcane (*Saccharum officinarum*). *Indian J. Agric.,* **42(3):** 422-424.

Sinha, U.P., K.C. Jha and S. Kumar. 1994. Inter-cropping systems in spring planted sugarcane with oilseeds and pulses. *Co-op. Sug.,* **26(4):** 273-275.

Sundara, B. 2004. Sugarcane based intercropping systems for tropical India. *Co-op. Sug.,* **35(5):** 377-385.

Thakur, D.R. 1994. Weed management in intercropping systems based on maize (*Zea mays*) under rainfed mid-hill conditions. *Indian J. Agron.,* **39(2):** 203-206.

Yadav, R.S., R.S. Verma and Rajesh Kumar. 2005. Need for new technologies. The Hindu, Survey of Indian Agriculture, pp. 96-100.

*J. Farming Systems Research & Development* **18** (2) : 314-322 (2012)

# PROSPECTS OF ORGANIC AGRICULTURE IN EASTERN HIMALAYAN REGION—A CASE STUDY OF MEGHALAYA

N.D. Shukla, Sunil Kumar, B. Gangwar, B.K Sharma and N.K. Jat

*Project Directorate for Farming Systems Research, Modipuram, Meerut*

## Abstract

Survey of Meghalaya was conducted during 2009-10 to assess the status of organic farming in the state. The analysis of data of districts Rebhoi, Jowai, East and West Khasi hills selected for the study showed that 61.4 per cent farmers were cultivating conventional agriculture while 38.4 per cent using chemical fertilizers with conventional agriculture. Since crop yield was declining due to deterioration in soil fertility and sufficient organic manure was not available, some farmer's utilizing inorganic manure for improving the crop yield. Conventional farmers used compost and FYM only for zinger and vegetables resulting low productivity of rice which is stable food for the state. The average productivity of rice during 2009-10 was 18.8 q/ha in Meghlaya as against national average of 21.3q/ha. The productivity of paddy and maize was recorded 34.8 and 22.0 per cent higher over conventional practice. While computing the economics of rice and maize, an additional gain of Rs 3723 and 1893/ha was recorded from these crops compared to those who did not use chemical fertilizers. As the consumption of fertilizers of sample farmers was less than 30kg/ha, the scope for expansion of inorganic farmers was observed. Further, as majority of the farming community were very much conscious about protection of soils health and environment from pollution, the study concluded bright scope for organic agriculture in Meghalaya if the sufficient organic manure are made available to them. However, scientific in puts, training and economic assistance was felt essentially required for preparation of sufficient quantity of organic manures for improving the crop yield. The scope for promoting farming systems which is the present need of Indian agriculture was also observed of high magnitude beside organic agriculture in the state.

**Keywords:** Conventional, conventional inorganic, compute, economics, burgeoning, non-judicious, organic

## Introduction

The green revaluation technologies which enable us to produce enough food grains to feed our burgeoning population, is now in a state of fatigue. It is true that due to chemical intensive agriculture, we were able to overcome the food grains deficiency from begging bowl to food surplus in just two decades. But today, to a common farmer, the high input chemical fertilizer is no more a welcome option; rather it is compulsion .The factor productivity in term of yield per unit of fertilizer, pesticides and other agro-chemicals are declining. Further, non-judicious and indiscriminate use of fertilizer resulted in to second generation problem like micro-nutrient deficiency in soils, soil degradation, increase in insect resistance against pesticides, pest residue in food stuffs and environmental and water pollution. Thus, sustainability of conventional synthetic chemical based agricultural production is at risk. Under the circumstances explained above, the need of organic farming that has been defined as production system which avoids or largely excludes the use of synthetically compounded fertilizers, pesticides, growth regulators and livestock feed additives, Lampkin (1990) is required in Indian agriculture. As per Funtilana (1990), organic farming is a means of giving back. Lotter (2003) was of the opinion that the concept of organic farming is managing a farm as an integrated whole system. In India, organic farming has its roots in traditional agricultural practices that evolved in countless villages and farming community over the millennium. However, large scale scientific organic production is a relatively recent development of fertility building strategies is warranted. About 2.5 lakh hectare area in India is under organic agriculture as against 25 million in other developing countries and total number of registered organic farmers in the country is 5661. As per APEDA report, about 6471 metric tones organic products valued at 80-90 crore were exported during 2004-05. The biggest hurdle to India for export of organic produce is lack of processing, packing, storing, transport facilities of International Standard besides lack of organic products demand in local market. Non availability of organic seeds, bio-pesticides and fertility management is another bottleneck in organic agriculture.

Meghalaya is one of the Seven Sister States of India. Agriculture in the state is characterized by low productivity and unsustainable farm practices, giving rise to a high incidence of rural poverty. Infrastructural constraints have also prevented the economy of the state from growing at a pace commensurate with that of the rest of the country. Planning Commission, Government of India, has estimated the percentage of population below poverty line in Meghalaya at nearly one-third the total population of the state in 2000. The incidence of poverty in rural areas at about 55% is almost double the percentage of poverty in the urban areas. Nearly 10% of the total geographical area of Meghalaya is under cultivation. Agriculture in the state is characterized by limited use of modern techniques and low productivity. As a result, despite the vast majority of the population engaged in agriculture, the contribution of agricultural production to the state's GDP is low and most of the population engaged in agriculture remains poor. A substantial portion of the cultivated area is under the traditional shifting agriculture known locally as "Jhum" cultivation. Rice is the dominant food grain crop accounting for over 80% of the food grain production in the state. Other important crops are maize, wheat, millets, pulses and oilseeds. Zinger, pine apple and straw berry are income generating crops to the farmers. In Meghlaya, there is a lot of scope of organic farming. The chemical fertilizers utilized at the rate of 13 kg/ha during 2008-09 was remained the same in 2009-10 in Meghlaya. This indicates that hills farmers do not have craze to enhance consumption of mineral fertilizer for boosting the crop production even after fifty years of green revolution. Further, each house hold maintains livestock (cow, bullock, pigs, poultry, goats etc.) and producing organic manure as was observed from recent survey data. However, the quantity of organic manure produced by the farmers is meager and not able to cope up the crop need. Besides, being hills, Meghlaya is receiving very high rainfall (2000-11000mm per annum) which leads to profuse production of biomass including weeds, shrubs and herbs. Many of these weeds could be efficiently used for organic production. During course of survey, farmers were observed conscious for maintaining the environment and soils from pollution even on low crop yield. These attributes clearly indicates for bright prospects of organic agriculture in Meghlaya. Keeping these facts in view, the present study was proposed to study the status of organic agriculture in

Meghalaya. The study results will be beneficial for planners, researchers and agencies involved in promoting organic farming in the country.

## Material and Methods

Survey of Meghlaya was conducted during 2009-10 and out of seven, 4 districts namely Jowai, West Khasi Hills, East Khasi Hills and Rebhoi were selected using multistage stratified random sampling method. Again 2 blocks namely Thodlasin and Lashkein from Jowai, Mawthdraishan and Mairang from West Hkasi Hills, Mawphlang and Myliem from East Khasi Hills and Umshing and Umling from Re-Bhoi districts were selected using the same sampling procedure. Thus a total of 8 blocks were chosen for the proposed study. Thereafter 2 village from each block and 20 farm families from each village were selected. Finally a total of 320 households were selected for collecting the data. Besides general information, the area under organic, inorganic and organic+ inorganic agriculture of each farm group was collected on the prescribed and well tested questionnaire through interview of the head of the farm families. The productivity of rice, maize, zinger and other such crops were also recorded. The information about other enterprises kept by the farmers, expenditure incurred and income derived from each enterprise was also noted. Similarly the details of inputs and their quantity used in production of each crop commodities along with per unit price were also recorded. Farm animal details and opinion of the farmers about organic and inorganic farming was also noted. The yield of rice for last five years grown with organic manures and mineral fertilizers were also collected to asses the impact of these materials on soil fertility beside grain yield. The constraints facing by the farmers in organic agriculture were also recorded. The name of agencies working in promoting for organic agriculture in the state was also noted. The simple average and percentage were used as analytical tools in processing the data.

## Results and Discussions

### Status of organic producers and their crop production scenario

In fact, in Meghalaya, none of the farmers was found cultivating organic farming as per norms of the organic agriculture during course of survey. The practice followed by the majority of farming community for crop cultivation was traditional and natural and as such, the crop cultivation in practice in Meghalaya may be termed as 'conventional' farming and not organic agriculture. Except few, conventional farmers do not apply any manure or mineral fertilizer in rice which is dominant crop for the state. The previous plants resides which decompose in the field and minerals came through irrigation water from hills, cater the plant nutrients needs of rice crop. The sufficient quantity of organic manures which may fulfill the nutrient requirement of the crop was also not found available with any of the farmers in the districts selected for study. It is because; buffaloes and bullocks which are the main source of farm yard manure were not observed to be reared by the farmers. Cows which are kept purposely for meat, their numbers were also very low. However, the organic manure obtained from other animal was noted to be used for ginger and vegetables crops only. Some farmer use meager quantity of chemical fertilizer for rice and maize only. The numbers of such farmers vary from district to district. However, based on that, the sample farmers were dived in two category (i) conventional and (ii) conventional inorganic farmers. The data presented in Table (1) showed that out of total sample farmers 71.9 and 67.2 per cent were following conventional agriculture in Rebhoi and Jowai districts while the corresponding figures in West and East Khasi hills were 53.1 and 43.8 per cent respectively. The average of all the districts indicated (61.6%) conventional and (38.4%) conventional inorganic cultivators.

The average productivity of rice and maize shown in Table (2) indicated marginal variation in productivity of these crops between both farm groups. The marginal disparity in yield was because the consumption of chemical fertilizers was less than 30kg/ha in case of conventional inorganic growers. The state average consumption of mineral fertilizes has been reported to be 13kg/ha during 2009-10. The average productivity of rice and maize was recorded 14.3 and 15.4q/ha in case of conventional farmers compared to 20.9 and 18.0 q/ha of conventional inorganic cultivators Table-2. These figures showed 34.8 and 22.0 per cent higher yield of rice and maize over conventional cultivators. However, the average productivity of these crops together with conventional and conventional inorganic was below to the national average

**Table 1 : Conventional and conventional inorganic farmers in Meghalaya**

| District | Sample size | Conventional farmers | | Conventional inorganic growers | |
|---|---|---|---|---|---|
| | | Number | (%) | Numbers | (%) |
| Rebhoi | 128 | 92 | 71.9 | 36 | 28.1 |
| Jowai | 64 | 43 | 67.2 | 21 | 32.8 |
| West Khasi Hills | 64 | 34 | 53.1 | 30 | 46.9 |
| East Khasi Hills | 64 | 28 | 43.8 | 36 | 56.2 |
| Total | 320 | 197 | 61.6 | 123 | 38.4 |

**Table 2 : Rice and maize productivity of conventional and conventional inorganic cultivators**

| District | Paddy (q/ha) | | Maize (q/ha) | | (%)increase over conventional | |
|---|---|---|---|---|---|---|
| | Conventional organic | Conventional inorganic | Conventional organic | Conventional inorganic | Paddy | Maize |
| Rebhoi | 15.3 | 19.8 | 15.2 | 17.8 | 29.4 | 17.1 |
| Jowai | 16.8 | 21.6 | 14.7 | 16.9 | 28.6 | 14.9 |
| W.Kh.Hill | 15.7 | 20.6 | 16.1 | 18.7 | 31.2 | 16.1 |
| E.Kh. Hill | 14.3 | 21.8 | 15.8 | 18.6 | 52.4 | 17.7 |
| Average | 15.5 | 20.9 | 15.4 | 18.0 | 34.8 | 22.0 |

productivity of 21.8 for rice and 24.4q/ ha of maize reported during 2009-10. Since conventional/ organic farmers do not provide any manure to cereal crops in general, the fertility of the soils was told continuously deteriorating resulting poor crop yield. If the organic materials like plant leafs, weeds and animal waste easily available with the farmers would have been decomposed and put in the soils, the crop productivity and soil fertility could have been sustained. Further, Meghlaya being a high rainfall area, vermin compost could be easily prepared by the farming community and used for cropping. Besides, to cater the need of milk, meat and FYM, keeping more cows on the farm needs to be encouraged for promoting the organic agriculture in Meghlaya.

**Yield trend of rice under conventional and conventional inorganic practice**

Continuous mining of nutrients by the crops under conventional practice showed declined trend of rice productivity. While on the other hand, the farmers using even meager quantity of mineral fertilizers, their yield was observed marginally increased as apparent from Fig. 1. In actual organic farming, the required quantity of plant nutrients are provided to the soil through organic sources which improve the crop yield as well as soil fertility. Since nothing is given to the soil under conventional practice, soil fertility might have been deteriorated resulted declining trend in rice productivity over the years.

As ginger was marked an income generating crops for the state, the major portion of available organic manures was used for this crop. However, since human population of all corners of the country including Meghlaya is growing fastly and per capita land is sharply decline, the per unit productivity of rice which is important stable food for the state, is required to be increased and for that other source of organic material are to be searched for improving the soil fertility and crop productivity. The rice productivity of conventional inorganic farmers was also not comparable to national average. This showed that soils of these farm groups were also hungry for plant nutrients. These results dictate for implementation of full package of organic agriculture by educating the north eastern farmers including Meghlaya for sustaining the crop yield. It is because; the organic agriculture was introduced for quality food production and check environmental pollution with comparable yield to inorganic growers. However, growing rice without organic manure/ fertilizers causing low crop yield and that's to below the national average will defect the objectives of the organic farming.

**Economics of conventional and non-conventional produce**

The cost and returns of rice and maize grown under conventional and non-conventional practice is presented in (Table 3) indicated disparity in net return of these crops. Since conventional farmers did not apply any organic manure to the crops, it is obvious that crop productivity will certainly low. Further, insufficient dose of mineral fertilizers provided to these crops by non-conventional farmers, also could not perform better except marginal improvement in yield over conventional farmers.

As evident from the data, improved yield of rice and maize increased the net return from these commodities produced by non-conventional growers. An additional gain of Rs3723/ha from rice and Rs 1893/ha from maize was recorded over conventional practice.

**Table 3 : Economics of conventional/inorganic conventional farming (In rupees)**

| Expenditure details | Conventional | Non-conventional | Conventional | Non-conventional |
|---|---|---|---|---|
| | Paddy | Paddy | Maize | Maize |
| Ploughing and leveling | 2650 | 2790 | 1891 | 1785 |
| Seed Cost | 675 | 790 | 650 | 650 |
| Nursery raising | 450 | 560 | — | — |
| Transplanting /sowing | 2500 | 2920 | 831 | 690 |
| FYM /fertilizers | — | 318 | — | 205 |
| Irrigation cost | 650 | 760 | — | — |
| Plant protection | — | 650 | — | — |
| Weeding | 2359 | 2692 | 1328 | 1462 |
| Harvesting cost | 2450 | 2700 | 1054 | 1195 |
| Threshing cost | 1990 | 2110 | 1750 | 1975 |
| Bagging & Transport | 465 | 627 | 462 | 540 |
| Cost of cultivation | 14189 | 16917 | 7966 | 8502 |
| Interest on capital | 580 | 609 | 364 | 405 |
| Total operational cost | 14769 | 17526 | 8330 | 8907 |
| Yield (q/ha) | 15.5 | 20.9 | 15.4 | 18.0 |
| Price of grain ( Rs/q) | 1200 | 1200 | 950 | 950 |
| Gross return | 18600 | 25080 | 14630 | 17100 |
| Net return | 3831 | 7554 | 6300 | 8193 |
| BC ratio | 1.26 | 1.43 | 1.75 | 1.92 |

*Note:* Local market price of produce was considered for computing the gross income.

Since rice is more responsive for plant nutrients, the effect of fertilizers on rice yield was of high order and as such, variation in net return was more pronounced compared to maize. However, the as per hectare return of maize produced was of high magnitude compared to rice. It is pertinent to mention here that domestic market demand of the commodity produced by conventional growers was more compared to non-conventional producers. However, since there is no distinction/ demarcation of conventional produce, the selling price of rice and maize were same in the local market for both the produce.

**Animal population and annual income there from**

Animals are major component for adoption of organic agriculture in any region or state. Further, cow, buffaloes, poultry, goats and pigs are not only the source of organic manures but it also provides additional income to the farming community in general and resource in particular. Food nutritional values also improve through inclusion of milk, egges and meat in food items. The data presented in Table (4) indicated average number of different kinds of animals kept on the farm by individual household in each district included in the study.

As apparent from the data, every household from each selected district were keeping animals. The average number of goat was recorded 1.5 with an average income of Rs 2129/annum. Per household poultry and pigs were noted 5.9 and 0.83 respectively. However, the average number of cow was only 0.6/ household which appeared very less. The overall figure showed 8.9 animals with each farm families which generate an average annual income of Rs 7592. These farm animals' figures underline the bright scope of organic farming in Meghalaya. Further, if excreta, urine, other waste of these animals are decomposed with plant leafs and weeds, sufficient organic manure could be produced and used for crop improvement. Further farmers needs to be encouraged to keep more cows on the farm to enhance the dung production besides to solve the milk and meat problem of the state. Further, the population of goats, poultry, pigs and other such animals also needs to be increased by giving incentive to the farmers for success of organic farming in the state.

**Farmer's perceptions about organic farming**

While conducting the survey, views of the farmers were gathered about the effect of conventional farming on soil fertility, weed infestation, disease and insects pests, consumer demand, and environmental pollution and per unit crop yield. The opinion expressed by the farmers of each selected district is presented in Table (5).

As evident from the data, only 32 per cent farmers of Jowai and 23 per cent of West Khasi hills were of the opinion that fertility of the soils improved under conventional farming. Similarly, 26 and 29 per cent of East Khasi and Rebhoi farmers were agreed with the above views. This showed that soil fertility is deteriorated under conventional agriculture as majority of the farming community were convinced with this

**Table 4 : Average number of animals per household and annual income their from Income (Rupees)**

| District | Cow | | Goat | | Poultry | | Pigs | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | No | Income | No | Income | No | Income | No | Income | No | Income |
| Jowai | 0.6 | 1200 | 1.5 | 2063 | 5.4 | 1823 | 0.80 | 2160 | 8.3 | 7246 |
| WK.Hills | 0.8 | 1608 | 1.7 | 2330 | 6.4 | 2160 | 0.75 | 2025 | 9.7 | 8123 |
| E.K.Hills | 0.7 | 1400 | 1.8 | 2475 | 6.2 | 2093 | 0.85 | 2293 | 9.5 | 8261 |
| Rebhoi | 0.4 | 800 | 1.2 | 1650 | 5.5 | 1856 | 0.90 | 2430 | 8.0 | 6736 |
| Overall | 0.6 | 1252 | 1.5 | 2129 | 5.9 | 1983 | 0.83 | 2227 | 8.9 | 7592 |

*Note*: Meat price of cow was considered Rs 100, Goat 250, poultry 150 and Pig 180/kg

**Table 5 : Opinions of the farmers about conventional/organic agriculture.**

| District | Soil fertility (%) farmers | | Weed infestation (%) farmers | | Insects, and disease (%) farmers | | Consumer Demand (%) farmers | | Environment pollution (%) farmers | | Per unit yield (%) farmers | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Improved | Not improved | High | Low | High | Low | High | Low | NO pollution | Polluted | Decreased | Increased |
| Jowai | 32 | 68 | 63 | 37 | 28 | 72 | 87 | 13 | 100 | — | 92 | 8 |
| W.K.Hill | 23 | 77 | 76 | 24 | 32 | 68 | 79 | 21 | 96 | 4 | 85 | 15 |
| E.K.Hill | 26 | 74 | 67 | 33 | 38 | 62 | 81 | 19 | 92 | 8 | 98 | 2 |
| Rebhoi | 29 | 71 | 43 | 57 | 42 | 58 | 74 | 26 | 89 | 11 | 93 | 7 |
| Overall | 27.5 | 72.5 | 62.3 | 37.7 | 35.0 | 65.0 | 80.2 | 19.7 | 94.3 | 5.7 | 92.0 | 8.0 |

opinion. Weed infestation in conventional agriculture was of high order as reported by the farmers. Incidence of insects, pests and disease was reported to be lower order while consumer's demand of conventional produce was of high magnitude. Since, industrial development has not taken place in the hills, environmental pollution has little scope in Meghlaya and other north east states. Farming community of all the selected districts were also of the same opinion. While asking the yield trend of rice and maize, more than 90 percent farmers reported that rice yield under conventional practice are declining from past many years. As apparent from the overall analysis, 72.5 per cent farmers reported that soil fertility is declining while 62.3 per cent expressed that weed infestation is growing under conventional farming. With regard to disease incidence and environmental pollution, 65.0 and 80.2 per cent farmers reported less insects and pests incidence and high consumer demand of conventional produce. However, grain yield was recorded decreasing while there was no bad effect on environment as per farmer's opinion.

**Future strategies for organic agriculture**

- Study results clearly showed bright prospects of organic farming in Meghlaya and for that traditional/ conventional agriculture which is in practice needs to be converted into organic agriculture by educating the farmers.
- As sufficient material for preparation of compost is available, farmers should be provided loan without interest as an incentive for preparation of compost pits.
- NGO'S and other such agencies involved in promoting the organic

agriculture should be directed to educate the farmers for preparation of vermin-compost and its use for crop production.

- Since soil fertility is deteriorating and as a result crop yield particularly rice is continuously declining, the number of cows and bullocks which are main source of FYM observed very less, required to be increased by giving loan and improved breeds of animals to the farmers to enable them to prepare sufficient organic manures to feed the crops besides milk and meat to meet domestic requirement..
- Though the Meghlaya farmers do not want any bad effect on soils and environment, however, they should me made aware about merits of organic farming, its long run effect, improvement in crop yield and value of the organic product.
- As organic producers are facing problem for marketing of the produce in domestic as well as in international market, a separate market for organic produce needs to be established in Shillong.
- The norms of organic agriculture are very strict and it was also made aware by the farmers. To make success of organic agriculture, in beginning, the norm may be liberalized up to some extent for Meghalaya farmers and produce may be sold in local market. In long run farmers gradually will follow the full norms as they were observed very conscious for maintaining the soil and environment intact and free from pollution.
- Though, APEDA and other agencies are engaged in promoting the organic agriculture in Meghlaya, however, there efforts were not observed up the mark. In this direction vigorous effort with collaboration of state department of agriculture is required to convert whole north eastern region in to organic agriculture.
- The farmers utilizing inorganic fertilizers needs to be discouraged and may be advised to use organic manure for improving the crop yield, soil health and keeping environment free from pollution.

## REFERENCES

Funtilana,S (1990) Safe, expensive, profitable and sensible. International Agricultural Development, March-April 24.

Lampkin N. (1990) Organic Faming. Farming press Book, Ipswich. UK. pp 701.

Lotter,D W. (2003) Organic Agriculture. Journal of Sustainable Agriculture. 21 (4): 59-128.

*J. Farming Systems Research & Development* **18** (2) : 323-327 (2012)

# EVALUATION OF TRAINING ON BACKYARD POULTRY: A CASE OF ENTREPRENEURSHIP DEVELOPMENT AMONG SMALL AND MARGINAL FARMERS

SURENDAR KUMAR*, VIPIN KUMAR** AND PRINCE TOMAR***

*Krishi Vigyan Kendra, Baghpat (U.P.)*

ABSTRACT

An investigation was carried out during the May month of 2011 on Evaluation of training on backyard poultry: A case of entrepreneurship development among small and marginal farmers at KVK, Baghpat, and U.P. On the basis of study, it may be concluded that training on disease management of chicks is most important area where training is highly required followed by improved breeding. The findings also showed that education, socio-economic status, scientific orientation, land holding, social participation and marketing intelligence having the positive correlation with amount of knowledge gained by participant. The knowledge gained during the three days training was calculated as 114%.

**Keywords:** Farming system, marketing intelligence and entrepreneurship.

There is no extension unless people are not changed, and there is no little constructive change unless the people do not cooperate. Extension moves forward only as it is changed with the dynamic energy of earnest men and women seeking answers to problems of everyday life'- "Farmers of the world". As defined FAO the term agricultural extension refer to an informal out of school education service for training an influencing farmer and their families to adopt improved practices in crop and livestock production, management, conservation and marketing. In India agriculture extension has been a central and state government service since 1953 with the establishment of National Extension Service. Agricultural extension system of the country has contributed significantly in the agricultural development. Over the years, it has expanded further and now reaches to almost every nook and corner of the country. The National Agricultural Technology Project (NATP) in the late 90s and in the early years of 21st century was a significant effort to overcome the existing weaknesses in the national extension system.

Agricultural extension, in the current scenario of a rapidly changing world, has been recognized as an essential mechanism for delivering knowledge (information) and advice as an input for modern farming besides performing the conventional task of transferring technology packages to the farming community. Hence, in this era of new technological development training of both the extension functionaries and the farmers in the use and application of appropriate technologies should receive topmost priority. Training is one of the most important activities of all the extension works. It primarily addresses the capacity building issues of the

*Subject Matter Specialist, Agriculture Extension, KVK Baghpat under SVBPA&T University, Meerut (U.P.)
**Technical Officer,PDFSR, Modipuram, Meerut (U.P.)
***Dept. of Biotechnology, CCS HAU Hisar

extension system. The large network of front-line ICAR-SAU extension system consists of 588 Krishi Vigyan Kendras.

Through, this network 6.5 lak farmers and farm women every year trained in agriculture and allied fields such as crop production, livestock production, plant protection, horticulture, home science, soil and water management and farm machinery etc. The effectiveness of a training programme which is essentially a specific learning process meant to improve the ability of the farmers to enable them to adopt modern agriculture technology, depends on the degree of retention of knowledge acquired through learning process. The main objective of the study was to find out the extent of gain in knowledge immediately after conducting a three days training programme and the role of characteristics of participants towards knowledge gained about backyard poultry among small and marginal farmers, which may be most important component of integrated farming system for employment generation, enhance income and enrich the family diet, the similar results were highlighted by Singh J.P. at all (2010) and suggested that integration of such kind agricultural based component of farming system will promote the livelihood security for small land holders.

## METHODOLOGY

The analysis presented under this study is based on three on and off campus training programme on "back yard poultry" which was organized during the month of May at KVK, Baghpat of U.P. In this programme 25 landless farmers from Sankrod village were participated. The training methodologies were adopted viz. lecture followed by questions and answers, group discussion, demonstration, practice and instruction through audio visual aids. In order to measure the knowledge level of the farmers no specific knowledge test was used however, some precautions were taken care during preparation of questionnaire with in the syllabus of training. A questionnaire with 20 questions was prepared with the help of subject matter specialists and veterinary officer of line department. For each correct and incorrect answer 1 & 0 score was assigned, the maximum and minimum obtainable score was 10 & 0 respectively for individual participant. During the training pre and post knowledge score of the trainees has been calculated. The gain in overall knowledge has been further calculated as the difference of post and pre knowledge score. In the present study entire analysis is based on change in knowledge. Subramanian V.S. (1976) defined knowledge as a "body of understood information possessed by an individual or by culture". Knowledge is one of the essential measurements of individual's behaviour, since the product of learning process is the body of knowledge. The variables related to personal orientation of the trainees were operational zed in the study. Regarding training needs, trainees were asked to write down their training requirements related to backyard poultry on priority wise and analyzed. As per the priority and obtained score training areas were ranked.

## RESULT AND DISCUSSION

On the basis of investigation, it was found from the study that the majority (60%) participants were from 25-40 years age, the whole sample age varies from 25-45 years. Regarding qualification, majority (44%) of the participants were up to the primary standard followed by

(32%) participants who can sign only, 16 percent were illiterate and only 8 per cent participants were having metric level of educations. Majority (48 %) of participants were having the experience more than 21 years. 96% participants attended 1-2 training and only 4% participants have attended more than 2 training programmes in different organizations (Table-1).

**Table 1. Trainees background information**

| Items | No. | Percentage |
|---|---|---|
| **Age (year)** | | |
| Low (Up to 40) | 8 | 32 |
| 25-40 | 15 | 60 |
| >40 | 2 | 8 |
| Total | 25 | 100 |
| **Education** | | |
| Illiterate | 4 | 16 |
| Literate who can sign | 8 | 32 |
| Primary | 11 | 44 |
| Matriculate | 2 | 8 |
| Total | 25 | 100 |
| **Experience of rearing of backyard poultry** | | |
| Up to 10 yrs | 3 | 12 |
| 11-20 | 5 | 20 |
| 21-40 | 12 | 48 |
| >40 | 5 | 20 |
| Total | 25 | 100 |
| **Training attended** | | |
| 1-2 | 24 | 96 |
| >2 | 1 | 4 |

Table 2 reveals the score range, total obtained score and mean score of before exposure, after exposure and knowledge added of all the participants in the training programme. It was found that before exposure score range was 1-4 and total knowledge obtained score was 97, after exposure score range was 3-8 and obtained score was 211, the score added was 114 and the knowledge increase was 118 percent. Khuspe (1963) concluded on the basis of a study undertaken on knowledge of paddy growers about Japanese method of paddy cultivation that the knowledge score was 6 out of 7 in case of 73 percent of high acceptors while in case of 80 percent low acceptors, the score was up to 3 only.

**Table 2. Impact of rearing of backyard poultry**

| Particulars | Before training | After training | Knowledge gained |
|---|---|---|---|
| Score range | 1-4 | 3-8 | 3-7 |
| Total score | 97 | 211 | 114 |
| Mean score | 2.4 | 5.9 | 3.5 |

Attempt is here made to ascertain the effectiveness of independent variables on knowledge gained in training programme. It was found from the Table-3 that age of the participants was negatively and non significantly correlated with knowledge gained. It

**Table-3: Zero order correlation co-efficient of independent variables with knowledge gained.**

| Independent variables | 'r' value |
|---|---|
| Age | -0.276 |
| Education | 0.543* |
| Experience | 0.332 |
| Family background | 0.033 |
| Socio-economic status | 0.603** |
| Number of trainings attended | 0.022 |
| Scientific orientation | 0.272** |
| Land holding | 0.312** |
| Social participation | 0.268** |
| Marketing intelligence | 0.740* |

* Significant at 0.05 probability level
** Significant at 0.01 probability level

shows that young age participants gained the more knowledge as compared to older one. Sadamate and Sinha (1976) concluded in his study that age influence the amount of knowledge gained. Education of the participants was positively and significantly correlated with knowledge gained. It indicates that the qualified participants gained more knowledge comparison to less/non qualified. Similar findings were also reported by Mishra and Sinha (1981) and Sharma et.al. (2006). Experience in agriculture, family background and training programmes attended by the participants did not show any relationship with knowledge gained. Socio-economic status, scientific orientation level holding social participation and marketing intelligence also having positive correlation towards knowledge gained.

On the basis of analysed data it can be concluded that majority of the trainees had express their need of training on backyard poultry as a whole. The analysis of the correlation of selected characteristics like education, socio-economic status, land holding, social participation, scientific orientation and marketing intelligence found positively and significantly towards their knowledge gained similar findings were highlighted by Rajput at all (2009). On the basis of investigation it was also concluded that all 25 trainees required training needs on all the aspect of backyard poultry production technology as perceived by the participants, that the most important area of the training has been found to be disease management in chicks ranked first (Table-4). This is understandable the point of view that disease management of chick needs a lot of skills to handle it. This is followed by improved breeds for backyard poultry as second. Feeding management and taking care is another important area identified to training need, its also required a sharp management skill for success entrepreneur, same thing was highlighted by Rao et all (2009) and suggested that management skill is relatively important component to all other dimension of any occupation that may be utilized in entrepreneurship development.

**Table 4. Training needs of participants**

| Particulars | Score | Rank |
|---|---|---|
| Disease management in chicks | 19 | I |
| Improved breeds for backyard poultry | 18 | II |
| Feed preparation | 11 | IV |
| Feeding management and take care | 15 | III |
| Marketing intelligence | 09 | V |

## CONCLUSION

It can be concluded from the study that young and qualified trainees gained more knowledge as compare to old and illiterate participants. The major and top ranked training needs of the participants were disease management in chicks and improved breeds for backyard poultry. Taylor (1961) rightly said that training mean to bring about the continuous improvement in the quality of work performed by the staff and the individuals. Thereby, training should be provided time to time to an individual to update them from the new technologies so they can perform well in their field.

## REFERENCES

Khuspe, T.S. (1963) A study of acceptance of Japanese method of paddy cultivation. New Delhi: IARI (Ph. D. Thesis).

Sharma, B.K., Singh, M.P., Kumar, Surendar and Singh, S.P. (2006) Study the impact of training on conversion of farm bio-based Enrich organic manure. J. Farming System Research & Development 12(1&2):150-152)

Mishra, S.P. & Sinha, B.P. (1981) Socio-economic correlates of technological know-how of farm entrepreneurs. Ind. J. Extn. Ed. 17(1&2).

Rajput H.D., Supe S.V., Chinchmalatpure U.R. and Girase C.P. (2009) Farmer training need on BT cotton technology. Indian Journal of Extension Education 45(1&2)

Rao M.S. and De Deepak (2009) Dimension of entrepreneurship behavior. Indian Journal of Extension Education 45(1&2)

Sing J.P., Gangwar, Singh Prem and Pandey B.K. (2010) Design and development of integrated farming system module for livelihood improvement of small farm holders of western plain zone of U.P. Journal of Farming System Research and Development 16 (1&2)

Subramanyan, V.S.(1976) The retentive knowledge gained through selected extension methods and their combination. Ind. J. Extn. Ed. 12(1&2).

Sadamate, V.V. and Sinha B.P. (1976) Dissemination of farm information through television radio and block extension agency-a comparative study. Ind.J.Ext.Ed.12 (1&2).

Taylor, M.H. (1961) Training of trainers, Kurukshetra 9((9).

*J. Farming Systems Research & Development* **18** (2) : 328-331 (2012)

# DIVERSIFICATION OF RICE-WHEAT CROPPING SYSTEM AND ITS ECONOMICS IN GARHWAL REGION OF UTTARAKHAND

PURUSHOTTAM KUMAR[1] AND D.K. SINGH[2]

*G.B. Pant University of Agriculture & Technology*
*Horticulture Research and Extension Centre, Srinagar Garhwal- 246174*

ABSTRACT

The present study was conducted during 2006-07 to diversifying and intensifying the rice-wheat cropping system under Garhwal region of Uttarakhand. The study revealed that rice-pea(vegetable)-frenchbean(vegetable) crop sequence produced highest gross and net returns per hectare (Rs. 185127 and Rs. 129448, respectively). All the crop sequences except rice-vegetable pea-vegetable frenchbean were at par among themselves for the gross and net returns.

**Keywords:** diversification, intensification, rice-wheat cropping system, economics

The rice-wheat is one of the most important cropping system in India covering about 10.5 million hectare area and contributing about 38% food grains to the national food basket (Gangwar, B. 2009). This system is considered as backbone of food grain security and predominates the north Indian states. This system is likely to continue its important role in sustaining self sufficiency of food grains in future too. The system production can be increased up to the level ranging from 9.1 to 21.5 tons/ha/year depending upon the choice of high value crops for diversification of existing cropping system. Continuous cropping of rice and wheat in sequence during the last three decades has been causing many second generation problems like decline in water table, emergence of multinutrient deficiencies, formation of hard pan and build up of weeds like *Phalaris minor* in wheat. Moreover, the stagnation in system productivity and profitability is experienced in recent years. As a result system subtainability is under threat. There is need to consider partial substitution of rice-wheat system through efficient alternatives as diversification and intensification approach.

In the state of Uttarakhand majority of holdings fall in the category of small and marginal farms as the average size of holding in the hilly areas is around 0.4 ha and for the state as a whole, it is 0.8 ha. Area of rice and wheat cultivation in the state is 273 and 391 thousand hectare, respectively, and the production of these crops is 533 and 800 thousand metric ton, respectively. Average productivity of rice and wheat in the state was 19.49 and 20.47 q/ha, respectively during 2006-07 (Anonymous, 2007). Although the agriculture in Uttarakhand has undergone widespread changes after green revolution but it also requires adjustments to suit the changed situations. Rice-wheat is the dominant cropping system of Garhwal region of Uttarakhand. With the overflow of cereal production, need is being felt to diversify and intensify to remunerative and efficient crops like pulses, oilseed and vegetables. Under Garhwal Himalayan conditions, viable alternative is selection of suitable cropping systems that generate maximum net profit per unit investment per unit time to farmers. Therefore, the present study was undertaken to find out the productivity and economics of various possible cropping systems by incorporating pulse, oilseed and vegetable crops that can replace rice-wheat system.

## Materials and Methods

The present study was conducted in districts of Dehradun and Pauri of Garhwal region of Uttarakhand during the year 2007-08. The field trial was conducted at farmers' field taking single farmer as a replication. Nine farmers were taken from district Dehradun and nine from district Pauri. In this way total eighteen replications were there. The treatments comprised of five crop sequence i.e. $T_1$: rice-wheat, $T_2$: rice-wheat+mustard, $T_3$: rice-mustard-urdbean, $T_4$: rice-mustard-mungbean and $T_5$: rice-vegetable pea-vegetable frenchbean. Recommended package of practices were followed in cultivation of every crop in sequence. The varieties of rice, wheat, mustard, urdbean, mungbean, pea and frenchbean were PR 113, UP 2572, Pusa Agrani, PU 35, Pant Mung 4, Arkel and Pant Anupama, respectively. The fertilizer doses were applied in rice (150:60:40 $N:P_2O_5:K_2O$ kg/ha), wheat (150:60:40 $N:P_2O_5:K_2O$ kg/ha), mustard (100:40:40 $N:P_2O_5:K_2O$ kg/ha), urdbean (15:45 $N:P_2O_5$ kg/ha), mungbean (15:45 $N:P_2O_5$ kg/ha), vegetable pea (30:70:50 $N:P_2O_5:K_2O$ kg/ha) and vegetable frenchbean (120:70:50 $N:P_2O_5:K_2O$ kg/ha as per the recommendations for the state. When the mustard was intercropped with wheat, the fertilizer was applied recommended for wheat only. Intercropping of wheat and mustard was done in ratio of 9 rows of wheat: 1 row of mustard as per the recommendation. The soil of the experimental sites were in general low in available nitrogen (205.0 kg/ha), medium in available phosphorus (12.2 kg/ha) and available potassium (173.0 kg), high in organic carbon (0.78 %), neutal in pH (7.0) and the mean electrical conductivity was 1.27 dS/m.

## Results and Discussions

The data on grain and straw yield of different crops in sequence has been summarized and depicted in Table 2. Productivity of wheat decreased from 4672 kg/ha to 4385 kg/ha and additional yield of mustard by 253 kg/ha was achieved when wheat was intercropped with mustard as compared to the pure crop of wheat.

### Cost of cultivation

All the crop sequences had rice crop during the *kharif* season which incurred Rs. 19061/ha cost of cultivation. During the *rabi* season highest cost of cultivation was recorded with pea (Rs. 18272/ha) which was significantly higher than rest of the *rabi* crops in sequence. It was followed by wheat crop either as pure crop or wheat intercropped with mustard (Rs. 17155/ha and Rs. 17301/ha, respectively). Mustard crop recorded lowest and significantly lower cost of cultivation (Rs. 14970/ha) than the rest of the *rabi* crops in sequence. In *zayad* highest cost of cultivation (Rs. 19425/ha) was recorded with frenchbean and it was significantly higher than the crops of urdbean and mungbean (Rs. 12805/ha and Rs. 12893/ha, respectively).

When the cost of cultivation was calculated for all the seasons collectively, it was found that rice-vegetable pea-vegetable frenchbean sequence recorded highest cost of cultivation (Rs. 55679/ha) and it was significantly higher than rest of the crop sequences. Next to this sequence, were the rice-mustard-urdbean and rice-mustard-mungbean crop sequences which were at par among themselves (Rs. 46126/ha and Rs. 46208/ha, respectively) regarding cost of cultivation. These crop sequences recorded significantly higher cost of cultivation over the rice-wheat and rice-wheat+mustard (Rs. 36217/ha and Rs. 36362/ha, respectively).

**Gross returns**

All the crop sequences had the rice crop during the *kharif*, and all the treatments were at par among themselves for the gross returns during *kharif*. The gross returns varied from Rs. 39814/ha to Rs. 41005/ha in *kharif*. During the *rabi* it was vegetable pea which produced highest (Rs. 78202/ha) and significantly higher gross returns than the rest of the *rabi* crops in sequence. Pure crop of wheat recorded at par gross returns with wheat crop intercropped with mustard (Rs. 65297/ha and Rs.67214/ha, respectively). The gross returns from pure wheat crop and from intercropping of wheat and mustard were recorded significantly higher over the gross returns from mustard crop. Mustard crop in rice-mustard-urdbean and in rice-mustard-mungbean crop sequences provided gross returns of Rs. 34825/ha and Rs. 34933/ha, respectively. During *zayad*, vegetable frenchbean produced highest (Rs. 70669/ha) and significantly higher gross returns than rest of the *zayad* crops in sequence. Urdbean and mungbean crops provided at par gross returns (Rs. 37067 and Rs. 41739/ha, respectively).

**Net returns**

At par net returns were recorded during kharif season, where all the crop sequences had rice crop. The net returns ranged from Rs. 20753/ha to Rs. 21944/ha during the *kharif* season. During the *rabi* season it was the vegetable pea which produced highest (Rs. 59930/ha) net returns and it was found significantly superior to all other *rabi* crops in sequence. Vegetable pea was followed by wheat and mustard intercropping (Rs. 49913/ha) for the net returns. Pure wheat crop of wheat produced net returns of Rs. 48142/ha. Pure wheat crop and wheat intercropped with mustard were found significantly superior to mustard crop regarding the net returns.

Mustard crop in rice-mustard-urdbean and in rice-mustard-mungbean provided net returns of Rs. 19855/ha and Rs. 19963/ha, respectively. In *zayad*, vegetable frenchbean recorded highest (Rs. 51244/ha) and significantly higher net returns over the urdbean and mungbean crops. Crops of urdbean and and mungbean produced net returns of Rs. 24262/ha and Rs. 28846/ha, respectively.

When net returns were calculated for the whole crop sequence collectively, highest net returns of Rs. 129448/ha were recorded with rice-vegetable pea-vegetable frenchbean, and this crop sequence was found significantly superior to rest of the crop sequences. Rest of the crop sequences were at par among themselves regarding the net returns.

Rice-vegetable pea-vegetable frenchbean was followed by the rice-wheat+mustard crop sequence (Rs. 70727/ha) for the net returns. Next to this sequence, rice-wheat produced Rs. 68894/ha as net returns. Rice-mustard-mungbean provided net returns worth

Rs. 68174/ha and it was followed by rice-mustard-urdbean (Rs. 64712/ha) which produced minimum net returns.

## References

Gangwar, B. 2009. Efficient cropping systems for commercialization in selected zones of India. Proceedings of 22nd training course on Advances in Commercial Agriculture. March, 18-April, 07, 2009. CAS Agronomy, GBPUAT, Pantnagar.

Anonymous. 2007. Statistical Diary Uttarakhand 2006-07. *Arth avam sankhya nideshalaya, Niyojan Vibhag, Uttarakhand Shashan, Neshvilla Road, Dehradun.*

*J. Farming Systems Research & Development* **18** (2) : 332-348 (2012)

# ENHANCING RESOURCE PRODUCTIVITY AND CARBON-BASED SUSTAINABILITY INDEX OF CEREAL BASED CROPPING SYSTEM UNDER CONSERVATION AGRICULTURE IN WESTERN UTTAR PRADESH

R.K. Naresh[1], Prem Singh[2], Raj K. Gupta[3], S.P. Singh[4], Kamal Khilari[5],
Pardeep Kumar[1] and Lalit Kumar[2]

*[1]Department of Agronomy; [4]Department of Soil Science;[5]Department of Plant Pathology*
*Sardar Vallabhbhai Patel University of Agricultuere & Technology, Meerut ( U. P.), India.*
*[2]Project Directorate For Farming System Research,Modipuram,Meerut-250110*
*[3]CIMMYT India office, NASC complex, Todapur Road, Pusa, New Delhi-11001*

## Abstract

Soil fertility depletion has been described as the single most important constraint to food security in western Uttar Pradesh.Over half of the western Uttar Pradesh population is rural and directly dependent on locally grown crops.Soil organic carbon (SOC) is simultaneously a source and sink for nutrients and plays a vital role in soil fertility maintenance. In most parts of western Uttar Pradesh agro-ecosystems the soils are inherently low in SOC.The low SOC content is due to the low shoot and root growth of crops and natural vegetation, the rapid turnover rates of organic material as a result ofclimate change and fauna activit.There is a rapid decline of SOC levels with continuous cultivation. For the sandy soils, average annual losses may be as high as 4.7% whereas with sandy loam soils, losses are lower, with an average of 2%. To maintain food production for a rapidly growing population, application of mineral fertilizers and the effective recycling of organic amendments such as crop residues and manures are essential especially in the smallholder farming systems that rely predominantly on organic residues to maintain soil fertility.There is need to increase crop biomass at farm level and future research should focus on improvement of nutrient use efficiency in order to increase crop biomass.New crop management technologies that drastically increase the productivity and efficiency of resource use will be required.This does not mean we can forget the population monster: the growth in world population must be slowed even as food production is increased. Rapidly evolving strategies and crop management technologies, such as conservation agriculture (CA), are being developed and used by farmers to confront the issues outlined above, creating innovative and sustainable opportunities for farmers.

Current paper deals as an adaptation strategies for enhancing resource productivity and efficiency should aim to meet the larger goals of reducing poverty,improve carbon based sustainability index,diversifying livelihoods,protecting common property resources and ecosystem services, and strengthening of collective action.The adaptation options that increase the resilience of people and ecosystems by improving access to water and ecosystem services in order to establish and maintain sustainable environments and livelihoods.

**Key words:**Conservation agriculture,cereal systems, carbon sustainability index,resource productivity

## Introduction

Green Revolution era,production increases resulted from expansion in both rice-wheat area and productivity.Now,however,with little additional land available,future demand growth will have to be met mainly through increases in yield per unit area.Further, the average 2% per year rice and wheat yield increases seen from 1970 to 1990 have dropped off due to a combination of environmental factors—such as declining soil health and access to irrigation—and reduced support for public agricultural research, causing yields to stagnate over the past two decades.However,the use of GR technologies showed signs of ecological imbalances.The recent agricultural trends show signs of stagnating production due to (i) decline in factor productivity, (ii) degrading soil health, (iii) inefficiency of current production practices, (iv) scarcity of resources, especially good quality water and labour, (v) changes in land use, driven by socio-economic factors and resource constraints, and good fertile lands going out of cultivation for roads, urban development and industrial uses,etc. and(vi) policy fatigue.The problem is likely to be further exacerbated by the climate change. Climate extremes and poor water availability will necessitate growing more food with less and less water in coming years. An average 1 C rise in temperature will increase the demand for irrigation water by 2-3 per cent to sustain production at the current level (Reeve *et al.* 2010).In last few decades,rice-wheat cropping system has emerged as a major production system in western Uttar Pradesh.Rice, sugarcane, and wheat crops are major consumers of irrigation water supplies in the State.

In recent years, farmers interested in sustainable crop production systems have begun to adopt and adapt improved crop management practices, a step toward CA, which may be considered the ultimate solution. CA,which focuses on the complete agricultural system, involves major changes in farm cropping operations from the widely used, traditional tillage-based farming practices (Sayre 1998; Derpsch 1999).Tillage practices contribute greatly to the labour cost in modern intensive agriculture in any crop production system resulting in lower economic returns, especially in western Uttar Pradesh where there is most concern for sustainable production without degradation of the natural resource base (Naresh et al., 2008).The traditional practice of growing these crops has limitations such as inconvenient input management when sown by broadcasting: improper plant geometry; uneven plant population resulting in inefficient utilization of space; and plant competition leading to low productivity and input efficiency. Shortage of water, labour and energy resources, together with inappropriate crop management practices and the adverse effects of conventional tillage on the carbon based sustainability index, as well as declining profit margins, are forcing farmers of western Uttar Pradesh to switch over to conservation agriculture practices.

The long term sustainability of a cropping system depends on its carbon inputs, outputs and carbon use efficiency which indicate long-term sustainability in terms of yield, environment and ecology. Similarly, efficient utilization of carbon-based resources mitigates the increasing level of $CO_2$ in the environment. Adoption of no-till practice helps in timely seeding of either of the crops, and hence leads to increase in productivity of different cereal-based cropping systems. In the present study four cropping system were evaluated under three different tillage and crop establishment practices in terms of system productivity, resource efficiency,carbon inputs and outputs and carbon based sustainability index. The study aims to develop conservation agriculture practices to increase the sustainability of the cereal-based cropping systems in western Uttar Pradesh.

## Materials and Methods

On-farm trials on three tillage

treatments (no-till on the flat, permanent raised beds, conventional till) and 4 cropping systems (rice-wheat, maize-wheat,Maize-barley and rice-barley) were implemented in large plots in the juridiction of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, U.P. districts Meerut and Ghaziabad of western Uttar Pradesh (UP), 28 402 073 N to 29 282 113 N,77 282 143 E to 77 442 183E. The climate of the area is semiarid, with an average annual rainfall of 805 mm (75–80% of which is received during July to September, minimum temperature of $4^0$C in January, maximum temperature of 41–$45^0$C in June, and relative humidity of 67–83% during the year. The soils are generally sandy loam to loam in texture and low to medium in organic matter content.The particle size distribution of the 0–20cm soil layer is 69.2% sand, 16.1%silt and 14.9% clay. Groundwater pumping is the predominant method of irrigation. Western UP has a diversified cropping system, with RW as the dominant cropping system. All crops except transplanted rice were planted using a multi crop planter with enclined plate seed metering device zero-till drill machine for line sowing and was calibrated every time before seeding to adjust the seeding rate along with all other intercultural operations were conducted to ensure a healthy crop stand in the field.The permanent beds were of 137cm width (furrow-to-furrow) with 6 rows of rice, wheat or barley and two rows of maize. In the conventional till system, the maize and wheat were planted after 4-dry ploughings, while the rice fields received dry tillage followed by wet tillage (puddling) and transplanting of 21 day old seedlings. The residue management was common irrespective of tillage wherein partial (30-cm anchored) residues of monsoon crops (rice and maize) were recycled and in winter crop (wheat, barley) only 10-cm stubbles were recycled.

Sustainability of the cereal-based cropping systems under the different tillage management practices was calculated by using the carbon sustainability index, the ratio of difference between total carbon output and input to the total carbon input. Total carbon input was calculated as the sum of the carbon equivalent of all inputs used under different tillage management practices in cereal based cropping systems i.e. tillage operation, seed, irrigation, fertilizer, pesticide, harvesting, threshing etc. Total carbon output was computed as the sum of the carbon equivalent of grain, straw and root biomass produced by the crop.Globally prescribed values by different scientists were used for calculation of carbon equivalent of inputs as well as outputs.The carbon sustainability index and carbon efficiency of different tillage practices and cropping systems was calculated as per the formula of Lal (2004) shown below:

$$Cs = (Co - Ci) / Ci$$

$$CE = Co / Ci$$

where; Cs= sustainability index, CE= Carbon efficiency, Co= Carbon output and Ci= Carbon input

## Results and Discussion

Conservation Agriculture Contributions to Enhanced Resource Productivity and Efficiency

For CA to succeed, farmers will need to be in the forefront, helping to identify, develop, and deploy new technologies.If we are to insure that adequate food, fiber, and fuel are produced, farmers must employ appropriate crop management technologies not only to stabilize or increase crop production in a cost-effective manner, but also to conserve the integrity and sustainability of their resource base.

Precision Farming Increase the Efficiency of water use for Crop Production

### Grain yields

**Maize:** Commonly, conversion from conventional tillage to reduced-till systems with straw retention requires several crop cycles before potential advantages or disadvantages become apparent (Phillips and Phillips 1984). In our experiment conducted at SVPUA&T,Meerut revealed that straw retention increased yield rapidly, starting from the second crop cycle. We believe this is an important finding because,if repeated on farmers' fields,farmers will quickly realise the benefits and be more interested in adopting the technology. Table 1 presents the grain yields from 2009-10 to 2010–11. The highest maize yields occurred in precision land leveling permanent wide beds with residue retain.Yields tended to be lower in conventional tillage (CT) than precision leveling wide or narrow beds without residue retain.Yields on raised beds consistently increased as residue retain increased from 0% to 100%, but the differences between precision leveling ZTF and traditional leveling ZTF with residue retain were not always significant for the two maize- wheat crop cycles.Precision leveling with residue retain increase 8-11% in maize and 7-9% in wheat as compared to conventional seeding.This is an extremely important finding in relation to practical management of such systems by farmers. Since there is high demand for straw for fodder, fuel or building materials in the IGP, especially by small- and medium-scale farmers,it is encouraging that retaining only 50% of the straw will provide adequate benefit to the crop while the remainder can be removed for other uses.

**Wheat:** Data pertaining to crop yield parameters of wheat (Table 1) showed significant variation due to land leveling, residue management and planting techniques during both the study years. The yield level, in general, under all the treatments was little higher during yr.2 compared to yr.1. This was attributed mainly due to more sunshine hours across the season in yr.2 compared to yr1. Also, the minimum temperature during flowering season was higher during yr.1 compared to yr. 2 which limits the reproductive period and responsible for lower yields of wheat. Grain yield of wheat varied significantly due to laser leveling permanent wide raised beds with residue retained (PWB PL+R) techniques and significantly higher yield levels of 5.45 and 5.55 $t \cdot ha^{-1}$ were recorded under (PWBPL+R) during yr.1 and yr.2,respectively compared to other treatments.The increase in grain yield with (PWB PL+R) was 12.47% and 12.61% during yr.1 and yr. 2,respectively whereas the corresponding increase under flat bed planting was recorded at 8.14% and 8.79%. The yield under permanent narrow raised beds traditional land leveling without residue retained (PNBTL-R) and zero till precision leveling without residue retained (ZTFPL-R) did not varied significantly during both the years. Further, with the same level of land leveling and different levels of planting techniques, the wheat yield varied remarkably. Raised bed showed 5.82% and 6.73% yield advantage over flat bed planting under precision leveling during yr.1 and yr.2, respectively whereas, the corresponding increase in yield under traditional leveling was recorded at 3.96% and 5.49%. It showed

**Table 1 : Maize and wheat water application (mm $ha^{-1}$) and crop yield (t $ha^{-1}$) in laser-leveled and traditionally leveled field under different tillage and crop establishment methods**

| Crop establish-ment | Maize | | | | | | | | Wheat | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2009 | | | | 2010 | | | | 2009-10 | | | | 2010-11 | | | |
| | Laser-aided land leveling | | Traditional land leveling | | Laser-aided land leveling | | Traditional land leveling | | Laser-aided land leveling | | Traditional land leveling | | Laser-aided land leveling | | Traditional land leveling | |
| | Water | Yield | Water | Yield | Water | Yield | Water | Yield | Water | Yield | Water | Yield | Water | Yield | Water | Yield |
| ZT F + R | 330 | 3.35 | 370 | 3.15 | 340 | 3.40 | 350 | 3.25 | 315 | 5.15 | 340 | 5.05 | 295 | 5.20 | 325 | 5.10 |
| ZT F – R | 360 | 3.25 | 425 | 3.08 | 375 | 3.30 | 410 | 3.16 | 355 | 4.95 | 395 | 4.80 | 335 | 5.05 | 380 | 4.85 |
| P NB +R | 320 | 4.30 | 350 | 4.06 | 305 | 4.45 | 335 | 4.27 | 305 | 5.30 | 325 | 5.10 | 285 | 5.35 | 310 | 5.15 |
| P NB – R | 345 | 4.07 | 365 | 3.85 | 320 | 4.23 | 340 | 4.05 | 320 | 5.20 | 335 | 5.02 | 298 | 5.26 | 315 | 5.05 |
| P WB +R | 310 | 4.40 | 335 | 4.18 | 290 | 4.60 | 310 | 4.35 | 285 | 5.45 | 305 | 5.25 | 265 | 5.55 | 285 | 5.38 |
| P WB – R | 330 | 4.18 | 345 | 3.95 | 315 | 4.45 | 332 | 4.20 | 305 | 5.25 | 315 | 5.08 | 290 | 5.32 | 305 | 5.16 |
| CT | 390 | 3.22 | 460 | 3.05 | 375 | 3.25 | 440 | 3.17 | 385 | 4.77 | 435 | 4.65 | 385 | 4.85 | 415 | 4.73 |
| CD at 5% | - | 0.21 | - | 0.29 | - | 0.37 | - | 0.18 | - | 0.24 | - | 0.19 | - | 0.21 | - | 0.31 |

Naresh et al.,2011 (unpublished)

that the raised bed planting technique is more advantageous under precisely leveled fields.

Significantly higher yield of maize-wheat rotation was recorded with precision leveling as it takes care of maintaining near homogeneity by way of cut and fill and also tillage [Naresh et al., 2011]. The formation of fragipan and duripan are two important diagnostic horizons responsible for formation of hard pans/crusts on the surface soils of semi-arid zones as in our experimental site due to accumulation of salts [USDA Salinity laboratory,1954]. Precision land leveling helps in the removal of these hard sub-surface layers by way of deep tillage and subsequent leveling. The frequent micro-relief which is a common characteristic of saline-alkaline soils as at the study site, is also eliminated through laser leveling. The precision land leveling helps in uniform distribution of water even if the depth of application of water is less (about 5 cm) that facilitates good establishment of maize-wheat crops in sodic soils [Tyagi,1984] that resulted in higher yields. The uniformity of land surface with precision land leveling also lowers within the field yield variability compared to traditional leveling [Jat et al., 2006] that in-turn leads to uniform germination, crop establishment and higher crop yields. These findings are in agreement with reference [Gupta & Sayre, 2007; Naresh et al., 2003] who summarized the finding of multi-location trails across IGP and reported higher yield of maize-wheat crops with raised beds compared to flat sowing.

ZTF+ R= Zero till flat Beds with Residue; ZTF– R= Zero till flat Beds without Residue;PNB +R= Permanent narrow raised Beds with Residue;PNB– R= Permanent narrow raised Beds without Residue; PWB+R= Permanent wide raised Beds with Residue; PWB– R= Permanent wide raised Beds without Residue CT = Conventional Tillage

Reducing non-beneficial evaporation losses in the field will lead to water saving. Changing to non-ponding/ unpuddled rice cultures may help solve such problems (Table 2). The transplanting of rice under unpuddled conditions or under zero-tillage can be an alternative for improving water productivity in the medium soils.This has been successfully demonstrated in the UPDASP project at SVPUA&T ,Meerut, U.P.Zero-tillage has enabled farmers to sow their wheat crop immediately after rice harvesting and without any pre-sowing irrigation in some cases.The water saving under zero-tillage has been recorded at the time of first post-sowing irrigation (Hobbs and Gupta, 2003;Malik et al.,2004). Similarly,the bed planting of wheat can be used for a significant improvement in the water productivity (Fig.1) but the success of this technology will depend on the type of soil and source of irrigation (Anonymous, 2005). Laser land levelling is an important component of resource conservation technology that can improve water productivity at field level (Gupta, 2003,Naresh et al, 2003).

**Conservation Agriculture in Sustaining Land Productivity**

The increase in food production in most countries was achieved by bringing new land into agricultural production. However, reserves of potentially arable prime agricultural land are dwindling (Bockman et al. 1990; Crosson and Anderson 1992) and the remaining land is claimed for numerous purposes, including the provision of essential ecosystem services. There are also

**Table 2 : Effect of crop establishment methods on crop yield, water productivity and profitability of rice and pigeonpea**

| Crop establishment | Grain yield t $ha^{-1}$ | | Water productivity (kg grain $m^{-3}$ water) | | Net profit (Rs $ha^{-1}$) | |
|---|---|---|---|---|---|---|
| | Rice | Wheat | Rice | Wheat | Rice | Wheat |
| No- till flat | 3.85 | 5.1 | 0.58 | 1.74 | 18820 | 22450 |
| FIRB narrow | 4.12 | 5.2 | 0.59 | 1.98 | 19225 | 25400 |
| FIRB wide | 5.18 | 5.7 | 0.67 | 2.17 | 22630 | 29650 |
| Conventional | 5.35 | 4.9 | 0.57 | 1.56 | 20725 | 20450 |
| Average | 4.63 | 5.23 | 0.60 | 1.86 | 20350 | 24490 |

indications that the highly effective fertilizer and seed technologies introduced over the past four decades may be reaching a point of diminishing returns (Cassman et al.1995; Flinn and De Datta 1984).Consequently,keeping pace with population growth while dealing with increasing land scarcity and degradation will be more difficult than in the recent past.Conservation agriculture, that involves an application of modern agricultural technologies to improve production,enables maximization of yields but also helps maintain ecosystem health and integrity unlike the traditional systems which mainly intend to maximize yields sometimes at the expensive of the environment (Dumanski et al, 2006).Expansion of conservation agriculture can create a

**Table 2 : Profitability of RW under various tillage and crop establishment methods.**

| Crop establishment | | Net returns(Rs $ha^{-1}$) | | | B:C ratio | | |
|---|---|---|---|---|---|---|---|
| Rice | Wheat | Rice | Wheat | System | Rice | Wheat | System |
| TPR | ZTW | 19575 | 25650 | 45225 | 1.76 | 2.78 | 2.22 |
| RT DSR | ZTW CT M | 20205 | 27180 | 47385 | 1.83 | 2.83 | 2.30 |
| RT TR | ZTW CT WM | 19665 | 25920 | 45585 | 1.79 | 2.74 | 2.23 |
| ZT TR | ZTW PR M | 21060 | 27720 | 48780 | 1.92 | 2.85 | 2.36 |
| ZT TRD | ZTW PR WM | 21240 | 26415 | 47655 | 1.89 | 2,81 | 2.31 |
| ZT DSR | ZTW NS M | 22725 | 26550 | 49275 | 2.07 | 2.86 | 2.43 |
| CT DSR | ZTW NS WM | 20700 | 24660 | 45360 | 2.03 | 2.82 | 2.39 |
| N Bed DSR | ZTW N Bed M | 13725 | 27675 | 41400 | 1.68 | 2.86 | 2.32 |
| N Bed TR | ZTW N Bed WM | 14625 | 26415 | 41040 | 1.70 | 2.82 | 2.27 |
| W Bed DSR | ZTW W Bed M | 15750 | 29700 | 45450 | 1.82 | 2.89 | 2.40 |
| W Bed TR | ZTW W Bed WM | 18450 | 28170 | 46620 | 1.86 | 2.85 | 2.35 |
| TPR | CTW | 19575 | 21870 | 41445 | 1.78 | 2.62 | 2.14 |

win-win situation through promoting more efficient crop production and reducing soil degradation while maintaining ecosystem integrity.As a result, the impacts of conservation agriculture have been markedly positive both in agricultural, environmental, economic and social terms (Garcia-Torres et al.,2003:FAO,2002;Dumanski et al.,2006).Naresh et al.,2011 revealed that the net income rice was higher with ZTDSR followed byZTTRD,ZTTR,CTDSR, RTDSR,RTTR and TPR and the lowest being recorded with beds (Table 2).The lower net income with the permanent beds was due to the cost on preparing the beds in first season. Profitability of wheat was remarkably higher with double no-till practices (ZTWPRM,ZTWCTM,ZTW and permanent beds due to higher productivity and less cost of production compared to conventional tillage practices.Further,the profitability of wheat was remarkably higher with residue retention compared to residue removal and the difference was more under ZTWWBedM compared to other practices. The maximum net income of the system was recorded with ZTDSR-ZTWNSM followed by ZTTR-ZTWPRM and the lowest being with permanent narrow raised beds.

TPR-puddle transplanted rice, RTDSR-reduced tillage direct seeded rice, RTTR-reduced tillage transplanted rice, ZTTR- zero till field transplanted rice, ZTTRD- zero till field transplanted rice with mid season drying, ZTDSR-zero till direct seeded rice, CTDSR-conventional till direct seeded rice, NBedDSR-direct seeded rice on narrow raised beds, NBedTR-transplanted rice on narrow raised beds, WBedDSR-direct seeded rice on wide raised beds, WBedTR-transplanted rice on wide raised beds, ZTW-zero till wheat planted by turbo happy seeder, ZTWCTM-wheat planted by zero till con trol traffic with mulch, ZTWCTWM- Wheat planted by zero till control traffic without mulch,ZTWPRM Wheat planted by zero till paired row with mulch, ZTWPRWM- Wheat planted by zero till paired row without mulch, ZTENSM- zero till wheat normal spacing with mulch, ZTWNSWM- zero till wheat normal spacing without mulch, ZTWN BedM- zero till wheat on permanent narrow raised bedswith mulch, ZTWNBedWM- zero till wheat on permanent narrow raised beds without mulch, ZTWWBedM- zero till wheat on permanent wide raised bedswith mulch, ZTWWBedWM- zero till wheat on permanent wide raised beds without mulch, CTW-conventional till wheat.

**Conservation Agriculture in Improving Nitrogen use efficiency**

An experiment conducted at SVPUA&T,Meerut during 2007-08 to 20010-11 and results revealed that the N uptake increased with increasing the basal dose on application in all sowing techniques of wheat.The increased N uptake 80% as basal for wide beds was 58%,narrow beds was 49%,turbo happy seeder was 44%,zero till drilling was 39%,strip till drilling was 36 % and roto till drilling was 23 % over conventional practices of wheat sowing .Nitrogen uptake was significantly ($P<0.5$) influenced by sowing techniques and N placement level.Wide beds + 80% N basal plots,total N uptake was maximum and there was a consistent trend for increasing N uptake upto strip till drilling sowing techniques.Limon et al.(2000) also observed that permanent beds with N placement gave the highest average wheat grain yield (5057Kg/ha),N use efficiency (28.2 Kg grain/Kg of N supply) and total N uptake (133 Kg/ha).N use efficiency (calculated PE,AE and RE) decreased as split application of N in all treatments (Table 3).At higher dose of basal N placement there was a consistent trend for higher AE on wide raised beds .There was a consistent trend for higher PE on Wide raised beds as the amount of basal dose of N placement increased from 3-split of N to 80% N basal.Higher dose of N as basal resulted in increased N uptake in both fertilized in conventional practices and resource conserving technologies are closely related to productivity,but are controlled by numerous abiotic and biotic factors in the soil-plant system.These include cultivar,fertilizer input,weather,pests and management of soil residues,irrigation and drainage (Yadvinder etal,2005).Given the complexity of cropping system associated with the pronounced aerobic cycles,and important question concern how N use efficiencycan be improved.Good N placement and sowing techniques may allow this.

**Table 3 : Nitrogen use efficiency of wheat as influenced by sowing techniques and N placement.**

| Treatments | AE (Kg grain $Kg^{-1}$ N Applied) | PE (Kg grain $Kg^{-1}$ N uptake ) | RE (%) |
|---|---|---|---|
| | | **Turbo Happy Seeder** | |
| 80 % N basal | 22.3 | 25.3 | 77.3 |
| 3 split of N | 21.5 | 22.4 | 74.6 |
| | | **Zero Till Drilling** | |
| 80 % N basal | 20.4 | 27.9 | 71.2 |
| 3 split of N | 19.2 | 22.8 | 64.3 |
| | | **Strip Till Drilling** | |
| 80 % N basal | 19.3 | 23.2 | 65.3 |
| 3 split of N | 18.6 | 21.7 | 62.7 |
| | | **Roto Till Drilling** | |
| 80 % N basal | 16.2 | 18.6 | 59.6 |
| 3 split of N | 14.5 | 16.4 | 50.9 |
| | | **Beds Planting** | |
| Narrow Beds Planting | | | |
| 80 % N basal | 24.3 | 33.7 | 81.3 |
| 3 split of N | 24.1 | 26.2 | 79.8 |
| | | **Wide Beds Planting** | |
| 80 % N basal | 29.5 | 34.2 | 87.3 |
| 3 split of N | 28.3 | 29.5 | 84.5 |
| | | **Conventional Practices** | |
| 80 % N basal | 12.4 | 13.5 | 53.4 |
| 3 split of N | 10.5 | 11.5 | 53.2 |

**Reductions in human and machinery labour**

Agricultural labor shortages are growing even in the western Uttar Pradesh, India—and this is causing many farmers to consider the adoption of CA-based technologies which, under most situations,can reduce labor requirements.One of the major benefits that smallholder farmers perceive with CA is the labor savings (Wall 2007).For example, hand transplanting of puddled rice after conventionally tilled, irrigated wheat has a high labor requirement that peaks in June and July (especially in north west India). This creates serious labor shortages during this critical time, and has provoked farmer interest in technologies available for direct seeding rice without puddling. One of these technologies is direct (zero till) seeding of rice into dry soil after zero till wheat.

Although there are few reliable economic comparisons of dry seeded,zero till rice compared to transplanted, puddled rice,much more is know in relation to wheat. Experiment conducted at SVPUA&T, Meerut during 2008-09 & 2009-10 the machine and human labour use in various tillage and crop establishment teshniques revealed that direct drill-seeded rice on narrow/wide raised beds had the highest machine labor requirement (13.4 &14.2 tractor hrs $ha^{-1}$) followed by transplanted rice either on raised beds or after conventional puddling (Table 4). No-till rice either direct-seeded or transplanted had the lower machine labor requirements. Conventionally tilled wheat had the highest machine labor requirement (12.8 tractor hrs $ha^{-1}$),whereas all other treatments had a machine labor requirement of about( 6 tractor hrs $ha^{-1}$ ) as they were seeded using the no-till drill except ZTWCTM and ZTWPRM. Along with reductions in labor,in mechanized systems CA results in a marked reduction in the use of

**Table 4 : Machine and human labour use in RW system with various tillage and crop establishment techniques**

| Crop establishment | | Machine labour | | Human labour | |
|---|---|---|---|---|---|
| Rice | Wheat | Rice | Wheat | Rice | Wheat |
| TPR | ZTW | 11.7 | 6.5 | 70.5 | 15.0 |
| RT DSR | ZTW CT M | 8.2 | 7.0 | 47.8 | 14.0 |
| RT TR | ZTW CT WM | 9.8 | 6.5 | 63.7 | 13.0 |
| ZT TR | ZTW PR M | 8.4 | 7.0 | 67.3 | 14.0 |
| ZT TRD | ZTW PR WM | 8.4 | 6.5 | 65.6 | 13.0 |
| ZT DSR | ZTW NS M | 7.6 | 6.5 | 48.3 | 14.0 |
| CT DSR | ZTW NS WM | 10.4 | 6.5 | 47.2 | 13.0 |
| N Bed DSR | ZTW N Bed M | 13.4 | 6.5 | 46.5 | 14.0 |
| N Bed TR | ZTW N Bed WM | 11.2 | 6.5 | 66.4 | 13.0 |
| W Bed DSR | ZTW W Bed M | 14.2 | 6.5 | 45.2 | 14.0 |
| W Bed TR | ZTW W Bed WM | 11.5 | 6.5 | 67.4 | 13.0 |
| TPR | CTW | 11.7 | 12.8 | 70.5 | 16.0 |

tractors and equipment,all of which cuts fuel use,reducing both farmers' costs and GHG emissions.The reduction in tractor use means that a single tractor can provide the required traction for a greater area.This provided for the expansion of the agricultural area using existing tractors,but in the western Uttar Pradesh it has meant that relatively large-scale farmers could become service providers to the smaller farmers in the community.Anyone who has watched a tractor working dry soil,especially alluvial soil,cannot help but notice the cloud of dust in which the tractor and the operator have to work.In CA systems, where residue covers the soil and is not tilled,dust is almost completely absent,benefitting the operator and the farmer, since tractors and equipment operating in dust-free environments require considerably less maintenance and their useful life is extended,reducing again the costs of production.

TPR-puddle transplanted rice, RTDSR-reduced tillage direct seeded rice, RTTR- reduced tillage transplanted rice, ZTTR- zero till field transplanted rice, ZTTRD- zero till field transplanted rice with mid season drying, ZTDSR- zero till direct seeded rice, CTDSR- conventional till direct seeded rice, NBedDSR- direct seeded rice on narrow raised beds, NBedTR-transplanted rice on narrow raised beds, WBedDSR- direct seeded rice on wide raised beds, WBedTR- transplanted rice on wide raised beds, ZTW-zero till wheat planted by turbo happy seeder, ZTWCTM-wheat planted by zero till control traffic with mulch, ZTWCTWM- Wheat planted by zero till control traffic without mulch, ZTWPRM- Wheat planted by zero till paired row with mulch, ZTWPRWM- Wheat planted by zero till paired row without mulch, ZTENSM- zero till wheat normal spacing with mulch, ZTWNSWM- zero till wheat normal spacing without mulch, ZTWNBedM- zero till wheat on permanent narrow raised bedswith mulch, ZTWNBedWM- zero till wheat on permanent narrow raised beds without mulch, ZTWWBedM- zero till wheat on permanent wide raised bedswith mulch, ZTWWBedWM- zero till wheat on permanent wide raised beds without mulch, CTW-conventional till wheat.

**Conservation Agriculture and its Role in Genotype x Tillage Interaction**

In an agronomical trial four varieties in 2007-08 and five varieties in 2008-011 were evaluated under six tillage options viz., turbo happy seeder, zero, strip, rotary, furrow irrigated raised bed system (FIRBS) and conventional tillage at SVPUA &T, Meerut. There was significant difference in yield of different varieties under various tillage options.In 2007-08,wheat variety UP-2338 performed better in zero and rotary tillage and PBW 343 in FIRB and conventional tillage as compared to other tillage options. The grain: straw ratio was high under rotary tillage conditions as it converted more biomass into grain compared to straw. On an average,root biomass was higher in raised bed and rotary tillage at different intervals but statistically all were at par. All the tillage options were at par in water storage capacity at different intervals. In 2008-011 also, variety x tillage interaction was significant. PBW-550, PBW 343, PBW-154 were at par and produced higher in turbo happy seeder, zero and conventional, while PBW 343, UP-2338 produced higher grain yield under strip, rotary and WH-711 was superior in FIRBS (Fig.2). On an average, root biomass was higher in rotary and raised bed. Varieties like PBW-550 which produced higher grain yield in zero tillage also had higher root biomass.Significant positive correlation was obtained between yield versus ear heads/$m^2$,yield versus biomass,leaf area versus grains/earhead,root biomass vs grains/earhead and root vs shoot biomass at tillering,leaf area versus root weight.It is believed that wheat genotypes with early vigour and better root system would perform better under zero-tillage conditions.Variability for root biomass accumulation and positive correlations between root length,root weight,biomass with grain yield have been observed.

Wheat Cultivars in Relation to Resource Conservation Technologies conventional tillage along with FIRBS.Experimentation over a period of four years has also confirmed the presence of genotype x tillage interactions.In general,it was observed that PBW 343 did exceedingly well across the tillage methods. Where as UP-2338 and PBW-154 performed better under conventional tillage.Thus,based on the research conducted in the last 3-4 years it seems imperative that breeding wheat genotypes for specific RCT will be very much required.It is necessary that selection for suitable plant type be initiated under zero tillage conditions.There is also a need to study the association of related parameters like root morphology,spread and their penetration with yield performance under zero tilled soils.

### Conservation Agriculture and its Role in Carbon-Based Sustainability Index

The system productivity in terms of rice equivalent yield was influenced significantly due to different tillage practices and various cropping systems under study. The results revealed that permanent wide beds planting resulted in maximum system productivity during both the years of investigation compared to zero till and conventional till (Table 5). In permanent wide beds better aeration,high infiltration rat and crop less root penetration resistance resulted into better plant growth and yield. Among the various cereal-based cropping systems Rice-Wheat resulted in maximum system productivity in both the years and in rice-wheat cropping system, the average yield of rice was slightly higher under the conventional puddled transplanted system (PTR) than with permanent wide beds and no-till direct dry seeding (DSR) (Table 5). However,wheat and total system yields were highest with permanent wide beds (PWB). In conventionally tilled systems, particularly puddled rice systems, intensive tillage leads to the development of a compacted layer in the root zone soil, and massive soil structure above this layer, resulting in restricted root penetration of succeeding wheat/barley crops, poor aeration and soil nutrient-moisture and crop root interactions, and hence low productivity of the crops (Naresh et al., 2011). In the maize-wheat system, maize,wheat and system productivity was higher in PWB than ZT and CT,while CT had the lowest system productivity.

The carbon-based sustainability index(CSI) and carbon efficiency (CE) was lower in rice than wheat, barley and maize (Table 5). The effect of cropping system on the CSI and CE was much greater than the effect of tillage/ establishment method,and was highest in rice-maize and least in rice-wheat.Across the systems CSI and CE declined in the order of Maize-Wheat>Maize-Barley>Rice-Barley>Rice-Wheat during both the years.The C sustainability of rice systems alternated with upland crops is lower than other system and is also contrary to continuous rice system wherein anaerobic conditions restricts oxidation of C.Within

**Table 5 : System productivity and carbon sustainability index of different cereal based cropping systems under different tillage practices**

| Treatments | System Productivity (t ha$^{-1}$) | | Carbon sustainability index (CSI) | | Carbon efficiency (CE) | |
|---|---|---|---|---|---|---|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| **Tillage practices** | | | | | | |
| Zero-tillage (ZT) | 7.98 | 7.79 | 10.9 | 10.6 | 12.5 | 11.8 |
| Permanent Wide raised Beds (PWB) | 9.06 | 9.08 | 12.3 | 11.9 | 14.9 | 14.1 |
| Conventional Tillage (CT) | 8.16 | 8.12 | 9.1 | 8.4 | 13.5 | 12.9 |
| **Cropping System** | | | | | | |
| Rice-Wheat | 9.95 | 9.82 | 7.4 | 6.9 | 12.5 | 11.9 |
| Rice-Barley | 8.44 | 7.87 | 7.7 | 7.2 | 12.9 | 12.1 |
| Maize-Wheat | 8.35 | 8.56 | 14.6 | 14.3 | 15.6 | 15.2 |
| Maize-Barley | 6.84 | 7.07 | 13.2 | 12.6 | 13.6 | 12.7 |

cropping systems,the CSI and CE with conventional tillage was much lower than the other tillage/ establishment methods,with only small differences between PWB and ZT.Dubey and Lal (2009) also reported that conservation tillage improved carbon sustainability index (CSI) and carbon efficiency (CE) in comparison to conventional planting system in two different types of ecologies and production systems.The productivity of various crops and their CSI under cereal-based cropping sequences having different degrees of correlation ranging from $R^2$=0.155 in rice to $R^2$=0.976 in maize.

Conservation agriculture based resource conservation technologies lead to significantly higher system productivity,CSI and CE irrespective of the various cereal based cropping systems. However,the greatest system productivity was achieved maximum under rice-wheat when planted on the permanent wide beds and conventional as compared to zero till direct seeded .

## Carbon Sequestration through Conservation Agriculture

Agricultural ecosystems have significant potential to increase carbon storage, thereby reducing atmospheric concentrations of $CO_2$ by sequestering C in soils and vegetation (Lal, 2004).Agricultural lands also remove $CH_4$ from the atmosphere by oxidation, though less than forests (Tate et al., 2006; Verchot et al.,2000),but this effect is small compared to other GHG fluxes (Smith and Conen, 2004). Increased carbon stocks can be achieved through a change in land use to one with higher carbon stock potential, usually revealed by a change in land cover or through management practices.

Conservation tillage to maintain higher levels of soil organic matter. This practice promotes sequestration of soil carbon, but tends to increase $N_2O$ emissions. The carbon sequestration potential of this practice is controversial.Carbon accumulation from a change in land use and management is not be sustained indefinitely. Eventually, inputs and losses balance, and carbon stocks approach a new, higher equilibrium (Davidson and Ackerman, 1993). The effect of the land-use change on atmospheric GHGs must be determined from a whole system point of view. In many "managed" ecosystems, there is significant removal of carbon in harvested products, some of which may accumulate in long-term storage pools (e.g., wood products), while some carbon rapidly returns to the atmosphere via respiration. Additionally,increases in soil organic carbon are often associated with increases in $N_2O$ emissions (Li et al., 2005).In wetlands,the effects of changes in land-use on soil $CH_4$ emissions also need to be considered. Conservation tillage is any tillage method that leaves sufficient crop residue in place to cover at least 30% of the soil surface (Lal, 2003).These practices have been increasingly used throughout the world.Given that soil disturbance is thought to stimulate soil carbon losses through enhanced decomposition and erosion, reduced- or no-till agriculture often (but not always) results in soil carbon gain in the surface portions of the soil. Reduced- or no-till practice may affect $N_2O$,emissions but the net effects are not well-quantified and under stood.Smith et al (2007) estimated the potential of this mitigation practice to sequester carbon and reduce $N_2O$ emissions under different climate zones is presented in Table 6.

## Conclusions

Inappropriate agricultural cultivation systems are one of the main reasons for the poverty and food insecurity faced by smallholders in most parts of the western Uttar Pradesh. Unsustainable agricultural practices lead to an exhaustion of soil resources,which results in reduced land productivity,land degradation,and a reduction in biodiversity. Conservation agriculture, which is mainly based on the three principles of minimum soil disturbance, permanent soil cover and crop rotation, has shown to improve, conserve and use natural resources in a more efficient way through integrated management of available soil,water and biological resources.It is now widely recognized as a viable concept for sustainable agriculture due to its comprehensive benefits in economic,environmental and

**Table 6 : Mitigation potential through improved tillage and residue management ($tCO_2e\ ha^{-1}\ yr^{-1}$)**

| Climate Zone | $CO_2$ | $N_2O$ |
|---|---|---|
| Cool-dry | 0.15 (-0.48 – 0.77 ) | 0.02 ( -0.04 – 0.09 ) |
| Cool-moist | 0.51 ( 0.00 – 1.03 ) | 0.02 ( -0.04 – 0.09 ) |
| Warm-dry | 0.33 ( -0.73 – 1.39 ) | 0.02 ( -0.04 – 0.09 ) |
| Warm-moist | 0.70 ( -0.40 – 1.80 ) | 0.02 ( -0.04 – 0.09 ) |

*Source:* Smith et al. (2007)

*Note:* Values in parentheses correspond to low and high mitigation potential. Positive values represent $CO_2$ uptake which increases the soil carbon stock, or a reduction in emissions of $N_2O$.

social terms.Its ability to increase grain yields to provide better economic performance and reduce production risks and to improve energy use efficiency has been well-documented.What is required is better understanding of its performance and requirements across wider geographic regions and environmental conditions to enable the diffusion of the technology.For its successful implementation in the irrigated agro-ecological regions of western Uttar Pradesh where it is needed most, the design and dissemination of cost-effective farming tools,access to herbicides and economic incentives will be required in addition to creating awareness.

Conservation agriculture offers an opportunity for arresting and reversing the downward spiral of resource degradation,diminishing factor productivity and decreasing cultivation costs making agriculture more resource use-efficient, competitive and sustainable. While, research and development efforts over the past decade have contributed to increasing farmer acceptance of zero tillage for wheat in rice-wheat cropping system,this has raised a number of institutional, technological and policy related questions related to technology generation, adaptation and further improvement,which must be addressed if CA practices have to be adopted on a sustained basis.

## REFERENCES

Anonymous. 2005. Agenda Notes.13$^{th}$ Regional Technical Coordination Committee Meeting of Rice-Wheat Consortium for Indo-Gangetic Plains held at Dhaka,Bangladesh during February 6-8, 2005.

Bockman, O.C., Kaarstad, O., Lie, O.H. and Richards, I. 1990. Agriculture and Fertilizers: Fertilizers in Perspective. Norsk Hydro, Oslo.

Cassman,K. G., S. K. De Datta, D. C. Olk, J. Alcantara, M. Samson, J. Descalsota, and M. Dizon. 1995. Yield decline and the nitrogen economy of long term experiments on continuous, irrigated rice systems in the tropics. In: R. Lal and B.A. Stewart (eds), Soil management: Experimental Basis for Sustainability and Environmental Quality, Crosson, P., Anderson, J. 1992 Resources and Global Food Prospects: Supply and Demand for Cereals to 2030. World Bank Technical Paper Number 184, The World Bank, Washington, D.C.

Derpsch, R. 1999. Expansión mundial de la SD y avances tecnológicos. In Proceedings of the 7th National Congress of AAPRESID, 18-20 August 1999. Mar del Plata, Argentina.

Dubey A, Lal R 2009 Carbon Footprint and Sustainability of Agricultural Production Systems in Punjab, India, and Ohio, USA, Journal of Crop Improvement, 23, 332–350.

Davidson EA and Ackerman IL. 1993. Changes in soil carbon inventories following cultivation of previously untilled soils. Biogeochemistry **20**: pp.161-193

Dumanski, J., R. Peiretti, R., Benites, J.R., McGarry, D and Pieri, C. 2006. The paradigm of conservation agriculture, Proc. World Assoc. Soil Water Conserv. P1 (2006), pp. 58–64.

FAO, 2002. The Conservation Agriculture Working Group Activities 2000 – 2001. Food and Agriculture Organization of the United Nations, Rome, 2002, 25 pp

FAO 2008. Conservation Agriculture Carbon Offset Consultation – West Lafayette, Indiana, USA, 28-30 October 2008.

Flinn, J. C., and S. K. De Datta. 1984. Trends in irrigated rice yields under intensive cropping at Philippine research stations. Field Crops Research **9**, 1-15.

García-Torres, L., J. Benites, A. Martínez-Vilela and A. Holgado-Cabrera. 2003. Conservation Agriculture: Environment, Farmers Experiences, Innovations, Socio-economy, Policy, Kluwer Academic Publishers, Boston, USA (2003).

Gupta, R. 2003. Agenda Notes 12th Regional Coordination Committee Meeting of Rice-Wheat Consortium for Indo-Gangetic Plains, February 7-9, 2004, Islamabad, Pakistan. pp. 39-50.

Gupta,R. and Sayre,K. D.2007. "Conservation Agriculture in South Asia," *Journal of Agricultural Sciences*, Vol. 145,pp. 207-214.

Jat, M.L.,Chandana,P.,Sharma, S. K., Gill, M. A. and Gupta, R.K. 2006. "Laser Land Leveling-A Precursor Technology for Resource Conservation," *Rice-Wheat Consortium Technical Bulletin Series* 7, Rice-Wheat Consortium for the Indo-Gangetic Plains, New Delhi.

Jat SL,Parihar,CM,Singh AK, Jat ML, Jat RK. 2010. Carbon sustainability and productivity of maize based cropping system under Conservation Agriculture practices in Indo-Gangetic plains.

Lal, R., 2003. Global potential of soil carbon sequestration to mitigate the greenhouse effect. Crit. Rev. Plant Sci. 22 (2), 151–184.

Lal R. 2004. Soil carbon sequestration impacts on global climate change and food security. Science. **304**: 1623-1627

Li C, Frolking S, and Butterbach Ball K. 2005. Carbon sequestration in arable soils is likely to increase nitrous oxide emissions, offsetting reductions in climate radiative forcing. Climatic Change. **72**: pp. 321-338.

Malik, R.K., Yadav, A., Gill, G.S., Sardana, P., Gupta, R.K. and Piggin, C. 2004. Evolution and acceleration of no-till farming in rice-wheat system of the Indo-Gangetic Plains. 4th International Crop Science Congress held in Brisbane, Australia from September 26 to October 1. 73 p.

Naresh, R.K.; Gupta R.K.; Malik R.K.; Ladha, J.K. and PandeySuresh 2003. Adopting conservation agriculture in the rice-wheat system of the Indo-Gangetic Plains:new opportunities for saving water.National Technical Coordination Committee meeting of RWCS New Delhi on July 28-29, 2003

NareshR.K.;GuptaRaj K.;Pande Suresh;Singh Devi;Singh I.P.;Singh B.;Malik Sunil and Shan mugasundaram S. 2008. Conservation agriculture for food security and improving farmers livelihoods of western Uttar Pradesh.4th National Symposium on Scenario of agriculture in changing climatic conditions. S.V.B.P Univerity of agriculture & technology,Meerut (U.P.): 39-148.

Naresh, R.K. ; Gupta Raj. K.; Kumar Ashok; Prakash Satya; Tomar, S.S.; Singh Adesh; Rathi R.C.; Misra A.K. and Singh, Madhvendra Singh.

2011. Impact of laser leveler for enhancing water productivity in Western Uttar Pradesh. International Journal of Agricultural Engineering, 4 (2):133-147.

Naresh, R.K.; Gupta Raj K.; Prakash Satya; Tomar, S.S.; Kumar Yogesh & Singh P.K. 2011. Evaluation of precision land leveling and permanent raised bed planting in maize–wheat rotation:productivity, profitability,input use efficiency and soil physical properties.Indian Journal of Agricultural Sciences (accepted).

Naresh, R.K., Kumar, Ashok, Shahi, U.P., Kumar, Yogesh, Tomar, S.S. & Rathore, R.S. 2011. Role of Conservation agriculture for enhancing productivity, sustainability of Rice-wheat systems in climate change scenario of North West India. Plant Archives (accepted).

Reeves,Timothy et al. 2010. The impacts of climate change on wheat production in India – adaptation, mitigation and future directions. Review for the Government of India. Food and Agriculture Organization of the United Nations. September 2009, New Delhi.

Sayre, K.D. 1998. Ensuring the use of sustainable crop management strategies by small wheat farmers in the 21st century. Wheat Special Report No. 48. Mexico, D.F.CIMMYT.

Salinity Laboratory Staff, "Diagnosis and Improvement of Saline and Alkali Soils," *Agriculture Handbook No.* 60, USDA, US Government Printing Office, Washington, D. C., 1954.

Smith KA and Conen F. 2004. Impacts of land management on fluxes of trace greenhouse gases. Soil Use and Management. **20**: 255-263

Smith P, Martino D, Cai Z, Gwary D, Janzen HH, Kumar P, McCarl B, Ogle S, O'Mara F, Rice C, Scholes RJ, Sirotenko O, Howden M,McAllister T, Pan G, Romanenkov V, Schneider U, Towprayoon S, Wattenbach M, and Smith JU. 2007. Greenhouse gas mitigation in agriculture. Philosophical Transactions of the Royal Society, B.

Tate KR, Ross DJ, Scott NA, Rodda NJ, Townsend JA, and Arnold GC. 2006. Post-harvest patterns of carbon dioxide production, methane uptake and nitrous oxide production in a Pinus radiata D. Don plantation. Forest Ecology and Management **228**: pp.40-50

Tyagi,N.K.1984."Effect of Land Surface Uniformity on Irri-gation Quality and Economic Parameters on Sodic Soils under Reclamation," *Irrigation Science*, Vol. 5:151-166.

Verchot LV,Davidson EA,Cattânio JH,and Ackerman IL.2000.Land-use change and biogeo -chemical controls of methane fluxes in soils of eastern Amazonia. Ecosystems, **3**: pp.41-56

Wall P.C. 2007. Tailoring Conservation Agriculture to the needs of small farmers in developing countries: An analysis of issues. Journal of Crop Improvement 19, 137-155.

Yadvinder singh;Bijay Singh and Timsina,J.2005.Crop residue management for nutrient cycling and improving soil productivity in rice-based cropping systems in the Tropics.Advances in Agronomy 69:393-407.

*J. Farming Systems Research & Development* **18** (2) : 349-356 (2012)

# INTEGRATED NUTRIENT MANAGEMENT IN CLUSTERBEAN [*CYAMPOSIS TETRAGONOLOBA* (L.) TAUB.] – WHEAT [*TRITICUM AESTIVUM* (L.) EMEND. FIORI & PAOL.] CROPPING SEYSTEM UNDER SEMI-ARID CONDITIONS OF RAJASTHAN

RAMAWTAR, A.C. SHIVRAN AND B.L. YADAV

*Department of Agronomy, S.K.N. College of Agriculture, Jobner (Rajasthan)*

## ABSTRACT

A field experiment was carried out during 2004-2005 and 2005-2006 to study the effect of integrated nutrient management on crop productivity and soil fertility in clusterbean [*Cymposis tetragonoloba* (L.) Taub.] – wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] cropping system. Application of 75% of RDF (15 kg N + 30 kg $P_2O_5$ $ha^{-1}$), vermicompost @ 2.0 t $ha^{-1}$ and sulphur @ 40 kg $ha^{-1}$ recorded significantly higher yield attributes (pods/ plant, seeds/pod and pod length) and seed yield of clusterbean over control.. The grain yield of succeeding wheat crop was also increased by 21.2 and 22.2% over control, respectively with residual fertility of 100% RDF over lower levels during both the years of experimentation. Similarly, application of vermicompost @ 2 t $ha^{-1}$ and sulphur @ 60 kg $ha^{-1}$ to clusterbean significantly improved the grain yield of succeeding wheat crop over lower levels and control. The available status of N, P and S was improved due to fertilizer application after harvest of clusterbean while organic carbon status was improved only due to application of vermicompost to clusterbean.

**Key words:** NP fertilizers, vermicompost, sulphur, clusterbean and wheat

## INTRODUCTION

Clusterbean [*Cyamopsis tetragonoloba* (L.) Taub.] commonly known as guar, is a drought hardy, deep rooted, summer annual legume and grown for grain, vegetable, green fodder, cattle feed and for green manuring purposes. Of late, the clusterbean has occupied the status of international cash crop with great export significance. This is due to presence of natural polysaccharide galactomannan gum content in seed endosperm. In last few years, price of clusterbean seed remained quite high and farmers realized high profit by producing clusterbean seed because the guar gum demand has increased substantially abroad due to its multiple uses in industries like mining, textile, confectionary *etc.* The productivity of clusterbean is quite low mainly due to its cultivation on marginal and sub-marginal lands with poor fertility status and having inadequate irrigation facilities. No single source of nutrient is capable of supplying plant nutrients in adequate amount and balanced proportion. Therefore, to maintain soil fertility and to supply plant nutrients in balanced proportion in specific ecological situation is only possible through combined use of organic and inorganic sources of plant nutrients. Inclusion of legumes with the use of organic manure in cropping sequence results in improvement of base as well as succeeding crop (Sharma and Vyas, 2001).

Sulphur application also produces significant residual response on succeeding crop (Sharma and Singh, 2005). Clusterbean being drought resistant crop can be grown successfully under rainfed condition and wheat can be succeeded to clusterbean by providing irrigation. Most of the Rajasthan soils are low in organic carbon and deficient in nitrogen, phosphorus and sulphur. Therefore, adequate supply of nutrients is must for obtaining good harvest. Keeping these views in mind the present investigation was undetaken.

## MATERIAL AND METHODS

The field experiment was conducted during 2004-05 and 2005-06 at Agricultural Research Station, Durgapura (Jaipur). The soil was loamy sand with pH 8.0, having 0.18% organic carbon, 171.20 kg $ha^{-1}$ available N, 27.2 kg $ha^{-1}$ available $P_2O_5$ and 210.6 kg $ha^{-1}$ available $K_2O$. The experiment consisted of thirty two treatment combinations with four levels of NP fertilizers (0, 50, 75 and 100% of RDF), two levels of vermicompost (1.0 and 2.0 t $ha^{-1}$) and four levels of sulphur (0, 20, 40 and 60 kg S $ha^{-1}$). The experiment was laid out in split plot design, allocating NP fertilizers and vermicompost in main plots and sulphur in sub plots and were replicated thrice. All the treatments were applied to clusterbean crop only. The nitrogen, phosphorus, vermicompost and sulphur (through gypsum) were applied as basal dose at the time of sowing. The nitrogen and phosphorus were applied in furrows while vermicompost and sulphur were incorporated into the soil by mixing them with soil. The clusterbean 'RGC 936' was sown in rows 30 cm apart using 20 kg seed $ha^{-1}$ on 22 and 23 July and harvested on 24 and 25 October 2004 and 2005, respectively.

Wheat 'Raj 3765' was sown in rows 25 cm apart with seed rate of 100 kg $ha^{-1}$. Wheat crop was sown on 1 and 3 December during respective years without disturbing the original layout. The half of recommended dose of fertilizer (60 kg N + 20 kg $P_2O_5$ $ha^{-1}$) was applied uniformly in all the plots. Half dose of N (30 kg $ha^{-1}$) along with full dose of $P_2O_5$ (20 kg $ha^{-}$) was applied as basal dose. The remaining N was top dressed at the time of first irrigation.The crop was evaluated in terms of yield attributes, yield, economics and residual soil fertility status.

## RESULTS AND DISCUSSION

### Effect on clusterbean

The pods/plant, pod length, seeds/pod and test-weight of clusterbean were significantly influenced by NP fertilizer application (Table 1). Application of 75% of RDF (15 kg N + 30 kg $P_2O_5$ $ha^{-1}$) significantly increased seed and straw yields of clusterbean over lower levels of fertilizers. The magnitude of increase in seed yield due to 75% of RDF was 56.3 and 39.6% over control, respectively during first and second year of experimentation. The improvement in yield components might have resulted from favouarble influence of NP fertilizers on growth attributes and efficient and greater partitioning of metabolites and adequate translocation of these to developing reproductive structures (Tisdale *et al.*, 1995). This ultimately led to improvement in seed yield. These observations are in line with the findings of Shivran and Ahlawat (2000).

Application of vermicompost @ 2.0 t $ha^{-1}$ brought a significant improvement in yield attributing characters of clusterbean viz, pods/plant, seeds/pod, pod length and test-weight over application of vermicompost @ 1.0 t $ha^{-1}$ (Table 1). Similar trend was also observed in seed and straw yields. The positive response of yield attributes to vermicompost may probably due to enhanced supply of macro as well as micro-nutrients during entire growing season led to higher assimilation of food

**Table 1 : Yield and yield attributing characters of clusterbean in clusterbean-wheat cropping system**

| Treatments | Pod/plant | | Pod length (cm) | | Seed/ pod | | Test-weight (g) | | Seed yield (q $ha^{-1}$) | | Straw yield (q $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 |
| **Fertilizer levels** | | | | | | | | | | | | |
| Control | 18.29 | 19.69 | 4.55 | 4.75 | 5.25 | 5.48 | 26.15 | 27.91 | 8.06 | 9.89 | 22.16 | 23.20 |
| 50% RDF | 24.33 | 27.60 | 5.52 | 5.44 | 6.56 | 6.62 | 27.82 | 28.31 | 10.31 | 12.66 | 26.50 | 27.15 |
| 75% RDF | 28.07 | 31.57 | 5.96 | 5.89 | 7.46 | 7.54 | 28.21 | 29.04 | 12.60 | 13.81 | 28.13 | 29.14 |
| 100% RDF* | 28.60 | 32.47 | 6.18 | 6.08 | 7.76 | 7.76 | 28.58 | 29.46 | 13.11 | 14.05 | 29.85 | 31.12 |
| S.Em± | 0.38 | 0.44 | 0.12 | 0.11 | 0.13 | 0.15 | 0.45 | 0.39 | 0.24 | 0.31 | 0.61 | 0.60 |
| CD (P=0.05) | 1.16 | 1.34 | 0.36 | 0.32 | 0.39 | 0.45 | 1.35 | 0.99 | 0.72 | 0.94 | 1.84 | 1.80 |
| **Vermicompost ( t $ha^{-1}$)** | | | | | | | | | | | | |
| 1.0 | 21.10 | 23.95 | 5.20 | 5.06 | 5.66 | 5.90 | 27.22 | 27.90 | 8.74 | 10.60 | 25.15 | 26.12 |
| 2.0 | 28.54 | 31.71 | 5.90 | 6.12 | 7.86 | 7.80 | 28.16 | 29.46 | 13.30 | 14.61 | 28.17 | 29.18 |
| S.Em± | 0.33 | 0.38 | 0.10 | 0.09 | 0.11 | 0.13 | 0.38 | 0.28 | 0.21 | 0.28 | 0.53 | 0.52 |
| CD (P=0.05) | 1.01 | 1.16 | 0.31 | 0.28 | 0.33 | 0.39 | NS | 0.86 | 0.63 | 0.81 | 1.59 | 1.56 |
| **Sulphur levels (kg $ha^{-1}$)** | | | | | | | | | | | | |
| 0 | 20.75 | 24.13 | 4.85 | 4.67 | 5.48 | 5.41 | 26.30 | 27.39 | 8.92 | 10.28 | 22.07 | 22.95 |
| 20 | 24.25 | 27.48 | 5.50 | 5.46 | 6.87 | 6.65 | 27.65 | 28.77 | 10.80 | 12.38 | 26.83 | 27.69 |
| 40 | 27.12 | 29.72 | 5.91 | 5.99 | 7.27 | 7.62 | 28.27 | 29.23 | 12.03 | 13.75 | 28.39 | 29.84 |
| 60 | 27.16 | 30.00 | 5.95 | 6.04 | 7.41 | 7.72 | 28.53 | 29.33 | 12.33 | 14.01 | 29.35 | 30.12 |
| S.Em± | 0.35 | 0.38 | 0.09 | 0.08 | 0.11 | 0.09 | 0.36 | 0.30 | 0.22 | 0.21 | 0.44 | 0.49 |
| CD (P=0.05) | 0.99 | 1.09 | 0.27 | 0.24 | 0.30 | 0.25 | 1.03 | 0.85 | 0.63 | 0.61 | 1.24 | 1.40 |

*(20 kg N + 40 kg $P_2O_5$ $ha^{-1}$)

and its subsequent partitioning in sink. Similar results were also reported by Devi Dayal and Agrawal (1998).

Graded application of sulphur up to 40 kg $ha^{-1}$ favourably influenced the yield contributing characters of clusterbean like pods/plant, seeds/pod and pod length. However, test-weight remained at par with 20 and 40 kg $ha^{-1}$ sulphur application during both the years of field investigation (Table 1). The sulphur application @ 40 kg $ha^{-1}$ brought significant enhancement in seed (12.03 q $ha^{-1}$) and straw (28. 39 q $ha^{-1}$) yields of clusterbean to the tune of 34.9 and 28.6% over control during first year of field study, the same trend was also followed in second year. The sulphur fertilization improved over all nutritional environments of rhizosphere as well as in the plant system and ultimately the plant metabolism and photosynthetic activity resulting in to better growth and development of plant. These results are in close conformity with those of Shekhawat *et al.* (1996) and Shivran *et al.,* (1996).

**Residual effect on wheat**

Application of 100% of RDF (20 kg N

+ 40 kg $P_2O_5$ $ha^{-1}$) to the preceding crop had a beneficial effect on yield and yield attributes of wheat during both the years of field investigation. Effective tillers/ metre row length and grains/spike increased significantly but test-weight was not affected significantly (Table 2). The maximum grain yield of 35.32 and 38.40 q $ha^{-1}$, respectively during both the years field study of wheat was obtained with 100% of RDF (20 kg + 40 kg $P_2O_5$ $ha^{-1}$) applied to preceding clusterbean and was significantly superior to all treatments. Conservative estimates show that clusterbean fixes 30-35 kg $ha^{-1}$ atmospheric nitrogen in the soil that may be available to the next crop, especially cereals. The residual response after higher phosphorus content of soil after clusterbean may be due to the fact that first crop utilizes 10-20% of applied phosphorus (Guar, 1982). In legume-cereal based cropping sequence, the legume always leaves a better effect on

**Table 2 : Yield and yield attributing characters of wheat in clusterbean-wheat cropping system**

| Treatments | Effective tillers $m^{-1}$ row length | | Grains/ spike | | Test-weight (g) | | Grain yield (q $ha^{-1}$) | | Straw yield (q $ha^{-1}$) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2004-2005 | 2005-2006 | 2004-2005 | 2005-2006 | 2004-2005 | 2005-2006 | 2004-2005 | 2005-2006 | 2004-2005 | 2005-2006 |
| **Fertilizer levels** | | | | | | | | | | |
| Control | 78.22 | 87.14 | 38.30 | 40.03 | 43.53 | 45.03 | 29.19 | 31.51 | 39.71 | 48.25 |
| 50% RDF | 81.24 | 89.88 | 38.48 | 41.47 | 43.68 | 45.14 | 31.53 | 33.18 | 40.16 | 48.63 |
| 75% RDF | 84.89 | 92.62 | 40.02 | 42.59 | 44.08 | 45.83 | 33.78 | 35.96 | 41.38 | 49.23 |
| 100% RDF* | 88.73 | 94.62 | 42.47 | 43.87 | 44.63 | 45.92 | 35.39 | 38.40 | 42.38 | 50.31 |
| S.Em± | 1.83 | 1.21 | 0.77 | 0.67 | 0.97 | 1.05 | 0.61 | 0.70 | 0.65 | 0.99 |
| CD (P=0.05) | 3.58 | 3.65 | 2.33 | 2.03 | NS | NS | 1.83 | 2.13 | 1.95 | 3.00 |
| **Vermicompost ( t $ha^{-1}$)** | | | | | | | | | | |
| 1.0 | 80.20 | 88.76 | 37.78 | 40.48 | 43.84 | 44.12 | 30.40 | 33.02 | 39.93 | 47.97 |
| 2.0 | 86.20 | 93.37 | 41.86 | 43.50 | 45.21 | 45.75 | 34.54 | 36.51 | 41.89 | 50.24 |
| S.Em± | 1.02 | 1.04 | 0.67 | 0.58 | 0.85 | 0.91 | 0.52 | 0.61 | 0.56 | 0.86 |
| CD (P=0.05) | 3.09 | 3.16 | 2.02 | 1.76 | NS | NS | 1.59 | 1.84 | 1.69 | 2.60 |
| **Sulphur levels (kg $ha^{-1}$)** | | | | | | | | | | |
| 0 | 79.11 | 87.74 | 37.26 | 39.96 | 43.56 | 45.14 | 29.40 | 31.47 | 39.65 | 47.14 |
| 20 | 81.32 | 89.92 | 38.42 | 41.15 | 43.78 | 45.22 | 31.65 | 33.60 | 39.90 | 48.38 |
| 40 | 84.33 | 92.17 | 40.62 | 43.17 | 44.28 | 45.41 | 33.51 | 35.59 | 41.57 | 49.54 |
| 60 | 88.33 | 94.43 | 42.94 | 45.19 | 44.31 | 46.16 | 35.32 | 38.40 | 42.57 | 51.36 |
| S.Em± | 0.87 | 0.91 | 0.72 | 0.57 | 0.60 | 0.77 | 0.43 | 0.56 | 0.59 | 0.70 |
| CD (P=0.05) | 2.46 | 2.51 | 2.20 | 1.62 | NS | NS | 1.23 | 1.60 | 1.67 | 1.99 |

*(20 kg N + 40 kg $P_2O_5$ $ha^{-1}$)

cereal crop. The findings are in close conformity to the findings of Shivran and Ahlawat (2000) and Singh (2002).

The residual effect of vermicompost application @ 2.0 $ha^{-1}$ over 1.0 t $ha^{-1}$ was quite evident on yield and yield attributes of wheat except test-weight during both years of field investigation (Table 2). The percent increase in effective tillers, grains per spike, grain yield, and straw yield was 7.5, 9.7, 13.6 and 4.9 during first year and 5.2, 7.5, 10.6 and 4.7 during second year, respectively due to application of 2.0 t $ha^{-1}$ vermicompost over 1.0 t $ha^{-1}$ applied to preceding clusterbean crop. Residual effect/ carryover benefit of vermicompost is due to the fact that nutrients present in organic matter are not fully available to the crop during the season of its application. Thus, rest of the nutrients may partially available to next crop. The results are in close agreement with those of Sharma and Vyas (2001) and Sharma *et al.,* (2003).

Sulphur application @ 60 kg $ha^{-1}$ to preceding clusterbean crop resulted in significant improvement of yield attributes *viz*, effective tillers/metre row length and grains/spike of succeeding wheat crop over lower levels of sulphur application (Table 2). The magnitude of increase in effective tillers and grains/ spike was 11.6 and 15.2% during first year and 7.6 and 13.1% during second year, respectively. Similar trend was also found for grain yield of wheat. The maximum grain yield of 35.39 and 38.40 q $ha^{-1}$ was obtained due to residual response of 60 kg S $ha^{-1}$ over lower levels. The marked improvement in productivity of wheat residual sulphur could be ascribed to enhancement in $SO_4^{-2}$ ion content, which modify soil environment along with improvement in physical properties of soil for growth and development. Similar residual responses to sulphur applied to preceding *kharif* clusterbean was recorded by Shivran *et al.*, (2000) and Sharma and Singh (2005).

**Economics**

The maximum total net returns in clusterbean-wheat cropping sequence of Rs.37860/- and ‘ 48154/- $ha^{-1}$ was obtained during first and second year, respectively due to 100% RDF (20 kg N + 40 kg $P_2O_5$ $ha^{-1}$) over lower levels of fertilizer application. The same trend was also existed in B:C ratio (Table 3).

Application of vermicompost @ 2.0 t $ha^{-1}$ recorded highest net returns and B:C ratio in clusterbean-wheat cropping sequence during both the years of field trial over vermicompost @ 1.0 t $ha^{-1}$ (Table 3).

Progressive application of sulphur up to 60 kg $ha^{-1}$ significantly increased net return sand B:C ratio over lower levels of sulphur application and recorded maximum net return $ha^{-1}$ (‘ 36515 and 48423 $ha^{-1}$) and B:C ratio (1.74 and 2.29) in clusterbean-wheat cropping sequence during both the years of field investigation. (Table 3)

**Available nutrient status of soil after harvest of clusterbean**

The available status of N, P and S was significantly improved due to 100% RDF (20 kg N + 40 kg $P_2O_5$ $ha^{-1}$) over control after harvest of clsuterbean during both the years. However, the effect on available N, P and S was at par between 50 and 75% RDF and 75 and 100% RDF, respectively. The effect of fertilizer levels was non-significant on organic carbon and available potassium status of soil. The findings are in line with Kachot *et al.* (2001) and Dubey and Khan (1993).

Vermicompost @ 2.0 t $ha^{-1}$

**Table 3 : Effect of fertilizer levels, vermicompost and sulphur levels on combined net returns (' $ha^{-1}$) and B:C ratio of clusterbean-wheat cropping system**

| Treatments | Net returns | | B : C ratio | |
|---|---|---|---|---|
| | **2004-05** | **2005-06** | **2004-05** | **2005-06** |
| **Fertilizer level** | | | | |
| Control | 23528 | 34093 | 1.16 | 1.67 |
| 50% RDF | 29668 | 41473 | 1.44 | 1.99 |
| 75% RDF | 35697 | 45827 | 1.70 | 2.17 |
| 100% RDF* | 37860 | 48154 | 1.79 | 2.25 |
| S.Em± | 558 | 807 | 0.04 | 0.05 |
| CD (P=0.05) | 1689 | 2440 | 0.11 | 0.14 |
| **Vermicompost ( t $ha^{-1}$)** | | | | |
| 1.0 | 26501 | 37429 | 1.35 | 1.88 |
| 2.0 | 36876 | 47345 | 1.70 | 2.16 |
| S.Em± | 484 | 699 | 0.03 | 0.04 |
| CD (P=0.05) | 1462 | 2113 | 0.09 | 0.12 |
| **Sulphur levels (kg $ha^{-1}$)** | | | | |
| 0 | 25015 | 34328 | 1.21 | 1.65 |
| 20 | 30620 | 41052 | 1.48 | 1.96 |
| 40 | 34604 | 45745 | 1.66 | 2.18 |
| 60 | 36515 | 48423 | 1.74 | 2.29 |
| S.Em± | 510 | 668 | 0.03 | 0.03 |
| CD (P=0.05) | 1446 | 1894 | 0.08 | 0.08 |

*(20 kg N + 40 kg $P_2O_5$ $ha^{-1}$)

significantly enhanced the organic carbon, available N, P and S status over vermicompost @ 1.0 t $ha^{-1}$ during both the years of field experimentation after harvest of clusterbean (**Table** 4). However, available K status remained unaffected in the soil. The increase in organic carbon might be due to direct incorporation of organic matter (Swarup, 1991) and increased available status of N, P and S may be because of rapid transformation i.e. mineralization of above nutrients in the soils. Similar findings were also reported by Kachot *et al.,* (2001) and Rao (2003).

The application of increasing levels of sulphur significantly increased the available N and S of soil after harvest of clusterbean (**Table** 4). This may be attributed to greater nitrogen and $SO_4^{2-}$ retention in the root zone under enhanced sulphur application which raised the available N and S status of soil. Similar results were also reported

**Table 4 : Effect of fertilizer levels, vermicompost and sulphur levels on organic carbon (%), available nitrogen, available phosphorus, available potassium (kg ha$^{-1}$) and available sulphur (mg kg$^{-1}$) of soil after harvest of clusterbean**

| Treatments | Organic carbon | | Nitrogen | | Phosphorus | | Potassium | | Sulphur | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 | 2004 | 2005 |
| **Fertilizer level** | | | | | | | | | | |
| Control | 0.193 | 0.200 | 173.47 | 173.64 | 29.42 | 28.91 | 208.25 | 208.10 | 6.45 | 6.57 |
| 50% RDF | 0.196 | 0.202 | 174.14 | 174.82 | 30.55 | 30.13 | 209.25 | 210.20 | 6.53 | 6.81 |
| 75% RDF | 0.199 | 0.203 | 179.27 | 179.91 | 33.10 | 33.19 | 209.45 | 210.20 | 7.10 | 7.18 |
| 100% RDF* | 0.199 | 0.203 | 185.53 | 186.00 | 35.25 | 35.44 | 209.45 | 210.30 | 7.64 | 7.84 |
| S.Em± | 0.003 | 0.003 | 2.97 | 3.02 | 0.60 | 0.49 | 4.17 | 4.91 | 0.11 | 0.13 |
| CD (P=0.05) | NS | NS | 8.96 | 9.15 | 1.82 | 1.47 | NS | NS | 0.32 | 0.38 |
| **Vermicompost ( t ha$^{-1}$)** | | | | | | | | | | |
| 1.0 | 0.190 | 0.199 | 174.18 | 175.10 | 31.22 | 31.42 | 208.05 | 208.30 | 6.65 | 6.79 |
| 2.0 | 0.204 | 0.205 | 182.02 | 182.08 | 32.94 | 32.42 | 210.05 | 211.10 | 7.22 | 7.41 |
| S.Em± | 0.003 | 0.002 | 2.56 | 2.65 | 0.52 | 0.42 | 3.61 | 2.93 | 0.09 | 0.11 |
| CD (P=0.05) | 0.008 | 0.007 | 7.77 | 7.92 | 1.57 | 1.28 | NS | NS | 0.27 | 0.33 |
| **Sulphur levels (kg ha$^{-1}$)** | | | | | | | | | | |
| 0 | 0.196 | 0.201 | 174.45 | 174.12 | 31.82 | 31.68 | 208.50 | 209.30 | 6.41 | 6.55 |
| 20 | 0.196 | 0.201 | 175.41 | 175.44 | 31.92 | 31.76 | 208.50 | 209.40 | 6.55 | 6.87 |
| 40 | 0.198 | 0.203 | 180.01 | 180.84 | 32.13 | 31.92 | 209.60 | 209.50 | 7.01 | 7.20 |
| 60 | 0.198 | 0.203 | 182.53 | 183.96 | 32.45 | 32.32 | 209.60 | 210.60 | 7.76 | 7.78 |
| S.Em± | 0.002 | 0.002 | 1.88 | 2.03 | 0.44 | 0.46 | 2.74 | 2.93 | 0.10 | 0.11 |
| CD (P=0.05) | NS | NS | 5.34 | 5.75 | NS | NS | NS | NS | 0.29 | 0.32 |

*(20 kg N + 40 kg $P_2O_5$ ha$^{-1}$)

by Dubey and Khan (1993) and Shekhawat (1998).

## References


Dubey, O.P. and Khan, R.A. 1993. Effect of nitrogen and sulphur on dry matter, grain yield and nitrogen content at different growth stages of mustard under irrigated vertisol. *Indian Journal of Agronomy* 38 : 270-276.

Shekhawat, P. S., Rathore, A.S. and Singh, M. 1996. Effect of sources of sulphur on yield attributes and seed yield of clusterbean (*Cyamopsis tetragonaloba* L.) under rainfed conditions. *Indian Journal of Agronomy* 41 (1) : 25-28.

Rao, S.S. 2003. Nutrient balance and economics of integrated nutrient management in groundnut (*Arachis hypogaea* L.) – mustard (*Brassica juncea* L.). *The Madras Agricultural Journal* 90 (7-9) : 465-471.

Kachot, N.A., Malviya, D.D., Solanki, R.M. and Sagarika, B.K. 2001. Integrated nutrient management in groundnut (*Arachis hypogaea*). *Indian Journal of Agronomy* 46(3): 516-522.

Shivran, D.R. and Ahlawat, I.P.S. 2000. Effect of cropping systems and fertilizers on pigeonpea (*Cajanus cajan*) and wheat (*Triticum aestivum*) in pigeonpea-wheat sequence. *Indian Journal of Agronomy* 45(4) : 669-676.

Sharma, O.P. and Singh, G.D. 2005. Effect of sulphur in conjunction with growth substances on productivity of clusterbean (*Cyamposis tetragonoloba*) and their residual effect on barley. *Indian Journal of Agronomy* 50(1) : 16-18.

Singh, R. 2002. Effect of integrated nutrient management in clusterbean (*Cyamposis tetragonoloba*) – wheat (*Triticum aestivum*) cropping system under Western Rajasthan conditions. *Indian Journal of Agronomy* 47(1) : 41-45.

Sharma, B.B., Singh, N.P., Kaushik, M.K., Singh V.K. and Sahu, J.P. 2003. Effect of FYM, phosphorus and zinc fertilization on urdbean and its residual effect on succeeding wheat. *Journal of Farming Systems Research & Development* 8(1) : 29-32.

Sharma, S.C. and Vyas, A.K. 2001. Residual effect of phosphorus and farmyard manure on productivity of succeeding wheat (*Triticum aestivum*) after soybean (*Glycine max*). *Indian Journal of Agronomy* 46(3) : 416-420.

Shivran, A.C. Khangarot, S.S., Shivran, P.L. and Gora D.R. 1996. Response of clusterbean (*Cyamposis tetragonoloba*) varieties to sulphur and phosphorus. *Indian Journal of Agronomy* 41(2) : 340-342.

Devi Dayal and Agrawal, S.K. 1998a. Response of sunflower (*Helianthus annus*) to organic manures and fertilizers. *Indian Journal of Agronomy* 43 : 462-473.

Guar, A.C. 1982. Review of research in India Part-I proceedings 12$^{th}$ International Congress of Soil Science, New Delhi pp. 178-302.

Swarup, 1991. Long-term green manuring (*Sesbania aculeata*) on soil properties and sustainability of rice and wheat on sodic soil. *Journal of the Indian Society of Soil Science* 39 : 777-780.

Tisdale, S.L. Nelson, W.L., and Beaton, J.D. and Havlin, J.L. 1995. Soil fertility and fertilizers, (Edns) Prantice Hall of India Pvt. Ltd., New Delhi, pp. 662-675.

*J. Farming Systems Research & Development* **18** (2) : 357-360 (2012)

# EFFECT OF BIOFERTILIZER ON NODULATION OF PEA (*PISUM SATIVUM* L.) IN ALLUVIAL SOIL

RAJIV KUMAR SINGH[1], NIRMAL DE[2], SAURABH SHARMA[3] AND [4]SURENDAR KUMAR

*Indian Institute of Vegetable Research, Varanasi, Uttar Pradesh - 221 005*

## ABSTRACT

An explorative trial was conducted during rabi season of 2000-01, 2001-02 and 2002-2003 in the institute's research farm to study the effect of biofertilizers on nodulation properties of popular genotypes of garden pea (Pisum sativum L.). The experiment was conducted in a factorial design with Azospirillum, Azotobacter, Rhizobium and phosphate solubilizing microorganism (PSM) in Arkel, Azad P1 and Azad P3 genotypes of pea. The nodule number, nodule weight per plant, leghaemoglobin content and nitrogenase activity were increased linearly from active growth stage to peak at flowering and then declined towards maturity irrespective of genotypic variation and or microbial association in the rhizoplane of pea crop. The nitrogenase activity and leghaemoglobin contents were highly correlated (r=0.93) irrespective of varieties or treatments. The N fixation was highly correlated to the contents of leghaemoglobin (r=0.69) and nitrogenase activity (r=0.73) in pea. The higher leghaemoglobin content and nitrogenase activity was indicative of the preference of Azad P1 to Rhizobium, Azad P3 to Azotobacter and Arkel to PSM for symbiotic N fixation.

**Key words:** Pea, Biofertilizers, Nitrogenase, Leghaemoglobin, PSM

The cultivation of vegetable pea [*Pisum sativum* L. *Sub. sp. hortense Asoh. Graebn*] is gaining momentum over the last decades in Varanasi region especially replacing the conventional wheat crop. The farmers of this region were not acquainted with the uses of biofertilizers particularly *Azotobacter, Azospirillum* and phosphate solubilizing microorganism (PSM), together with *Rhizobium.* The scientific information on nodulation properties of pea as affected by *Azotobacter, Azospirillum* and P solubilizers are also limited. The present experiment was focused on the effect of biofertilizers on the nodulation and nitrogen fixation properties in widely grown pea varieties of eastern Uttar Pradesh.

## MATERIALS AND METHODS

The present experiment was conducted for three years in a typic Ustochrept soil (82.52$^0$ longitudes and 25.10$^0$ N latitude) of Varanasi, with three popular varieties of vegetable pea (Azad P1, Azad P3 and Arkel) and four biofertilizers [*Rhizobium, Azotobacter, Azospirillum and phosphate solubilizing microorganism* (PSM)] along with control (no applied biofertilizers). The N- fixing biofertilizers were procured afresh from the Microbiology Division of IARI, New Delhi and PSM from KRIBHCO, Varanasi while the seeds of vegetable pea from certified seed pool of National Seed Project under IIVR, Varanasi. The live population count of the organism was made for taking care of quality and dose to provide functional and effective biofertilizer treatments. The soil of the experimental site was sandy loam, typic ustochrept. Important properties of the soil are: pH (1:2.5)-7.8, E.C at 25$^0$C -0.45

[1]SMS Agronomy KVK Sehore, [2]Reader Soil Science ,B.H.U Varanasi [3]SMS Ag.Extension KVK Sehore (MP) and [4]SMS Ag.Extension KVK Baghpar (U.P.)

($dSm^{-1}$), C.E.C -7.9 cmol ($P^+$) $kg^{-1}$, A.E.C -1.1 cmol ($e^-$) $kg^{-1}$, organic C -0.47%, clay-13.5%, silt-35.5%, sand-49.0%, free $CaCO_3$ -1.5%, $Ca^{+2}$+$Mg^{+2}$ - 4.6 cmol ($p^+$) $kg^{-1}$, percent base saturation-69.5, available nitrogen -218 kg $ha^{-1}$, available potash-371 kg $ha^{-1}$, available phosphorus 12 kg $ha^{-1}$, water holding capacity - 20.8%, non occluded Al- and Fe-bound P-57.9 mg $kg^{-1}$, P occluded within Fe-oxides and hydrous oxides-10 mg $kg^{-1}$, Ca-bound P-315.8 mg $kg^{-1}$, Smectite-9%, Chlorite-18%, Illite-45%, Kaolinite-26%, Vermiculite-1%. The seeds of pea crops were treated @ 200-250g /10 kg with individual biofertilizers, sown in each plot at a spacing of 30 x 10 cm and then covered with soil. The recommended fertilizer doses (N @ 30 kg/ha, P @ 60 kg/ ha and K @ 60 kg/ha) were applied during the field preparation through urea, diammonium phosphate and muriate of potash. The plants were uprooted at three specific crop growth stages for counting the nodules number, nodule weight, leghaemoglobin contents and nitrogenase activity. The data were taken at active growth stage (S1, at 28 days after sowing), 50 % flowering stage (S2, at 42 days after sowing) and pod filling stage (S3, at 49 days after sowing). The nodules were carefully detached from the roots and collected in an icebox form the experimental site. In laboratory, nodules were kept over filter paper for soaking of excess adhered moisture. The leghaemoglobin contents of nodule were estimated following the spectrophotometric method of Bergersen (1980). Nitrogenase activity was measured by acetylene reduction assays (Turner and Gibson, 1980).

## RESULTS AND DISCUSSION

The nodule number and leghaemoglobin contents were significantly varied with the crop growth stage in all the three varieties. Chattopadhya *et al.* (2000) indicated that the nodule number and leghaemoglobin content were highly correlated at the early pod setting stage. In Azad P3, *Azotobacter* influenced significantly higher nodulation over other biofertilizers. The highest average nodule number (34.47) was recorded in Azad P3 at 50% flowering stages when inoculated with *Azotobacter*, which was 42.8 % more to the uninoculated pea (Figure1). Significantly higher root nodule number (31.21) at pod filling stage was recorded in Azad P1 when inoculated with *Azotobacter*. In Arkel variety the significantly higher nodule number (25.37) and leghaemoglobin contents was observed at 50 % flowering stage when inoculated by PSM. This was an indication of higher affinity for the phosphorus by the Arkel variety for the active nodulation on pea rhizoplane, which corroborates with the finding that plant growth and nodulation in pea increased by supplementary P (Santhaguru and Hariram 1998). The leghaemoglobin content of the nodule has a significant positive impact on the nitrogenase activity, which ultimately plays an important role in nitrogen fixation (Mathur *et al.*, 1998). Scientific literature hypothesized that more the leghaemoglobin content, more would be the nitrogenase activity and more the N fixation. (Dakora 1995). The highest leghaemoglobin (1.33) was recorded in Azad P3 at 50% flowering stage when inoculated with Azotobacter. *Azotobacter* application leads to an increased active nodulation, higher nitrogenase activity and nitrogen fixation. The nitrogenase activity was 18.79 % more when inoculated with *Azotobacter* as compared to the uninoculated pea which corroborates with the findings of (Groppa *et al.* 1998) and Saran (1995). In Azad P1 the leghaemoglobin content was 16.26 % higher when inoculated with the *Rhizobium* compared to the control. In Arkel the highest leghaemoglobin content was 0.99 mg/g nodules at 50 % flowering stage when inoculated with PSM that was 12.12 % higher than the control. The nodule number and the leghaemoglobin was maximum at 50 % flowering stage, which linearly increases from active growth stage to flowering stage and starts to decline from pod filling stage (Figure 1). In general nitrogenase activity was more in all three varieties when inoculated by *Azotobacter*. Nitrogenase activity was 2.5 and 3.4 times more in Azad P3 compared to Azad P 1 and Arkel when inoculated with *Azotobacter*. Inoculation of PSM in Arkel and *Rhizobium* in Azad p1 induced higher nitrogenase activity (Table 1). High degree of correlation between the nitrogenase activity and leghaemoglobin contents (r=0.93) was observed in the root nodules of pea irrespective of genotypic variation and association of biofertilizers in the rhizoplane. The maximum number of nodule, leghaemoglobin content and nitrogenase activity was recorded in the variety inoculated with *Azospirillum* in Azad P3. The similar correlation of nodule number was also reported (Mathur *et al.* 1998) in *Vigna mungo* crop. The present finding indicated that more the leghaemoglobin content, more the nitrogenase activity (Table 1). The nitrogenase activity in the root nodules of pea was calculated only at the 50 % flowering stage as the maximum leghaemoglobin contents was observed at this stage. The nutrient status of the experimental soil sample was analyzed before the sowing and after the harvest of the crop. There was a positive change in the available N status of the experimental soil sample, due to the contribution of biofertilizers in the fixation of atmospheric nitrogen. An average positive balance of N ranged 25 to 46 kg $ha^{-1}$, zero balancing of S, marginal positive balance (0.2 to 3.5 kg $ha^{-1}$) in phosphorus and potassium (0.7 to 8.4 kg $ha^{-1}$) was recorded depending on varieties of garden pea crop. Significantly higher N fixations was observed in Azad P3, followed by Azad P1 and Arkel, which could be explained by the contents of leghaemoglobin and nitrogenase activity of the respective varieties.

**Table 1 : Effect of biofertilizers on leghaemoglobin content (mg/g nodule) and nitrogenase activity (m moles $C_2H_4$/plant/h) of pea at flowering stage (42 days after sowing)**

| Treatments | Azad P-1 | | Azad P-3 | | Arkel | |
|---|---|---|---|---|---|---|
| | Leghaemo-globin of nodule | Nitrogenase activity | Leghaemo-globin of nodule | Nitrogenase activity | Leghaemo-globin of nodule | Nitrogenase activity |
| *Azotobacter* | 0.56 | 5.34 | 1.33 | 13.45 | 0.45 | 3.97 |
| *PSM* | 0.30 | 2.92 | 0.49 | 3.95 | 0.99 | 7.69 |
| *Rhizobium* | 1.23 | 9.89 | 0.296 | 2.63 | 0.43 | 3.25 |
| *Azospirillum* | 0.35 | 3.78 | 0.3 | 2.53 | 0.69 | 4.63 |
| Control | 0.20 | 2.21 | 0.25 | 1.98 | 0.12 | 1.02 |
| $LSD_{0.05}$ | 0.037 | 0.029 | 0.09 | 0.32 | 0.07 | 0.41 |

REFERENCES

Bergersen F. J. 1980. In: Methods for evaluating Biological Nitrogen Fixation. John. Willy & Sons. New York

Chattopadhyay A. Dasgupta T. Hazra P and Som M. G. 2000. Nodule characters and their relationship with pod yield and pod protein content in cowpea. *Annals of Agricultural Research* **21**(1): 140-2.

Dakora Felix D. 1995. A functional relationship between leghaemoglobin and nitrogenase based on novel measurements of the two proteins in legume root nodules. *Annals of Botany* **75**: 49-54.

Groppa M. D. Zawoznik M. S. and Tomaro M. L. 1998. Effect of co-inoculation with *Bradyrhizobium japonicum* and *Azospirillum brasilense* on soybean plants. *European Journal of Soil Biology* **34** (2): 75-80.

Mathur V. L. Laxmi K. Joshi A. Kant L and Joshi A. 1998. Study of nodulation, leghaemoglobin content and NRA in black gram (*Vigna mungo* L. Hepper). *Legume Research* **21** (3-4): 221-4.

Santhaguru K. and Hariram N. 1998. Effect of *Glomus mosseae* and *Rhizobium* on growth, nodulation and nitrogen fixation in Lablab purpureus (L) Sweet under different phosphorus regimes. *Indian Journal of Plant Physiology* **3** (2): 156-8

Turner G. L and Gibson A. H. 1980. In: Methods for evaluating Biological Nitrogen Fixation (Bergerson, F.J.Ed), pp.111-138. John. Willy, New York.

*J. Farming Systems Research & Development* **18** (2) : 361-365 (2012)

# SEASONAL VARIATION IN CHARACTERISTICS OF UNDERGROUND IRRIGATION WATERS AND THEIR INFLUENCE ON SOILS OF BIKANER DISTRICT OF RAJASTHAN

RANJEET SINGH*, B.R. CHHIPA, I.J. GULATI AND B.L. YADAV

*SKN College of Agriculture, S.K. RAU, Jobner (Rajasthan)*

## ABSTRACT

Two sets of well water were collected, one before the monsoon rains in the month of April-May and second after the cessation of monsoon rains in the month of October. After the rains, salt concentration in the waters was reduced in the study area. Soil samples collected from areas irrigated by water of some selected tube wells, and analysed to study the effect of continuous use of irrigation water on them. Amount of salt retained in soil after the rains was linearly related to initial salinity in the soil. Being low rainfall in the studied area, the negative values of salt regime constant 'd' were also of very low order indicating very less leaching of salts from the crop root zone and thus, continuous use of higher salinity water might hinder the crop production.

**Key words:** Seasonal variation, salt regime constant, leaching of salts, crop root zone

The Concentration and nature of the salts present in irrigation water determine its quality. The nature of salts in irrigation water, sometimes may be more important than the total amount of salts e.g. if the proportion of sodium in irrigation water is high, the soils may become gradually unproductive. Even water of doubt full quality can be used without serious damage to soils and crops, if the necessary precautions are taken in irrigation and soil management. The limits for maximum permissible salt content of water depend also on the nature of the salts and amount of rainfall. Saline irrigation water is better suited on soils which are permeable and where the water table remains 1.8 to 3 meters below the surface.

A large area in Bikaner district of Rajasthan is irrigated by tube wells. A critical study of the variation in quality of well waters and their influence on soils in long use was under taken

## MATERIALS AND METHODS

A field survey based study entitled seasonal variation in characteristics of under ground irrigation waters and their influence on soils of Bikaner district of Rajasthan was conducted during, 2004-05. For this purpose water samples were collected from fifty six tube wells from twenty villages of Bikaner district of Rajasthan. The first set of samples was drawn before the monsoon in April-May 2004 and the second set after the cessation of monsoon rains in October 2004. For salt balance studies soil samples (0-30 cm depth) from twenty selected sites were also collected in month of April-May and October 2004 and salt balance in irrigated soils was calculated by equation given by Szabolcs (1969) as

Corresponding author's postal address: SMS, Soil Science, Krishi Vigyan Kendra, Borwat Farm, Banswara-327001 (Raj.) email: ranjeetsingh1970@gmail.com

$d = b - [a+(cv/mds)x10^{-5}]$

where,

d = salt leached or accumulated, g/100 g soil

b = amount of salt at end of observation, g/100 g soil

a = amount of salt at start of observation, g/100 g soil

c = salt content in rain water, g/L

v = amount of monsoon rains, mm

m = thickness of soil layer, m

ds = bulk density of soil, $mg/m^3$

Water and soil samples were analysed using standard methods and procedures. Soils of the studied area were aeolian, coarse textured, calcareous and alkaline in nature with low fertility status, low water holding capacity and susceptible to wind erosion.

## RESULTS AND DISCUSSION

The ionic composition of tube well waters are presented in table 2. Values under A relate to the pre-monsoon period and values under B related to post monsoon period. Calculated value of SAR, RSC, pH and EC are given in table 3. Soil analysis data are presented in table 1 and 4.

Data presented in table 2 indicate that the tube well waters contain relatively high sodium, chloride and bicarbonate barring a few exceptions. Another feature about these waters is that magnesium is generally higher than calcium. After the monsoon rains, salt concentration in the tube well waters were reduced. The ions which have decreased are sodium, chloride and sulphate while, magnesium, bicarbonate are increased and calcium and carbonate ions not showed much difference. The pH values of all irrigation waters were noticed to fluctuate during April-May to October (Table 3) . The mean pH value of water samples was increased from 8.30 to 8.44 during April-May to October. The increase in pH of these irrigation waters during rainy season might be due to increase in concentration of neutral salts of calcium and magnesium. The results get support from finding of Gupta et al (1982).

Electrical conductivity of underground irrigation waters of Bikaner district showed decreasing trend from April-May to October (Table 3). The mean value of EC of irrigation waters was decreased from 2.58 to 2.02 dS $m^{-1}$. Systematic decreasing trends was observed in EC of waters between the periods of April-May

**Table 1 : Physico-chemical parameters of soils of Bikaner district of Rajasthan**

| Characters | Depth (cm) | Bulk density (mg $m^{-3}$) | Perme-ability Index | EC (dS $m^{-1}$) | pH | ESP | Dehydro-genase activity (ug TPF $g^{-1}$ soil) |
|---|---|---|---|---|---|---|---|
| Range | 0-15 | 1.38-1.60 | 54.70-136.84 | 0.10-1.15 | 8.57-9.21 | 0.37-4.35 | 0.90-10.12 |
| | 15-30 | 1.40-1.63 | 56.08-156.82 | 0.08-0.95 | 8.62-9.28 | 0.66-4.75 | 0.46-8.33 |
| Mean Value | 0-15 | 1.49 | 89.30 | 0.42 | 8.74 | 2.19 | 4.25 |
| | 15-30 | 1.52 | 96.16 | 0.37 | 8.80 | 2.42 | 3.48 |

**Table 2 : Ionic composition of tube well waters of Bikaner district of Rajasthan**

| Characters | Ions (me $L^{-1}$) | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | $CO_3^{--}$ | | $HCO_3^-$ | | $Cl^-$ | | $SO_4^{--}$ | | $Ca^{++}$ | | $Mg^{++}$ | | $Na^+$ | |
| | A* | B** | A | B | A | B | A | B | A | B | A | B | A | B |
| Range | 0.5-2.0 | Nil – 2.0 | 0.75-5.5 | 1.0-4.0 | 4.0-52.0 | 3-42.3 | 0.49-9.89 | 0.03-8.0 | 0.4-7.36 | 0.15-5.80 | 0.60-10.20 | 0.60-10.0 | 4.34-55.74 | 3.0-40.9 |
| Mean Value | 1.08 | 0.90 | 3.27 | 2.79 | 17.28 | 14.47 | 3.43 | 1.93 | 1.57 | 1.59 | 2.76 | 3.55 | 20.95 | 14.59 |

A* Before monsoon B** After monsoon

to October. The highest and lowest EC values of all the samples were observed during the months of April-May and October, respectively. The EC of irrigation water was decreased 21.71 per cent during the observation period. Owing to the rain water induced dilution and leaching of salts, the electrical conductivity decreased during the rainy season. Similar results were also reported by Kameriya (1977).

It is evident from the data presented in table 3 that a systematic decreasing trend in SAR values was observed in all irrigation waters between the period of April-May to October. The highest SAR values of all waters were observed during the month of April-May, while the lowest values were observed during the month of October. The mean SAR value of irrigation waters of Bikaner district was decreased from 14.84 to 9.77 (34.16 per cent) during the study period. The decrease in SAR value during rainy season might be due to a decrease in the salt concentration. This showed that there was improvement in the quality of underground irrigation waters both in salinity and sodium hazards after monsoon rains. Similar findings were also reported by Gupta et al (1982).

Residual sodium carbonate contents of all irrigation waters were observed. The minimum value was recorded during the month of October and maximum during the months of April-May (Table 3). The decrease in mean RSC values of irrigation waters of Bikaner district was recorded from 1.30 to 0.44 me $L^{-1}$ during April-May to October. This showed that there was improvement in the quality of underground irrigation waters with respect to alkali hazards also. This might be due to leaching of soluble salts and increase in neutral salts of calcium and magnesium during rainy season. The

**Table 3 : Seasonal variations in characteristic of underground irrigation waters of Bikaner district of Rajasthan**

| Character | EC (dS $m^{-1}$) | | pH | | SAR | | RSC (me $L^{-1}$) | |
|---|---|---|---|---|---|---|---|---|
| | A* | B** | A | B | A | B | A | B |
| Range | 0.67-6.52 | 0.49-5.28 | 7.30-8.78 | 7.75-8.90 | 4.85-34.65 | 3.16-52.16 | Nil-5.50 | Nil-3.0 |
| Mean Value | 2.58 | 2.02 | 8.30 | 8.44 | 14.84 | 9.77 | 1.30 | 0.44 |

A* Before monsoon B** After monsoon Nil- Negative RSC values

**Table 4 : Salt regime constant (d) as related to salt and water characteristics of selected villages of Bikaner district of Rajasthan**

| Sample Code | ECe (dS $m^{-1}$) during April-May, 2004 | ECe (dS $m^{-1}$) during October, 2004 | $EC_w$ (dS $m^{-1}$) | Total rain water (mm) | Soil depth | Bulk density (Mg $m^{-3}$) | Salt regime constant (g/100g soil) |
|---|---|---|---|---|---|---|---|
| | (a) | (b) | (c) | (v) | (m) | (ds) | (d) |
| $Pal_2$ | 3.71 | 2.76 | 0.01 | 114 | 0.3 | 1.56 | -0.0150 |
| $Kil_2$ | 3.25 | 1.92 | 0.01 | 114 | 0.3 | 1.48 | -0.0210 |
| $Bam_2$ | 4.18 | 2.67 | 0.01 | 114 | 0.3 | 1.57 | -0.0220 |
| $Pem_1$ | 6.21 | 4.83 | 0.01 | 114 | 0.3 | 1.54 | -0.0200 |
| $Pem_2$ | 5.06 | 3.81 | 0.01 | 114 | 0.3 | 1.55 | -0.0180 |
| $Sud_1$ | 1.80 | 1.37 | 0.01 | 181 | 0.3 | 1.54 | -0.0070 |
| $San_1$ | 2.37 | 1.86 | 0.01 | 181 | 0.3 | 1.53 | -0.0080 |
| $Jet_1$ | 23.23 | 13.60 | 0.01 | 181 | 0.3 | 1.62 | -0.1310 |
| $Thu_1$ | 4.22 | 2.96 | 0.01 | 181 | 0.3 | 1.58 | -0.0180 |
| $Aka_3$ | 3.63 | 2.02 | 0.01 | 123 | 0.3 | 1.49 | -0.0260 |
| $Jha_3$ | 17.10 | 11.97 | 0.01 | 123 | 0.3 | 1.51 | -0.0810 |
| $Cha_1$ | 5.31 | 3.83 | 0.01 | 123 | 0.3 | 1.45 | -0.0240 |
| Kot | 6.33 | 4.42 | 0.01 | 123 | 0.3 | 1.53 | -0.0290 |
| $Mul_1$ | 1.40 | 0.90 | 0.01 | 182 | 0.3 | 1.48 | -0.0078 |
| $She_1$ | 7.09 | 4.16 | 0.01 | 182 | 0.3 | 1.49 | -0.0460 |
| $Kho_1$ | 5.78 | 4.09 | 0.01 | 182 | 0.3 | 1.45 | -0.0280 |
| $Dhap_1$ | 7.00 | 4.04 | 0.01 | 182 | 0.3 | 1.51 | -0.0460 |
| $Mnk_1$ | 20.20 | 17.45 | 0.01 | 222 | 0.3 | 1.49 | -0.0420 |
| $Mnk_2$ | 7.48 | 4.05 | 0.01 | 222 | 0.3 | 1.57 | -0.0500 |
| $Ras_1$ | 6.06 | 2.75 | 0.01 | 222 | 0.3 | 1.44 | -0.0540 |

results of present investigation get support from the findings of Datta and Tyagi (1996).

Salt balance in plant root zone is very important. Water evaporates in a pure state leaving salt behind. As water is removed from the soil by evaporation/ evaportranspiration, the salt concentration in the soil solution is increased. Each irrigation adds some salts to soil depending upon the water entering into the soil and the salt concentration in the water. This salts remains in the soil and accumulates unless it is leached away by rain water or water applied in excess of crop requirement in the present study, salt removal by rain water was estimated using the equation given by Szabolcs (1969). Results of salt balance studies of soils of Bikaner district given in table 4. The negative values of salt regime constant 'd' indicated that the salt added through irrigation water was either leached down to lower layers of the soil profile or washed through the surface run off. It is further clear from the data that amount of salt retained in soil after the rains was linearly related to initial salinity in the soil. In other words, higher was the amount of accumulated salt in soil after the irrigation cycle, greater was the amount of salt leached/ washed. However, being low rainfall in the studied area. The negative values of salt regime constant 'd' were also of very low order indicating very less leaching of salts from the crop root zone and thus continuous use of higher salinity water might hinder the crop production.

## References

Datta, P.S. and Tyagi, S.K. 1996. Major ion chemistry of ground water in Delhi area. Chemical weathering processes and ground water flow regime. *J. Geolog Soc. India* **47(2)** : 179-188

Gupta, R.K. and Khosla, B.K. 1982. Seasonal variations in salt and water content profiles in shallow and saline ground water table. *Indian J. Agric. Sci.* **52(8)**: 506-510

Kameria, P.R. 1977. A comparative study of the physic-chemical characteristics and fertility status of the irrigated and unirrigated soils of Jobner and surrounding regions. M.Sc. (Ag.) Thesis, University of Udaipur, Udaipur.

Szabolcs, I. 1969. The role of salt balances in the prediction and prevention of the secondary salinization and alkalisation of irrigated soils (H) Nemzet Kozi Mezogazd, Tzemele, **13**:45-50 (English Summary).

*J. Farming Systems Research & Development* **18** (2) : 366-369 (2012)

# PATH ANALYSIS STUDIES IN BRINJAL (*SOLANUM MELONGENA* L.)

S. K. Dhaka[1], A. K. Soni[1], Santosh Choudhary[2] and Pawan Kumar[3]

*Department of Horticulture, S. K. N. College of Agriculture, Jobner, SKRAU, Bikaner (Rajasthan)-303 328*

## Abstract

Path analysis for fruit yield/plant and its component characters was studied in 20 genotypes of brinjal grown at Jobner, Rajasthan during the *kharif* season of 2007. The highest positive direct effect on fruits yield/plant (0.8153) was exerted by average fruit weight followed by number of fruits/plant (0.6875), days taken to first flower (0.3405), number of branches/ plant (0.3026), iron content of (0.0925), number of leaves per plant (0.0208) and plant height at harvest (0.0157).The maximum negative direct effect on fruit yield/plant was noticed by days taken to first pickings followed by number of pickings. The estimated residual effect at genotypic level was equal to 0.26 and at phenotypic levels it was equal to 0.31.

**Key words:** Brinjal genotypes, Direct effect, Indirect effect, Path analysis

## Introduction

Brinjal or egg plant (*Solanum melongena* L.) is worldwide known as aubergine or guinea squash and is one of the most important vegetable crops in India. It is a perennial crop but grown as an annual in all parts of the country except on higher altitude. In India, egg plant is cultivated since ancient times and is popularly known as poor man's crop, due to its affordable price and available year round. It is grown for its immature, unripe fruits which are used in the variety of ways as cooked vegetable in curries. It is popular among people of all social strata and hence, it is rightly called as vegetable of masses (Patel and Sarnaik, 2003). Brinjal is consumed in both, fresh and preserved forms. The most common dish of brinjal is 'bhurta' fried and it is also used as mixed with other vegetables like potato, tomato. It has much potential as raw material in pickle making the dehydration industries. Besides, being used as culinary purposes, fruits have got medicinal properties, particularly, white brinjal is said to be good for diabetic patients, it has also been recommended as an excellent remedy for those suffering from liver complaints (Choudhary, 1996). There is an ample scope for its improvement particularly in yield through, the breeding techniques as there is much variability present in brinjal with respect to fruit size, shape, colour and quality etc. Genetic variability plays an important role in a crop in selecting the best genotypes for making rapid improvement in yield and other desirable characters as well as to select the potential parent for hybridization programmes. In plant breeding, correlation coefficient analysis measure the mutual relationship between various plant characters and determines the component characters on which selection can be based for genetic improvement in yield. In this context,

[1]Department of Horticulture, SKNCOA, Jobner. [2]Department of Horticulture, COA, Bikaner. [3]PDFSR, Modipuram , Meerut.

path coefficient analysis provides an effective means of finding out direct and indirect effect of association between yield and its components and permits a critical examination of a specific forces acting to produce given correlation and measure the relative importance of each factor. Therefore, present investigations were carried out to generate such information for brinjal.

## Materials and Methods

The experiment was carried out at Horticulture Farm, Department of Horticulture, S.K.N College of Agriculture, Jobner during *kharif* season of 2007 in order to generate the information in interrelationship between yield and its component in 20 genotypes of crop. All the genotypes of brinjal were first raised in the nursery beds of 3.0 m x 1.0 m x 0.15 m in size. Thirty days old seedlings were transplanted in *randomized block design* with three replication of each genotype with a spacing of 75 cm between rows and 60 cm between the plants in the first week of August. All the recommended cultural practices were followed under irrigated conditions. In each treatment five plants were selected randomly for recording the observations on various parameters *i.e.* plant height, number of branches/plant, number of leaves/plant, days to first flowering, days to first pickings, number of pickings, number of fruits/plant, average fruit weight, yields/plant and iron content in fruits. The amount iron in fruits was estimated by the methods of atomic absorption spectrophotometer (Lindsay and Norwell, 1978) and results were expressed in ppm. The estimates of direct and indirect effect were calculated by the path coefficient analysis as suggested by Wright (1921) and elaborated by Dewey and Lu (1959) at both phenotypic and genotypic levels.

## Results and Discussion

The direct and indirect effects of different characters on yields/plant at phenotypic and genotypic level are presented in Table. The path coefficient analysis was carried out by taking fruit yields/plant as dependent variable and other components as independent variables. The result of path coefficient analysis indicated that at the genotypic levels, the maximum direct positive effect on fruit yields/plant was exerted by average fruit weight followed by number of fruits/plant, days taken to first flower, branches/plant, iron content in fruit, leaves/plant and plant height at harvest and other characters had negligible positive direct influence. The maximum negative direct effect on yields/plant was exerted by days taken to first pickings and other characters had negligible direct influence on yields/plant. The plant height showed positive indirect effect on yields/plant through average fruit weight. Number of branches/plant showed positive indirect effect through seven characters, maximum being the number of pickings. Regarding number of leaves/plant, all the seven characters had indirect negligible effect in the positive direction on yields/plant. Days taken to first flower exerted maximum positive indirect effect on yields/plant through days taken to first pickings. Number of fruits/plant indirectly influenced the yield in a positive way via number of pickings. Average fruit weight showed maximum positive indirect effect via plant height at harvest. The iron content in fruit indirectly influenced the yields/plant in a positive way through days taken to first pickings followed by days taken to first flower.

At phenotypic level among the various characters studied, average fruit weight had the highest positive direct

**Table. Estimation of direct and indirect effects of different characters at phenotypic (P) and genotypic (G) levels in brinjal**

| Characters | | Plant height at harvest (cm) | Branches /plant | Leaves /plant | Days to first flower | Days to first pickings | Number of pickings | Fruits /plant | Average fruit weight (g) | Iron content in fruit (ppm) | Yields/ plant (kg) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Plant height at harvest (cm) | P | 0.0487 | 0.0025 | 0.0092 | 0.0043 | 0.0017 | -0.0012 | -0.0018 | 0.0334 | -0.0128 | 0.5730 |
| | G | 0.0157 | 0.0008 | 0.0033 | 0.0022 | 0.0003 | -0.0007 | -0.0006 | 0.0111 | -0.0044 | 0.6123 |
| Branches /plant | P | 0.0092 | 0.1823 | 0.1272 | 0.0348 | 0.0431 | 0.1241 | 0.0207 | 0.0046 | -0.0168 | 0.2084 |
| | G | 0.0146 | 0.3026 | 0.2194 | 0.0691 | 0.0740 | 0.2297 | 0.0351 | 0.0080 | -0.0256 | 0.2238 |
| Leaves /plant | P | -0.0033 | -0.0122 | -0.0175 | -0.0041 | -0.0049 | -0.0095 | -0.0070 | -0.0026 | 0.0043 | 0.4220 |
| | G | 0.0044 | 0.0151 | 0.0208 | 0.0055 | 0.0061 | 0.0130 | 0.0085 | 0.0031 | -0.0053 | 0.4631 |
| Days taken to first flower | P | -0.0009 | -0.0020 | -0.0024 | -0.0103 | -0.0089 | -0.0013 | 0.0009 | -0.0005 | -0.0003 | 0.0223 |
| | G | 0.0481 | 0.0778 | 0.0890 | 0.3405 | 0.3492 | 0.0456 | -0.0322 | 0.0154 | 0.0090 | 0.0231 |
| Days taken to first pickings | P | 0.0007 | 0.0050 | 0.0059 | 0.0181 | 0.0210 | 0.0020 | -0.0009 | 0.0001 | 0.0007 | 0.0247 |
| | G | -0.0060 | -0.0799 | -0.0965 | -0.3355 | -0.3271 | -0.0458 | 0.0165 | -0.0025 | -0.0100 | 0.0426 |
| Number of pickings | P | 0.0018 | -0.0489 | -0.0387 | -0.0092 | -0.0070 | -0.0718 | -0.0329 | 0.0148 | 0.0002 | 0.1502 |
| | G | 0.0105 | -0.1861 | -0.1527 | -0.0329 | -0.0344 | -0.2452 | -0.1213 | 0.0546 | 0.0034 | 0.1537 |
| Number of fruits /plant | P | -0.0223 | 0.0683 | 0.2388 | -0.0523 | -0.0258 | 0.2759 | 0.6025 | -0.1308 | -0.0374 | 0.3996 |
| | G | -0.0265 | 0.0797 | 0.2809 | -0.0650 | -0.0346 | 0.3400 | 0.6875 | -0.1500 | -0.0431 | 0.4099 |
| Average fruit weight (g) | P | 0.5597 | 0.0207 | 0.1186 | 0.0387 | 0.0030 | -0.1679 | -0.1771 | 0.8159 | -0.0786 | 0.7274 |
| | G | 0.5771 | 0.0217 | 0.1224 | 0.0368 | 0.0062 | -0.1817 | -0.1779 | 0.8153 | -0.0806 | 0.7460 |
| Iron content in fruit (ppm) | P | -0.0206 | -0.0072 | -0.0191 | 0.0024 | 0.0025 | -0.0002 | -0.0049 | -0.0075 | 0.0782 | -0.0626 |
| | G | -0.0256 | -0.0078 | -0.0236 | 0.0024 | 0.0028 | -0.0013 | -0.0058 | -0.0091 | 0.0925 | -0.0641 |

effects on the yields/plant followed by number of fruits/plant, branches/plant, iron content in fruit, plant height and days taken to first pickings, whereas, days taken to first flower, leaves/plant and number of pickings had negative direct effect. The residual effect at genotypic level was equal to 0.26 and at phenotypic levels it was equal to 0.31. Since, it was moderate in magnitude indicating that most of the effects estimated are genetically governed.

In the present study, the residual effect was very low indicating the adequacy of the characters chosen for the study. The maximum direct effect on yield was though average fruit weight, number of fruits/plant. The results are in agreement with those reported by Daliya and Wilson (2002). As the days taken to first pickings and number of pickings were negatively correlated negative association of yield/plant with days taken to first pickings was reported by Bora and Shadeque (1993). Present investigations revealed that in brinjal yield can be improved through selection of genotypes producing more number of fruits along with high average fruit weight.

## References

Bora, G.C. and Shadeque, A. 1993. Genetic variability and correlation between yield and its component characters in brinjal (*Solanum melongena L.*). *Indian journal of Agricultural Sciences*, **63(10):** 662-664.

Choudhary, B. (1996). Vegetables (9th Edn.). National Book Trust, New Delhi, pp. 55-63.

Daliya, T. and Wilson, D. 2002. Correlation and path analysis in brinjal (*Solanum melongena* L.). *Madras Agriculture Journal*, **89 (10 & 12):** 675-677.

Dewey, O.R. and Lu, K.H. 1959. A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal*, **57:** 513-518.

Lindsay, W.L. and W.A. Norwell. (1978), Development of a DTPA soil test for zinc,

iron, manganese and copper, Soil science society of America journal, **42**, pp 421-428.

Patel, K.K. and Sarnaik, D.A. 2003. Performance study of long fruited genotypes of brinjal under Raipur conditions. *The Orissa Journal of Horticulture*, **31(1):** 74-77.

Wright, S. (1921). Correlation and causation. *Journal of Agriculture Research,* **20:** 557-587.

*J. Farming Systems Research & Development* **18** (2) : 370-379 (2012)

# EFFECT OF ORGANIC NUTRIENT MANAGEMENT USING ON/OFF- FARM ORGANIC INPUTS ON THE PRODUCTIVITY OF BASMATI GROUP OF RICE (*ORYZA SATIVA*) - CHICKPEA (*CICER ARIETINUM*)/WHEAT (*TRITICUM AESTIVUM*) CROPPING SYSTEM

Shrikant Chitale*, Alok Tiwari, S.K. Sarawgi, J.S. Urkurkar and Vinod Kumar Sharma**

*Indira Gandhi Krishi Vishwa Vidyalaya, Raipur, Chhattisgarh – 492006*

## Abstract

Experiment was conducted at Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, India during 2004-05 to 2008-09 with the objectives to develop organic nutrient management options by using green manure and on/off-farm organic sources for organic farming of basmati rice-chickpea/wheat cropping system and their effect on soil health, quality of rice and sustainability of the system. On the five year mean basis, it was observed that maximum rice yield was recorded under application of 1/3 N each from non edible oilcake (NEOC)+ cow dung manure (CDM)+ enriched compost (EC) followed by application of 50% N each from EC+CDM under both the cropping sequence. Increase in grain yield of basmati type 'Kasturi' rice was 60 to 70% higher than control in rice-wheat/chickpea cropping system. 1/3 each of NEOC+CDM+EC for N supply registered highest grain yield of chickpea (8.66 q/ha) followed by 50% each of NEOC+EC and 50% each of NEOC+ CDM. Hence, the application of non-edible oil cake is essential for harvesting of maximum output alongwith either of application of enriched compost or cow dung manure or in combination of both.

The highest mean total productivity of organic nutrient management was higher under rice- wheat (rice equivalent yield, REY 45.4 q/ha) than rice-chickpea (REY 43.78 q/ha) cropping system while highest net return (Rs.44,350/ha) and B:C ratio ( Rs. 1.82) were recorded under rice-chickpea than rice-wheat cropping system at the end of 2008-09. The length and breadth of spikelet and kernel were comparatively superior under full package of organic sources. Soil health was also improved under application of all three sources of organics like enhanced OC and also increased the available N, P and K in soil.

**Key words**: Organic nutrient management, Rice equivalent yield, Total productivity

Food material produced organically has got its place in food market in developed and developing countries. Organic food as itself explanatory needs large quantity of organic manures to supply nutrients in soil. Application of organic manure not only improves the soil organic carbon for sustaining the soil physical quality but it also increases the soil N which is the key nutrient element limiting the yield of rice. Long term addition of organic materials to soil results in increased organic matter, crop productivity and soil biological activity (Collins *et al.*, 1992) and quality of the produce. The replacement of external inputs *viz.* chemical fertilizers by farm-derived organic inputs normally leads to a reduction in variable input costs under organic management. In Chhattisgarh, by virtue of using less quantity of chemical fertilizers and pesticides and dependency upon naturally available sources of nutrients, organic food could

*corresponding author email: shrikantmadhukar@yahoo.co.in
** Senior Scientist, Project Directorate for Farming Systems Research, Modipuram, Meerut

provide better vistas towards high remuneration with premium price in market with inherent lesser cost advantage. FYM is very common source of nutrients to the farmers of Chhattisgarh, which is prepared easily and contains substantial amount of plant nutrients. Although, in a few cases, a higher input costs due to the purchase of compost and other organic manure and unawareness of farmers for the market opportunities of high priced organically produced food might be seen (Mahapatra *et al.*, 2009). With the increasing trend in price of fertilizers and the reduction in the use of chemical fertilizers it has become necessary to judiciously manage the inflow of organic sources of nutrients. Therefore, information needs to be generated with respect to suitable combination of different organic sources to develop the suitable nutrient management practices for better quality and high productive food as well as sustainability.

## Material and Methods

Experiment was conducted at indira Gandhi Krishi Vishwa Vidyalaya, Raipur (C.G.) during 2004-05 to 2008-09 under the Network Project on Organic Farming to manage the soil fertility using on-farm organic inputs in Basmati group of rice-wheat/chickpea cropping system. The objectives were to study the impact of various on-farm and off-farm organic resources on nutrient supplying capacity and health of soil, crop yield and quality and economics. The soil of the experimental field was clayey in texture (*Vertisol*) locally known as *kanhar*. It was neutral in pH (7.45) having organic carbon of 6.1 g/kg, low in available N (248 kg/ha), medium in available P (16.2 kg/ha) and available K (252 kg/ha). Two cropping systems viz. rice-wheat and rice – chickpea and five organic nutrient management systems having different organic sources *viz* $ONM_1$: ½ each of EC (enriched compost) + CDM (cow dung manure), $ONM_2$ : ½ each NEOC (non edible oilcake) + CDM, $ONM_3$ : ½ each NEOC + EC, $ONM_4$ : $^1/_3$ each NEOC + CDM + EC on N basis and $ONM_5$ : Control (no nutrients) were tested in split plot design with three replication. Quantity of organic manures was determined on the basis of recommended doses of each crop viz. rice – 80:50:30, wheat – 100: 60:40, chickpea – 20:50: 00 kg $N:P_2O_5$: $K_2O$/ha respectively. Nitrogen, P and K content (%) of different organic manures on dry weight basis were 0.5, 0.37 and 0.80 in CDM; 5.0, 1.0 and 1.25 in NEOC and 0.5, 0.5 and 0.75 in EC, respectively. The green manure (GM) of sunhemp (*Sesbania rostrata*) was *insitu* incorporated before rice for supporting the nutrient requirement particularly for N every year. The GM was grown in all the plots except control. The green manure was incorporated at 40-45 days after seeding. The average N, P and K content (%) of GM on dry weight basis were 2.25, 0.51 and 1.63 respectively.

In organic treatments, P requirement was supplemented through rock phosphate (23 % $P_2O_5$ grade) after adjusting the quantity of P supplied through manures. Basmati type rice 'Kasturi' was grown during *kharif* and chickpea 'Vaibhav' and wheat 'GW 273' were grown during *rabi*. Transplanting of rice at spacing of 20 x 10 cm was done from 15 to 25 July and harvested in 1st week of November to facilitate the timely sowing of wheat and chickpea during 2nd fortnight of November each year. The total rainfall received during *kharif* (July to October) was 690, 1290, 930, 746 and 735 mm and during *rabi* (November to March) was 84, 115, 159, 22, 44 and only 2.2 mm in 2004-05, 2005-06, 2006-07, 2007-08 and 2008-09 respectively. The experiment was conducted under assured irrigation facilities and need based irrigations were applied to rice and wheat and chickpea. Due to yearly variation in price of crops, the total productivity in terms of rice equivalent yield and total net return of ending year i.e. 2008-09 is only presented in the study considering with the farm gate prices for different crops for this particular year.

## RESULTS AND DISCUSSION

### Rice yield

The effects of GM incorporation in rice and different combinations of organic manures sources applied during *rabi* in rice-chickpea and rice - wheat cropping system were found significant and gradually sustained the rice productivity over the years. Similar results of gradual increase in grain yield with the use of organic sources over a period of time was also observed by Surekha (2007). On five years mean basis, increase in grain yield of rice was summarily 59 to 68% higher than control (19.05q/ha in rice-chickpea cropping system) and 58 to 66% over control (18.84 q/ha in rice-wheat cropping system. Increase in rice yield with integrated use of two or three organic sources was also obtained by Singh *et al.* (2011). Rice yield obtained in rice-chickpea system with 1/3 each of NEOC+CDM+EC for N supply was significantly superior over rice-wheat in all organic nutrient management options as given in *rabi* during 2008. However, use of bulky organic manure through different sources in wheat during *rabi* did not affect rice grain yield significantly (Table 1).

**Table 1 : Grain yield and percent increase in yield of rice over control as affected by different combinations of organic nutrient sources (over 5 year)**

| Cropping system/ Treatment | Grain yield (q/ha) | | | | | Over five years | |
|---|---|---|---|---|---|---|---|
| | 2004 | 2005 | 2006 | 2007 | 2008 | Mean grain yield | % Increase over control |
| **$CS_1$:Rice-Chickpea** | | | | | | | |
| $ONM_1$ :EC+CDM | 28.57 | 31.11 | 35.17 | 35.09 | 30.24 | 32.04 | 68.2 |
| $ONM_2$ : NEOC + CDM | 27.78 | 26.31 | 33.42 | 34.69 | 30.28 | 30.50 | 60.1 |
| $ONM_3$ :NEOC +EC | 26.94 | 27.59 | 31.59 | 34.88 | 30.44 | 30.29 | 59.0 |
| $ONM_4$ : NEOC+ CDM +EC | 27.51 | 28.79 | 35.45 | 32.66 | 32.39 | 31.36 | 64.6 |
| $ONM_5$:Control | 18.72 | 20.27 | 20.53 | 18.02 | 17.72 | 19.05 | - |
| **$CS_2$:Rice-wheat** | | | | | | | |
| $ONM_1$ :EC+CDM | 28.04 | 29.89 | 37.06 | 33.34 | 28.19 | 31.30 | 66.1 |
| $ONM_2$ : NEOC + CDM | 28.04 | 28.36 | 35.23 | 32.35 | 27.36 | 30.27 | 60.7 |
| $ONM_3$ :NEOC +EC | 26.45 | 27.36 | 36.45 | 32.49 | 26.16 | 29.78 | 58.1 |
| $ONM_4$ : NEOC+ CDM +EC | 26.99 | 31.03 | 37.48 | 31.71 | 28.31 | 31.10 | 65.1 |
| $ONM_5$:Control | 19.13 | 20.49 | 19.53 | 17.25 | 17.80 | 18.84 | - |
| CS X ONM CD (P=0.05) | 4.0 | 4.2 | 5.1 | 2.88 | 3.70 | - | - |

## Nutrient Uptake in rice

### *Nitrogen*

A marked influence of various combinations of organic manures (applied during *rabi*) with *insitu* green manure incorporation in *kharif* was recorded on N uptake in grains, straw and total uptake and was higher under rice-chickpea than the rice-wheat cropping system. Nitrogen uptake in rice grains ranged from 35.67 to 38.75 kg/ha in rice-chickpea and 30.96 to 34.23 kg/ha in rice-wheat system in combination of organic manures applied as superimposed during *rabi*. A similar kind of pattern was recorded in N uptake by straw and total uptake of N amongst various organic sources of nutrient combination. The N uptake in grain control plot was 19.36 and 20.26 kg/ha in rice-wheat and rice-chickpea system, respectively. Increase in the N uptake with various combinations of organic sources due to slow release of N as a result of decomposition of organic manures throughout the season.

### *Phosphorus*

Highest total P uptake was recorded under $ONM_4$ i.e. NEOC+CDM+EC. The mean P uptake by rice grain under the organic sources plot was more than two times over control and it was ranged between 5.75 to 7.19 kg/ha with the use of different combinations of organic sources of nutrient in rice- wheat system. The P uptake was 3.66 kg/ha in control plot in rice- chickpea system. Almost similar trend was observed in regard to P uptake by rice straw and total P uptake under various organic nutrient sources. The organic nutrient and green manure applied during *kharif* season resulted in substantial quantity of P being left over in *kharif* under submerged condition as brought in rice field which could be subsequently utilized by the succeeding wheat crop. The increase in uptake of P and K particularly by rice crop may be ascribed to more availability of these nutrients from the added organic manure and also to the solubilizing action of organic acids produced during degradation followed by decomposition of green manuring, thus rendering more release of P and K from the soil and organic nutrients under wetland rice culture (Table 2).

### *Potassium*

The highest removal of K by crop from soil was under rice-chickpea cropping system than the rice-wheat system. The highest total (grain +straw) K uptake (103.64 kg/ha) by rice was recorded under treatment $ONM_2$ i.e. 1/2 each of NEOC+CDM and it was the lowest (51.70 kg/ha) in control plot under rice-chickpea cropping system. The increased uptake of K by rice may be ascribed to the release of K from the K-bearing minerals.

## Quality parameters

The quality parameters including spikelets and kernel length and breadth and their ratio were calculated and no perceptible differences were observed in sub plot of rice with combinations of organic sources nutrient plot. However, all the organic sources of nutrient treatments showed superiority over control treatment. Increase in spikelet length and breadth and L:B ratio by using green manuring were also observed by Deshpande and Devasenapathy (2010). The spikelets length and breadth of rice is genetical character and it did not affect much due to different combinations of nutrient sources. However, in control plot, reduction in spikelets length and

**Table 2 : Nutrient uptake (kg/ha) of rice as affected by different combinations of organic nutrient sources under two cropping system at the end of 5th crop cycle**

| Cropping system/ | Nitrogen | | | Phosphorous | | | Potassium | | |
|---|---|---|---|---|---|---|---|---|---|
| treatment | Grain | Straw | Total | Grain | Straw | Total | Grain | Straw | Total |
| **$CS_1$:Rice- chickpea** | | | | | | | | | |
| $ONM_1$ EC+CDM | 35.67 | 19.42 | 55.08 | 7.06 | 3.61 | 10.67 | 6.23 | 92.04 | 98.27 |
| $ONM_2$ : NEOC + CDM | 36.54 | 20.68 | 57.22 | 6.56 | 3.83 | 10.38 | 5.96 | 97.68 | 103.64 |
| $ONM_3$ :NEOC +EC | 36.61 | 20.37 | 56.98 | 7.41 | 3.76 | 11.17 | 5.87 | 91.99 | 97.86 |
| $ONM_4$ : NEOC+ CDM + EC | 38.75 | 22.01 | 60.76 | 8.10 | 4.27 | 12.38 | 6.81 | 93.07 | 99.89 |
| $ONM_5$:Control | 20.26 | 10.08 | 30.34 | 3.66 | 1.49 | 5.16 | 3.19 | 48.51 | 51.70 |
| **$CS_2$:Rice-wheat** | | | | | | | | | |
| $ONM_1$ EC+CDM | 33.83 | 17.92 | 51.75 | 6.68 | 3.73 | 10.41 | 5.55 | 87.24 | 92.79 |
| $ONM_2$ : NEOC + CDM | 32.73 | 18.69 | 51.42 | 6.84 | 3.62 | 10.46 | 5.72 | 89.02 | 94.74 |
| $ONM_3$ :NEOC +EC | 30.96 | 17.56 | 48.52 | 5.75 | 2.98 | 8.73 | 5.33 | 83.98 | 89.30 |
| $ONM_4$ : EOC+ CDM +EC | 34.23 | 20.93 | 55.16 | 7.19 | 3.19 | 10.38 | 5.82 | 96.79 | 102.62 |
| $ONM_5$:Control | 19.36 | 9.78 | 29.13 | 3.41 | 1.24 | 4.65 | 2.85 | 47.91 | 50.76 |
| CS X ONM CD (P=0.05) | 4.23 | 3.20 | 5.57 | 1.28 | 1.16 | 2.05 | 0.89 | 13.66 | 13.70 |

breadth were observed. Same trend was also observed in kernel length and breadth of rice (Table 3).

## Rabi cropping

### *Grain yield of chickpea and wheat*

On five year mean basis, $ONM_4$-S! each (NEOC+EC+CDM) registered highest grain yield of chickpea (8.66 q/ha) followed by $ONM_3$ (50% each of NEOC+EC) and $ONM_2$ (50% each of NEOC+ CDM). This indicates, application of non-edible oil cake is essential for harvesting of maximum output alongwith either of application of enriched compost or cow dung manure or in combination of both (Table 3). However, it was noticed that the grain yield recorded under $ONM_4$ (1/3 each of (NEOC+EC+CDM) was statistically at par with all the other organic treatments, except control plots over the years. Thus, the effect of different organic sources of nutrients did not visualize in respected of grain yield.

On the otherhand, the grain yields of wheat were significantly increased with different levels of organic sources over control. The yield of wheat was ranged from 18.1 to 27.2 q/ha during the study period except during 2005-06 when the overall wheat yield was much lower as compared to rest of the years. The grain yield of wheat recorded with treatments having different combinations of organic manure was significantly greater than control plot indicating the possibility of harnessing the residual nutrients of green manuring applied to rice and various organic sources of nutrients to wheat. This shows that application of GM provided minimum guaranteed sustainable yield of wheat in that

**Table 3 : Quality parameter of rice as affected by different combinations of organic nutrient sources under two cropping system**

| | Spikelet length (mm) | | Spikelet breadth (mm) | | Spikelet L/B ratio | | Kernel length (mm) | | Kernel breadth (mm) | | Kernel L/B ratio | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **2005** | **2008** | **2005** | **2008** | **2005** | **2008** | **2005** | **2008** | **2005** | **2008** | **2005** | **2008** |
| **$CS_1$:Rice- chickpea** | | | | | | | | | | | | |
| $ONM_1$ EC+CDM | 10.39 | 10.57 | 2.19 | 2.22 | 4.74 | 4.75 | 6.41 | 6.53 | 1.73 | 1.71 | 3.70 | 3.82 |
| $ONM_2$ : NEOC + CDM | 10.46 | 10.47 | 2.19 | 2.22 | 4.77 | 4.72 | 6.39 | 6.48 | 1.70 | 1.64 | 3.76 | 3.95 |
| $ONM_3$ :NEOC +EC | 10.47 | 10.60 | 2.19 | 2.21 | 4.79 | 4.79 | 6.45 | 6.47 | 1.72 | 1.71 | 3.74 | 3.79 |
| $ONM_4$ : NEOC+ CDM +EC | 10.59 | 10.50 | 2.22 | 2.26 | 4.77 | 4.65 | 6.64 | 6.55 | 1.75 | 1.70 | 3.79 | 3.85 |
| $ONM_5$:Control | 10.34 | 10.27 | 2.17 | 2.15 | 4.76 | 4.78 | 6.23 | 6.36 | 1.71 | 1.64 | 3.65 | 3.88 |
| **$CS_2$:Rice-wheat** | | | | | | | | | | | | |
| $ONM_1$ EC+CDM | 10.51 | 10.63 | 2.19 | 2.22 | 4.79 | 4.80 | 6.47 | 6.50 | 1.73 | 1.73 | 3.75 | 3.75 |
| $ONM_2$ : NEOC + CDM | 10.43 | 10.47 | 2.19 | 2.20 | 4.76 | 4.76 | 6.48 | 6.46 | 1.72 | 1.71 | 3.78 | 3.78 |
| $ONM_3$ :NEOC +EC | 10.51 | 10.53 | 2.18 | 2.25 | 4.82 | 4.69 | 6.42 | 6.50 | 1.71 | 1.71 | 3.76 | 3.80 |
| $ONM_4$ : EOC+ CDM +EC | 10.64 | 10.63 | 2.22 | 2.24 | 4.80 | 4.74 | 6.57 | 6.58 | 1.75 | 1.74 | 3.76 | 3.79 |
| $ONM_5$:Control | 10.35 | 10.17 | 2.17 | 2.15 | 4.76 | 4.73 | 6.26 | 6.38 | 1.68 | 1.64 | 3.73 | 3.90 |
| CS X ONMCD (P=0.05) | 0.07 | 0.17 | 0.03 | 0.04 | NS | 0.09 | 0.10 | 0.13 | 0.02 | 0.05 | 0.06 | 0.14 |

**Table 4 : Grain yield of *rabi* crops and available nutrient status in soil as affected by different organic nutrient management**

| Treatment | Grain yield (q/ha) | | | | | Over five years | | OC (g/kg) | Available soil nutrient status (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2004-05 | 2005-06 | 2006-07 | 2007-08 | 2008-09 | Mean grain yield | % Increase over control | | N | P | K |
| **Chickpea** | | | | | | | | | | | |
| $ONM_1$ :EC+CDM | 8.80 | 7.25 | 7.49 | 7.28 | 8.13 | 7.79 | 35.90 | 6.1 | 217 | 13.3 | 291 |
| $ONM_2$ : NEOC + CDM | 8.30 | 7.64 | 9.37 | 7.03 | 7.18 | 7.90 | 37.89 | 6.1 | 213 | 14.0 | 304 |
| $ONM_3$ :NEOC +EC | 9.10 | 7.92 | 9.42 | 7.10 | 7.48 | 8.20 | 43.13 | 6.0 | 223 | 13.6 | 283 |
| $ONM_4$ : NEOC+ CDM +EC | 9.30 | 8.11 | 9.89 | 7.72 | 8.27 | 8.66 | 51.05 | 6.2 | 230 | 14.0 | 308 |
| $ONM_5$:Control | 6.00 | 5.14 | 5.72 | 5.27 | 6.53 | 5.73 | - | 5.5 | 183 | 11.7 | 266 |
| CD (P=0.05) | 0.30 | 1.11 | NS | 1.92 | 1.44 | - | - | 0.35 | 27 | 2.2 | 19 |
| Wheat | | | | | | | | | | | |
| $ONM_1$ :EC+CDM | 16.7 | 9.8 | 23.2 | 17.20 | 16.54 | 16.70 | 62.14 | 5.9 | 213 | 14.9 | 304 |
| $ONM_2$ : NEOC + CDM | 16.2 | 9.7 | 22.2 | 17.49 | 15.31 | 16.18 | 57.09 | 5.8 | 217 | 16.1 | 312 |
| $ONM_3$ :NEOC +EC | 17.6 | 10.7 | 25.9 | 19.63 | 15.35 | 17.84 | 73.20 | 5.9 | 220 | 14.4 | 300 |
| $ONM_4$ : NEOC+ CDM +EC | 18.1 | 11.7 | 27.2 | 21.81 | 18.93 | 19.55 | 89.81 | 6.0 | 230 | 16.3 | 317 |
| $ONM_5$:Control | 12.3 | 7.8 | 14.4 | 9.46 | 7.53 | 10.30 | - | 5.4 | 177 | 12.3 | 287 |
| CD (P=0.05) | 0.30 | 1.11 | 0.85 | 1.92 | 1.44 | - | - | 0.4 | 27 | 2.2 | 19 |

particular environment (Urkurkar *et al.*, 2010). On the basis of five years mean values, it was observed that highest grain yield of wheat was registered under $ONM_4$ (application of 1/3 each of NEOC+CDM+EC) followed by $ONM_3$ (1/2 of each of NEOC+EC). However, the control plot, where nutrient was not applied, produced 10.33 q/ha wheat which was far below (almost 90%) to that of 1/3 each of NEOC+CDM+ EC ($ONM_4$) on five year mean basis.

**Available soil nutrients**

Since the organic carbon in soil takes a long time to improve over initial hence even different organic nutrient management options having ½ of N each from enriched compost and cow dung manure had no effect on the OC of the soil. However, study indicated that the application of organic manure have helped in maintaining organic carbon content in soil over initial value (6.1 g/ kg). Different levels of organic sources of nutrients markedly increased the organic carbon content in soil (6.2 and 6.0 g/kg soil in rice-chickpea and rice-wheat cropping system respectively) under 1/3 each of NEOC+CDM+ EC ($ONM_4$) to that of control (5.5 and 5.4 g/kg) at the end of 5$^{th}$ cycle of experiments. Exclusion/ omission of organic source of nutrients totally from system (control plots) resulted in significantly lowest (5.47 g/ kg) amount of organic carbon in soil as compared to all other organic sources of nutrient.

Available N, P and K status in soil after chickpea harvest (completion of 5$^{th}$ cycle) ranged from 213 to 230 kg/ha under various sources of nutrients. Incorporation of S!rd each NEOC+EC+CDM recorded significantly highest N status (230 kg/ha) followed by ½ each NEOC+EC (223 kg/ha) over control treatment. The available P and K status of soil were increased due to incorporation of 1/3$^{rd}$ each NEOC+EC+CDM and also due to incorporation of ½ each EC+CDM, ½ each NEOC+CDM and ½ each NEOC+EC in rice-chickpea cropping system. The P and K status in control plot was significantly lowest. In general, all the available nutrients were at par under the organic sources and registered significantly higher values over control.

In wheat, the various levels of organic sources of nutrients significantly increased the soil available nutrients. The available N content in the soil ranged from 177 to 230 kg/ha and exhibited increase with the addition of organic manures and it was significantly increased (230 kg/ha) in 1/3 N each from NEOC+CDM+EC ($ONM_4$) treatment as compared to control (177 kg/ha). Incorporation of various organic sources of nutrient also increased the available soil P content over control. However, the performance of all organic sources of nutrients was similar and /or superior to control plots. The significantly highest available potassium (317 kg/ha) was recorded in treatment receiving 1/3$^{rd}$ each of NEOC+EC+CDM which was at par with other treatment receiving organics as compared to other organic source of nutrient and control plots (Table 4).

***Economics of the system***

Despite of the 25% premium price given to organically grown produce the rice-chickpea system was relatively more beneficial than rice-wheat system as wheat crop supplied with more nutrient than chickpea and thus, higher quantity of nutrient increases the cost of organic inputs resulted wheat crop during rabi gave comparatively lower net return than rice-chickpea system. The system based analysis revealed that rice-chickpea

**Table 5 : System productivity and economic analysis of rice–chickpea and rice-wheat system as affected by different organic nutrient management (2008-09)**

| Cropping system/treatment | System productivity | | | Cost of cultivation (Rs/ha) | | | Net return (Rs/ha) | | | Benefit cost ratio | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Rice yield (q/ha) | REY of rabi crop (q/ha) | TP (q/ha) | Kharif | Rabi | Total | Kharif | Rabi | Total | Kharif | Rabi | Total |
| **Rice-chickpea** | | | | | | | | | | | | |
| $ONM_1$ :EC+CDM | 30.24 | 13.55 | 43.79 | 12,036 | 12,087 | 24,123 | 36,244 | 8,240 | 44,485 | 3.01 | 0.68 | 1.84 |
| $ONM_2$ : NEOC + CDM | 30.28 | 11.96 | 42.24 | 12,036 | 12,240 | 24,276 | 36,487 | 5,711 | 42,198 | 3.03 | 0.47 | 1.74 |
| $ONM_3$ :NEOC +EC | 30.44 | 12.47 | 42.91 | 12,036 | 12,240 | 24,276 | 36,500 | 6,476 | 42,976 | 3.03 | 0.53 | 1.77 |
| $ONM_4$ : NEOC+ CDM +EC | 32.39 | 13.78 | 46.17 | 12,036 | 12,454 | 24,490 | 39,512 | 8,226 | 47,738 | 3.28 | 0.66 | 1.95 |
| $ONM_5$:Control | 17.72 | 10.88 | 28.6 | 12,036 | 8,721 | 20,757 | 16,214 | 4,347 | 20,561 | 1.35 | 0.50 | 0.99 |
| Rice-wheat | | | | | | | | | | | | |
| $ONM_1$ :EC+CDM | 28.19 | 17.91 | 46.1 | 12,036 | 23,786 | 35,822 | 32,989 | 5,425 | 38,414 | 2.74 | 0.23 | 1.07 |
| $ONM_2$ : NEOC + CDM | 27.36 | 16.58 | 43.94 | 12,036 | 24,194 | 36,230 | 31,878 | 2,953 | 34,831 | 2.65 | 0.12 | 0.96 |
| $ONM_3$ :NEOC +EC | 26.16 | 16.63 | 42.79 | 12,036 | 24,194 | 36,230 | 29,853 | 3,039 | 32,892 | 2.48 | 0.13 | 0.91 |
| $ONM_4$ : NEOC+ CDM +EC | 28.31 | 20.50 | 48.81 | 12,036 | 23,297 | 35,333 | 33,488 | 9,986 | 43,474 | 2.78 | 0.43 | 1.23 |
| $ONM_5$:Control | 17.08 | 8.15 | 25.23 | 12,036 | 8,690 | 20,726 | 15,328 | 4,867 | 20,195 | 1.27 | 0.56 | 0.97 |

**Market Price (Rs./q) :**

Organic rice (Kasturi) Rs 1500/q premium over normal price Rs1200/q

Organic chickpea Rs 2500/- over normal Rs 2000/-

Organic wheat Rs 1625q premium over normal price Rs 1300/q

Rice straw – Rs. 60/qRs Wheat straw Rs100/q system gave net return between a range of Rs. 42,200 to 47,700/ha amongst various sources of organic nutrient. Maximum total net return (Rs. 47,738/ha) was obtained under NEOC+EC+CDM organic sources in rice-chickpea system. Further, it has also been observed that the rice-wheat system gave net return of Rs. 32,892 to a maximum of Rs 43,474/ha. The sub plot nutrient treatment $ONM_4$ (NEOC+CDM+EC) gave maximum net return than rest of the nutrient supply systems. While, being control, $ONM_5$ produced lowest net return (Rs. 20,195/ha). In both the rice based cropping system, the mean B:C ratio was more in rice-chickpea (1:95) system in NEOC+ EC+CDM treatment.

## References

Collins, H.P., Rasmussen, P.E and Douglas, C.L., 1992, Crop rotation and residue management effect on soil carbon and microbial biomass dynamics. *Soil Science Society of America Journal*. **56**: 783-788.

Deshpande, H. H. and. Devasenapathy, P. 2010. Effect of green manuring and organic manures on yield, quality and economics of rice (*Oryza sativa* L.) under lowland condition. *Karnataka Journal of Agriculture Science.* **23** (2): 235-238

Mahapatra, B.S., Ramasubramaniun, T. and Chowdhury, H. 2009. Organic farming for sustainable agriculture: Global and Indian perspectives. *Indian Journal of Agronomy*. **54**(4): 178-185

Singh, Y.V., Dhar, D.W. and Agarwal, B. 2011. Influence of organic nutrient management on basmati rice (*Oryza sativa*) - wheat (*Triticum aestivum*)-greengram (*Vigna radiata*) cropping system. *Indian Journal of Agronomy*. **56**(3): 169-175

Surekha, K. 2007. Nitrogen release pattern from organic sources of different C:N ratios and lignin content and their contribution to irrigated rice (*Oryza sativa*). *Indian Journal of Agronomy* **52**(3): 220-224.

Urkurkar, J.S.,Tiwari, A., Chitale, S., and Bajpai, R.K. 2010. Influence of long-term use of organic and inorganic manures on soil fertility and sustainability of rice (*Oryza sativa*) and wheat (*Triticum aestivum*) in Inceptisols. *Indian Journal of Agricultural Sciences*. 80(3): 208-212.

*J. Farming Systems Research & Development* **18** (2) : 380-384 (2012)

# RESPONSE OF PHOSPHORUS AND SULPHUR FERTILIZATION ON GROWTH PAREMETERS AND YIELD OF PIGEONPEA [*CAJANUS CAJAN* (L.) MILLSP.]

SUDHIR KUMAR AND SUBODH KUMAR

ABSTRACT

A field experiment was conducted on pigeonpea during *kharif* season of 2006 and 2007 to study the effect of phosphorus and sulphur fertilization on growth paremeters and yield of pigeonpea. The experiment conducted five levels of phosphorus (0, 40, PSB, 40+PSB and 80 kg $P_2O_5$/ha), three levels of S (0, 30 and 60 kg S/ha). Application of phosphorus 40 kg/ha resulted plant height 5.98%, dry weight 14.38%, primary branches 6.49% and secondary branches 6.88% per plant over control, respectively. However 30 kg sulphur application resulted plant height 3.31%, dry weight 14.04%, primary branches 4.13% and secondary branches 8.43% per plant over control, respectively. Application of phosphorus up to 40 kg/ha and application of sulphur up to 30 kg/ha increased seed and stalk yields. Application of phosphorus 40 kg/ha resulted 18.69% higher yield than control. However, 30 kg sulphur application resulted a net yield gain of 23.76% over control.

## INTRODUCTION

Among the legumes, pigeonpea (Cajanus cajan) arhar is grown extensively. These crops had wide variations in their morphological characters,root system and nutrients requirements; thereby these crops possess differential capability to utilized plant nutrient from different soil layers, resulting in better use efficiency of the applied nutrient and residual fertility (Singh et al., 2005).

Pulses or food legumes form the linchpin of cropping systems in India for their diversified characteristics of quick (mungbean, urdbean, cowpea etc.) and late maturity (pigeonpea), versatile habit adopted to different agro-climatic situations and soil requirements, providing crop cover soil conservation etc. This group of crops has a very broad spectrum of cover dozens of varieties of pulses belonging to many species genera because of their food value these pulses occupy a very significant place in Indian farming providing the cheapest source of vegetable protein for human and animal nutrition since time immemorial.

Legumes are the rich source of protein, especially for vegetarian. After fish (dry) (335 g protein/kg) they are the second most important source of protein. In every developing country, there is protein deficiency, which can be come over by a large production of pulses.

Pulses are wonderful gift of nature. Unique ability of biological nitrogen fixation, deep root system mobilization of insoluble soil nutrients and bringing qualitative changes in soil physical properties, make them known as soil fertility restoer. By improving physical, chemical and biological environment in soil, pulses can arrest the declining trend in productivity of cereal-cereal system. Inclusion of pulses in intensive cereal based system acts as a component of integrated nutrient supply. Therefore, pulses have emerged as a viable option to improve soil health, conserve the natural resources and sustain the agricultural productivity (Ali *et al.*, 2002).

Pigeonpea being a leguminous crop shows special response of phosphatic fertilizer, because of the need of phosphorus in large quantity for multiplying *Rhizobia* in the nodules. Phosphorus also improves the crop quality and make the crop resistance to diseases. Phosphate application to pulses not only benefit the particular crop in increases its yield but also favourably affects the soil nitrogen content for the succeeding non legume crop which requires lower dose of nitrogen application.

The adequate supply of phosphorus to legume is more important than that of nitrogen. Because it has beneficial effect on nodulation, growth and yield. It plays an important role in energy transfer reactions and in oxidation reduction processes. Phosphorus application increases cell division, as a result of which growth in legumes is increased. It also improves the crop quality and resistance against diseases.

To achieve maximum yield from pigeonpea, adequate supply of all plant nutrients including Sulphur must be available from seeding to harvest. Sulphur requirement for particular cropping situation depends on the S supplying power of the soil and balance between all soil additions of this nutrient viz. precipitation, air, irrigation water, crop residues, animal manure, fertilizers and other agricultural chemicals.

## Material and Methods

The experiment was conducted during the *kharif* seasons 2006 and 2007 at Agricultural Research Farm of J.V. College, Baraut, Baghpat. The soil was sandy clay loam, having pH 7.60, electrical conductivity (EC) 2.11 dS/m, organic carbon 0.55% and available N, $P_2O_5$, $K_2O$ and S 235.76, 16.58, 246.40 and 15.0 kg/ha, respectively. The treatments consisted of five levels of phosphorus (0, 40, PSB, 40+PSB and 80 kg $P_2O_5$/ha), three levels of S (0, 30 and 60 kg S/ha).The experiment was conducted in split plot design, replicated three times. A uniform dose of nitrogen for pigeonpea @ 20 kg/ha N (urea) and potassium 40 kg/ha (MOP) were applied to all plots, at the time of sowing. Extraction of sulphur in seed was done by procedure developed by Williams and Steinbergs (1959) and was analyzed as per methodology of Chesnin and Yien (1951), protein content in seed was calculated by multiplying N content (%) in seed by a factor 6.25.

## Results and Discussion

### Effect of phosphorus

The beneficial effects of increasing rates of phosphorus on growth characters have been clearly brought out in this investigation. Growth parameters, viz. plant height, dry matter accumulation and primary and secondary branches increased significantly with increasing levels of phosphorus up to 40 kg $P_2O_5$ $ha^{-1}$.

Plant height was significantly affected by Phosphorus supply at all the growth stages. Higher dose of phosphorus (80 kg $P_2O_5$ $ha^{-1}$) produced taller plants which were at par with 40 kg $P_2O_5$ $ha^{-1}$. The favorable effects of phosphorus application on plant height have also been reported by Maurya and Rathi (2000), Baboo and Mishra (2004) and Parihar *et al.* (2005). The lowest value of growth parameters were recorded with no phosphorus. This might be due to inadequate nutrient availability to plants under control plots.

Dry matter production is resultant effect of growth parameters viz. plant height and number of branches per plant. Dry matter increased with increasing doses of phosphorus up to 80 kg $P_2O_5$ $ha^{-1}$ at all the growth stages except early stage. The slow growth and lesser dry matter accumulation during initial stage of crop growth might be due to the lower assimilating surface area leading to low photosynthetic rate.

**Table 1 : Effect of phosphorus and sulphur fertilization on growth and yield of pigeonpea**

| Treatments | Plant height (cm) | | Dry matter (g) | | Primary branches | | Secondary branches | | Seed yield (q/ha) | | Stalk yield (q/ha) | | Biological yield (q/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 | 2005 | 2006 |
| **$P_2O_5$ levels** | | | | | | | | | | | | | | |
| 0 | 191.47 | 184.60 | 120.37 | 116.87 | 14.14 | 14.07 | 32.09 | 31.30 | 12.38 | 11.45 | 43.09 | 42.43 | 55.47 | 53.88 |
| PSB | 195.03 | 187.87 | 131.83 | 127.76 | 14.75 | 14.68 | 32.80 | 32.28 | 14.11 | 12.88 | 45.03 | 44.26 | 59.14 | 57.14 |
| 40 | 202.57 | 193.70 | 140.40 | 136.67 | 15.13 | 15.04 | 33.48 | 34.59 | 15.23 | 14.09 | 47.17 | 46.65 | 62.40 | 60.74 |
| 40+PSB | 204.87 | 197.23 | 146.40 | 143.41 | 15.65 | 15.35 | 35.09 | 34.88 | 15.71 | 14.90 | 48.34 | 47.60 | 64.06 | 62.50 |
| 80 | 208.97 | 200.63 | 151.00 | 147.95 | 16.00 | 15.62 | 36.47 | 35.76 | 16.66 | 15.84 | 50.16 | 48.81 | 66.82 | 65.15 |
| CD | 7.70 | 6.66 | 2.08 | 1.96 | 0.441 | 0.529 | 1.21 | 1.32 | 0.412 | 0.518 | 1.73 | 1.46 | 2.17 | 2.09 |
| **S levels** | | | | | | | | | | | | | | |
| 0 | 195.04 | 187.74 | 122.72 | 119.49 | 14.42 | 14.37 | 32.47 | 31.82 | 12.21 | 11.46 | 43.37 | 42.80 | 55.58 | 54.26 |
| 30 | 201.58 | 194.28 | 142.56 | 139.22 | 15.66 | 14.98 | 34.93 | 34.66 | 15.55 | 15.51 | 48.30 | 47.37 | 63.85 | 61.87 |
| 60 | 205.12 | 196.40 | 148.72 | 144.88 | 15.55 | 15.38 | 35.56 | 34.92 | 16.69 | 15.53 | 48.80 | 47.98 | 65.30 | 63.51 |
| CD | 5.96 | 5.16 | 1.62 | 1.52 | 0.342 | 0.410 | 1.03 | 1.21 | 0.412 | 0.401 | 1.34 | 1.13 | 1.69 | 1.62 |

Every increase in level of phosphorus brought about a significant increase in the number of primary and secondary branches per plant of pigeonpea crop. The maximum number of primary and secondary branches per plant was recorded with the application of 80 kg $P_2O_5$ $ha^{-1}$.

The increase in seed, stalk and biological yields of pigeonpea by phosphorus fertilization above 40 kg P2O5/ha was largely a function of improved growth and the consequent increase in yield attributes of pigeonpea. The present trend of increase in yields by application of phosphorus is in close conformity with the findings of Srivastava *et al.* (1993) and Chittapur *et al.* (1994).The seed production is dependent on yield attributes and all these traits were favourably affected by phosphorus application. Similar results were obtained by Maurya and Rathi (2000), Singh *et al.* (2005), Gupta *et al.* (2006), Kumar and Kushwaha (2006), Sharma and Rana (2006), Kumar *et al.* (2007) and Prasad *et al.* (2007).

The beneficial effect of phosphorus on production of grain, straw and biomass (q/ha) was observed in this investigation. Higher seed yield 15.80 and 16.66 q/ha was obtained with the application of 80 kg $P_2O_5$. The second higher seed yield of 14.90 and 15.71 q/ha was obtained with 40 kg $P_2O_5$ + PSB inoculation. The straw yield was recorded more with 40 kg $P_2O_5$/ha + PSB inoculation than 40 kg $P_2O_5$/ha and PSB alone. This is apparently due to increase in dry matter accumulation and yield attributes.

Biological and straw/stalk yields (kg $ha^{-1}$) were also affected by levels of phosphorus. The maximum biological and straw/stalk yields were recorded with 80 kg $P_2O_5$ $ha^{-1}$ but this was found statistically at par with 40 kg $P_2O_5$ $ha^{-1}$ PSB inoculation. The beneficial influence of phosphorus application on yields obtained in the present investigation, are in close conformity with the findings of Parihar *et al.* (2005), Singh *et al.* (2005), Kumar and Kushwaha (2006), Sharma and Rana (2006) and Kumar *et al.* (2007).

**Effect of sulphur**

It is evident from the results that application of 30 kg S/ha significantly increased the growth attributes viz., plant height, branches/plant and dry matter accumulation/plant over no sulphur in both the years.

The overall improvement in vegetative growth of the crop with the application of S in the present investigation is in close conformity with the findings of Singh *et al.* (1994) who reported marked increase in dry matter of crops with the application of sulphur.

Results showed that application of 30 kg S/ha significantly increased the yield attributes viz., grain, stover and biological yields of pigeonpea over no sulphur. Improvement in yield components might have resulted from favourable influence of S on the growth characters viz., plant height, branching and dry matter accumulation and efficient and greater partitioning

The increase in grain, stover and biological yields of pigeonpea by application of S was largely a function of improved growth and consequent increase in yield attributing characters. The results of present investigation are in conformity with those of Trivedi and Sharma (1997) and Shivran *et al.* (2000).

On the basis of two years data, it was concluded that the pigeonpea affected with application of phosphorus and sulphur in respect of root charecters and seed yield. Higher yield could be obtain with the application of phosphorus 40 kg/ha and sulphur 30 kg/ha. From the present study, it was concluded that the most suitable dose of phosphorus 40 kg/ha and and 30 kg S/ha for pigeonpea cultivation.

## REFERENCES


Ali, M.; A.N. Ganeshamurthy and S. Rao (2002). Role of pulse in soil health and sustainable crop production. *Indian J. Pulses. Res.* **15**(2): 107-117.

Baboo, R. and S.K. Mishra (2004). Growth and pod production of cowpea (*Vigna sinensis*) as effected by inoculation, nitrogen and phosphorus application. *Ann. Agric. Res.* **25**(4): 467-469.

Chittapur, B.M.; B.S. Kulkarni; S.M. Hiremath and M.M. Hosami (1994). Influence of nitrogen and phosphorus on the growth and yield of short duration pigeonpea (*Cajanus cajan*). *Indian J. Agron.* **39**(4): 657-59.

Gupta, Ajay; Vinod Kumar Sharma; G.D. Sharma and Pankaj Chopra (2006). Effect of biofertilizer and phosphorus level on yield attributes, yield and quality of urdbean. *Indian J. Agron.* **51**(2): 142-144.

Maurya, B.M. and K.S. Rathi (2000). Growth and development of soybean as influenced by intercropping with pigeonpea and phosphorus level. *Gujarat Agric. Univ. Res. J.* **26**(1): 1-5.

Kumar, Avanesh and H.S. Kushwaha (2006). Response of pigeonpea to sources and levels of phosphorus under rainfed condition. *Indian J. Agron.* **51**(1): 60-62.

Kumar, Vinod; R.S. Chauhan; R.K. Rajput and A.S. Yadav (2007). Effect of phosphorus fertilization and seed inoculation on growth, yield attributes and yield of chickpea. National Symposium on Legumes for Ecological Sustainability: Emerging Challenges and Opportunities held on November 3-5 at I I P R, Kanpur. pp. 50.

Parihar, C.M.; M.M. Kaushik and D.R. Palsaniya (2005). Effect of varieties, plant density and phosphorus levels on growth and yield of clusterbean [*Cyamopsis* texagonoloba (L.) taub]. *Ann. Agric. Res. New Series.* **26**(1): 5-7.

Prasad, Angad; Ghanshyam, Singh and O.P. Rai (2007). Effect of irrigation and phosphorus levels on the productivity of chickpea. National Symposium on Legumes for Ecological Sustainability: Emerging Challenges and Opportunities held on November 3-5 at I I P R, Kanpur. pp. 59.

Sharma, R.P. and S.S. Rana (2006). Response of rajmash varieties to phosphorus in cold arid region of Himachal Pradesh. *Indian J. Pulses Res.* **19**(2): 231-233.

Srivastava, G.P. and V. C. Srivastava (1993). Response of rainfed pigeonpea to phosphorus and sulphur in acid red loam soil. *Indian J. Agric. Sci.* **63**(1): 43-44.

Singh, G.K.; R. Singh and S. Singh (1994). Yield and yield attributes of greengram in response of sulphur level. *Indian J. Agric. Sci.* 64(6): 390-391.

Singh, Atar; Lakhan, Singh and N.P. Singh (2005). Performance analysis of pulses in trontline demonstrations. *Indian J. Pulses Res.* **18**(2): 202-205.

Shivran, P.L.; I.P.S. Ahlawat and D.R. Shivran (2000). Effect of phosphorus and sulphur on pigeonpea-wheat cropping system. *Indian J. Agron.* **45**(1): 25-30.

Trivedi, S.K. and U.K. Sharma (1997). Response of soybean to nitrogen and sulphur fertilization and fate of mustard grown on residual nutrients. *Crop Res. Hissar.* 1**3**(1): 81-85.

*J. Farming Systems Research & Development* **18** (2) : 385-395 (2012)

# EFFECT OF IRON OXIDE NANOPARTICLE ON THE REMOVAL OF SELECTED PESTICIDES ENDOSULPHAN FENITROTHION

YOGENDRA SINGH*, INDERJEET SINGH** AND PREM SINGH***

**Division of Chemistry Government Polytechnic Moradabad*

ABSTRACT

Iron oxide nanoparticles (IONPs) can play a significant role in the cycling of selected pesticides like fenitrothion (FT) and endosulfan (es). Pesticides are highly toxic, mobile, and predominant species in pesticides-contaminated groundwater. IONPs have been synthesized and tested for the removal of pesticides from pesticides contaminated water. In this work, we synthesized IONPs, as a finely divided loose nanopowder, using a chemical method involving a dispersion of the metal cations (Fe3+) through polymer molecules of polyvinyl alcohol (PVA) in an aqueous medium-ray diffraction (XRD) analysis confirmed the formation of a single phase rhombohedral crystal structure of R3c space group. Transmission electron microscopic images corroborate the result of IONPs of 45 nm average size and the rhombohedral shape. Selective experiments, conducted with an initial concentration of 25$\mu g/l$ of pesticide have demonstrated the maximum adsorption capacity (98%) for ferinitrothion and 100% for endosulphon in 2.0 $gL^{-1}$ IONPs in water at pH 4.5–7.5. At room temperature, the adsorption isotherm studies have revealed a better correlation with the Langmuir isotherm than the Freundlich isotherm. Characteristic surface hydrolysis of IONPs as = Fe-OH species has been studied in terms of the vibration bands. The results reveal that the removal of the fenitrothion and endosulfan species from water is associated with the adsorption onto the IONPs followed by a surface hydrolysis of the iron species.

**Keywords:** Pesticides, adsorption, iron oxide nanoparticle, water.

For the last couple of decades, millions of people in the world are suffering from skin lesions, cancers, and other related diseases due to consumption of pesticides in underground water in Bangladesh, Taiwan, India, Japan, Mongolia, China, Poland, Hungary, Belgium, Chile, Argentina, North Mexico, United States, etc.[1"15] Long-term geochemical changes in nature have led to release of pesticides c from agro industries by air reaching underground aquifers through the tube well conducts and also released by current or historical mining activities and oxidation are available for decontamination of pesticide from the groundwater supply such as coagulation,[19] softening,[20]adsorption on alumina,[21] activated carbon,[22] anion exchange, reverse osmosis (RO),[23] biological treatment,[24] using hardened paste Portland cement,[25] composite iron matrix,[11] etc.Iron-containing compounds have immense applications in the soil sedimentation and the groundwater remediation. They are also known to be highly efficient in spontaneous adsorption and co-precipitation of .[26] Small iron oxide or hydroxide particles can be transported effectively by the groundwater.[27] They are easy to inject as sub colloids (in forms of oxides, hydroxides, or oxyhydroxides) into, contaminated soils, sediments, and aquifers due to large susceptibility to form and exist in a suspension in an aqueous medium.

**Associate, Professor, CCRD Muzaffarnagar, ***Principal Scientist PDFSR,Modipuram Meerut

Large surface area in small particles and high porosity are desired in order to promoting the surface adsorption capacity and form stable complexes with $H_2O$ species from the medium. The aim of our present work is to investigate the applications of laboratory-synthesized IONPs in the removal of pesticides from pesticides-contaminated water. Selective doses with IONPs have been examined in testing the adsorption process of pesticides on the IONPs, which were dispersed in an aqueous medium containing pesticides. Infrared spectra and energy-dispersive X-ray (EDX) analysis in conjunction with microstructure of the samples before and after treating pesticides species corroborate the results of considerable pesticide adsorption on IONPs.

## MATERIALS AND METHODS

### Instruments and reagents

A rotary incubation shaker (Innova-4200, USA) and a digital pH meter (EA-940, Orion Research Inc. USA) have been used for shaking FT and ES species and IONPs in aqueous medium and measuring average pH of the medium before and after adsorbing part of FT and ES species on the IONPs, respectively. The pesticide (Endosulphon and fenitrothion) amount adsorbed on IONPs from the medium has been measured with a spectrophotometer (Beckman Coulter, DU 640B). The sample was put in a cell of quartz cuvette of 1 cm width. The reagents polyvinyl alcohol (PVA), sucrose, ferric nitrate [Fe(NO3)3·9H2O], and ammonia solution (25% GR) used in this work were of analytical grade (99.90% purity).PVA has been obtained from Merck SchuchardtOHG (Germany) while sucrose, Fe(NO3)3·9H2O, and ammonia solution were obtained from Merck Specialities Private Limited (Mumbai, India). Fenitrothion and endosulfan solution has been prepared from its 100 % pure salt (Merck Ltd., UK).

### Preparation of IONPs

The IONPs used in this experiment were synthesized from a precursor of $Fe^{3+}$ species dispersed in PVA molecules in water as follows. Aqueous solutions were prepared for $Fe(NO_3)_3.9H_2O$ (1 M) and PVA (30 gL"1) by stirring in hot conditions at 60-70æ%C. The 30 gL"1 sucrose in water was admixed to the PVA solution by stirring at 55–65æ%C and that was used as a dispersive medium to obtain a metal ion-polymer precursor (Fe3+ -sucrose-PVA). In this process, the nitrate solution was added into this solution drop wise with stirring at 60æ%C for 30 min.A $Fe^{3+}$ -sucrose-PVA complex thus obtained had been aged for a few hours at room temperature and then at ice-cooled temperature. Then, ammonia solution was added drop wise until a gel appears at 12–14 pH. IONPs were obtained after firing a dried gel (at 80–90æ%C in air) at 300æ%C in air.

### FT&ES-IONPs uptake in batch processes

The FT and ES uptake through IONPs as a vehicle was performed in selective batches. In a typical batch, 100 mg of IONPs is dispersed in a 100 mL solution of 0.25 *ì*g/ FT and ES in water (as mentioned above) in an Erlenmeyer flask. The sample was shaken thoroughly on a rotary shaker at 80 rpm under heating condition at 25æ%C. After selective incubation times, i.e., 0, 20, 40, 60, 80, 100, or 120 min, the supernatant samples were analyzed for the residual FT and ES concentration left behind in the final medium.

### Effect of pH and adsorbent dose on FT and ES

In order to study the pH effect on FT

and ES adsorption behavior of IONPs, 100 mg of IONPs had been dispersed in 100 mL of FT (0.25 ppm). The experiment was carried out in nine batches under identical conditions. After adjusting selective pH values, i.e., 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, and 10 by using 0.1N HCl or 0.1N NaOH, the samples in the 9 test bottles were shaken thoroughly with the mechanical shaker for a common period of 1 h. According to the observations, in a typical pH value 6.0, we varied further the IONPs amount such as 50, 100, 150, 200, 250, or 300 mg in the common value 100 mL of NaAsO2 solution in optimizing the adsorbent dose for the FT and ES adsorption process. All the samples were shaken in identical conditions before using further.

**Equilibrium adsorption dose**

The equilibrium FT and ES adsorption experiments were performed with IONPs of 2.0 mg mass per mL solution and 0.05–0.50 ìg/mL FT and ES species in a total 100 mL volume (V) in a flask. In order to induce a chemical equilibrium, thesample had been agitated on a rotary shaker with 80 rpm at 25æ%C. The uptake (q) of the FT and ES species onto IONPs from the medium in constructing an isothermhas been calculated using the equation: ($C_i$ - $C_f$) V/M, where $C_i$ is the initial FT and ES concentration, $C_f$ is the equilibrium FT and ES concentration, andMis the amount of IONPs used.

**Phase and microstructure analysis**

The phase analysis and crystal structure of IONPs had been studied in terms of XRD. The XRD pattern was recorded using a diffractometer of Rigoku Instruments, with filtered CuKá radiation of wavelength ë = 0.15406 nm. Their particle size and morphology were studied with a high resolution scanning electron microscope (HRSEM) of Carl Zeiss of model Supra-40 (with an accelerated voltage 10–20 kV) and a high-resolution transmission electron microscope (HRTEM) of JEOL (JEM-2100), with an operating voltage 200 kV. Average compositions for IONPs and FT and ES- IONPs were studied with in situ EDX in conjunction with the HRSEM imaging of selective regions. In sample preparation for HRTEM studies, a small amount of IONPs were dispersed in acetone and sonicated for 30 min

**FTIR analysis**

The IR spectra were studied of thin pellets of the IONPsand FT and ES -IONPs in forms of powders in a KBr matrix. ANexusTM 870 FT-IR (Thermo Nicolet, USA) spectrophotometer equipped with a deuterated triglycine sulfate thermoelectric cool (DTGS-TEC) detector collected the data over a range of 200–4000 $cm^{-1}$.

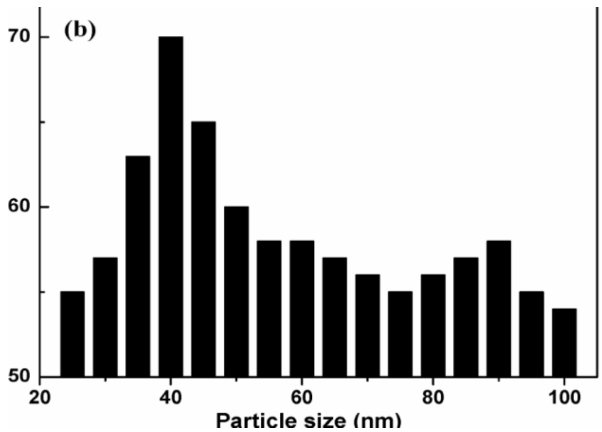
**Statistical analysis**

All the data reported in this work represent the mean of the values obtained from each experiment repeated at least three times. The values had been subjected to regression analysis using the

## Results and Discussion

**Phase formation and microstructure of IONPs**

A typical XRD pattern, as given in Figure 1, characterizes formation of a single phase sample of IONPs after heating an Fe3+ -sucrose-PVA polymer complex in air at 300æ%C for 2 h. All the XRD peaks in this pattern are indexed assuming the usual rhombohedral crystal structure (R3c space group),[28] with lattice parameters *a* = 0.5426 nm,c = 1.3745 nm and ã = 124.69æ%, of hematite (á-Fe2O3).Bulk *á*-Fe2O3 is reported with very similar *a* = 0.50355 nm and c = 1.37471 nm[28] confirming that IONPs prepared using a chemical method in this work forms the usual *á*-Fe2O3 crystal lattice. An analysis of the peak broadening the particle size distribution of IONPs used in the FT and ES removal experiments. in the characteristic XRD peaks as per the Debye-Scherrer relation reveals an average 34 nm crystallite size (D).Representative HRTEM images (bright field) in Figure 2(a) reveal nearly rhombohedral shaped particles of IONPs obtained in this work. The size distribution is given in the histogram in Figure 1 (b). Average values included in this histogram were obtained by analyzing several frames of similar bright field images of the specimen. The majority of IONPs in this histogram are of the average size <"45 nm,which is in close agreement with an average D-value



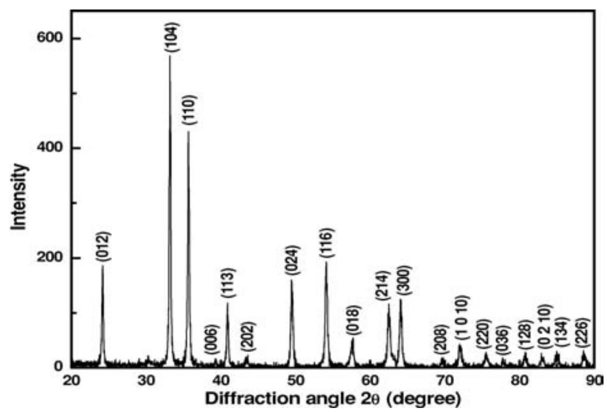




**Fig. 1. XRD pattern of *á*-Fe2O3 NPs used in the FT and ES removal experiments.**

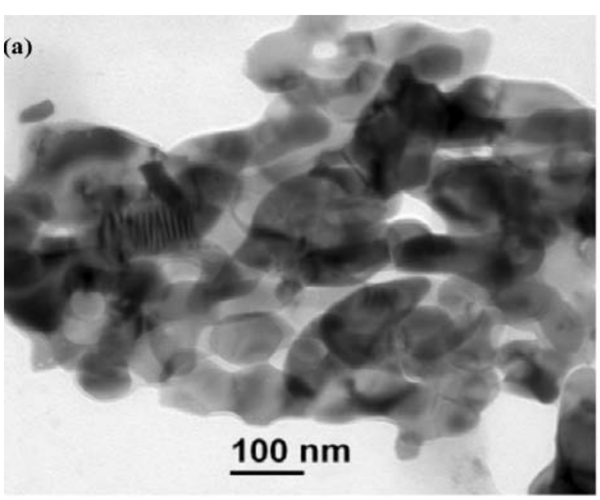
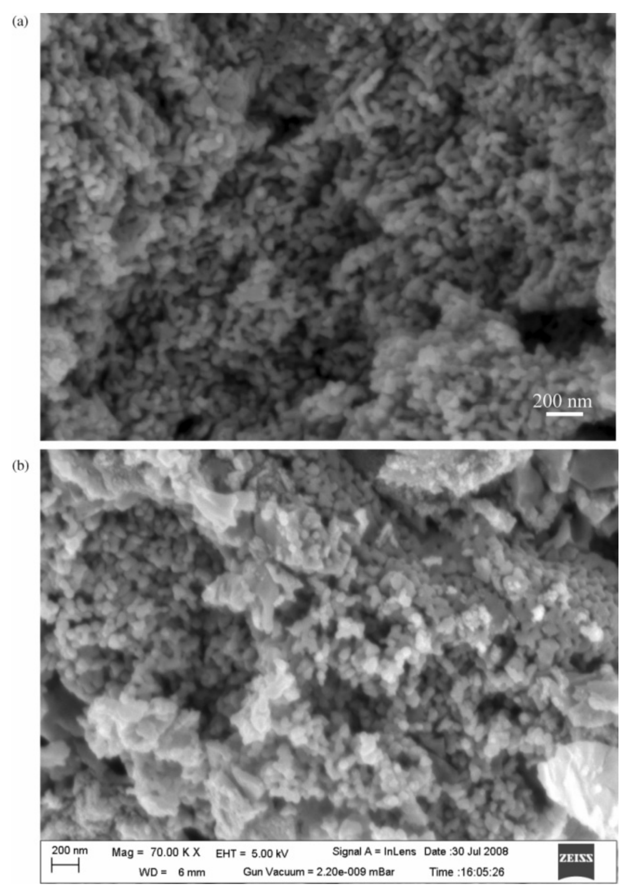



**Fig. 2. (a) TEM (bright field) images and (b) a histogram showing**



34 nm determined above from the XRD peak broadening. Such small particles (separated) present as a large value of the surface area _ as 39 m2/g, i.e., efficiently large value for the purpose of the FT and ES removal from a contaminated water. In addition to a large _-value, such small *á*-Fe2O3particles were chosen because of their magnetic properties,

Fig. 3. SEM images of IONPs (a) before and (b) after treating with FT and traces in water. Bulk *á*-Fe2O3 is an ant ferromagnetic material, while small *á*-Fe2O3 particles assume modified ferromagnetic properties in prominent surface magnetism.[29,30] The HRSEM images from the IONPs before and after adsorption of FT and ES in a typical experiment are shown in Figure 3(a) and (b), respectively. It is clear from Figure 3a that the virgin IONPs are of acicular shapes, with 50–100 nm lengths and 25–50 nm widths, showing a high value of number density of particles *ñn* 0.08 particles/nm2. InFigure 3b, the FT and ES adsorbed IONPs present a marked modification in apparent contrasts of their images, with an eventually increased *ñn*-value 0.1 particles/nm2 along with an increased particle aggregation. This is feasible owing to the *Iron oxide nanoparticles used to remove pesticide*

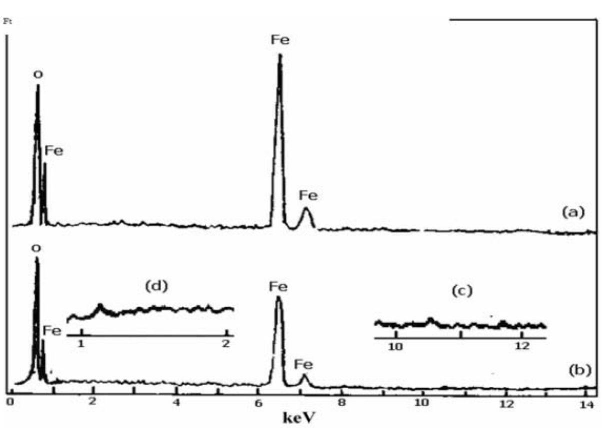



Fig. 4. EDX spectra for IONPs (a) before and (b) after treating with FT and ES traces in water (aqueous NaAsO2 with 0.25 ppm FT and ES content and 2.0 gL"1 IONPs dose). (c) & (d) Close-up of two different parts of the spectrum (b) show weak bands from the FT and ES-species. Adsorption of the FT and ES species, possibly in the form of hydroxides, over the IONPs to a significant amount. The EDX spectra for the virgin and FT and ES adsorbed IONPs are compared in Figure 4a and b, respectively. Close-up of two different parts of the spectrum in the insets in Figure 4b show weak peaks from the As-species. The occurrence of the characteristic As-peaks along with those from the Fe and O species from the IONPs confirms that the As (III) is deposited onto the IONPs surfaces.

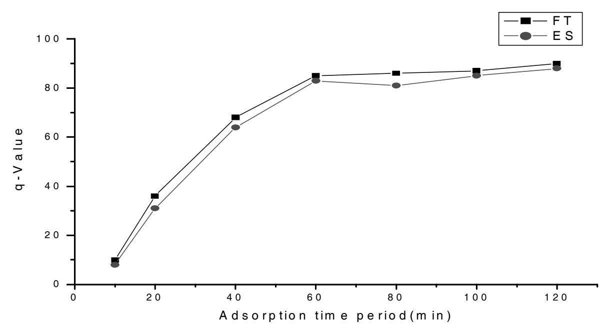



**Fig. 5. A plot of the FT and ES removal by IONPs as a function of the contact time in an aqueous NaAsO2, with 0.25 ppm FT and ES**

Batch studies (optimum conditions for FT and ES removal) *Optimal shaking and FT and ES -adsorption processes*

Adding a NaAsO2 solution (<" 0.25 ppm) to IONPs as adsorbent in a specific ratio *{*typicallyAs/Fe=(1–10) 10"2*}* in a test bottle allows part of the FT and ES species to separate fromthe medium and adsorb onto the active surfaces of the IONPs. This process prolongs over a specific span of thetime period (i.e., the incubation time) t*p*, depending upon the As/Fe ratio, the effective As-Fe contact area, average pH value, the adhesion coefficient, and the experimental temperature. Shaking under particular conditions promote the process. In optimizing the t*p* –value, after selective durations of the adsorption process, i.e., 0, 20, 40, 60, 80, 100,or 120 min, the FT and ES adsorbed IONPs were taken out from the solutions with the help of an external magnetic field. Then, the residual amounts of the FT and ES species left behind in the individual solutions were estimated in terms of the atomic absorption spectra with a spectrophotometer.The difference between the C*i* and C*f* values thus measures the fractional FT and ES value removed from the solution after a specific period of the adsorption process. The experiments were repeated 2 to 3 times to check the reproducibility.The q-value so obtained in a typical batch of the experiment using 100mLofNaAsO2 solution (<“0.25 ppm) and 100 mg of IONPs is portrayed against the adsorption time period used in Figure 5. The data points are average values of the repeated measurements. It is found from this plot that the FT and ES adsorption has reached a maximum value after 60 min of the shaking period, i.e., the t*p*-value.Over t*p*>60 min, the adsorption process does not change further with the time period. Thus, the 60 min of the contact period is sufficient enough to achieve the adsorption equilibrium in this experiment at room temperature.

## Effect of pH on the FT and ES removing process

The pH of the medium is an important factor to tune uptake of FT and ES species as adsorbate from the medium. Chemical characteristics of both adsorbent and adsorbate vary with average pHof the medium. It has thus become important to study the effect of pH on the adsorption of FT and ES species in this experiment onto dispersed IONPs in an aqueous medium at room temperature. For this process, the residual FT and ES concentrations in selective solutions of different pH values 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, and 10 have been studied after adsorbing part of the FT and ES species onto content and 2.0 gL”1 IONPs dose.IONPs by separating from the respective solutions by using an external magnetic field.For example, the removal of FT and ES species as a function of pH is demonstrated in Figure 6 for a typical batch composition consisting of 100 mL of NaAsO2 solution (0.25 pm) and 100 mg IONPs. It can be seen by the area ABCD marked on the plot that over a specific range 4.5–7.5 of pH values, the adsorption of FT and ES species on IONPs is reasonably very efficient. Over higherpHabove 7.5, the FT and ES adsorptivity onto IONPs decreases sharply. Such high pHoffers competitive processes between FT and ES species and $OH^-$ ions of occupying the adsorption Fe3+ sites onto reactive

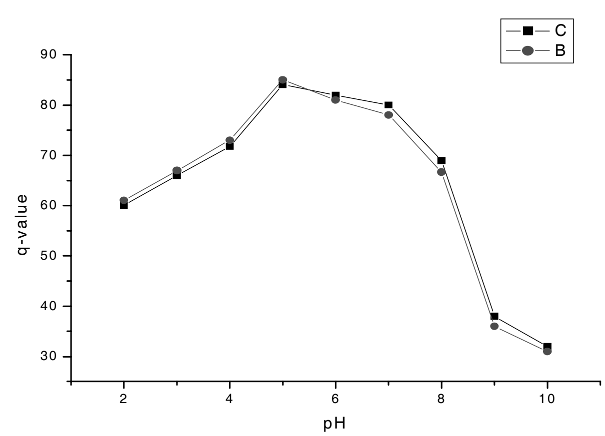



**Fig. 6. A plot of the FT and ES removal by IONPs as a function of average pH value in an aqueous NaAsO2, with 0.25 ppm FT and EScontent and 2.0 gL”1 IONPs dose.**

IONPs. Ultimately, a surface hydrolysis of IONPs dominates over the FT and ES adsorption process. Part of the FT and ES species converts into hydroxides, which dissolve back into the medium, leading adversely to rather lowered q-values.

Effect of adsorbent dose on the FT and ES removing process

Whether the dose of the adsorbent IONPs has any effect on the removal process of FT and ES from a contaminate water

has been studied at a specific pH value 6.0 which allows a maximal q-value as per the results in Figure 6. The IONPs have been taken in selective amounts 0.5, 1.0, 1.5, 2.0, 2.5, and 3.0 mg/mL in test bottles and then 100 mL of 0.25 ppm $NaAsO_2$ solution has been added to each of them at room temperature. After 60 min of shaking the total mixture,the FT and ES adsorbed IONPs have been separated by applying an external magnetic field. The FT and ES concentrations in the residual solutions have been estimated and found that the adsorption of FT and ES species

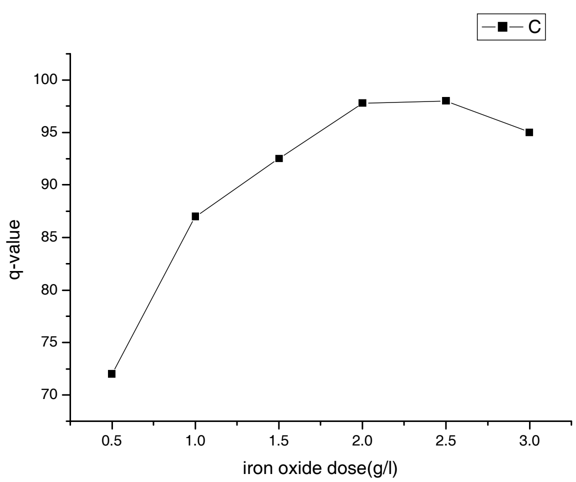



**Fig. 7. A plot of the FT and ES removal by IONPs as a function of the IONPs dose in an aqueous $NaAsO_2$, with 0.25 ppm FT and ES content and pH value 6.0.**

reached almost to the maximum level (96% removal) with a specific dose 2.0 gL”1 of the adsorbent as can be seen from the q-values plotted against the IONPs dose in Figure 7. Beyond this specific dose value, there is no significant change in the FT and ES removal efficiency. A maximum value 96% of FT and 98% ES removal achieved here stands higher than a value 90.9% reported by Mayo et al.[23] {1 kg of $Fe_3O_4$ nanoparticles (20 nm) were dispersed in 2 L aqueous solution of 500 ìg/L FT and ES , after 24 h of shaking at pH 8.0 at 0.5 1.0 1.5 2.0 2.5 3.0

*Iron oxide nanoparticles used to remove pesticide* 161room temperature}. In another experiment,Kundu et al.[25] obtained a similar result in case of As(V) removal, using hardened paste portland cement (15 g/L), from an aqueous

As(V) solution (0.2 ppm), with 8 h of shaking at pH 5.0 at 30æ%C. In our experiment with IONPs, a large surface area <“39 m2/g of adsorbent of small particles promoted a reasonably high value of the FT and ES adsorption. Moreover,small particles move faster in solution than larger ones, and hence can sustain a greater shearing effect due to the collisions and intraparticle effects on their surfaces.

## FT and ES adsorption isotherm

The FT and ES uptake by IONPs in an aqueous medium is obviously a result of the chemical co-ordination of the metal cations FT and ES to the surface anions O2" from the IONPs. When adsorbent and adsorbate species come in contact to each other, a dynamic equilibrium is established between the adsorbent and adsorbate concentrations in the two components. Considering the optimum conditions, i.e.,0.25 ppm FT and ES concentration, 4.5–7.5 pH, t*p*= 60 min,adsorbent dose 2.0 gL”1, a set of experiments have been performed and different adsorption isotherms have been drawn to work out the model the adsorption process follows.The relation between the adsorption capacity (q*e*) by an adsorbent and the equilibrium concentration (C*e*) of the adsorbate at a constant temperature 25æ%C could be described best with a linear model of the Langmuir isotherm as portrayed in Figure 8. A linear 1/q*e* Vs 1/C*e* plot yields a correlation coefficient<R2> = 0.9656. The experimental parameters used were C*i* = 0.25 ppm FT and ES , t*p*= 60 min,and the adsorbent dose varied from 0.5 gL”1 to 3.0 gL”1,with common values for the other parameters.

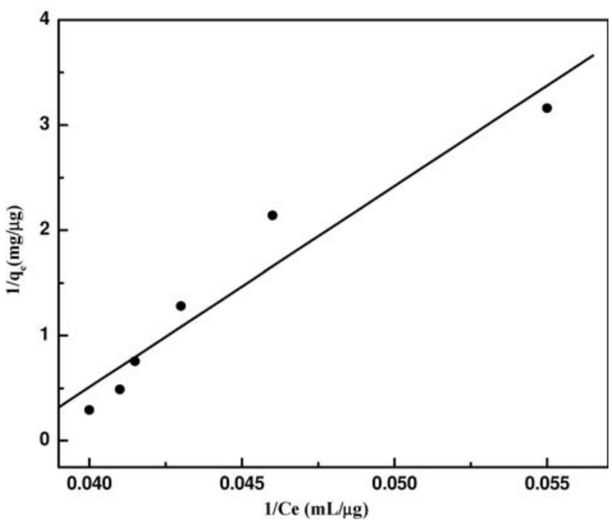



**Fig. 8. A linear Langmuir isotherm plot of FT and ES adsorption on IONPs in NaAsO2 in water at room temperature.**

Fig. 9. FTIR spectra for IONPs (a) before and (b) after treating with FT and ES traces in water (aqueous NaAsO2 with 0.25 ppm FT and ES content and 2.0 gL”1 IONPs dose).

**FTIR spectrum in FT and ES adsorption onto IONPs**

The FTIR spectrum is a powerful tool for analyzing the adsorption process by the adsorbate species on the adsorbent

in a dilute medium. The spectra of IONPs before and after adsorbing FT and ES in different aqueous solutions in this work are shown in Figure 9. As marked over the spectrum (Fig. 9a), the virgin IONPs have nine distinct bands of 918, 1045, 1170, 1330, 1385, 1460, 1530, 1630 and 1740 cm”1 frequencies. As described elsewhere,[31] these bands arise from Fe-OH stretching and bending vibrations from part of hydroxyl groups, which are converted from the ironoxide in the forms of transient complex species such as = Fe-OH, -Fe(OH)2, or FeO(OH) on the bare surfaces in the IONPs. The FT and ES adsorption leads to promote intensity of the spectrum by an order of magnitude with not many changes in the individual positions in these bands of 915,1045, 1170, 1330, 1385, 1460, 1530, 1625 and 1740 cm”1.The band that shifts from 918 cm”1 in the IONPs to at 915cm”1 upon the FT and ES adsorption attributes to the FT and ES-O stretching band in a partial As3+ ’! Fe substitution. Theresult reveals that the FT and ES is bonding to the IONPs in a surface complex rather than precipitating as a separatephase.

CONCLUSIONS

A series of systematic experiments have been performedin optimizing the experimental parameters for removingtraces of FT and ES species from contaminated water at room temperature. The conditions involve variable doses for the adsorbate and adsorbent at selective pH values 2–10. Iron oxide nanoparticles (IONPs) of large bare surfaces, such as 39 m2/g or still larger as much as possible, have been found to be an effective adsorbent for the trace removal of FT and ES from an pesticide contaminated water. At a specific 4.5–7.5 range of pH, a maximum

FT and ES removal capacity of IONPs, i.e., as large as 96% in 60 min of the incubation time (i.e., usefully a small practical value), has been worked out from an extremely dilute aqueous FT and ES solution such as 0.25 ppm FT and ES as NaAsO2 in water. The FT and ES adsorption process onto IONPs occurs to be most efficiently at a critical dose of 2.0 gL"1 IONPs. The corresponding adsorption isotherm has been found to be a kind of the Langmuir isotherm. The employed IONPs in this FT and ES -removal process from a water medium can be separated easily after the use by using a magnet.

## References

Karim, M.M. Pesticide in ground water and health problems in Bangladesh. Water Res. **2000**, *34*, 304–310.

Shrestha, R.R.; Shrestha, M.P.; Upadhyay, N.P.; Pradhan, R.;Khadka, R.; Maskey, A.; Maharjan, M.; Tuladhar, S.; Dahal, B.M.;Shrestha, K. Ground- water pesticide contamination, its health impact and mitigation program in Nepal. J. Environ. Sci. Health Pt. A **2003**, *38*, 185–200.

Bundschuh, J.; Farias, B.; Martin, R.; Storniolo, A.; Bhattacharya,P.; Cortes, J.; Bonorino, G.; Albouy, R. Ground water pesticide in the Chaco-Pampean Plain, Argentina: case study from Robles county,Santiago del Estero Province. Appl. Geochem. **2004**, *19*, 231–243.

Tseng, C.-H.; Huang, Y.-K.; Hhung, Y.-L.; Chung, C.-J.; Yang, M.-H.; Chen, C.-J.; Hsueh, Y.-M. Pesticide exposure, urinary pesticide speciation, and peripheral vascular disease in blackfoot disease hyperendemic villages in Taiwan. Toxicol. Appl. Pharmacol. **2005**,*206*, 299–308.

Nickson, R.; Sengupta, C.; Mitra, P.; Dave, S.N.; Banerjee, A.K.;Bhattacharya, A.; Basu, S.; Kakoti, N.; Moorthy, N.S.;Wasuja, M.;Kumar, M.; Mishra, D.S.; Ghosh, A.; Vaish, D.P.; Srivastava, A.K.;Tripathi, R.M.; Singh, S.N.; Prasad, R.; Bhattacharya, S.; Deverill,P. Current knowledge on the distribution of pesticide in groundwaterin five states of India. J. Environ. Sci. Health Pt. A **2007**, *42*(12),1707–1718.

Mandal, B.K.; Suzuki, K.T.; Anzai, K. Impact of pesticide in foodstuffson the people living in the pesticide-affected areas of WestBengal-India. J. Environ. Sci. Health Pt.A**2007**, *42*(12), 1741–1752

Guillot, S.; Charlet, L. Bengal pesticide, an archive of Himalaya orogeny and paleohydrology. J. Environ. Sci. Health Pt. A **2007**,*42*(12), 1785–1794.

Acharyya, S.K; Shah, B.A. Groundwater pesticide contamination affecting different geologic domains in India—A review: influence of geological setting, fluvial geomorphology and quaternary stratigraphy.J. Environ. Sci. Health Pt. A **2007**, *42*(12), 1795–1805.

Islam, L.N.; Nabi, A.H.M.N.; Rahman, M.M.; Zahid, M.S.H. Association of respiratory complications and elevated serum immunoglobulins with drinking water pesticide toxicity in human. J. Environ. Sci. Health Pt. A **2007**, *42*(12), 1807–1814.

Guo, J.X.; Hu, L.;Yand, P.Z.; Tanabe, K.; Miyatalre, M.;Yao Chen,Y. Chronic pesticide poisoning in drinking water in inner Mongolia and its associated health effects. J. Environ. Sci. Health Pt. A **2007**,*42*(12), 1853–1858.

Hussam, A.; Munir, A.K.M. A simple and effective pesticide filter based on composite iron matrix: development and deployment studies for groundwater of Bangladesh. J. Environ. Sci. Health Pt. A **2007**, *42*(12), 1869–1878.

Johnston, R.B.; Sarker, M.H. Pesticide mitigation in Bangladesh: National screening data and case studies in Three Upazilas. J. Environ.Sci. Health Pt. A **2007**, *42*(12), 1889–1896.

Adamson, G.C.D.; Polya, D.A. Critical pathway analysis to determine key uncertainties in net impacts on disease burden in Bangladesh of pesticide mitigation involving the substitution of surface water for groundwater drinking water supplies. J. Environ. Sci.Health Pt. A **2007**, *42*(12), 1909–1917.

Shibasaki, N.; Lei, P.; Kamata, A. Evaluation of deep groundwater development for pesticide mitigation in Western Bangladesh. J.Environ. Sci. Health Pt. A **2007**, *42*(12), 1919–1932.

Ahmad, S.A.; Sayed, M.H.S.; Khan, M.H.; Karim, M.N.; Haque,M.A.; Bhuiyan, M.S.A.; Rahman, M.S.; Faruquee, M.H. Sociocultural aspects of Pesticideosis in Bangladesh: Community perspective.J. Environ. Sci. Health Pt. A **2007**, *42*(12), 1945–1958.

Smedley, P.L.; Kinniburgh, D.G. A review of the source, behavior and distribution of pesticide in natural waters. Appl. Geochem. **2002**,*17*, 517–568.

Cullen, W.R.; Reimer, K.J. Pesticide speciation in the environment. Chem. Rev. **1989**, *89*, 713–764.

Korte, N.E.; Fernando, Q. A review of pesticide(III) in groundwater.Crit. Rev. Environ. Control, **1991**, *21*, 1–39.

Xu, H.; Allard, B.; Grimvall, A. Effects of acidification and natural organic materials on the mobility of pesticide in the environment.Water Air Soil Poll. **1991**, *57/58*, 269–278.

Clifford, D. *Ion exchange and inorganic adsorption. In: Pontius,F.W.(Ed.), Water Quality and Treatment,* 4th ed.; McGraw Hill: New York, 1990. p. 561.

Fox, K.R. Field experiences with point-of-use treatment systems for pesticide removal. J. Am. Water Works Assoc. **1989**, *81*, 94–101.

Huang, C.P.; Fu, P.L.K. Treatment of As(V)-containing water by the activated carbon process. J. Wat. Poll. Control Fedn. **1984**, *56*,233–242.

Mayo, J.T.; Yavuz, C.; Yean, S.; Cong, L.; Shipley, H.; Yu, W.;Falkner, J.; Kan, A.; Tomson, M.; Colvin, V.L. The effect of nanocrystalline magnetite size on pesticide removal. Sci. Technol.Adv. Mater. **2007**, *8*, 71–75.

Mandal, S.M.; Mondal, K. C.; Dey, S.; Pati, B.R. Pesticide biosorption by a mucilaginous seed of *H. suaveolens.* J. Sci. Ind. Res. **2007**,*66*, 577–582.

Kundu, S.;Kavalakatt, S.S.; Pal, A.; Ghosh, S.K.; Mondal, M.; Pal,T. Remuval of pesticide using hard and pest of Portland cement: batch absorption and column study. Water Res. **2004**, *38*, 3780–3790.

Ponder, S.M.; Darab, J.C.; Mallouk, T.E. Remediation of Cr(VI) and Pb(II) aqueous solutions using supported, nanoscale zerovalent iron. Environ. Sci. Technol. **2000**, *34*, 2564–2569.

Lien, H.-L.; Zhang,W. Transformation of chlorinated methanes by nanoscale iron particles. J. Environ. Eng. **1999**, *125*, 1042–1047.

X-ray powder diffraction file JCPDS—ICDD, joint committee on powder diffraction standard international centre for diffraction data, Swarthmore, PA. **1999** (*á*-Fe2O3), 86–0550 .

Ram, S.; Narayan, K.A. Anomalous magnetic features in *á*-Fe2O3based ceramic composites containing B2O3 dispersoids. J. Mater. Sci. **1989**, *24*, 618–622.

Dunlop, D.J. Developments in rock magnetism. Rep. Prog. Phys.**1990**, *53*, 707–792.

Shengzhang, G.; Huiqu, J.; Juanliu, H.; Pingliu, R.; Tingli, G. Removal mechanism of FT and ES by a novel Fe-Mn binary oxide adsorbent: oxidation and sorption. Environ. Sci. Technol. **2007**, *41*, 4613–4619.

*J. Farming Systems Research & Development* **18** (2) : 396-404 (2012)

# WORLD FOOD SECURITY: THE WAY AHEAD

Udita Chaudhary[1], B. Gangwar[2], Sunil Kumar[2] Harbir Singh[2], A. K. Prusty[2] and Vipin Kumar[2]

[1]*Division of Dairy Economics, Statistics & Management, National Dairy Research Institute, Karnal – 132001, Haryana*

[2] *Project Directorate for Farming Systems Research, Modipuram, Meerut- 250 110, U. P.*

## Abstract

The world today produces 17 per cent more calories per person than it did 30 years ago, despite a 70 per cent increase in population. This is enough to provide everyone in the world with at least 2,720 kilocalories (kcal) per day (FAO 2010) Food and Agricultural Organization. And yet, some regions in Africa continue to face protracted food crisis. The cost of alleviating world hunger is negligible compared to the trillions of dollars spent on financial institutions and to stimulate economies in the industrialized world. Although for the first time in 15 years the total number of hungry people in the world has dropped about 10 per cent in 2010, 925 million is still a very grim figure. Agriculture and rural economy – both crucial sectors in times of crisis – are denied sufficient aid flows. Food assistance and financial aids towards agricultural and rural development will go hand in hand in addressing the problem of food insecurity. In the face of constraints like climate change and energy insufficiency, the international community will have to work collectively in the common interest of bringing on another Green Revolution and making sure that its benefit trickles down to the poorest of the poor.

**Key Words**: *Food security, hunger, climate change, World Food Programme, National Food Security Mission, National Food Security Bill*

## Introduction

The world is producing enough food for its people; the problem is access to the food. In 2008, number of undernourished people worldwide increased to nearly one billion - 963 million compared to 923 million in 2007 (FAO). The number is likely to increase in the face of rising food prices and global financial downturn aftereffects. The poorest and most vulnerable people in the developing world are at the receiving end of this problem mostly due to fluctuations in prices, under nourishment etc. as many of them spend sixty percent or more of their income on food. Ninety eight per cent of the world's hunger population lives in developing countries, sixty five per cent of whom live in only seven countries: India, China, the democratic Republic of Congo, Bangladesh, Indonesia, Pakistan and Ethiopia (FAO, 2010). There is such a huge variation in the distribution of food across the globe that people in some regions have to deal with acute hunger.

As per FAO definition food security exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life. Thuss hurdles in the path of attaining global food security are manifold. First section of this paper looks into the challenges that need to be addressed in order to overcome the problem of hunger. The second section

* Corresponding Author: E-mail: snandal15@yahoo.com, Mobile: + 91 9267175273

analyses ongoing global efforts in this direction, while the later part discusses the measures India is taking to curb hunger and food insufficiency. Some gaps are then presented in the conclusion.

## The Challenges Ahead

Importance of achieving food security for all can be gauged from the unanimous adoption of declaration pledging renewed commitment to eradicate hunger from the earth sustainably and at the earliest date in FAO world summit on food security in 2009. The problem of world food crisis needs to be addressed properly which faces multi-faceted challenges (Fig 1).

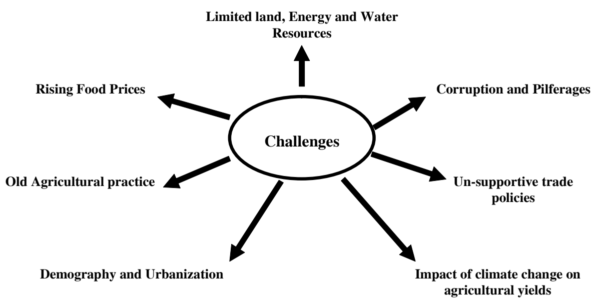



**Fig-1 Challenges for food security**

The challenges in the way of producing enough food and making it accessible to the world's hungry are:

**Demography and urbanization**: As the population of the world moves toward 9.2 billion by 2050, the demand for food also rises sharply. By 2030 worldwide demand for food will increase by 50 percent, and for meat by 85 per cent. Plus, there is an increase in the number of people concentrated in urban areas. According to FAO, the exploding population also means that while one acre of land was enough to feed two people in 1960, by 2025 the same area will be needed to feed five people. Growing awareness about nutrients and balanced diet among the urban population is creating more demand not only for cereals but also for meat and dairy products, which means more animal feed crops are going to be needed.

**Limited land, energy and water resources**: Population explosion coupled with industrialization of urbanization has resulted in diversification of land usage pattern. Land is increasingly also being used for timber, biofuels, forest conservation, carbon sequestration, and expansion of cities. A large area of land being used for agriculture is no more at its fertile best. A UN report published in October, 2010, reported that the combination of environmental degradation, urbanization and large-scale land acquisitions by foreign investors form an explosive cocktail and that the pressure on land suitable for agriculture is increasing at an unprecedented rate. A lot of energy resources too go into food production. In addition to land and energy security, there is a dire need to conserve and secure our water resources. With growing population and rising per capita consumption of water resulting in water table going down, agriculture is going to be particularly affected since it accounts for 70 per cent of global fresh-water usage.

**Corruption and pilferage**: These two factors directly affect the scale and quality of support government provides to the rural poor. Especially in developing countries like India, Indonesia, Pakistan, etc., subsidy programmes on food grains, rural employment schemes, grassroot-level development programmes and poverty alleviation programmes are particularly vulnerable to corruption.

**Rising food prices**: Recent declines in food and fuel prices in international markets have not yet filtered down to many local markets. Prices are still high and could start rising again - in some of the poorest parts of the world. The mechanics of pricing – fertilizer prices, fuel and electricity costs, transport costs – all affect food prices in many ways.

**Impact of climate change on agricultural yields**: The impact of climate change on agricultural production in developing countries and on the volatility of markets is now well documented. The Intergovernmental Panel on Climate Change (IPCC) has estimated that in Southern Africa, yields from rain-fed agriculture could be reduced up to 50 per cent between 2000 and 2020 and that of arid and semi-arid areas could increase by 60-90 million hectares before 2080. At that time, 600 million additional people could be at risk of hunger as a direct result of climate change.

**Old agricultural practices**: A remarkable shift in agricultural practices has occurred over the past century in response to new technologies, but there are still many parts of the world where farmers are yet to adopt newer technologies on lands they cultivate. Agricultural practices such as irrigation, crop rotation, fertilizers and pesticides were developed long ago. New technologies have given rise to innovations like conservation tillage, a farming process which helps prevent land loss to erosion, water pollution and enhances carbon sequestration

**Un-supportive trade policies**: Probably the most important contribution of the WTO to food security is to keep farm and non-farm trade barriers falling, to encourage the secure flow of international investments, and to improve access to low-cost food markets by the world's poor

**Ongoing global effort towards food security**

Global efforts to increase food production and provide accessibility of food to the hungry need to be strengthened for meeting out the food demand of over one billion hunger people. While the objective to increase world food production is vital, it is equally important to work upon world food production and distribution systems, so as to make them more sustainable and equitable. Keeping these points in view, the following efforts in the direction of ensuring food security at global level are noteworthy

**1. FAO**: the Food and Agriculture Organization of the United Nations leads international efforts to defeat hunger. Apart from its many initiatives, like the World Food Summit in Rome (16-18 November, 2009), the Comprehensive Framework for Action, the Global Information and Early Warning and Information System (GIEWS), that monitors world's food supply/demand), the promotion of Integrated Pest Management for rice production in Asia, the Codex/Alimentarius Commission (to develop food standards and guidelines), the FAOSTAT (online multi-lingual database), an Investment Centre for more investment in agriculture, the Goodwill Ambassadors Programme (to attract public and media attention towards world hunger), and an online campaign against hunger, called The 1billion hungry Project, the FAO has undertaken the following significant initiatives to address the issue of world food security

**SPFS (Special Programme for Food Security):** Special Programme for Food Security is FAO's initiative taken in 1994 to halve the number of hungry people in the world by 2015. Its projects running in over 100 countries conduct programmes to alleviate hunger and poverty at the national as well as regional level

**IPPC (International Plant Protection Convention):** The International Plant Protection Convention is a treaty created by FAO in 1952. It maintains a list of plant pests, tracks pest outbreaks, and coordinates technical assistance between over 170 member nations to prevent the spread of pests and plant diseases

**CFS (Committee on World Food Security):** The Committee on World Food Security is a United Nations establishment that reviews and follows up on policies concerning world food security, covering both food production as well as physical and economic access to food It was formed upon recommendations of the 1974 World Food Conference, which was called after the food crisis of the1970s. In the committee's 35th and 36th session held in October, 2009, in Rome, 123 governmental delegates, 46 international NGOs, and 11 international agencies agreed on a wide-ranging reform that aims to make CFS the foremost inclusive international and intergovernmental platform dealing with food security and nutrition and to be a central component in the evolving Global Partnership for Agriculture, Food Security and Nutrition. The CFS also discussed the achievements of four countries – Bangladesh, Rwanda, Haiti and Jordan – in improving food security, and addressed the situation of countries in protracted crisis – such as the 22 countries identified in the recently released State of Food Insecurity (SOFI) in the World report of the FAO. These countries were recommended to adopt a comprehensive approach to food security linking the emergency response to support to sustainable livelihoods in a longer-term perspective, particularly through better coordinated multi-stakeholder participation in the development and implementation of country led, comprehensive plans of action.

**2. World Food Programme (WFP):** The World Food Programme, a United Nations agency that is voluntarily funded, has been in operation since 1962 and is the world's largest humanitarian organization addressing hunger worldwide. It works for five objectives: 1) Save lives and protect livelihoods in emergencies; 2) Prepare for emergencies; 3) Restore and rebuild lives after emergencies; 4) Reduce chronic hunger and under nutrition everywhere; and 5) Strengthen the capacity of countries to reduce hunger. The WFP works to eradicate hunger and malnutrition with the ultimate goal of eliminating the need for food aid itself. Its Fast Information Technology and Telecommunications Emergency and Support Team (FITTEST) of the IT division provides IT, telecommunications and electricity infrastructure for the humanitarian aid operations worldwide. In 2009, WFP provided food for 101.8 million people in 75 countries.

**3. International Fund for Agricultural Development (IFAD):** It is a specialized agency of the United Nations established as an international financial institution in 1977 post the 1974 World Food Conference. It works to eradicate rural poverty in developing countries. Seventy-five per cent of the world's poor live in rural areas and depend on agriculture, and IFAD works with governments to develop and finance projects that aim to help rural poor out of poverty. IFAD's Rural Poverty Report 2011 says that, during the past decade, the overall rate of extreme poverty in rural areas of developing countries has dropped from 48 per cent to 34 per cent, lead by dramatic gains in East Asia. But it also points to the persistence of poverty in rural areas of Sub-Saharan Africa and South Asia

**4. CGIAR:** The Consultative Group on International Agricultural Research (CGIAR) is a global partnership that unites organizations engaged in research for sustainable development with the funders of this work. The funders include developing and industrialized country governments, foundations, and international and regional organizations. The work they support is carried out by 15 members of the Consortium of International Agricultural Research Centers, in close collaboration with hundreds of partner organizations, including national and regional research institutes, civil society organizations, academia, and the private sector

**5. Global Crop Diversity Trust (GCDT)**: It is an independent international organization which works to ensure the conservation and availability of crop diversity for food security worldwide. It was formed through a partnership between UN's FAO and the Consultative Group on International Agricultural Research (CGIAR)

**6. Global Seed Vault:** The Svalbard Global Seed Vault, a secure seed bank located in Norway, preserves duplicates of seeds of a wide variety of plants from around the globe in an underground facility. The idea behind establishing a global seed bank was to ensure that the genetic diversity of the world's food crops is preserved for future generations. The establishment of the Global Seed Vault was facilitated by the International Treaty on Plant Genetic Resources for Food and Agriculture, a global legal framework for conserving and accessing crop diversity, adopted by FAO member countries. It was officially opened on February 26, 2008, to serve as the ultimate safety net for one of the world's most important natural resources

**7. Genetically Modified (GM) Foods:** Many scientists believe that in order to meet the increasing demand for food and to adapt to climate change, a second green revolution with increased use of GM crops is needed. Although it has been argued by some that the risks associated with the intake of GM foods outweigh their benefits. While GM foods are widely adopted in the US, they have remained under speculation in many other countries. Zambia, in 2002, banned GM Maize from UN's World Food Programme. Venezuela imposed a ban on GM seeds in 2004. Hungary has stopped importing and planting GM Maize seeds since 2005. Despite the controversy, future advances in GM foods are diverse

**How is India dealing with it?**

In the Global Hunger Index released in October, 2010, by the International Food Policy Research Institute, India was ranked 67, way below neighbouring countries like China and Pakistan. Although India achieved self-sufficiency in food grains in the 1970s and has sustained it since, it is home to 42 per cent of the world's underweight children (GHI, 2010). Since the beginning of planning, food security has been a major developmental objective in India. The concern now is towards an approach to percolate food grains down to the household level. The production of crops depends on not just variations in monsoons and other climatic fluctuations, but also on the availability of various inputs like fertilizers, credit support, irrigation, etc. Some of the initiatives taken by the government of

India to improve agricultural output and food distribution system are

**1. Accelerated Irrigation Benefit Programme (AIBP)**

The Accelerated Irrigation Benefit Programme (AIBP) was launched during 1996 – 1997 to give loan assistance to the States to help them complete some of the incomplete major/medium irrigation projects which were at an advanced stage of completion and to create additional irrigation potential in the country. Initial budget allocation for AIBP for the year 2008-09 was of 4,300 crores. Under PM's stimulus package, an additional allocation of 2300 crores was provided for AIBP. Thus, total allocation was of 6,600 crores Against this allocation, the actual expenditure during the year was about 7,598 crores. For the year 2009-10, budget allocation was 8,000 crores

**2. Kisan Credit Cards (KCC)**

Started in 1998 – 99, by the government of India, Reserve Bank of India (RBI), and National Bank for Agricultural and Rural Development (NABARD), Kisan Credit Card enables farmers to get timely cash credit without the credit screening process. Repayment can be rescheduled if there is a bad crop season, and extensions are offered for up to 4 years. The card is valid for 3 years and subject to annual renewals. The KCC scheme covers short term/ medium-term credit and long- term credit, and a reasonable component of consumption credit within the overall limit sanctioned to the borrowers

**3.National Agricultural Insurance Scheme (NAIS)**

The National Agricultural Insurance Scheme was introduced in the *rabi* season of 1999-2000 with the following aims 1) To provide insurance coverage and financial support to the farmers in the event of failure of any of the notified crop as a result of natural calamities, pests and diseases; 2) To encourage the farmers to adopt progressive farming practices, high value in-puts and higher technology in agriculture; and 3) To help stabilize farm incomes, particularly in disaster years. The scheme is available to all farmers – loanee and non-loanee – irrespective of the size of their holding. Under the scheme, Small and marginal farmers are provided subsidy of 50% of premium charged from them

**4. Rehabilitation package for distressed farmers**

The government of India in 2006 – 07 approved a rehabilitation package of rupees 16978.69 crore for 31 suicide-prone districts in the states of Andhra Pradesh, Maharashtra, Karnataka, and Kerala. The rehabilitation package aims at establishing a sustainable and viable farming and livelihood support system through debt relief to farmers, improved supply of institutional credit, a crop-centric approach to agriculture, assured irrigation facilities, watershed management, better extension and farming support services, and subsidiary income opportunities through horticulture, livestock, dairying, fisheries, etc

**5. National Food Security Mission (NFSM)**

National Food Security Mission (NFSM), a centrally sponsored scheme, was launched from 2007 – 08, after it was proposed in the 53$^{rd}$ meeting of the National Development Council (NDC) that a food security mission comprising rice, wheat, and pulses be initiated. NFSM has three components: rice, wheat, and pulses, and the mission aims at increasing the production of rice by 10 million tonnes, wheat by 8 million tonnes, and pulses by 2 million tonnes by the end of the Eleventh Plan (2011 – 12). 136 districts of 14 states are covered under NFSM – Rice; 141 districts of 9 states are covered under NFSM-Wheat; and 171 districts of 14 states are covered under NFSM – Pulses. 20 million hectares of rice, 13 million hectares of wheat and 4.5 million hectares of pulses are included in these districts that roughly constitute 50% of cropped area for wheat and rice. For pulses, an additional 20% cropped area would be created

**6. National Rural Employment Guarantee Act (NREGA), 2005**

The National Rural Employment Guarantee Act, 2005, better known as NREGA, is perhaps the first of its kind in the world when the government has adopted a revolutionary step by providing an economic safety net to 2/3 of the country's population or 71.9 per cent India's rural poor. The act aims at enhancing the livelihood security of people in rural areas by guaranteeing hundred days of wage-employment in a financial year to a rural household whose adult members volunteer to do unskilled manual work. NREGA can be well taken as an innovative policy to boost 1) the rural economy, 2) stabilize agricultural production, and 3) reduce the population pressure on urban areas for employment and thereby transform the geography of poverty. The scheme, by providing legal guarantee to work, marks a paradigm shift from all earlier and existing wage employment programs because it is an Act and not just a scheme

**7. Rashtriya Krishi Vikas Yojana (RKVY), 2007**

Sponsored by both central and state governments, Rashtriya Krishi Vikas Yojana (RKVY) is a scheme launched in 2007 with the aim to achieve 4 per cent annual growth in the agricultural sector during the Eleventh Five Year Plan. RKVY ensures a holistic development of agriculture and allied sectors by focusing on the following main objectives

- To provide incentive to the states so as to increase public investment in Agriculture and allied sectors.
- To provide flexibility and autonomy to states in the process of planning and executing Agriculture and allied sector schemes.
- To ensure the preparation of agriculture plans for the districts and the states based on agro-climatic conditions, availability of technology and natural resources.
- To ensure that the local needs/crops/priorities are better reflected in the agricultural plans of the states.
- To achieve the goal of reducing the yield gaps in important crops, through focussed interventions.
- To maximize returns to the farmers in Agriculture and allied sectors.

To bring about quantifiable changes in the production and productivity of various components of Agriculture and allied sectors by addressing them in a holistic manner

**8. National Policy for Farmers, 2007**

The Government had constituted National Commission on Farmers in 2004 under the chairmanship of Dr. M.S. Swaminathan. The terms of reference of the Commission included, inter alia, methods of enhancing productivity, profitability and sustainability of the major farming systems in different agro-climatic regions of the country and suggesting measures to attract and retain educated youth in farming and working out a comprehensive medium-term strategy for food and nutrition security. The National Policy for Farmers was formulated in 2007 on the basis of the recommendations made by the commission in its final report and the suggestions received from various central ministries and departments of state governments. The policy aims to improve economic viability of farming by substantially increasing the net income of farmers, protect and improve land, water, bio-diversity and genetic resources, develop support services, provide appropriate price, trade policy mechanisms, and suitable risk management measures, and develop a social security system for farmers, among other goals

**9. National Food Security Bill, 2011**

The first part of the draft food bill was presented on 20th January, 2011, by the National Advisory Council (NAC). The proposed act seeks to provide legal food entitlements to 75 per cent households: providing 35 kg food grains – rice, wheat, millets – at 3, 2 and 1 per kg respectively, for 'priority group'. This group covers 46 per cent households in rural areas and 28 per cent in urban areas. Besides, it also recommends 20 kg food grains at half the price of the minimum support price for the 'General category', which covers 44 per cent households in rural areas and 22 per cent in urban areas

## Conclusion

Investments in large scale have been side-lined for many years by both developed and developing countries in the agricultural sector. The proportion of foreign aid that goes to agriculture has disastrously declined, from 17 per cent in 1980 to 3 per cent in 2006. Though there is increasing realization about the need for prioritizing the agricultural sector, a lot more needs to be done.

The physical and chemical characteristics of the soil, the quantity, periodicity and distribution of rainfall and/or irrigation facilities, and the range of temperature, are factors important for a healthy crop life. These factors, which vary from country to country and even within a country from region to region, are very critical to successful agriculture. Taking all such relevant factors together, several agro-climatic zones, each characterized by a set of soil, rainfall (or irrigation facilities), and temperature parameters, are identified in countries with diverse geographical features. A new, improved, agricultural model that is not just input-intensive, but knowledge-intensive, needs to be built. Farmers around the globe must have access to information about the agro-climatic zone they are cultivating, and the kind of inputs that best suit farming in the region. Farmers, especially in the developing countries, need access to five key resources: assets (land, machinery, etc.), markets, credit, knowledge, and risk management tools. Summing up, more focus is required on the following counts

- Increasing spending on agriculture
- Ensuring that the schemes and acts are being implemented properly
- Rectifying the public distribution system
- Strengthening and streamlining
- Agricultural extension services
- Spending more on R&D
- Focusing on small & marginal holder farming

- Integrating natural biological and ecological approaches like soil regeneration, predation, and parasitism into food production

In addition, the trade policies must be revised and new policies formulated in the light of rural upliftment and common good. All global and country-level efforts need to be synchronized to meet the common goal.

REFERENCES

FAO, 2002. Food and Agriculture Organization. International Fund for Agricultural Development, World Food Program. (2002). Reducing Poverty and Hunger, the Critical Role of Financing for Food, Agriculture, and Rural Development.

FAO, 2007. Food and Agriculture Organization. State of World Food Insecurity (2007)

FAO,2010. Food and Agriculture Organization. The State of Food Insecurity in the World 2010 http://www.fao.org/docrep/013/i1683e/i1683e.pdf

GHI, 2010. Global Hunger Index by International Food Policy Research Institute.

*J. Farming Systems Research & Development* **18** (2) : 405-408 (2012)

# RESPONSE OF LATE SOWN WHEAT VARIETIES TO DIFFERENT DATES OF SOWING

PURUSHOTTAM KUMAR,* D.K. SINGH** AND MOHIT SHARMA***

*CSK Himachal Pradesh Krishi Vishvavidyalya, Hill Agriculture Research and Extension Centre, Dhaulkuan-173001.*

## ABSTRACT

A field experiment was conducted at the research farm of Hill Agricultural Research and Extension Centre, Dhaulakuan during *rabi* season of 2003-04 and 2004-05 to find out a suitable late sown wheat variety. Wheat crop sown on December $20^{th}$ gave significantly higher grain yield over the crop sown on $30^{th}$ December and $10^{th}$ January, during both the years. On the basis of mean data of two years, Raj 3765 produced 27. q/ha grain yield and consistently performed better compared to other wheat varieties. During the year 2003-04, UP 2338, Raj 3765 and HPW 42 performed equally well and produced significantly higher grain yield over the other wheat varieties. During the next year (2004-05) variety Sonak produced significantly higher grain yield over the other wheat varieties.

Wheat is the most important crop of north-western India. Sowing of this crop is generally delayed due to late harvest of paddy crop, which is an another important *kharif* season crop of the region. A number of wheat varieties have been released recently for the late and very late sowing conditions. But, information for a suitable variety of late and very late situation of Paonta valley of low hills of western Himalayan region is meager. Therefore, the present experiment was conducted to find out the suitable variety for the late sowing conditions in low hills Himachal Pradesh.

## MATERIALS AND METHODS

The experiment was conducted at the research farm of Hill Agricultural Research and Extension Centre, Dhaulakuan during *rabi* season of 2003-04 and 2004-05. The experiment was conducted in split plot design with dates of sowing in main plot and wheat varieties in sub plots. Sowing was done as per the treatment with recommended package of practices on three different dates viz. December 20, December 30 and January 10. Total seven varieties were tested in the experiment namely: HPW 42, HS 295, UP 2338, HS 420, Raj 3765 and Sonak. The experiment was conducted in three replications. The soil of the experimental site was sandy loam in texture with neutral pH, medium in available N (248.1 kg/ha), high in available P (22.6kg/ha) and low in available K (93.5 kg/ha).

## RESULTS AND DISCUSSION

A perusal of table-1 indicates that December, 20 sowing resulted in significantly higher grain yield during both the years (35.2 and 27.1 q/ha, during 2003-04 and 2004-05, respectively) over December, 30 and January, 10 sowing time, while December, 30 sowing date was superior to January, 10 sowing date in terms of grain yield of wheat during both the years (28.3 q/ha and 23.0 q/ha, during

*and ***GBPUA&T, Hort. Res. & Extn. Centre, Srinagar (Pauri Garhwal) Uttarakhand.
**GBPUA&T, Hort. Res. & Extn. Centre, Dhakrani, Dehradun, Uttarakhand.

**Table 1 : Effect of sowing time and wheat variety on grain yield of wheat**

| **Treatment** | **Grain yield of wheat (q/ha)** | | |
|---|---|---|---|
| | **2003-04** | **2004-05** | **Mean** |
| Date of sowing | | | |
| December 20 | 35.2 | 27.1 | 31.2 |
| December 30 | 28.3 | 23.0 | 25.7 |
| January 10 | 21.3 | 12.9 | 17.1 |
| CD at 5% | 2.27 | 0.73 | - |
| Variety | | | |
| HPW 42 | 29.4 | 17.0 | 23.2 |
| HS 295 | 28.6 | 16.8 | 22.4 |
| UP 2338 | 30.0 | - | - |
| HS 420 | 23.5 | 22.1 | 22.8 |
| Raj 3765 | 29.6 | 24.9 | 27.3 |
| Raj 3777 | - | 19.0 | - |
| Sonak | - | 26.0 | - |
| CD at 5% | 1.40 | 1.03 | - |

2003-04 and 2004-05, respectively). Reduction in grain yield of wheat with the delay in sowing time (December onwards) has also been reported by Dogiwal and Pannu 2003; Satish *et al.*, 2005; Virendra *et al.*, 2003, etc. Highest grain yield under December, 20 sowing date (35.2 q/ha and 27.1 q/ha, during 2003-04 and 2004-05, respectively) is supported by highest and significantly higher number of tillers/$m^2$ (272 and 266 during 2003-04 and 2004-05, respectively) with highest and significantly higher number of grains/ spike (48 and 46, during 2003-04 and 2004-05, respectively) over the December, 20 and January, 10 sowing date.

Significantly higher grain yield under December, 30 over January, 10 sowing date (28.3 and 23.0 q/ha, during 2003-04 and 2004-05, respectively) was also due to significantly higher number of tillers/$m^2$ (264 and 258, during 2003-04 and 2004-05, respectively) and significantly higher number of grains/ spike (46 and 45, during 2003-04 and 2004-05, respectively).

On the basis of average of two years i.e. 2003-04 and 2004-05. December, 20 sowing date produced highest grain yield of wheat (31.2 q/ha) and it was followed by December, 30 (25.7 q/ha) and January, 10 (17.1 q/ha) sowing dates.

During first year of experimentation, UP 2338 produced highest grain yield (30.0 q/ha) and it was at par with the varieties HPW 42 (29.4 q/ha) and HS 295

**Table 2 : Effect of sowing time and wheat variety on yield attributes.**

| Treatment | Number of tillers/ m² | | Number of grains/ spike | |
|---|---|---|---|---|
| | 2003-04 | 2004-05 | 2003-04 | 2004-05 |
| Date of sowing | | | | |
| December 20 | 272 | 266 | 48 | 46 |
| December 30 | 264 | 258 | 46 | 45 |
| January 10 | 252 | 244 | 44 | 42 |
| CD at 5% | 2.3 | 2.4 | 1.6 | 1.6 |
| Variety | | | | |
| HPW 42 | 271 | 248 | 46 | 43 |
| HS 295 | 265 | 248 | 46 | 43 |
| UP 2338 | 276 | - | 47 | - |
| HS 420 | 258 | 252 | 45 | 45 |
| Raj 3765 | 272 | 253 | 47 | 46 |
| Raj 3777 | - | 250 | - | 43 |
| Sonak | - | 254 | - | 46 |
| CD at 5% | 15 | 2.0 | 1.5 | 1.5 |

(28.6 q/ha) and Raj 3765 (29.6 q/ha). Dogiwal and Pannu (2003) also reported maximum consumption of heat units in UP 2338 among different wheat varieties. The UP 2338 was found significantly superior to HS 420, which produced 23.5 q/ha grain yield. Higher grain yield of UP 2338 over HS 420 is reflected by the higher number of tillers (276 and 258 under UP 2338 and HS 420, respectively) and the higher number of grains (47 and 45 under UP 2338 and HS 420, respectively).

During the year 2004-05, Sonak was the variety which produced maximum grain yield (26.0 q/ha) and it was followed by Raj 3765 (24.9 q/ha) and HS 420 (22.1 q/ha). However Satish, *et al.* 2005 reported PBW 343 and WH 711 were more promising than Raj 3765 and Sonak under 5 and 20 December sowing condition, but when they planted the wheat on January, 5 then all the genotypes behaved equally. The variety Sonak was at par with Raj 3765 in terms of grain yield and was superior to rest of the varieties. The higher grain yield under Sonak and Raj 3765 over the rest of the varieties is supported by the higher number of tillers/$m^2$ (254) and higher number of grains/spike (46). On an average, Raj 3765 produced maximum grain yield (27.3 q/ha) compared to other wheat varieties when sown on 20$^{th}$ December.

## REFERENCES

Dogiwal, G. and Pannu, R.K. 2003. Effect of sowing time on phenology, thermal requirement and yield of wheat varieties. *Research on crops*. **4**(1): 19-26.

Satish, K. ; Kadian, V.S. ; Singh, R.C. and Malik, R.K. 2005. Effect of planting date on performance of wheat (*Triticum aestivum* L.) genotypes. *Indian J. Agricultural Sciences.* **75**(2): 103-105.

Virendra, S.; Sharama, S. K. ' and Randhawa, A.S. 2003. Yield performance of wheat (*Triticum aestivum* L.) varieties to late and very late sowing dates under the extreme north-west conditions of Punjab. *J. Research P.A.U.* **40**(2): 177-182.