Volume 19
Number 1
Jan. - June, 2013

ISSN 0972 – 6977

RNI No. UP - ENG/2001/6732

Journal of Farming Systems Research & Development

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.)

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NAAS Rating : 2.4

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Journal of Farming Systems Research and Development

Volume 19 **January - June 2013** **Number 1**

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IMPACT OF ON-CAMPUS FARMERS' TRAINING ON CROP PRODUCTION TECHNOLOGY

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ABSTRACT

The farmers of western Uttar Pradesh have been highly successful in adopting the green revolution technologies. Since research and technology development are continuous process, the knowledge and skill of the farmers also need to be upgraded through training. Some selected farmers of western Uttar Pradesh were trained by the scientists of PDFSR during 2010 on scientific techniques of kharif crop production. The training was organized on-campus at PDFSR premises for 3 days which was attended by 31 farmers. The impact of training was determined by assessing the pre-training and post- training knowledge level through pre-structured questionnaire. Statistical tools like percentage, mean, standard deviation and correlation were used for analysis of data. The results revealed that the farmers of middle age group, having more education and moderate experience in agriculture with 1-2 hectare land holdings, formed the majority among the participant trainees. There was about 30 percent gain in overall knowledge of the participant farmers as a result of training imparted to them. Age and land holding of the farmers were found to be significantly associated with their knowledge gain, whereas education was found to have highly significant association with knowledge gain. Age was negatively correlated while education and land holding were positively correlated with knowledge gain. It can be inferred that training programmes should be focused on younger group of farmers having higher education and socio-economic status.

Key words: Training, Impact, Knowledge

The western Uttar Pradesh is one of the green revolution area where the impact of high yielding varieties and other input intensive technologies has been widely felt. Due to availability of infrastructural support, almost all the transfer of technology programmes were successful in this area. As a result, the farmers of the area have become highly progressive and obtain good yield from the crop like rice, wheat and sugarcane. Of late, the farmers are also growing other cash crops like vegetables and potato.

Agriculture is also endowed with instability in income of farmers due to vagaries of weather and price fluctuation in wholesale market. The farmers need to ensure their income under such situation by adopting the farming systems approach. This approach envisages adoption of different enterprises to minimize the risk in income and to ensure livelihood security. One of the important component of farming systems approach is knowledge management. The knowledge of farmers become obsolete over the years due to advancement in agricultural research and upcoming of superior technologies in the development areas. Hence, farmers need to upgrade their knowledge in order to keep pace with the technological advancement for improving agricultural production.

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Training is an important component of technology transfer programme and an effective tool for knowledge upgradation. Literally, training refers to an educational activity in order to make a person proficient in doing some particular job. Training improves the knowledge and skill of the person and brings about a desired attitudinal change towards the goal. Operationally training has been defined by Rao (1969) as "a kind of learning process where a selected group of individuals undergo learning experiences to internalise the skills, resulting in the modification of behaviour towards specific job performed". Farmers' training has been given the top priority in almost all the transfer of technology programme like ORP, LLP, Training & Visit system and programmes of Krishi Vigyan Kendras. The results of these programmes have indicated that there has been significant improvement in knowledge and skill of the farmers through training and their attitude also changed positively towards superior technologies.

An attempt was made to train selected farmers of western Uttar Pradesh by PDFSR during 2009-10 in order to upgrade their knowledge in cultivation of cereals, pulses and oil seeds and also to orient them towards the farming systems approach. The training was part of the Directorate's project on capacity building and skill upgradation. The scientists of PDFSR have been continuously conducting on-farm trials at different locations of western Uttar Pradesh. These on-farm trials helped in demonstrating the superior technologies of different crops to the farmers and resulted in significant improvement in the crop yield. However, it was felt that the on-farm trials should be supplemented by training so as to make greater impact on the cognitive domain of the farmers.

MATERIALS AND METHODS

The training was organized before the *kharif* season of 2010 in order to upgrade the knowledge of the farmers in cultivation of rice, maize, oilseed (sesame) and pulses (arhar, moong and urd). The farmers were also imparted training on plant protection measures in these crops. The training was of 3 days duration and was organized the Directorate premises. It was attended by 31 farmers of two villages namely, Mahal and Shyampur of Daurala block of Meerut district. The training was imparted through classroom lecture with power point presentation in Hindi followed by practical session at the Directorate's farm. The participant farmers were also given supportive literature on the crops included in the training.

A questionnaire was developed to asses the impact of training on farmers' knowledge. The same set of questionnaire was given to the farmers before the start of the training and after the end of the training. The difference in scores obtained by the farmers in the two tests was taken into consideration for assessing the impact. Statistical tools like percentage, mean, standard deviation and correlation were used for analysis of data.

RESULTS AND DISCUSSION

Socio-economic profile of the farmers has significant influence on almost all of their activities including the learning process. A total of 4 socioeconomic variables viz., age, education, land holding and experience in agriculture were taken as independent variables. The participant farmers were distributed with respect to age and experience in agriculture into three categories by using statistical tools of mean and standard deviation as follows:

Low category: Less than (Mean- SD)

Medium category: (Mean-SD) - (Mean +SD)

High category: Above (Mean + SD)

For distribution of farmers with respect to education and land holding, standard criteria of classification were used. The distribution of participant farmers on these variables has been mentioned in Table 1.

The Table 1 reveals that majority (67.74%) of the participating farmers belonged to the age group of 31-57 years followed by 19.4 percent farmers above the age of 57 years. It suggests that the farmers of middle age group are more interested in obtaining latest technological know-how in agriculture. This could be due to the fact that farmers of this age group are mostly family heads and have major role in the decision making process.

Majority (51.61) of the participating farmers had above middle school level of education followed by 29 percent having up to middle and 19.4 percent up to primary level of school education. This suggests that higher educated farmers are more inclined towards obtaining the latest technical knowledge in agriculture.

As far as the land holding of the participant farmers is concerned, majority (55%) belonged to small category having 1-2 ha of land holding followed by 39 percent belonging to marginal category with less than 1 ha land holding. There were only 6 percent farmers who belonged to medium category with more than 2 ha of land holding.

Experience in agriculture plays an important role in the learning process as more experience makes a person more receptive to new knowledge. Majority (61.31%) of the participant farmers were having experience of 7-35 years followed by 29 percent having more than 35 years

Table 1: Socio-economic profile of participant farmers

Independent variables	Category	No. of participants	Percentage
Age (Years)	Below 31 years	4	12.91
	31-57 years	21	67.74
	Above 57 years	6	19.35
Education	Up to primary	6	19.35
	Up to middle	9	29.03
	Above middle	16	51.61
Land holding	Less than 1 hectare	12	38.71
	1-2 hectare	17	54.84
	More than 2 hectares	2	6.45
Exp. in Ag.	Below 7 years	3	9.68
	7-35 years	19	61.29
	Above 35 years	9	29.03

of experience in agriculture. Only 9.7 percent farmers were having less than 7 years of experience which suggests that more experienced farmers give priority to acquiring knowledge through training.

Impact of Training

Impact refers to change in the situation after an activity. The change is measured by assessing the situation before the start of the activity as benchmark and the final situation after the completion of the activity. The difference between the two situations is referred to as impact. The impact of an activity may be immediate, medium term or long term depending on the type and scope of the activity. For any training programme, it is imperative to asses the impact in order to evaluate the efficacy of the training and also to improve upon the similar activity in future.

In the present training programme, immediate impact on the knowledge of participating farmers was assessed by administering a set of questionnaire to the farmers before and after the training programme. The questionnaire consisted a set of multiple choice questions pertaining to the subject matter dealt with in the training course. Each question was having four alternative answers out of which one was correct and the farmers were asked to put tick mark on the alternative which they thought correct. The raw scores obtained by the farmers were converted into standard scores as percentages and the standard scores obtained under each category (crop, plant protection etc.) before and after the training were compared. The difference between the two scores was taken as impact on knowledge, the details of which are described in Table 2.

The study reveals that there was about 30 percent gain in overall knowledge of the participant farmers as a result of the training imparted to them (Table-2). The highest gain in knowledge (34%) was recorded in case of plant protection measures, whereas in case of production of different crops the gain in knowledge was in the range of 28-30 percent.

The correlation matrix in Table 3 reveals that the age of the participant farmers was negatively and significantly correlated with the gain in knowledge at 0.05 level of significance. On the other hand, the education of the participant farmers was positively and significantly correlated with the gain in knowledge at

Table 2: Impact of training on farmers' knowledge with relation to crop production

Name of crop	% Score obtained by farmers		% Gain in knowledge (B-A)
	Pre-training (A)	*Post training (B)*	
Rice	8.26	46.32	28.06
Maize	8.26	32.81	29.55
Oil seed	9.29	37.29	27.94
Pulse	12.97	42.42	29.45
Plant protection	12.61	46.74	34.13
Total	12.28	42.10	29.83

Table 3: Correlation of independent variables with gain in knowledge

Independent variables	Gain in Knowledge					Total
	Rice	***Maize***	***Oil seed***	***Pulse***	***Plant Prot.***	
Age	-0.173	-0.379*	-0.375*	-0.306	-0.131	-0.373*
Education	0.365*	0.744*	0. 506**	0.743**	0.362**	0.738**
Land holding	0.267	0.238	0.314	0.448*	0.394*	0.447*
Exp. in Agri.	-0.082	-0.282	0-0.278	-0.164	0.070	0.206

* Significant at 0.05 level ** Significant at 0.01 level

0.01 level of significance. The land holding of the participant farmers was found positively and significantly correlated with the gain in knowledge at 0.05 level of significance. The experience in agriculture of the farmers was not significantly associated with gain in knowledge.

It can be inferred that the age of the farmers has negative association with the learning process since the receptiveness of the farmers to acquire new knowledge decreases with increase in their age. This fact is supported by the findings of Subramanyan (1976) who reported that the youngsters were superior to older people in retention of knowledge. Kadian and Kumar (2002) also found that the age of the participant farmers was negatively and significantly correlated with knowledge gain, which could be due to their conservative and localite type of nature. On the other hand, farmers' education improves the receptiveness to knowledge acquisition, which is evident from positive and highly significant association of education with the gain in knowledge (Table-3). Subramanyan (1976) inferred that the more educated a farmer, the more likely he was to show a better retention of knowledge. Similar observation was made by Sadamte and Sinha (1976) who concluded that the more educated farmer showed a better retention of knowledge. The land holding is an indicator of economic status of the farmers. It helps in improvement of social status and also the educational status of the farmers through the use of income generated from the agricultural land. Thus, the land holding also contribute indirectly towards improvement in receptiveness of the farmers to acquire new knowledge.

Conclusion

The present study revealed that there was about 30 percent gain in overall knowledge of the participant farmers. Knowledge gain in the range of 25-50 percent is considered as modest and is an indicator of good impact. It can be concluded that the farmers' training was moderately effective in achieving its goals. The effectiveness of the training is influenced by extraneous factors like age, education, and land holding of the farmers. These factors were found to be significantly associated with the knowledge gain. The educated and well-off farmers performed better in knowledge gain after training. Negative correlation of age with knowledge gain indicates that training should be focused more on younger group of farmers so as to have maximum impact.

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ASSESSMENT OF NITROGEN AVAILABILITY INDICES TO RICE AND WHEAT IN THE SOILS OF WESTERN UTTAR PRADESH

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ABSTRACT

Laboratory and pot experiments were conducted to assess he nitrogen availability indices for predicting the nitrogen availability to rice and wheat crops grown in the soils of western Uttar Pradesh. The potentially mineralizable nitrogen, per cent yield and total nutrient uptake in rice and wheat were calculated to determine the suitability of indices. The alkaline $KMnO_4$ extractable nitrogen in the soils was not found significantly correlated with other methods, except acid $KMnO_4$. The other methods were found significantly correlated with each other. The predictability of potentially mineralizable nitrogen was highest with organic carbon method (74.8%) followed by total nitrogen, soil biomass nitrogen, anaerobic incubation and alkaline permanganate methods. The per cent yield in wheat had highest correlation with total nitrogen (0.740**) followed by anaerobic incubation and soil biomass nitrogen. Total nitrogen uptake in wheat showed significantly high correlation with all methods except alkaline permanganate and dichromate extractable nitrogen. Acid $KMnO_4$ extractable nitrogen gave highest correlation (0.987**) with per cent yield of rice. However, organic carbon method showed highest correlation (0.78) with total nitrogen uptake by rice. It was also observed that anaerobic incubation method was superior to aerobic incubation both for wheat and rice.

Key Words: Nitrogen availability indices, Rice, Wheat, Potentially mineralizable nitrogen, Nitrogen uptake.

In recent years, a limited number of field and laboratory studies have centered on developing more definite methods of assessing soil nitrogen availability involving mineralizable as well as residual mineral nitrogen and more rigorous systems of predicting optimal N requirements of the crops. Prediction of soil nitrogen availability to crops requires knowledge of two soil characteristics (i) a measure of potentially mineralizable N during crop growth and (ii) residual N left in soil during previous crop (Stanford and Smith, 1972). Rice and wheat cultivation is done on soils that differ considerably in their characteristics, including their nitrogen supplying power. Studies have shown that about one half to two-third of the total N utilized by the rice and wheat crops, comes from the soil mineralizable N pool. A number of biological and chemical laboratory methods have been proposed for predicting soil nitrogen availability to various crops, and these have been reviewed by Bremner (1965), Gasser(1969) and Chang (1978). Some methods are suitable for one set of conditions but not be appropriate for different soil conditions. Although a number of methods have been proposed for prediction of nitrogen supplying capacity of soils, assessment of the most suitable soil test method for predicting soil N availability in soils of western Uttar Pradesh still forms an important component of soil nitrogen research. The present study was carried out to evaluate a suitable soil test method for predicting N availability in soil to rice and wheat crops.

MATERIALS AND METHODS

To assess the suitability of different soil test methods for wheat and rice for predicting nitrogen mineralization potential in the soils the nitrogen availability indices tested as, alkaline $KMnO_4$ (Subbiah and Asija, 1956), acid $KMnO_4$ (Stanford and Smith, 1978), aerobic incubation (Keeney and Bremner, 1965), anaerobic incubation (30 ^{0}C and 2 week) method (Keeney and Bremner,1965) soil biomass N (Jenkinson and Pawlson,1970), total N determination (Bremner, 1976), organic carbon(Walkey and Bllack,1934) 0.01 N $K_2Cr_2O_7$ method. For this method the procedure suggested by Sahrawat (1982) was followed for the analysis with the modification that 0.01 N $K_2Cr_2O_7$ instead of 0.1 N $K_2Cr_2O_7$ was used on the ground that 0.1 N $K_2Cr_2O_7$ might reflect very high amount of nitrogen than it is available in the soils. The potentially mineralizable nitrogen in the soils was determined by the procedures of (Stanford and Smith, 1972).

Green house experiments were conducted with 15 different soils of western Uttar Pradesh. The general characteristics of the soils are presented in table 1. The experiment was laid under CRD with three levels of N (0, 30 and 60 mg N kg^{-1} soil) and two replications. Rice and wheat crops were grown in the pots. The per cent yield for each treatment was calculated as:

Table 1: General characteristics of soils.

Soil series	Classification	Organic-N(%)	Total-N(%)	Exchangeable-NH_4^+	Fixed-NH_4^+	NO_3^-	C/N ratio
Dhamora	Typic Eutrochrept	0.031	0.046	10.2	47.4	7.3	11.5
Milak	Typic Eutrochrept	0.046	0.067	11.1	23.1	8.9	9.9
Rathoda	Typic Hapludalf	0.069	0.085	9.3	15.8	7.8	9.2
Joya	Typic Argiudoll	0.070	0.078	9.1	42.8	8.3	10.3
Mallpura	Ultic Hapludoll	0.041	0.055	8.3	25.3	9.1	9.8
Siwaya-1	Typic Ustochrept	0.022	0.036	8.9	30.0	6.7	10.4
Siwaya-2	Typic Natrustalf	0.053	0.068	5.4	32.8	6.7	10.7
Nagina-1	Typic Hapludalf	0.031	0.046	5.4	25.6	9.1	11.5
Nagina-2	Ustic Argiudalf	0.055	0.071	9.2	31.3	7.8	9.1
Nawabganj	Typic Haplaqualf	0.078	0.093	7.3	32.4	6.9	10.5
Phoolbagh	Typic Haplaquoll	0.088	0.108	6.7	17.4	10.3	10.3
Haldi	Typic Haplaquoll	0.090	0.1123	7.4	15.3	9.5	11.15
NPK plot**	Aquic Hapludoll	0.093	0.110	7.2	15.6	12.7	11.12
FYMplot*	-do-	0.079	0.099	6.8	18.9	8.9	11.10
No-fertilizer plot*	-do-	0.087	0.103	6.1	20.1	9.3	12.2

*Samples collected from the plots of the AICRP on the long term fertilizer experiment.

% yield = (Yield without nutrient application X 100) / yield with optimum nutrient application and total uptake in control plot was calculated as, total N uptake = % N in the plat X dry matter yield (kg ha^{-1}). In order to test the suitability of a soil test method, N determined by different methods was correlated with per cent yield and total N uptake by both the crops.

Results and Discussion

The data pertaining to relationship between methods of N availability indices (Table 2) showed that the nitrogen estimated by acid $KMnO_4$ and 0.01 N $K_2Cr_2O_7$ methods and it was not found significantly correlated with the other methods. The results are in accordance with Stanford (1978). However, acid $KMnO_4$ extracted available N was also found positively correlated with acid $KMnO_4$ method with other N availability indices. Similar to acid $KMnO_4$, the N extracted by 0.01 N $K_2Cr_2O_7$ method was also found having high correlation with other methods. Aerobic and anaerobic incubation methods, soil biomass-N, total N and organic carbon methods had significant correlation with each other. Similar results were also observed by Patnaik (1970), Ghosh and Hasan (1980) and Sahrawat (1982). Closeness of the dichromate extractable nitrogen with other soil test methods indicates that this method may be used for prediction of nitrogen availability in the soil.

The regression equations of nitrogen availability indices on the potentially mineralizable nitrogen (Table 3) indicate that the predictability of N (R^2) with lowest in 0.01 N $K_2Cr_2O_7$ (35.4%) to highest with organic carbon (74.8%), and it was followed by total –N, soil biomass –N and anaerobic incubation, and alkaline $KMnO_4$. Other methods showed comparatively poor predictability. However, the predictability of N_0 by all methods was found significant.

The correlation coefficient between per cent yield and N uptake in wheat and rice are presented in Table 4. The per cent yield in wheat had highest correlation with total nitrogen (0.740**) followed by anaerobic incubation and soil biomass N. However, there was no significant correlation between per cent yield in wheat and alkaline $KMnO_4$, aerobic incubation and organic carbon. The total N uptake in wheat was found

Table 2: Relation between nitrogen mineralization potential and N availability

Regression equation of N_0 on availability indices		r^2
N_0 = 355.99 -120.33	(alkaline $KMnO_4$)	0.631*
N_0 = 4058 + 580.99	(Acid $KMnO_4$)	0.437*
N_0 = 84.82 + 3.34	($K_2Cr_2O_7$ extractable-N)	0.358*
N_0 = -456.6 + 4.59	(aerobic incubation)	0.445*
N_0 = 375.2 + 1.21	(anaerobic incubation)	0.631*
N_0 = 337.74 + 0.109	(soil biomass-N)	0.682*
N_0 = -2527.3 + 37400.9	(total – N)	0.723*
N_0 = 510.52 - 181.63	(organic carbon)	0.746*

Table 3: Correlation between % yield and nitrogen uptake and N availability indices

Nitrogen availability indices	Wheat		Rice	
	% yield	nitrogen uptake	% yield	nitrogen uptake
Alkaline $KMnO_4$	0.323	0.571*	0.636*	0.552*
Acid $KMnO_4$	0.638*	0.872**	0.981**	0.762**
0.1 N $K_2Cr_2O_7$	0.619*	0.575*	0.206	0.531*
Aerobic incubation	0.419	0.791**	0.850**	0.738**
Anaerobic incubation	0.688**	0.892**	0.834**	0.724**
Soil biomass-N	0.665**	0.877**	0.839**	0.741**
Total-N	0.740**	0.816**	0.842**	0.754**
Organic Carbon	0.543	0.671**	0.834**	0.780**

* significant at P = 0.05, ** significant at P = 0.01

Table 4: Correlation between different methods of nitrogen availability indices

Indices	1	2	3	4	5	6	7	8
1	1.00	0.698**	0.59**	0.44	0.61*	0.523*	0.405	0.416
2		1.00	0.78**	0.79**	0.79**	0.81**	0.82**	0.84**
3			1.00	0.73**	0.71**	0.76**	0.78**	0.79**
4				1.00	0.96**	0.98**	0.69**	0.92**
5					1.00	0.94**	0.71**	0.92**
6						1.00	0.67**	0.90**
7							1.00	0.86**
8								1.00

1. Alkaline $KMnO_4$, 2. Acid $KMnO_4$, 3. 0.1 N K_2Cr_2O, 4. Aerobic incubation, 5. Anaerobic incubation, 6. Soil biomass-N, 7. Total-N, 8. Organic Carbon; * significant at P = 0.05, ** significant at P = 0.01

highly and significantly correlated (P=0.01) withal methods except alkaline $KMnO_4$ and 0.01 N $K_2Cr_2O_7$ extractable nitrogen. It may therefore be concluded that alkaline $KMnO_4$ and 0.01 N $K_2Cr_2O_7$ methods had not shown as promising index of nitrogen availability for wheat crop as the other methods.

In rice, the acid $KMnO_4$ extracted N gave highest correlation (0.987**) with per cent yield. It also gave significantly high correlation with nitrogen uptake in rice. This result was in conformity with Sahrawat (1982). 0.01 N $K_2Cr_2O_7$ extracted N did not have significant correlation with per cent yield, but showed the significant correlation (P=0.05) with N uptake. Similarly, alkaline $KMnO_4$ extractable nitrogen was found moderately correlated with both per cent yield and N uptake. In contrast to dichromate extractable nitrogen, the organic carbon gave significantly high correlation with nitrogen uptake suggesting organic carbon as a better index of available N for rice.

Therefore, alkaline KMnO4 method of N determination had poor correlation with other methods. It gave the 63.01 per cent predictability of potentially mineralizable N and it was also observed that poor correlation between alkaline permanganate method and nitrogen uptake in rice and wheat. 0.01 N $K_2Cr_2O_7$ extractable N was not observed a good nitrogen availability index for both wheat and rice. For predicting N availability, anaerobic incubation was found more suitable for wheat and rice than the aerobic incubation method which was only suitable for rice crop. It was also observed that those indices having better correlation with nitrogen supplying power in terms of per cent yield and nitrogen uptake in both the crops, were not necessarily explaining the potentially mineralizable nitrogen determined by the method of Stanford and Smith (1972).

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J. Farming Systems Research & Development **19** (1) : 12-19 (2013)

EFFECT OF ORGANIC NUTRIENT MANAGEMENT IN HIGH VALUE RICE (*ORYZA SATIVA*) – ONION (*ALLIUM CEPA*) CROPPING SYSTEM IN CHHATTISGARH

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ABSTRACT

Field experiments were conducted at Raipur in *Inceptisols* from 2009-10 to 2011-12 to compare organic, integrated and chemical fertilizer nutrient inputs packages in scented rice (*Oryza sativa* L.) – onion (*Allium cepa* L.) sequence as a high value cropping system. Seven different nutrient treatments, five of them having use of organic inputs and one each having integrated 50% through chemical fertilizer and 50% through organic nutrient, and 100% through chemical fertilizers were studied in RBD with three replications. Organic transition effect in which decline in yield during first year and again increase in yield, was noticeable in rice as well as in onion under organic nutrient inputs packages. These treatments followed a steady increase and registered 18% more rice yield over first year i.e. 2009-10 and 11 % more onion bulb yield at the end of study compared to previous year yield i.e. 2010-11. However, bulb yield of onion obtained from organic inputs treatments was still lower as compared to inorganic and integrated treatment. Total productivity in terms of rice equivalent yield of the system (13.11 t/ha) was the highest with 50% recommended dose of fertilizer (RDF) + 50% N 1/3rd each from cow dung manure + *neem* cake + composted crop residues closely followed by 100% chemical fertilizer dose (12.76 t/ha). 100% N (1/3 each from cow dung manure, *neem* cake and composed crop residue) + green manuring in rice appreciably increased the organic carbon (5.5 g/ha) and available N over initial value (5.2 g/kg OC and 226kg N/ha) and generated maximum total net return (Rs. 1,40,496/ha) owing to premium price given to the produce. Organic as well as integrated nutrient approaches failed to enhance or maintain the K content of soil after three years.

Key words: Organic nutrient management, Rice-onion cropping system, bulb yield, Total productivity, Cow dung manure, Composted crop residue

Organic farming is not new to Indian farming community. Several forms of organic farming have been successfully practiced by 80% of the farmers in diverse climate, particularly in rainfed, tribal, mountains and hill areas of the country as well as in Chhattisgarh state. By virtue of using less quantity of chemical fertilizers and pesticides and dependency upon naturally available sources of nutrients, organic food could provide better vistas towards high remuneration with premium price in market producing safe and varied food, being sustainable in the long term with inherent lesser cost advantage in the state. The constraints for lesser productivity like inadequate use of fertilizers; herbicides, pesticides and other chemicals could become a boon by adopting organic agriculture in this state. Although, in a few cases, a higher input costs due to the purchase of compost and other organic manure and

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unawareness of farmers for the market opportunities of high priced organically produced food (Mahapatra *et al.*, 2009) might be seen. But the replacement of external inputs by farm-derived resources can lead to a reduction in variable input costs and premium prices of organically produced food can make organic farming equally or often more profitable than conventional farming. The use and application of these products has to be adapted to local conditions, markets, and consumer demands hence, integrated use of nutrient sources can be preferred, as it implies the use of all available and appropriate technologies that have been used to benefit crop production on the other hand. There is several research findings that balanced inorganic fertilizers and/or integrated nutrient management have sustained the soil fertility and crop yield on long term basis (Urkurkar *et al.*, 2010). Farmers of the state have been practicing *in situ* green manuring and using organic manures for years and sustained varietal aroma and special taste of rice. FYM is very common source of nutrients to the farmers of Chhattisgarh, which is prepared easily and contains substantial amount of plant nutrients. However, persuasive confirmation of maintaining the comparable crop yield under organic farming is not adequate. 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.

Materials and Methods

Field experiment was conducted during 2009-10 to 2011-12 on rice- onion cropping system at Indira Gandhi Krishi Vishwavidyalaya, Raipur Chhattisgarh under All India Coordinated Research Project on Integrated Farming Systems to evaluate the performance of rice based high value cropping system under organic and inorganic nutrient packages and their impact on soil physico-chemical properties. Seven treatments, having five different organic nutrient inputs packages and one each of integrated and chemical fertilizer treatment *viz.* T_1: integrated- 50% recommended dose of fertilizer (RDF) + 50% N $_{1/3}{}^{rd}$ each from cow dung manure (CDM) + *neem* cake (NC) + composted crop residues (CCR)-; T_2:100% N ($_{1/3}{}^{rd}$ each from CDM + NC + CCR); T_3:T_2 + green manuring in rice + intercropping of raddish in potato; T_4:T_2 + deep summer ploughing, T_5: 50% N ($_{1/3}{}^{rd}$ each from CDM + NC + CCR)+ *Azospirillum*. + phosphorus solubilizing bacteria culture (PSB), T_6 :T_2 + *Azospirillum* + PSB and T_7 :100% RDF were tested in randomized block design replicated thrice with a plot size of 10.0 x 4.10 m. Bunds of 50 cm height were made between replications and individual plots to check the outflow of nutrients and reduce the border effect. Under the treatment T_3, green manuring was done *in situ* with *Sesbania aculeata* (1.6 t /ha dry weight having 2.4 to 2.5% N) in different years. Recommended dose of fertilizer (RDF) for rice crop was 80-22.0- 25.2 kg N-P-K/ha and onion was 150-35.2-83.3 and 100-25.2-83.3 kg N-P-K/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 *neem* cake and 0.5, 0.5 and 0.75 in CCR respectively. The full dose of P and K and half of the fertilizer N was applied as basal dose. The remaining quantity of N was given at tillering and panicle initiation stage to rice and at inter cultivation of onion i.e. 25 and 50 days after germination. Nitrogen was given in the form of urea, CDM, NC and CCR as per treatment requirement as basal dose. 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 variety "Kasturi" was grown during *kharif* and onion "Nasik Red" during the *rabi* season of all the three years. Transplanting of rice at spacing of 20 x 10 cm was done from 15 to 25 July and harvested in last week of October to first week of November every year to facilitate the planting of onion in rows of 30 cm apart during last week of November. The experiment was conducted under assured irrigation facilities and need based irrigations were applied to rice and onion as per recommended practices. The total rainfall received during *kharif* (July to October) was 1131, 797 and 1283 mm and during *rabi* (November to April) was 161, 64 and 70 mm in 2009-10, 2010-11 and 2011-12, respectively. Due to yearly variation in price of crops, the cost of cultivation and net return of ending year i.e. 2011-12 for rice – onion cropping system was only presented in the study and calculated on the basis of 25% premium price to organic produce where organic nutrient inputs packages was applied.

RESULTS AND DISCUSSION

Rice

Highest grain yield of rice (4.67 t/ha) was recorded under the treatment where green manuring was done in addition to 1/3rd each of FYM + NC+ CCR (T_3) were applied over all the treatments irrespective of any organic nutrient management (Table 1) at the end of 2011-12 with third cropping cycle of rice – onion system. However 100% of RDF (4.55 t/ha) and application of 50% RDF through chemical fertilizers + 50 % N through cow dung manure (4.45 t/ha) both have registered comparable yield to that of T_3. Application of 1/3rd each of FYM + NC+ CCR either alone or combined with deep summer ploughing in T_4 and with *Azospirillum* +PSB in T_6 produced considerable yield advantages of about 17% over T_5 i.e. 50% N (FYM) + *Azospirillum*+ R/P + PSB which gave lowest yield of 3.44 t/ha. The treatment consisting 100% N (1/3d each FYM + NC+ CC) + green manuring in rice maintained its superiority over the other organic treatments. However, at the end of third year of growing rice, the overall performance of organic packages on yield is very obvious. higher rice yield in T_3 might be due to greater availability of nutrients in soil and improvement of soil environment by green manure and for higher root penetration leading to better absorption of moisture and nutrients and by providing beneficial micro environment by bio-fertilizers which, ultimately resulting in higher yield. 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) and Singh *et al.*, (2011).

Onion

During the 3rd year of experimentation the bulb yield of onion obtained from organic inputs treatments was still lower as compared to inorganic and integrated treatment. However, an increase in yield was observed in the year 2011-12 as compared to previous year 2010-11 under organic nutrient management. The maximum bulb yield (11.25 t/ha) was obtained with treatment T_1 where integrated nutrient

Table 1: Yield attributes and Yield of rice and onion under organic, inorganic and integrated inputs supply over the years

Treatment	No. of panicles/ m^2			Grain yield of rice (t/ha)			Bulb diameter (cm)		Bulb yield of Onion (t/ha)		
	2009-10	2010-11	2011-12	2009-10	2010-11	2011-12	2010-11	2011-12	2009-10	2010-11	2011-12
T1 = 50% RDF + 50% N (FYM)	333	341	354	3.5	4.28	4.23	5.32	5.36	3.64	3.92	4.45
T2 = 100% N (1/3d each FYM + NC+ CC)	318	326	350	3.58	3.66	3.92	5.29	5.24	3.41	3.63	4.17
T3 = T2 + green manuring in rice	315	326	353	3.87	4.03	4.13	5.42	5.49	3.5	3.8	4.67
T4 = T2 + DSP	309	316	343	3.92	3.37	3.69	5.3	5.37	3.46	3.66	4.14
T5 50% N (FYM) + Azos.+ R/P + PSB	289	289	300	2.99	3.58	3.41	4.25	5.01	3.05	3.09	3.44
T6 = T2 + Azos +PSB	310	314	328	3.49	4.03	3.99	5.41	5.47	3.43	3.66	4.33
T7 = 100% RDF	341	335	336	4.13	4.1	4.16	5.43	5.53	3.59	3.97	4.55
SEm±	5	5	5	0.02	0.05	0.04	0.08	0.06	0.06	0.12	0.1
CD (P= 0.05)	14	16	14	0.07	0.14	0.13	0.26	0.2	0.19	0.36	0.31

ie.50% RDF+50% N through CDM was applied (Table 1). It was followed by 100% RDF (10.67 t/ha) treatment. Integration of inorganic and organic sources has also increased the plant height and bulb diameter in T_1 (i.e. 50% RDF+50% N through CDM). Among organic treatments, T_3 produced higher (9.76 t/ha) bulb yield with bigger bulb size (5.49 cm) than other full organic treatments i.e. T_2, T_4 and T_6. Lowest onion bulb yield (5.28 t/ha) was realized with 50% N (CDM) + *Azospirillum* + RP + PSB (T_5) with smaller sized bulb (4.25 and 5.01 cm diameter) and plant height. Highest net return (Rs. 84,625/ha) and B: C ratio (2.26) were recorded with the application of 100% N ($1/3^{rd}$ each CDM+NC+CCR) in treatment $T_{3.}$

Total productivity

The total productivity of rice- onion cropping system was calculated on the basis of giving 25 % premium price to organic input supplied treatment (T_2, T_3, T_4, T_5 and T_6). The highest rice equivalent yield (13.11 t/ha) was obtained with T_{1-} i.e 50% RDF+50% N through CDM followed by T_7: inorganic treatment (12.75 t/ha) while, T_5 -50% N (CDM) + *Azospirillum* + RP + PSB remained the lowest (7.50 t/ha). Highest total net return (Rs.1,40,946/ha) was also

Table 2: Total productivity (TP) and economics of rice-onion cropping system under organic and inorganic inputs supply

Treatment	Total productivity (t/ha) in terms of REY			Pooled over 3 years	Net return (Rs./ha) 2011-12			B:C ratio of the system
	10-Sep	11-Oct	12-Nov		Rice	onion	Total	
T1- 50% RDF + 50% N (CDM)	11.12	10.11	13.11	11.44	41,376	77,346	1,18,722	2.09
T2- 100% N (1/3rd each CDM+NC+ CCR)	8.96	8.79	11.3	9.68	48,717	78,505	1,27,223	2.07
T3- T2+ GM in rice	8.91	9.63	12.17	10.24	56,320	84,625	1,40,946	2.26
T4- T2 + DSP	9.04	8.82	11.38	9.74	45,384	80,198	1,25,582	1.95
T5- 50%N(CDM)+ azos.+RP+ PSB	5.68	5.68	7.5	6.28	38,814	31,496	70,310	1.25
T6- T2 + PSB+ *Azospirillum*	9.18	8.95	11.76	9.96	50,879	83,153	1,34,033	2.16
T7- 100% RDF	11.57	9.86	12.76	11.4	45,228	73,738	1,18,966	2.28
SEm±	0.18	0.26	0.27	0.37	1560	3,704	-	-
CD (P= 0.05)	0.56	0.8	0.81	1.13	4730	11,237	-	-

obtained with the application of 100% N (1/3rd each CDM+NC+CCR) + GM in rice in treatment T_3. The lowest net return (Rs. 70,310 /ha) was recorded with the treatment T_5 (Table 2). This shows that the application of organic sources of the nutrients, integrated management of organic and inorganic and 100% chemical fertilizer had their significant role to affect the productivity of scented rice- onion cropping sequence. Microbes in rhizosphere of crops provide benefits to crops through better nutrient availability by way of mineralization of organic N, atmospheric N-fixation or solubilizing fixed mineral forms of P and other nutrients (Hegde *et al.* 2007).

Physico-chemical properties of soil

Bulk density and organic carbon

Bulk density of soil under various organic source of nutrient was recorded at par with each other (1.29 to 1.34 Mg/m^3) and remained unaffected. However, it was slightly higher in 100% RDF (T_7) as compared to organic treatments. The organic carbon (OC) content in soil after onion harvesting ranged from 5.0 to 5.6 g/kg under various organic, and & inorganic treatments. It was increased significantly in the plots receiving 50% N through chemical fertilizer and 50% N from NC + CDM+ CCR (5.6 g/kg) followed by the application of 100% N (1/3rd each CDM+NC+CCR) + GM in rice in T_3 (5.5 g/kg) as compared to the treatment received sub optimal dose of N through organic sources i.e. in T_5 which even failed to maintained the initial OC content (5.2 g/kg) of the soil (Table 3 and Fig. 3).

Available nutrient content in soil

Available N and P content in soil after onion harvesting have increased

Table 3: Effect of different organic farming inputs on bulk density, organic carbon and available nutrients at harvest of onion after *rabi* harvest of 2011-12

Treatment	Bulk density (Mg/m^3)	OC (g/kg)	Available nutrient status (kg/ha)		
			N	P	K
T1- 50% RDF + 50% N (CDM)	1.37	5.6	245	21.1	262
T2- 100% N (1/3rd each CDM+NC+ CCR)	1.31	5.3	233	20	248
T3- T2+ GM in rice	1.3	5.5	250	20.5	251
T4- T2 + DSP	1.31	5.2	229	18.6	248
T5- 50%N(CDM)+ Azos.+RP+ PSB	1.34	5	233	17.2	242
T6- T2 + PSB+ *Azospirillum*	1.29	5.4	237	19.1	256
T7- 100% RDF	1.43	5.3	265	23.5	294
Initial value	1.66	5.2	226	19.6	268
SEm±	0.02	0.2	5	1.1	6
CD (P= 0.05)	0.05	0.5	17	3.3	19

after three years of study over initial values irrespective of nutrient management options. Contrarily, K content of the soil was declined over initial values under all the nutrient management options except under the application of inorganic source of nutrients i.e. 100% RDF (Table 3 and Fig. 4, 5 and 6). This might be due to luxury consumption of K by the onion which could not be fulfilled by the organic manures under organic/ integrated options. It is interesting that the organic carbon (%) and available N, P and K content in soil of the organic and integrated nutrient management options had decreased firstly during 2010-11over the previous year i.e. 2009-10 and thereafter showed increasing trend during 2011-12. This authenticates the conversion of conventional field to organic which normally takes 2-3 years. 100% RDF treatment recorded the highest N status (265 kg/ha) as well as P and K status. Higher availability of N, P and K nutrients are also found in organic treatments i.e. 100% N (1/3 each from CDM + NC + CCR) and 50% N (CDM) + *Azospirillum* + RP + PSB. Available P content remained higher in inorganic source of nutrient *i.e.* 100% RDF (23.5 kg/ha). The integrated nutrient management treatment i.e. application of 50% RDF + 50% N supplied through CDM (T_1) stood third (21.1 P kg/ ha) with regards to P content in soil. It was remained at with using of 100% N through organic nutrient package to that of initial value (Table 3). However the lowest status of available soil phosphorus (17.2 kg/ha) was recorded under sub optimal N i.e. 50% N through CDM+*Azospirillum* +RP+PSB+DSP (T_5). The data on available potassium content in soil ranged from 242 to 294 kg/ ha. The available K content remained higher in 100% RDF followed by 50% RDF + 50% CDM and lower in T_5 (50% N through CDM+Azos.+RP+PSB). Amongst the various sources of organic nutrients, application of 100% N (1/3rd each from CDM + NC + CCR) + *Azospirillum* + PSB

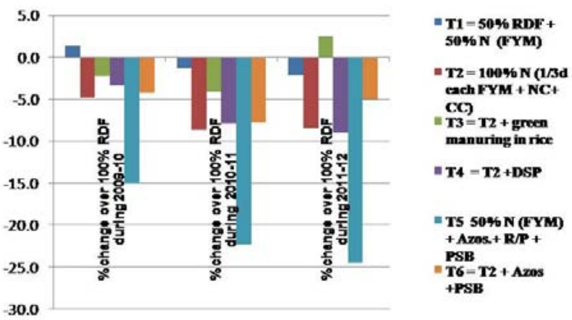

Fig. 1: Percent change in onion yield under integrated and organic nutrient management options over 100% RDF

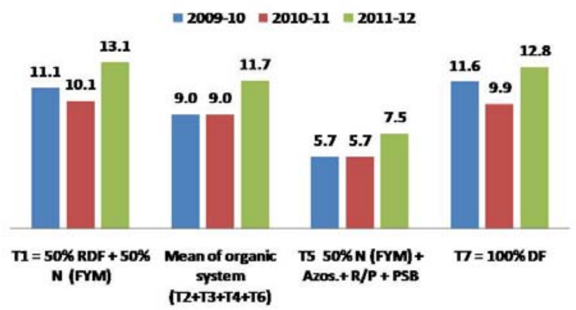

Fig 2: Effect of different nutrient packages on total productivity (t/ha) of rice-onion cropping system over the years

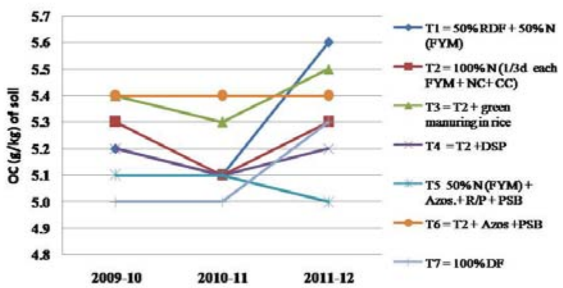

Fig. 3: Trend in organic carbon content (%) in soil as affected by organic nutrient management in rice – potato/onion system over the years

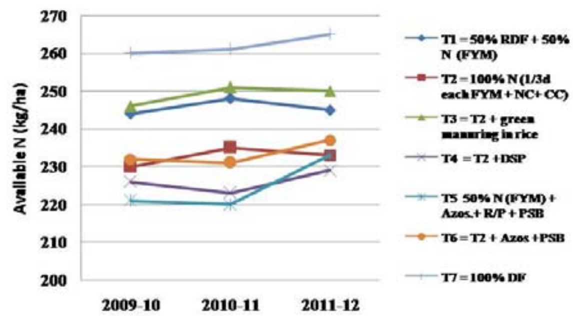

Fig. 4: Change in available Nitrogen (kg/ha) in soil as affected by organic nutrient management in rice –onion system over the years

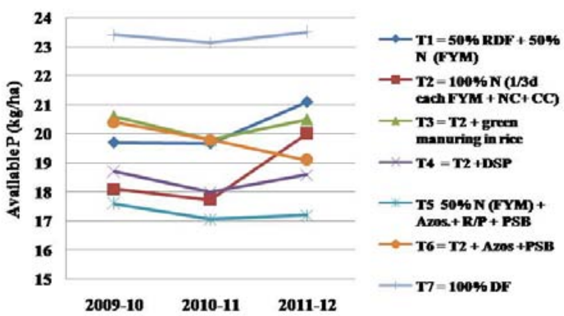

Fig. 5: Change in available P (kg/ha) in soil as affected by organic nutrient management in rice – potato/onion system over the years

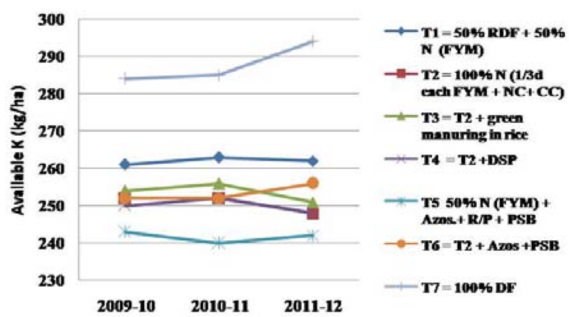

Fig. 6: Trend in available K (kg/ha) in soil as affected by organic nutrient management in rice – onion system over the years

or GM in rice recorded higher status (251 kg/ha) of available potassium in soil.

It can be concluded that application of organic sources of the nutrients had their considerable role to affect the productivity of scented rice- onion cropping sequence as compared to integration of organic and inorganic nutrients and 100% chemical fertilizer. Steady increase in rice productivity, build-up of organic carbon and soil N can be achieved over the years. In rice, 100% N (1/3 each from CDM + NC + CCR) either with green manuring or supplemented with *Azospirillum* + PSB could be a promising combination for obtaining profitable yield. However, in onion, organic treatments failed to register any noticeable increase in yield over the years. This is due to heavy nutrient requirement of onion and consumption of potassium could not be replenished by organic sources in the soil.

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J. Farming Systems Research & Development **19** (1) : 20-29 (2013)

EVALUATION OF LASER LAND LEVELING TECHNOLOGY ON CROP YIELD AND WATER USE PRODUCTIVITY IN WESTERN UTTAR PRADESH

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ABSTRACT

The major cropping systems of western Uttar Pradesh,India are Sugarcane-wheat and Rice-wheat. Sugarcane and rice accounts for more than 80 per cent of the water use. In the past one decade, ground water table has declined from 18 metres to 27 metres.This trend can be checked to a large extent by using appropriate natural resource management technologies including laser land levelling technology.A study has been conducted for 3 year on impacts of the laser land leveling versus traditional land leveling on water use productivity and crop yields.The major research question was laser land leveling an effective water saving tool in the new context of land use and ownership on smaller private plots. Can farmers afford the costs of laser land leveling and how economically viable is it? These research questions were studied in a sizable area of laser leveled and neighboring non-leveled (control) fields for 2009–2011.The result indicated that with laser levelling farmers could save irrigation water 21%,energy by 31% and obtained 6.6%,5.4% and 10.9% in rice,wheat and sugarcane higher yields.The total irrigation duration and applied water depth was reduced 10.9,14.7% in rice;13.7,13.3% in wheat and 13.5,20.3% in sugar- cane as compared to traditional leveled fields.The laser leveled fields exhibited the highest water use efficiency (WUE),which was 48%,47% & 49% higher in precisely leveled field than control (unleveled), 22%,19% and 20% higher than traditionally leveling fields,respectively.The average water productivity in rice,wheat and sugarcane improved by 33 per cent.The average annual net income from the laser field was 14%,13.5% and 23.8% in rice,wheat,sugarcane higher than that from the traditional leveled field.It was concluded that the use of laser land leveling increases yield and saves irrigation water as compared to traditional method of leveling in different cropping system prevailing in western U.P.

KeyWords: Crop productivity,laser leveled land leveling,water use efficiency,water productivity

Declining water table and degrading soil health are the major concerns for the current growth rate and sustainability of Indian Agriculture.Thus proper emphasis is being given on the management of irrigation water usage for adequate growth of agriculture. Keeping in view, the need for judicious use of our natural resources,concerted efforts are being made to enlighten the farmers for efficient use of irrigation water at farm level (Kaur et al.,2012).Generally,in sugarcane-wheat and rice-wheat rotation farmers believed that their fields are leveled and needed no further leveling. But the digital elevation survey sheet of a field shows that the most of the fields are not adequately leveled and requires further precision land leveling. The enhancement of water use efficiency and farm productivity at field level is one of the best options to readdress the problem of declining water level in the state. The planner and policy makers are properly informed and motivated to develop strategies and programs for efficient utilization of available water resources. Laser Land leveling is one such important technology for using water efficiently as it reduces irrigation time and enhances productivity not only of water but also of other non-water farm inputs.

The use of laser technology in the precision land leveling is of recent origin in India.It not only minimizes the cost of leveling but also ensures the desired degree of precision.However,the laser land leveling was introduced in the state in 2001 by Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (U. P.) in collaboration with Rice-Wheat Consortium,New Delhi under the leadership of Dr.R.K. Naresh.Land leveling of farmers field is an important process in the preparation of land.It enables efficient utilization of scarce water resources through elimination of unnecessary depression and elevated contours (Naresh et al.,2011).It has been noted that poor farm design and uneven fields are resposible for 30% water losses (Asif et al.,2003)..Precision land leveling (PLL) facilitated application efficiency through even distribution of water and increased water-use efficiency that resulted in uniform seed germination,better crop growth and higher crop yield (Jat et al.,2006).The scarcity of canal water supplies coupled with unfit ground water has compelled the farmers to utilize available water resources more wisely and efficiently. Under these circumtances,PLL can help the farmers to utilize the scarce land and water resource more effectively and efficiently towards increased crop production (Abdullaev et al.,2007). It was estimated that around 25-30 per cent of irrigation water could be saved through this technique without having any adverse affect on the crop yield (Bhatt and Sharma,2009).

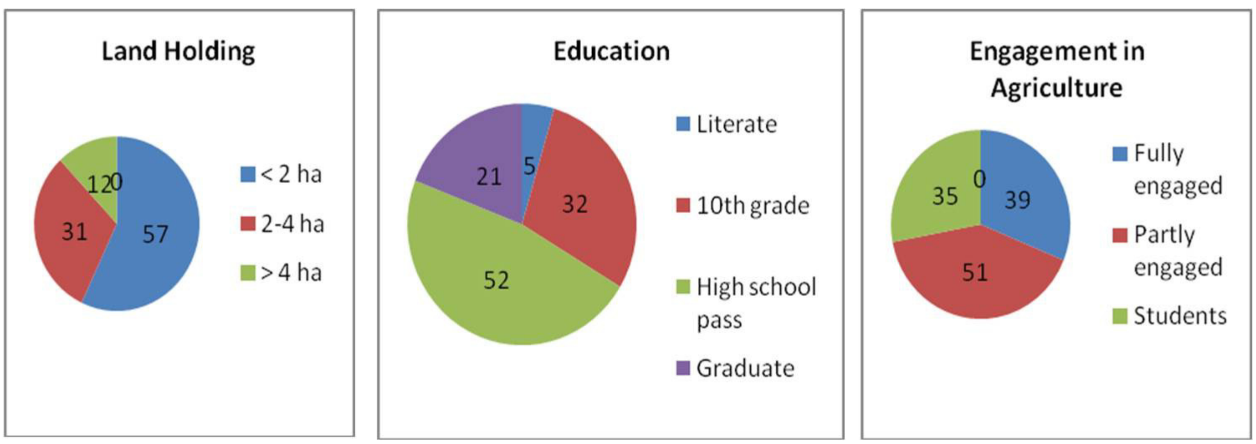
The land leveling have resulted smoother soil surface, reduction in time and water required to irrigate the field, more uniform distribution of water in the field, more uniform moisture environment for crops, more uniform germination and growth of crops, reduction in seed weight, fertilizer, chemicals and fuel used in cultivation, and improved field trafficability (for subsequent operations).Limitations of laser leveling include high cost of the equipment/laser instrument, the need for a skilled operator to set/adjust laser settings and operate the tractor,and restriction to regularly shaped fields.Farmers, as entrepreneurs, are unwilling to adopt new technologies unless they clearly see quick and tangible results in terms of farm profitability. Theoretically,a farmer would opt for a new technology if assurance of earning a net profit were shown. Some economists believe that the net returns must be at least 30% higher than for the traditional technology before farmers would consider adoption. According to an estimate, the number of laser levellers in western Uttar Pradesh has increased sharply from mere 01 in the year 2001 to 450 in the year 2011 of this,on farm resource conservation technologies in states like Uttar Pradesh have an edge over other technologies.Land levelling through laser leveller is one such proven technology that is highly useful in conservation of irrigation water and enhancing productivity.Keeping this in view,this study was undertaken with the objective to asess the impact of laser land levelling on the productivity of rice, wheat and sugarcane crop by comparing it with the conventional practice and to find out the extent of water and energy saving as a result of laser or precision land levelling.

Materials and Methods

Biophysical, demographic, and socioeconomic profile

Initially,a baseline survey of randomly selected farmers from different villages was conducted to understand their social, economic, and educational status in addition to input use (seed, irrigation, tractor, labor,fertilizer,and pesticide use) and outputs (grain and straw yield) in conventional farmers' practices. The study was conducted for three years from June 2009 to May 2011 in 50 farmers' fields at Sardar Vallabhbhai Patel University of Agriculture &Technology Meerut and Ghaziabad sites.Out of 50 farmers 57% had land holdings of<2 ha, 31% had 2 to 4 ha, and 12% had more than 4 ha (Fig.1A). About 75% of the farmers were literate,out of which 32% were middle-school pass,52% were high-school pass, and 21% were college pass (Fig.1B).The literacy rate was higher for large farmers than for small farmers.The average family size was 6.4 family members.Impact of laser leveled land leveling on crop yield and water productivit in western Uttar Pradesh per household.The large farmers usually lived in joint families,where as medium and small farmers had a separate nucleus family. Out of 320 family members of the 50 households surveyed,39% were fully engaged in agriculture and 51% partly engaged,whereas 35% were students who also helped with agricultural activities during vacation and/or leisure periods (Fig.1C).Some 38% of the farmers were members of different cooperatives existing in the area.Sugarcane and wheat were the major source of income for 52% of the farmers, followed by rice (34%), vegetables (12%), and oilseeds (9%).

An experiment was conducted on sugarcane-wheat and rice-wheat rotation in two districts (Meerut and Ghaziabad) in farmers participatory mode in the juridiction of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut (Uttar Pradesh), India, (28 402 073 N to 29 282 113 N, 77 282 143 E to 77 44183 E) during 2009 to 2011.The experiment was farmer-managed ,with a single replicate,repeated over many farmers.Therefore,the experimental



Socio economics and demographics of project sites of Uttar Pradesh, India

design was Randomized Block Design in which the number of treatments varied from farmer to farmer,with the farmer as a replicate/ block.The treatments consisted of Laser land leveling (T_1),Traditional land leveling (T_2) and Control (Unleveled) (T_3).In treatments T_1 and T_2 leveling of experimental field was done as per treatment and information on the topography of each experimental unit was compiled.The climate of the area is semiarid, with an average annual rainfall of 650 mm (75–80% of which is received during July to September),minimum temperature of 4^0C in January, maximum temperature of 41–45^0C 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. soil with a bulk density of 1.48 Mg m^{-3}, weighted mean diameter of soil aggregates 0.74 mm, pH =7.9, total C = 8.3 g kg^{-1}, total N =0.83 g kg^{-1}, Olsen P = 28 mg kg^{-1}, and K =128 mg kg^{-1}.Groundwater pumping is the predominant method of irrigation.Western UP has a diversified cropping system,with Sugarcane-Wheat and Rice-Wheat as the dominant cropping system.The crop was kept free of weeds by chemical spray. Observations on the desired parameters were recorded using the standard procedures.The main source of irrigation was canal water,which was supplemented with tubewell water as and when needed to meet the crop water requirements.The discharge available at outlet was measured every time.The time of irrigation application for each treatment was noted during each irrigation.The applied irrigation depth was calculated from measured discharge applied to known area for recorded time by the following equation:

$$QT = AD$$

Q = Discharge (Cusec,ft^3 s^{-1}) T = Time (hr) A = Area (acres) D = depth (inches)

The amount of water (ft^3) applied to each treatment was determined by multiplying the discharge at field outlet with the time of application.The total amount of water so applied was computed for the entire crop season.The amount of water saved was determined by the difference of water applied to precisely leveled,unleveled and traditionally leveled experimental units.

Water use efficiency was computed as follow:

$$WUE = \text{Yield (kg)}/\text{Water applied } (m^3)$$

Water productivity and economic analysis

Water productivity analysis combines physical accounting of water with yield or economic output to assess how much value is being obtained from the use of water (Molden et al.,2003;Abdullaev et al., 2007;Bouman et al., 2008). For this analysis, physical water productivity was calculated by:

$$WP = \text{Output}/Q$$

where: WP is the productivity of water in kg/m^3, Output is the mass of crop in kilograms and Q is water resources applied and depleted (m^3). In this study, only physical productivities of the applied and depleted water are analyzed.To compare the laser-leveled field to the control field, both gross margin analysis and partial enterprise budgeting techniques[2] were applied for three cropping seasons of 2009,2010 and 2011.

[2]*The use of partial enterprise budgets required to evaluate technological innovations compared to old techniques, as the capital costs associated must be discounted over the live of the new investment.*

Results and Discussion

Yield and yield components

The laser leveling significantly affected the yield and yield components of rice ,wheat and sugarcane crop (Table 1 & 3).The maximum productive tillers were recorded in laser leveled field against the minimum in the unleveled field.No significant difference was recorded for 1000 grain weight.Laser land leveling produced maximum grain/ cane yield (5.73,4.60 & 82.8 t ha^{-1})against the minimum(4.25,3.85 & 54.9 t ha^{-1}) in unleveled field.Significantly higher grain/cane yield over traditionally leveled field and unleveled field might be attributable to better development of yield components like higher productive tillers m^{-1} row length and more 1000 grain weight due to more efficient use of inputs,uniform internode length, thicker canes and uniform availability of soil moisture in the effective root zone of the crop. Naresh *et al.*, (2012) attributed higher grain yield in precision land leveling to more uniform "wattar" conditions that facilitated timely preparation of field and timely sowing of the crop as compared to unleveled fields.The reason for lower grain/cane yield in unleveled field might be uneven distribution of water over the field which drastically reduced the yield and yield components in lower and elevated spots.

Water saving

There was a significant improvement in irrigation performance when the precision laser land leveling was under taken prior to sowing (Table 2 & 3).The maximum water depth for rice (122.4),for wheat (100.3) and (218.9) for sugarcane were required to irrigate unleveled field during each irrigation as against the minimum in the field precisely leveled by laser and followed by traditionally leveled field.On an average 36 to 12 % in rice 47 to15% in wheat and 36% to 15% in sugarcane crop as compared to control and traditionally leveled fields reduced the total irrigation duration and water depth in each irrigation event, respectively.Thus,laser leveled field utilized less water per irrigation.The precisely leveled and smooth field showed a positive impact on the total

Table 1: Rice - Wheat yield and its components as affected by laser land leveling and traditional leveling techniques

Treatments	Plant height (cm)		Productive tillers (m^{-1}row length)		Grains $spike^{-1}$		1000 grain weight (gm)		Grain yield (t ha^{-1})	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Laser land leveling	131.6	95.5	105	84	82	45	24.1	42	5.73	4.47
Traditional land leveling	127.7	87.4	97	68	77	43	23.4	39	5.35	4.23
Control (Unleveled)	111.8	76.1	84	59	68	39	21.3	39	4.25	3.75
C D at 5%	16.9	12.3	13.7	14.3	9.5	5.3	NS	NS	0.47	0.32

Table 2: Total duration,applied water depth and water use efficiency as affected by laser land leveling and traditional leveling techniques

Treatments	Total duration min ha^{-1}		Water depth applied (mm)		Water depth/ Irrigation (mm)		Volume of water applied (m^{-3})		WUE kg m^{-3}	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Laser land leveling	3049	1263	810	340	90	63	4316	3310	1.33	1.35
Traditional land leveling	3414	1456	950	392	101	73	4982	3842	1.07	1.10
Control (Unleveled)	4134	1857	1260	501	122	93	6118	4915	0.69	0.76
C D at 5%	385	298	183	97	17	15	873	786	0.21	0.23

For Rice

Total duration	LLvs TL	3049.6 – 3414.7	= - 365.1 (12%)
	LLvs UL	3049.6 – 4134.3	= - 1084.7 (36%)
Water depth per irrigation	LLvs TL	90.3 – 101.5	= - 11.2 (12%)
	LLvs UL	90.3 – 122.4	= - 32.1 (36%)
Water use efficiency	LLvs TL	1.33 – 1.07	= 0.26 (21.8%)
	LLvs UL	1.33 – 0.69	= 0.64 (48.1%)

For Wheat

Total duration	LLvs TL	1263.05 -1456.3	= - 192.95 (15%)
	LLvs UL	1334.05 – 1857.9	= - 594.85 (47%)
Water depth per irrigation	LLvs TL	63.2 – 72.9	= - 9.7 (15%)
	LLvs UL	63.2 – 93.1	= - 29.9 (47%)
Water use efficiency	LLvs TL	1.35 – 1.10	= 0.25 (18.52%)
	LLvs UL	1.35 – 0.76	= 0.59 (43.7%)

LL = Laser land leveling TL = Traditional land leveling UL = Unleveled

water use resulting in a tangible reduction.At uniform discharge,before and after laser land leveling there was about 32% saving in water over control and 13% over traditional leveled field.Significantly higher amount of water (6118.4 ; 4915.1 & 10362.8 m^3) were required for unleveled field than laser leveled field (4316.2 ; 3310.3 & 7500.4 m^3), which did not differ significantly from the traditionally leveled field.The results further revealed that 1802.2 m^3 in rice crop, 1604.8 m^3 in wheat crop and 2862.4 m^3 in sugarcane crop i.e. about 42 ,47% and 38% excess volume of water was required to irrigate unleveled fields as against 15% (666.2 ; 531.7 & 861.9 m^3) in traditional leveled field.The only reason for excessive water application in control treatments was uneven surface to the unleveled treatment.The greater variation in surface level on unleveled and traditional leveled field resulted not only in wastage of water but also reduced crop yield by about 26 to19 % in rice crop,28 to 11% in wheat crop and 28 to 15% in sugarcane crop, respectively.

Water use efficiency

WUE was significantly affected by different land leveling techniques (Table 2 & 3).The highest WUE for rice,wheat and sugarcane crops (1.33,1.35 & 1.03 kg m^{-3}) were recorded in laser- leveled field against the lowest (0.69 ,0.76 &

Table 3: Sugarcane yield and total duration,applied water depth and water use efficienas affected by laser land leveling and traditional leveling techniques

Treatments	Total duration min ha^{-1}	Water depth applied (mm)	Water depth/ Irrigation (mm)	Volume of water applied (m^{-3})	Yield (t ha^{-1})	WUE (yield /mm water/ha)
Laser land leveling	6386	1630	160	7500	77.3	1.03
Traditional land leveling	7353	2046	185	8362	68.9	0.82
Control (Unleveled)	8382	2350	219	10363	55.7	0.53
C D at 5%	529	314	39	962	9.6	0.23

For Sugarcane

Total duration	LLvs TL	6385.6 -7352.7	= - 987.1 (15%)
	LLvs UL	6385.6 – 8682.1	= - 2296.5 (36%)
Water depth per irrigation	LLvs TL	160 – 184.5	= - 24.5 (15%)
	LLvs UL	160 – 218.9	= - 58.9 (36%)
Water use efficiency	LLvs TL	1.03 – 0.82	= 0.21 (20.4%)
	LLvs UL	1.03 – 0.53	= 0.50 (48.5%)

LL = Laser land leveling TL = Traditional land leveling UL = Unleveled

0.53 kgm^{-3}) in unleveled field while in traditionally leveled field it were (1.07,1.10 & 0.82 kg m^{-3}).Overall,the water-use efficiency was 48%,47% & 49% higher in precisely leveled field than control and 22%,19% and 20% higher than traditional leveling.This huge difference in water use efficiency was because of reduced grain/cane yield and higher amount of water applied to unlevel and traditional leveled fields.The decrease in water use efficiency in unleveled fields also reflected the sensitivity of the crop to water excess/ deficit,a characteristic of undulating fields surface of unleveled fields.The reason for lower WUE in traditionally leveled and unleveled fields was the inefficient use of the water applied.The result suggests that laser land leveling is more water use efficient more cost effective and give higher crop yield through efficient utilization of scarce land and water resources.Thus, in the light of this study it is imperative to recommend that laser land leveling should be popularized among the farmers at it not only increase water use efficiency and yield but also ensure better germination,better utilization of water and non water inputs towards increased yield.

Profitability

Using scarce water resources in rice,wheat and sugarcane cultivation in a sustainable manner brought a larger area under rice-wheat and sugarcane cultivation;the laser land leveling fields irrigation of these crops appeared to be an eco-friendly and economically viable technology.It led to higher productivity in rice,wheat and sugarcane and increased sucrose content in sugarcane and ultimately increased income for the farmers (Table 4 & 5).Higher net returns were observed by laser land leveling technology Rs.41,720;30,581 and 66,280 ha^{-1} in rice,wheat and sugarcane crops in comparison to control (unleveled) fields.Other benefits include saving on fuel expenses,improvement in fertilizer use efficiency,uniform internode length, thicker canes,less weed growth and uniform irrigation of rice/wheat/

Table 4:Comparative energy and economics of laser land leveling and traditional leveling techniques

Parameters	Laser land leveling		Traditional land leveling		Control (Unleveled)	
	Rice	Wheat	Rice	Wheat	Rice	Wheat
Energy requirement, MJ ha^{-1}	4768	2498	5658	2885	6960	3647
Tillage cost, Rs ha^{-1}	11675	8470	12450	10350	14370	12675
Grain yield , t ha^{-1}	5.73	4.47	5.17	4.23	4.25	3.75
Straw yield , t ha^{-1}	-	6.05	-	5.12	-	4.25
Gross income, Rs ha^{-1}	65,895	49,301	61,525	46,045	48,875	40,031
Cost of production, Rs ha^{-1}	24,175	18,720	25,700	19,578	27,425	21,460
Net income, Rs ha^{-1}	41,720	30,581	35,825	26,467	21,450	18,571
Benefit : cost ratio	2.73	2.63	2.08	2.35	1.78	1.87

Table 5: Economics of some agronomic measures on sugarcane production (plant cane)

Parameter	Demonstrated agronomic measure		
Parameters	Laser land leveling	Traditional land leveling	Control (Unleveled)
Energy requirement, MJ ha^{-1}	8339	9670	12100
Cane yield (t ha^{-1})	77.3	65.9	55.7
Cost of production (Rs ha^{-1})	49,640.0	52,830.0	56,790.0
Gross return (Rs ha^{-1})	115,920.0	103,350.0	83,550.0
Net return (Rs ha^{-1})	66,280.0	50,520.0	23,760
Benefit : cost ratio	2.34	1.87	1.47

sugarcane grown on undulated terrains.Although laser land-levelling is beneficial, there are certain limitations associated with it such as high cost of the equipment/laser instrument and need for a skilled operator.It may be less efficient in irregular and small sized fields.Utilizing these eco-friendly and economically viable options will go a long way in sustaining rice,wheat and sugarcane productivity and economizing water under conditions of ever-depleting water resources.

Conclusion

Over the past decade,researchers in association with farmers and entrepreneurs have been trying to overcome the problems of depleting water resources,diminishing input use efficiency,declining farm profitability,and deteriorating soil health by developing, evaluating and refining conservation and precision agriculture-based resource-conserving technologies for the sugarcane-wheat and rice-wheat system in western Uttar Pradesh. Recently, laser-assisted precision land levelling has shown promise for better crop establishment,water savings and enhanced input use efficiency.This study have shown the effect of rice,wheat and sugarcane planting on laser levelled fields increased yields (av. of 3 yrs) by 6.6%,5.4% and 10.9% on traditionally levelled fields.The saving in irrigation water with precision-conservation were 13.4%,13.8% and 10.3% compared to traditional levelling field and 29.5%, 32.7%, 27.6% to unleveled fields in rice, wheat and sugarcane crop, respectively. Therefore,this study confirms that Precision- Conservation Agriculture (PCA) based crop management solutions seem to be promising options to sustain the irrigated sugarcane-wheat and rice-wheat systems of western U. P. on a long-term basis.

ACKNOWLEDGEMENTS

Financial assistance by the Uttar Pradesh Council of Agricultural Research,Lucknow under the Resource Conservation Technologies for Sustainable Development of Agrculture project is duly acknowledged.

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J. Farming Systems Research & Development **19** (1) : 30-36 (2013)

COMPARATIVE EVALUATION OF FARM AND NON-FARM INCOME FOR POVERTY ALLEVIATION IN ORISSA

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The problem of poverty and unemployment is considered as the biggest challenge to development planning in India. Agriculture, interalia has been playing crucial role in economic development. However, the diminishing land frontiers together with rapid. Population growth in rural areas is leading to fragmented holdings and reduction in the average size of operational holding (Fig.1 & Fig. 2). Consequently, the farming in India has become non-viable, specifically for marginal and small farmers. They lead a miserable life since their meager land is not sufficient to earn adequate income to maintain their family. It has resulted in a sharp increase in the number of agricultural labours. The modem agricultural and tra4e policy which always stress the need for low cost technology to make the per unit cost of commodity cheaper has also helped in increasing the unemployment in rural sector. Under these circumstances, rural non-farm sector seems to be one of the best options available for them to boost their employment and to stabilize their

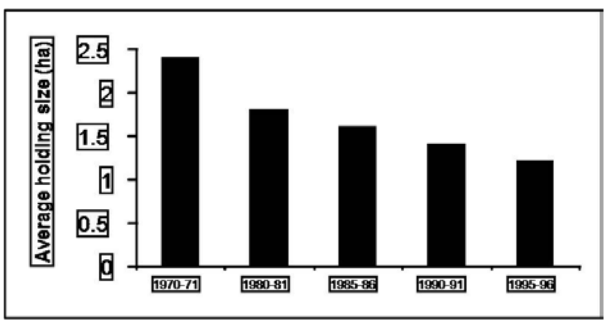

Fig.1. Reduction in average size of operational holding (ha)

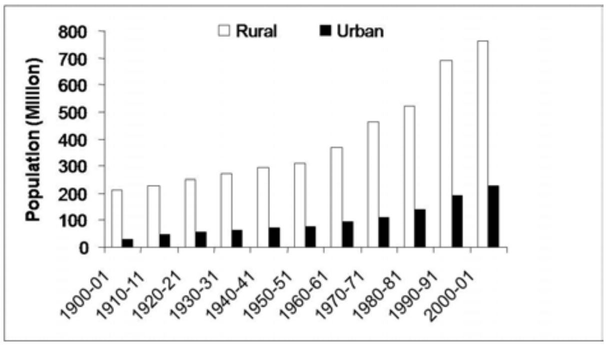

Fig. 2. Comparative growth of rural and urban population

household income. The non-farm employment has, in recent time, assumed added importance in economic development (Rao 1995). The non-farm sector contributes 20-50 per cent of rural employment in most developing countries (Islam 1997). According to Peter Lanjouw (1999), in many developing countries, agriculture is not the sole sector -sometimes not even the dominant sector for household employment and income in rural sector. The non-farm sector offers potential to absorb the growing rural force; slow down the rural urban migration and also to contribute towards the economy of rural peasantry. Poor rural people seek livelihood from non-farm sector to complement seasonal agricultural incomes and to supplement inadequate agricultural income. The rural households are pushed to non-farm activities because of lack of access to productive resources to expand farm output, unequal distribution and costly mechanism of diversification while higher income in non-farm activities relative to the farm sector and low risk are attributed to pull factors that attract households. to non-farm employment (Deininger and Olinto , 2001).

In Orissa, where 85.03 per cent of the total population resides in village, the marginal and small farmers together account 88.6 per cent and occupying 44.2 per cent of the land holdings. The agriculture production system in the state is so weak that it neither provides sufficient food nor employment to the farming community. Rice, which is staple food and cultivated on 76.5 per cent of the net sown areas, is yielding at the rate of 1446 kg/ha compared to 1698, 1737, 1900, 2247 and 2472 kg/ha harvested in Nagaland, Meghalaya, Mizoram, Tripura and Manipur, representing the same agro-eco region. The productivity of pulses and oilseeds recorded to 338 and 568 kg/ha in the state are also much lower to national average. Following traditional agriculture, coupled with less infrastructural development restricting growth in food grain production in the state. This has resulted to put 47.1 per cent of the state population below the poverty line. Under this agricultural scenario, there is no other alternate except to seek employment in non-farm sector to cop up the family expenditure for weaker section of the farming community. Keeping this in view, an attempt was made to make comparative study of farm and non- farm sectors and their contribution in poverty alleviation of rural people in Orissa

Methodology

Districts Balasore, Jaipur and Khurda of Orissa state were surveyed during 2001- 02 following the multistage stratified random sampling method. To compute the farm income, the quantity of input used for production of individual crop, quantity of total produce, prevailing market price of the produce, input price, wage rates of labourers were collected through personal interview from the respondents on the perform a framed for this purpose. The incomes from crops were worked out keeping in view the area occupied and cost of cultivation of the respective crop. Further, the expenditure incurred on fodder, concentrate, minerals and maintenance of miltch cattle's were also gathered along with per unit milk yield and their selling price. Similarly, the annual income realized from coconut, which is grown by each farm families were also collected. Under non-farm, income from wage, business and service were taken into account and data on these were gathered. Besides, other non-farm activities prevailing in the study districts were identified and income earned from those sources by farm groups were worked out. The farmers having small shop or doing part time business like selling of fish, vegetable, fruits and other such occupation for enhancing their family income were also taken into account for computing the non-farm income. Simple average and ratio were used as analytical tools for the study.

Results and Discussions

Income from rice cultivation

Rice production being main occupation in Orissa, occupied 85.0, 93.3 and 89.1 per cent of the gross cropped area in districts Balasore, Jaipur and Khurda respectively during course of survey. During rabi season, lands are mostly kept fallow and used for grazing of cattle's. Rabi rice was grown on small area where irrigation facility was available. The cost and returns, per unit of rice area and total income realized from rice production for different farm groups in respect of Balasore, Jaipur, and Khurda districts are presented in Table-I. As evident from the data, none of the farmer was found cultivating five or more than five hectares of land in these districts, which may be put up under large farmer category. Similarly, in Khurda district, all samples were categorized marginal and small farm groups. This indicates the scarcity of cultivable land resources in the state, which is the base for survival of farming community. The total annual income obtained from rice production by each farm group, computed to Rs.1826, 4525 and Rs.9554 for marginal, small and medium farmers, respectively in district Balasore. However, after adding the family labour income, the total income increased to Rs.3746, 6725 and 10994 for these farm groups. In Jaipur and Khurda districts, the total income from rice cultivation was recorded Rs.4531 and 4716 for marginal and Rs.7584 and 8106 for small group of farmers respectively. The marginal variation in income attributed to difference in rice productivity in these districts. The low income from rice produce was mainly due to low yield of rain fed rice influenced with erratic rainfalls and frequent drought and flood in the area.

Table 1. Costs and returns (Rs/ha.) and total income realized from rice production by farm groups in Orissa during 2001-02

Detail of operation	Balasore			Jaipur			Khurda	
	Marginal farmer	Small farmers	Medium farmer	Marginal farmer	Small farmers	Medium farmer	Marginal farmer	Small farmers
Operational Cost	10695	10950	11600	10350	10800	11200	10500	10500
Fixed Cost	4413	4532	4760	4822	5000	5400	5075	4665
Total Cost	15138	15482	16360	15172	15800	16600	15575	15165
Grain yield (q/ha)	33.5	34	35.6	34.2	34.9	36.15	39.5	38.4
Straw yeild (q/ha)	42	43	45	43	44	45	49	48
Selling Price of grain (Rs./qtl)	450	450	450	450	450	450	400	400
Price of Straw (Rs./qtl)	70	70	70	72	72	72	70	70
Gross Income	18015	18310	19170	18486	18873	19508	19250	18720
Net return	2877	2828	2810	3314	3073	2908	3675	3555
Area culitivated (ha)	0.8	1.6	3.4	0.8	1.7	3.2	0.75	1.65
Total income (Rs.)	1826	4525	9554	2651	5224	9306	2756	5866
Family labour (incomes (Rs)	1920	2200	1440	1880	2160	1500	1960	2240
Net household income (Rs)	3746	6725	10994	4531	7384	10806	4716	8106

Further, against minimum support price of rice (Rs.530/q) announced by the government during 2001-02, the rice growers of the study districts sold their produce at the rate of Rs.400 and 450/q with a loss of Rs.80 and 130/q respectively. This indicates another reason for low farm income of rice producer in the state. The low farm income do not allow to the poor farmers to use plant nutrients and other inputs as per crop requirements resulting low crop yield. Since this system of low crop productivity is continued from years together, the state is always in shortage of food grain production, which causes growth in poverty.

Income from other crops and farm enterprises

Besides rice, the annual income generated by other crops in Balasore was calculated to Rs.2500, 3810 and Rs.6490 for marginal, small and medium farmers, respectively Table-2. The income from crops other than rice in Jaipur and Khurda districts was also on the similar line with different magnitude. As the districts included in the study falls in coastal belt of Orissa, all categories of farmers were keeping 4-10 coconut plants near by their house. Each coconut plant provided a net income of Rs.400 to 500 per annum as informed by the farmers during survey period. The highest income realized from coconut plants was Rs.2410 for medium farm group in Jaipur and lowest Rs.1800 per annum to marginal farmers in Khurda district. Similarly, the average annual income received from dairy by marginal farmers was recorded Rs.1800, 2200 and Rs.2300 in Balasore, Jaipur and Khurda districts respectively. The income from dairy of other group of farmers was of higher order. The total farm income was worked out Rs.9446, 15035, 23234 in Balasore and Rs.10610, 15845 and Rs.23231 in Jaipur for marginal, small and medium size farms. The per annum income for marginal and small farmers in Khurda district was Rs.1 0566 and 18561 respectively. The total annual farm income ranging from Rs.9446 to 18561 for marginal and small

Table 2. Annual income from crops and other farm enterprise (in rupees)

Detail of operation	District / Farm Size			District / Farm Size			District / Farm Size	
	Balasore			Jaipur			Khurda	
	Marginal farmer	Small farmers	Medium farmer	Marginal farmer	Small farmers	Medium farmer	Marginal farmer	Small farmers
Income From rice cultivation	3746	6725	10994	4531	7384	10806	4716	8106
Income from other crops	2500	3810	6490	2350	3630	6515	2250	5890
Total annual income from crops	6246	10535	17484	6881	11014	17321	6966	13996
Income from coconut plantation	1400	1800	2250	1530	1931	2410	1300	1765
income from dairy	1800	2700	3500	2200	2900	3800	2300	2800
Total farm income	9446	15035	23234	10610	15845	23531	10566	18561

farmers of the representative districts appear to be insufficient to cope the household expenditure for an average family of 6-8 members. The situations enforce for these groups of farming community to search other source of income from non-farm sector. Further, since the household expenditure including education, clothing, conveyance and other social expenses have increased many fold, the annual farm income realized Rs 23531 by medium farm group also appears much below the family requirement and because of this, these group of farmers also prefer employment in non-farm sector for augmenting the household income. It is relevant to mention here in this context that rich farmers were also not willing to engage their children in farming as the present agricultural production system has become costlier, time consuming, problem oriented and unprofitable occupation. It is further added that in recent time where every one desires to leave comfortably, the young generation of the farming community prefer employment in urban sector even on the low wage rate instead of involving themselves in agriculture.

Non-farm income

Data presented in (Table-3) showed that all group of farmers were enjoying the benefit of non-farm employment for augmenting their household income. It was noticed that the farm families getting income from non-farm sector, their crop performance as well as social status was observed better than those depended only on agricultural income. This disparity was noticed in all farm groups. Data further showed maximum income from wage in case of marginal and small farmers in all the districts included in the study. The average annual income from wage earned by marginal and small farmers were calculated to Rs. 18000 and 12000 in Balasore, Rs 21500 and 18300 in Jaipur and Rs 14500 and 18700 in district Khurda respectively. The marginal variation in income appears due to discrimination in wage rates from place to place. The income from wage was

Table 3. Annual income from non-farm employment by farm size (in rupees)

Details of non farm earning	District / Farm Size			District / Farm Size			District / Farm Size	
	Balasore			Jaipur			Khurda	
	Marginal farmer	Small farmers	Medium farmer	Marginal farmer	Small farmers	Medium farmer	Marginal farmer	Small farmers
Service	0	9600	42000	0	19200	60000	7200	19400
Business	8000	10500	0	10000	0	0	9500	0
Wages	18000	12000	0	21500	18300	0	14500	18700
Total Non-farm income	26000	32100	42000	31500	37500	60000	31200	38100
Total farm + non farm income	35446	47138	65234	42110	53345	83231	41766	56661
Share of non farm (%)	73.4	68.1	64.4	74.8	70.3	72.1	74.7	67.2
House hold income (Rs/month)	2954	3928	5436	3509	4445	6936	3481	4722

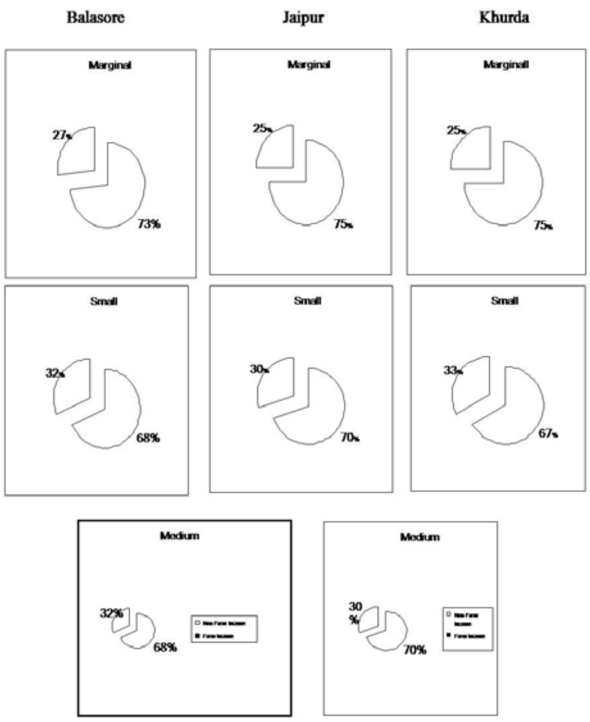

Fig. 3. Share of farm and non farm income with the different farm groups in Orissa

received through bricks making, road and building construction and working as a farm labour. While examining the contribution of income from various non -farm activities, it was observed that wage and business shared 69.2 and 30.8 per cent for marginal and 37.4 and 32.7 per cent for small farmers in district Balasore, respectively. The medium category of farmers received income only from service. The contribution of income obtained from non-farm activities by different farm groups in district Jaipur and Khurda were also on the similar line with different magnitudes. In Balasore and Jaipur district none of the marginal farmers observed receiving income from service. Low education might have become hurdle in obtaining regular job in government or private sectors to resource poor farmers and hence the labour wage was only the alternative to stabilize the household income for this farm group. While on the other hand, higher educational qualification provided better job opportunity to resource rich farmers.

Comparative Study of Farm and Non-Farm Income

In Balasore, marginal and small farmers were observed obtained 73 and 68 per cent of total household income through non-farm employment (Fig-3). The contribution of non- farm income in districts Jaipur and Khurda were recorded 75 and 70 percent of the total annual earning as apparent from figure-3. Non-farm sector shared 64 to 72 percent of the total income in case of medium farm group in districts Balasore and Jaipur, respectively. These figures underline the importance of non-farm sector for providing livelihood to the weaker section of the farming community in Orissa. The contributiC!f:l of non-farm income was observed on the similar pattern for all farm groups in other districts. Data further revealed that farm sector in Orissa is so weak that none of the farm group observed to feed their family even half of the year from farm income and this is the root cause for growing poverty in the state. Lack of irrigation infrastructure, mono cropping, traditional farming, frequent occurrence of drought and flood, using traditional varieties and less attention of the government towards agricultural developments appears to be the main factors causing low farm income. Since sufficient employment opportunity under non-farm sector is also not available in rural areas of the state, the weaker section of the farming community either work on low wage rats in agriculture, keep themselves ideal or migrate in other states for better job opportunity.

CONCLUSION AND POLICY DECISIONS

The study inferred that The non-farm sector is playing pivotal role for providing bread and butter to the farming community in general and resource poor farmers in particular in Orissa. Study further revealed that the agriculture production system in the state is so weak that majority of the farm groups are not able to get two time meals throughout the year from crop production. Besides providing livelihood, non- farm sector is also contributing for improving the social status of farming community by enhancing household income. Considering the importance of non-farm, the study suggest that there is an urgent need to establish cottage industry, food and animal products processing units nearby the rural areas for providing sufficient employment to the weaker section of the farming community.

Creation of irrigation infrastructure, evolving drought and flood tolerant varieties of rice and other crop commodities, field demonstration to encourage the farmers to use recommended and balanced dose of fertilizer on crop yield and developing better marketing and transport facilities will improve the crop productivity and farm income in Orissa. Providing crop loan on low rate of interest will also facilitate the weaker section of the farming community for timely purchase of farm inputs that will increase the crop productivity. In view of the continuous shrinking of size of holding, it is required to keep more enterprises on the .farm by all group of farmers for augmenting farm income.

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DIRECT AND RESIDUAL EFFECTS OF N, P, K, ZN AND B ON YIELD AND NUTRIENT DYNAMICS OF WINTER RICE – TORIA SEQUENCE

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Abstract

Field experiments were conducted on a sandy loam (Aeric Haplaquept) soil to study the effect of graded level of N, P, K and Zn in winter rice and N, P, K and B on toria crop with winter rice-toria sequence. Winter rice responded significantly to higher level of N, P, K and B application. The response in terms of yield, nutrient uptake and nutrient dynamics was recorded highest in treatment T_4which received 80:40:40 NPK kg ha^{-1} in both the crop of the seq'uence which was followed by treatment T_3 where micronutrients Zn and B were incorporated as $ZnS0_4$ and Borax in rice and toria crop respectively in winter rice -toria sequence. A large portion of the applied nutrients remained in the soil, which significantly increased the grain yield and nutrient uptake by the succeeding toria crop. The residual effects of Zn and B should be considered during fertilizer application to different crops.

Key words: Rice-toria cropping sequence; higher level of NPK, Zn and B; nutrient uptake; nutrient dynamics.

Multiple cropping using short and medium duration crop cultivars and intensive input management is practised to enhance land-use efficiency and to increase production, choice of a cropping system is very much location specific. The second most predominant cropping system followed in Assam is winter rice-toria (Ahmed and Thakur, 1998; Bonik, *et. al,* 1999). Rice in summer(*Kharif*) due to water stagnation in fields and toria in winter(*Rabi*) as rainfed crop may be the suitable combination in the prevalent soil and climatic conditions of Assam. Total area under winter rice is 18.00 lakh hectares with average productivity of less than 20q/ha.

The practice of intensive cropping for boosting food production causes marked depletion in inherent nutrient reserves in soil. Frequent Zn deficiencies were reported by Islam *et. al.*, 1997. Similarly, B deficiency was well established by Jahiruddin *el, aI.*, 1992. Chibba *el, al.*, 1989 and Houque and Jahiruddin, 1994 reported that Zn and B have residual effect on crops. Thereby, fertilizer is by and large the most important resource affecting the production and productivity of any cropping system. Judicious use of fertilizers in combination with micronutrient is required to ensure balanced nutrition as well as higher productivity. Hence, the present investigation was carried out to study the productivity and uptake pattern of winter rice-toria cropping sequence as affected by graded level of NPK fertilizer, Zn and B application.

Materials and Methods

A field experiment was conducted from 2003-04 to 2005-06 to study the effect of N,P,K, Zn and B with winter rice-toria sequence on acidic (pH 4.67,1:2.5 soil water suspension), sandy loam, aeric haplaquept soil at medium land situation in the Instructional cum

Research Farm of Assam Agricultural University, Jorhat. The site is intercepted by 94 ^{0}12$^/$ E longitude and 26^{0}47 $^/$N latitude at an elevation of 86.6metre above mean sea level.

Surface (0-0.15m) soil samples were collected from the plots before land preparation and incorporation of fertilizers ‘and were analysed for organic carbon (Walkley and Black, 1934), available nitrogen by alkaline permanganate method (Subbiah and Asija, 1956), available P by Bray method (Bray and Kurtz, 1945), available K by ammonium acetate method (Hanway and Heidel, 1952), OTPA extractable Zn by Lindsay and Norvell (1978), hot water extractable B by azomethine-H method (John *el al,* 1975) by Atomic Absorption Spectrophotometer (Pye Unicam SP- 9). Plant samples were analysed for total N,P, and K by the method as described by Jackson (1967), Zn by Oithiozone method (Shaw and Dean,1952) and B by dry ashing and determined by azomethine-H method (John *et. aI.*, 1975). The variety of winter rice was Basundhara (medium duration variety) and toria variety was TS-38.

The practice of intensive cropping for boosting food production causes marked depletion in inherent nutrient reserves in soil. Frequent Zn deficiencies were reported by different workers;similarly, B deficiency was well established. Zn and B have residual effect on crops. Thereby, fertilizer is by and large the most important resource affecting the production and productivity of any cropping system. Judicious use of fertilizers in combination with micronutrient is required to ensure balanced nutrition as well as higher productivity. Hence, the present investigation was carried out to study the productivity and uptake pattern of winter rice-toria cropping sequence as affected by graded level of NPK fertilizer, Zn and B application.

There were four treatments (Table 1) with common agronomic practices for winter rice and toria except nutrient level. In winter rice, 50% N along with full doses of phosphorus and potash was applied as basal application. The remaining one fourth of N as top dressing in tillering stage and rest one fourth was applied in panicle initiation stage. However, in case of toria 50% N and full doses of phosphorus and potash as basal application and the remaining 50% N was applied as top dressing after thirty days of sowing. The yield of both the crops was recorded after harvesting each year and data were pooled. System productivity in terms of rice equivalent yield (REY) was calculated by multiplying the economic yield of toria with price per ton of toria and divided by price per ton of rice in the local market. The benefit: cost ratio of the system was also calculated as the gross income divided by the total variable cost of cultivation of winter rice-toria cropping sequence.

Table 1. Treatment details

Treatment	Levels of NPK (kg ha^{-1})	
	Rice	**Toria**
T_1	40:20:20	40:35:15
T_2	60:20:40	60:40:40
T_3	40:20:20 + $ZnSO_4$ @ 15 kg ha^{-1} once in 3 years	40:35: 15 + Borax @ 10 kg ha^{-1} annually
T_4	80:40:40	80:40:40

After harvest of toria, soil samples were analyzed for available N, P, K, Zn and B (Table 2 and Fig 1). The experiment was laid out in randomized block design, replicated five times with 35m^2 plot size and statistical analysis was done by following standard methods.

Grain Yield

Grain yield of rice responded significantly to the applied nutrients Table 3. The highest grain yield of 4.29 ton ha-^{1} was obtained in T_4 (80:40:40 of NPK kg ha-'). The yield obtained from T_3 (having Zn and B application) was at par with that recorded with T2 (minus Zn and B application, but with higher level of NPK application) Further it was observed that' the yield recorded in T_1 was lowest (3.39 ton ha-^{l}) among all the four treatments i.e. with normal fertilizer dose.The increase in yield of rice with applied P has earlier been reported by Rajkhowa and Baroova (1992) in Assam soils. The best treatment for optimum yield of winter rice-toria cropping system was (T_4) application of 80:40:40 NPK kg ha-^{1} to both the crops of the system.

Straw yield

The highest straw yield of 5.87 ton ha-^{I} was recorded with application of higher doses of fertilizer i.e. T_4 (Table-3). But application of normal doses of fertilizer along with $ZnS0_4$ @ 15kg ha-^{1} once in every 3 years (T_3) had recorded a yield of 5.26 ton ha-^{I} which was at par with 60:20:40 application (T_2). The normal rate of application of fertilizer (T_1) produced the lowest straw yield (4.66 ton ha-^{l}).

Table 2. Soil fertility status after completion of the sequence as well as initial status

Treatment	pH	O.C	Avl. N (kg ha-^{1})	Avl. P. (kg ha-^{1})	Avl. K. (kg ha-^{1})	Avl. Zn. (mg ha-^{1})	Avl.B (mg ha-^{1})
T_1	4.66	0.66	299.6	12.26	77.2	1.59	0.54
T_2	4.64	0.66	310.2	14.12	81	1.6	0.52
T_3	4.64	0.65	322	12.16	76.8	1.93	3.45
T_4	4.62	0.66	327	17.3	84.8	1.58	0.51
Initial	4.67	0.67	303	11	76	1.73	0.55

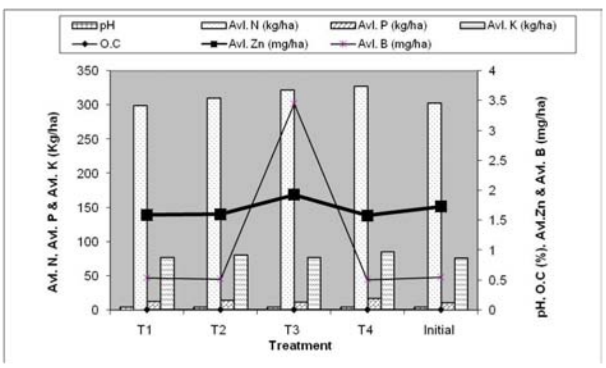

Fig. 1. Soil fertility status after completion of the sequence as well as initial status

Seed yield

The seed yield of toria increased significantly in the treatment T_4 (0.79 ton ha-^{1}). But the application of Borax @ 10 kg ha-^{I} every year along with 40:35:15 NPK kg ha-^{I} application(T_3) recorded highest toria yield (0.66 ton ha-^{l}) than yields recorded either with treatments T_2 or T_1. Such seed yield increase was expected because only the previous winter rice crop took up a small portion

Table 3. Yield of Rice andToria crops in Rice-Toria sequence under different treatments

Treatment	Rice yield (ton ha^{-1})		Toria yield (ton ha^{-1})	
	Grain	Straw	Seed	Stover
T_1	3.39	4.66	0.41	0.97
T_2	3.75	5.15	0.58	1.18
T_3	3.98	5.26	0.66	1.44
T_4	4.29	5.87	0.79	1.66
CD (P= 0.05)	18.51	1.68	2.63	1.18

of the applied nutrient and left over nutrient in the soil could have utilized by toria crop. The beneficial effect of B application on toria was also reported by Biswas *et. at.* (1995). The system productivity of winter rice-toria cropping sequence also followed the similar pattern as that of yield obtained with winter rice and toria crop individually (Table 6 and Fig 2).

Stover yield

Stover yield of toria responded signifieantly to the applied nutrients (Table 3).

The highest stover yield of 1.66 ton ha^{-I} was obtained in T_4 i.e. with higher level of fertilizer applicatIon. But the treatment T_3 i.e. application of Borax @ 10 kg ha^{-1} every year recorded significantly higher stover yield of 1.44 ton ha^{-I} in comparison to the treatments T_1 and T_2.

Nutrient uptake by rice

The nutrients viz. N, P, K, Zn and B uptake by rice after the application of fertilizers in winter rice-toria cropping sequence is presented in Table 4, which revealed highest N,P and K uptake in rice grain and straw with T_4 (receiving 80:40:40 NPK kg ha^{-1} for both the crops) followed by T_3 treatment receiving $ZnS0_4$ in winter rice @ 15 kg ha^{-1} once in 3 years (Datta and Singh, 2010). The application of Zn and B followed the similar pattern of significant increase in

Table 4. Effect of different treatments on nutrient uptake by rice under Winter rice- Toria cropping sequence from 2003-04 to 2005-06 (pooled analysis)

Treatments	Nutrient uptake (Pooled)									
	N (kg ha-')		P (kg ha-')		K (kg ha-')		Zn (mg ha-')		B (mg ha-^{I})	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
T,	23.64	20.80	9.53	3.56	12.75	28.73	276.07	392.07	107.73	146.73
T_2	27.34	24.72	10.41	4.51	14.67	32.21	302.60	423.60	118.47	158.20
T_3	27.34	24.83	10.84	4.19	14.69	32.66	375.40	507.40	135.07	181.20
T_4	36.85	34.05	13.62	7.13	60.33	42.50	366.20	511.73	139.27	181.53
CD (0.05)	14.05	13.51	5.23	5.39	8.24	16.40	213.93	268.63	56.76	80.73

the contents of Zn and B in winter rice grain and straw with highest concentration in T_4 followed by T_3. Munda *et. al.* (2008) also reported that winter rice-toria cropping sequence removed maximum NPK from soil.

Nutrient uptake by toria

The seed and stover yield of toria increased significantly in all the treatments – T_1, T_2 and T_3 while the highest were recorded in T_4 with higher fertilizer dose (Table 5). The treatment T_3 with application of Borax @ 10 kg ha-^{1} has influence on the nutrient content of both seed and stover which was at par with T_2. Similar results were also revealed by Munda *et. al. (2008).*

Soil nutrient dynamics after harvest of Toria

The application of N, P, K, Zn and B improved the available nutrient status of soil after the harvest of toria crop in winter rice-toria cropping sequence (Table 2 and Fig 1). This was due to the fact that the uptake of nutrient by winter rice and toria crop was much lower compared to the amount of nutrients applied. However, Zn and B availability showed decreasing trend as compared to initial soil test value in the

Table 5. Effect of different treatments on nutrient uptake by toria under Winter rice-Toria cropping sequence from 2003-04 to 2005-06 (pooled analysis)

Treatments	Nutrient uptake (Pooled)									
	N (kg ha-')		P (kg ha-')		K (kg ha-')		Zn (mg ha-')		B (mg ha-^{1})	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
T,	3.02	3.61	1.94	1.70	T73	3.20	25.40	43.27	20.13	31.07
T_2	4.70	5.50	2.77	2.34	2.75	4.72	36.13	59.07	29.27	42.27
T_3	4.87	5.71	3.10	2.72	2.80	5.20	42.27	70.73	42.60	66.80
T_4	6.99	8.33	4.02	3.66	3.94	6.99	51.00	80.60	42.20	61.20
Total	19.58	23.15	11.83	10.42	11.22	20.01	154.80	253.67	134.20	201.34
CD (0.05)	2.26	1.48	1.45	1.41	1.29	1.34	21.12	34.71	13.59	20.55

Table 6. Economic analysis of Winter rice-Toria sequence under different treatments

Treatments	REY (ton ha-^{1})	Gross Return (in 000'Rs.)	Total Variable cost (in 000'Rs.)	Net Return (in 000'Rs.)	B: C ratio
T_1	4.53	29.48	14.85	14.63	1.99
T_2	5.45	35.44	16.07	19.38	2.21
T_3	6.04	39.29	15.74	23.54	2.50
T_4	6.68	43.08	17.22	25.87	2.51

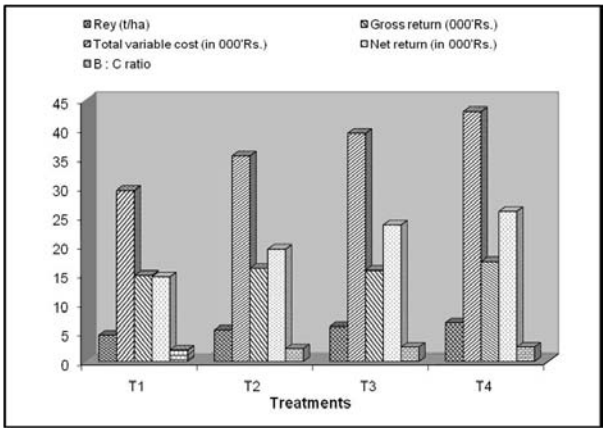

Fig. 2. Economic analysis of Winter rice-Toria sequence under different treatments

treatments where these two nutrients were not added (Table 2).

Economics of rice-toria cropping sequence

Highest net returns were obtained from winter rice-toria cropping sequence with T_4 treatment, where higher levels of fertilizers were applied (Table 6 and Fig 2). This was followed by the application of fertilizers at normal dose together with $ZnS0_4$ @ 15 kg ha-$^{-11}$ once in every three years in winter rice and B @ 10 kg ha-^{I} annually in toria crop. The net profit increased appreciably due to higher productivity which was mostly associated with residual effect as well as higher level of fertilizer to the previous crop.The highest B:C ratio (2.51) was obtained in application of higher level of fertilizer (T_4) which was at par with T_3 (2.50) receiving normal dose of fertilizer with $ZnS0_4$ @ 15 kg ha-^{1} once in three years in winter rice and Borax @ 10kg ha-^{1}annually to toria crop in winter rice-toria cropping sequence. So, the treatment T_3 was found to be more economically viable due to the lower cost incurred by fertilizer application as compared to treatment T_4 (higher level of fertilizer application). The highest B:C ratio associated with treatment T_3 was in conformity with the findings of Munda and Islam (2006) and Munda *et. al (2008).*

Conclusion

It may be concluded from the present study that highest grain yield (4.29 ton ha-^{I}) was obtained in treatment receiving 80:40:40 NPK kg ha-^{I} (T_4) and the treatment receiving 40:20:20 NPK kg ha-^{1} (T_1) was associated with lowest grain yield (3.39 ton ha-$^{-1}$). Similar observation was also recorded in case of straw yield. In case of toria crop highest seed yield (0.79 ton ha-^{1}) and stover yield (1.66 ton ha-^{1}) was associated with treatment receiving 80:40:40 NPK kg ha-^{1}(T_4) and followed by T_3 treatment (40:35:15 NPK + Borax @ 10 kg ha-^{1}) with 0.66 ton ha^{-1} seed yield and 1.44 ton ha^{-1} stover yield respectively (T_3). The highest nutrient uptake in case of both rice and toria was recorded with treatment receiving 80:40:40 NPK kg ha-^{I} (T_4) followed by T_3 and T_2. Highest soil nutrient build up was observed in treatment T_4 as most of the nutrients remain in soil in available form, which can be easily absorbed by plants. The highest net return, B:C ratio and REY obtained in application of higher level of fertilizer (T_4) was at par with application of normal dose of fertilizer together with $ZnS0_4$ @15 kg ha-^{1} once in three years to rice and Borax @ 10 kg ha-^{I} annually to toria crop in winter rice tori a cropping sequence.

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EFFECT OF PHOSPHO-COMPOST ON CROP YIELD, QUALITY AND SOIL NUTRIENT BALANCE UNDER RICE-WHEAT CROPPING SYSTEM

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Abstract

A field experiments was conducted for three consecutive years (2000-2003) at the agriculture form of Sheila Sheila Dhar Institute of Soil Science, Allahabad with an objective to study the preparation of phospho-compost and its effect on productivity of rice-wheat cropping system. The prepared phosphorus enriched compost and ordinary compost were analyzed for C, N, C: N, total phosphorus, water soluble phosphorus, citrate soluble phosphorus besides major and micronutrient content. The phosphocompost was found to be superior to FYM, ordinary compost in terms of organic carbon and total and N, Ca, Mg, K, Fe, Mn, Zn, and Cu content, and can supplement single super phosphate in field trial with rice and wheat crop. The application of phosphocmpost for supplementing inorganic P source and part of N and K was found to be effective and recorded comparable result in rice and wheat crop for plant population, grain yield, protein per cent, N and P content in crop plant and available nutrients and their balances in soil after harvesting.

Key words: Phosphocompost, quality, rice-wheat cropping system and yield

Many researches have evaluated the direct and residual effect of different dose of phosphocompost in meeting the phosphorus reqirment of crop. Combined application of organic source with phosphocompost has also been evaluated in neutral to alkaline soil. In inchubation studies rock phosphate applicarion with farm yard manure has been found to improve the available phosphorus status in soil. Rock phosphate applied along with farm yard manure, compost or sludge increased the soil available phosphorus. The dynaumis of phosphorus solubility in a puddled rice soil will be significantly different compared to normal soil because of change of pH, EC and theumod yhamics reduction sequence. Composting of agricultural wastes with rock phosphate is known to increase the solubility of the phosphate ion and availability of other major and micro elements (Tian and Kolawole 2004). An attempt was made in the present study to quantify the yield and yield attributes, quality of rice and wheat crop and nutrient balance in the puddle soil when supplemented by phosphocompost @ 5 or 10 t/ha at different proportion (1/3, ½, 2/3 & full) of recommended N and K fertilizers and was compared with the application of ordinary compost.

Materials and Methods

The field experiment was conducted during 200-2003 at the agriculture farm of Sheila Dhar Institute of Soil Science, Allahabad University, at the Institute research farm (82.52^0 longitudes and 25.10^0 N latitude), Allahabad. The detailed chemical analysis of soil and plant sample was carried out at Indian Institute of Vegetable Research, Varanasi during 2003-04. 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 25⁰C - 0.45 (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 Aluminum and Iron bound phosphorus 57.9 mg kg^{-1}, phosphorus occluded within iron oxides and hydrous oxides-10 mg kg^{-1}, calcium-bound phosphorus-315.8 mg kg^{-1}, Smectite-9%, Chlorite-18%, Illite-45%, Kaolinite-26%, Vermiculite-1%. Low cost, easily available inputs like decomposable farm waste+ urine and fresh cow dung, green weeds + water hyacinth, rice and wheat straw at the ratio 80:10:10 was used as substrate and allowed for composting with Missouri rock phosphate (MRP) @2 per cent P_2O_5 (MRP) kg per 100 kg substrate for 120 days. The prepared phosphorus enriched compost and ordinary compost were analyzed for carbon, nitrogen, C: N ratio, total and different fraction of phosphorus, besides major and micro nutrients. The detailed methodology on preparation of phosphocompost (PC) and analysis of physio-chemical properties has been described elsewhere (Sahu and Jana 2000). The compost sample obtained after 120 days of decomposition were used to quantity its effect on the yield of rice and wheat in field experiment during the Kharif and Ravi season. A set of eleven treatment combinations comprising recommended nitrogen, phosphorus and potash level, 33%, 50% and 75% of recommended nitrogen, potash and no inorganic phosphorus fertilizer, supplemented by phosphocompost (PC) either @ 5t/ha or @ 10t/ha alone or combination were tested in a randomized block design with three replications. The size of each plote was 5m² recommended agronomic practices and plant protection measures were fallowed. The treatment details were as follows: Tc, Compost @ 5t/ha, T_1, phosphocompost @ 10 t/ha, T_2, Nitrogen: Phosphorus: Potash @ 120:60:60 kg/ha, T_3, Nitrogen & Potash @ 120 and 60 kg + phosphocompost @ 5 t/ha, T_4, Nitrogen & Potash @ 120 and 60 kg + phosphocompost @ 10 t/ha, T_5, Nitrogen & Potash @ 60 and 30kg + phosphocompost @ 5 t/ha, T_6, Nitrogen & Potash @ 60 and 30 kg + phosphocompost @ 10 t/ha, T_7, Nitrogen & Potash @ 40 and 20 kg + phosphocompost @ 5 t /ha, T_8, Nitrogen & Potash @ 40 and 20 kg + phosphocompost @10 t/ha, T_9, Nitrogen & Potash @ 80 and 40 kg + phosphocompost @5 t/ha T_{10}, Nitrogen & Potash @80 and 40 kg + phosphocompost @ 10 t/ha.. The test crop varieties Saket-4 of rice and K-68 of wheat. The standard agronomical practice irrigation and crop management were followed to raise a good crop stand. Observation on panicle length (cm), number of grain/ panicle, 1000 seed weight and yield recorded following the standard methodology. The above ground parts of the plant were harvested and the weight of grain and straw were recorded separately for each treatment. The soil samples were collected from field before start of the experiment and after harvesting of the crop. The phosphorus content in different stage, nitrogen and phosphorus content in grain and straw were determined.. The plant and soil samples were digested in di-acid mixture in an automated digester following standard methodology (Novozamsky et al., 1983). The N content in grain and straw and protein content in grain was determined by digestion, micro Kjeldhal distillation and titration following the standard methodology in a kjeldhal-N analyzer (FOSS-TECATOR) system. The protein content in grain and straw was estimated by multiplying N content with a conversion factor of 6.24. The phosphorus content was determined by phospho-molybdic blue color method (Jackson, 1973). The potassium content was measured on a flame photometer (Chemito, India). using neutral 1N NH_4OAC as extracting. The statistical analysis of the data was carried procedure describe by

Results and Discussion

Effect of P-enrichment on quality of phosphor-compost

The physico-chemical properties of P-enriched compost and ordinary compost were significantly different. The P-enrichment with rock phosphate during composting enhanced the concentration of Ca, Mg and micronutrients particularly Fe and Mn in phosphocompost. A significantly high water soluble P (42.6%), organic carbon (16.7%), total Ca (28.6%), total Mg (50%), and 1.5 to 2.8 fold increase in micronutrient (Zn, Cu, Mn and Fe) content was noted in phosphor-compost as compared to ordinary compost (Table1). This was primarily due to the presence of calcium carbonates and salts of Fe, Mg, Zn, Cu and Mn in the rock phosphate, and microbial dissolution via formation of organic acids (Sreenivas and Narayanasamy, 2003).

Effect of phosphor-compost on yield attributes and yield

The effect of phosphocompost on yield attributes of rice and wheat viz. plant population/m^2, Panicle length (cm), number of grain/ panicle, 1000 seed weight and yield were significantly higher when treated with recommended N K@120: 60 kg/ha plus phosphocompost @ 10t/ha as compared

Table 1. Physico-chemical properties of ordinary compost and phosphor-compost

Nutrient status	Ordinary compost	Phospho-compost	% increase
pH	6.70	7.1	6
Organic carbon (%)	13.76	16.07	17
Total N (%)	0.58	0.76	31
Total K (%)	0.89	0.96	8
Total P (%)	0.63	2.28	262
Water-soluble P (%)	0.061	0.087	42.1
Citrate soluble P (%)	0.069	0.67	71
Total Ca (%)	1.78	2.29	29
Total Mg (%)	0.32	0.48	50
Fe (ppm)	5072	12700	150
Mn (ppm)	178	498	180
Zn (ppm)	56	86	50
Cu (ppm)	9	22	140

to recommended NPK @ 120:60:60 kg/ha level of nutrition. Application of recommended dose NK and 10 tones /ha of phosphor-compost increased the panicle length (cm) 44.2 and 40.17%, number of grain/ panicle 20.84 and 31.45%, 1000seed weight by 34.77 and 32.23%,plant population/m^2 38.3 and 58.06%, grain yield by 76.35 and 46.98% and straw yield by 72.57 and 68.53% over the control i.e. compost @ 5t/ha. The yield and yield attributes of rice and wheat was significantly effected by partial or complete supplementation of nutrient N, P and K by incorporation of phosphocompost @ 5 or 10t/ha in combination with inorganic N and K fertilizer (Table 2), which corroborate with the findings of Whitbread et. al. 1999, Tian and Kalawole, 2004. Application of phosphocompost @ 10 t/ ha could supplement 33% of recommended inorganic N and K and 100% of P fertilizer as evidenced through at par grain and straw yield. The yield performance under combined application of phosphocompost @ 5t/ha with 2/3rd of recommended N, K was at par to ½ of recommended N, K indicating that a maximum of 50% recommended dose of N, K and 100% of inorganic P fertilizer could be supplemented by addition of phosphocompost @ 5t/ha. A comparison of yield data indicated that application of low input i.e. half of recommended dose of N&K with phosphocompost @ 5t/ ha could fetched 90% of actual yield realized under recommended N, P & K fertilization in rice and wheat (Table-2). Similar results regarding application of

Table 2. Effect of phosphor-compost supplementation on yield and yield attributes of rice-wheat crop.

Treatment details	Plant Population/ m^2		Panicle Length (cm)		No of Grain/ Panicle		1000 seed Weight (g)		Yield q/ha Grain		C: B ratio	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Compost @ 5 t/ha	250	62	17.42	6.82	78.35	41.24	13.92	33.85	20.3	24.9	1:1.39	1:1.6
PC @ 10 t/ha	286	70	20.34	7.02	85.37	43.17	1561	36.27	22.5	28.5	1:1.62	1:2.1
N P K @ 120:60:60	319	86	23.97	8.65	88.12	48.54	15.74	38.56	34.35	33.9	1:2.46	1:2.8
N120, K60 & PC @ 5 t/ha	340	81	20.65	8.11	87.76	46.97	16.95	37.74	30.4	32.7	1:1.79	1:2.6
N120, K60 & PC @ 10 t/ha	3521	98	25.12	9.56	94.68	54.21	18.79	44.76	35.8	36.6	1:1.80	1:2.5
N60, K60 & PC @ 5 t/ha	310	84	21.67	7.21	83.11	46.89	15.68	36.95	28.1	30.4	1:2.31	1:2.8
N60, K60 & PC @ 10 t/ha	332	88	22.39	7.82	87.68	48.75	16.57	39.75	30.6	31.1	1:1.97	1:2.0
N40, K20 & PC @ 5 t/ha	28	79	19.54	7.00	8125	44.20	14.32	36.41	24.5	26.9	1:1.99	1:2.1
N40, K20 & PC @ 10 t/ha	293	82	20.86	7.50	84.36	48.12	14.97	38.64	26.6	28.8	1:1.87	1:1.9
N80, K40 & PC @ 5 t/ha	325	89	21.22	7.91	87.43	40.85	16.26	40.86	34.4	30.2	1:2.22	1:2.7
N80, K40 & PC @ 10 t/ha	338	93	23.87	8.61	86.78	41.51	17.68	41.51	35.1	33.5	1:2.12	1:2.2
CD at 5%	28.23	-	2.07	-	1032	-	1.08	2.34	0.624	1.77		

phosphocompost or single super phosphate has been also reported by Nazirkar et al., 2004.

Effect of phosphor-compost on nutrients uptake

The phosphorus and nitrogen uptake by grain and straw was found to follow the similar trend of P content in grain and straw and was correlated significantly with their respective yield. The N and P content in grain and straw at different stage of growth as influenced by alone or combined application or phosphocompost with inorganic N&K fertilizers have been presented. (Table 3). The steady decrease in available soil P and successive increase in P content in rice plant tissue from active tillering to grain development stage in the present study was in conformity with earlier works of Waigwa et al., 2003. The increased uptake of phosphate ions by plants from active tillering to grain development stage was further evidenced in the higher P content in grain as compared to straw in rice crop. The N content in grain was significantly higher than the N content in straw. Phosphorus nutrition had significant impact on protein content (31.37 and 21.81% increase) of rice and wheat grain when applied nutrient levels proved

Table 3. Effect of phosphor-compost supplementation on nitrogen, phosphorus, and protein content (%) in rice and wheat crop.

Treatments Details	Protein content in Grain (%)		P Content percent				N Content percent			
			Grain		Straw		Grain		Straw	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
Compost @ 5 t/ha	5.1	12.24	0256	0.20	0.046	0043	1.22	1.02	0.20	0.09
PC @ 10 t/ha	5.7	13.12	0277	021	0053	0052	1.24	1.04	0.19	0.11
N P K @ 120:60:60	6.1	13.16	0298	023	0.079	0078	1.36	1 16	0.27	0.19
N120, K60 & PC @ 5 t/ha	6.1	13.62	0.310	0.25	0.054	0.050	122	1.12	0.24	0.9
N120, K60 & PC @ 10 t/ha	6.7	14.91	0.350	0.26	0.086	(J.081	1.19	1.09	029	0.17
N60, K60 & PC @ 5 t/ha	60	12.85	0.285	0.23	0057	0052	1.17	107	02()	0.10
N60, K60 & PC @ 10 t/ha	6.1	12.76	0.315	024	(J054	0053	1.24	1 14	0 30	0.20
N40, K20 & PC @ 5 t/ha	5.3	13.01	0275	0.21	0.043	0.045	1.29	121	0.29	0.14
N40, K20 & PC @ 10 t/ha	5.6	12.81	0.300	0.23	0.051	0.048	1.26	I 16	0.28	0.16
N80, K40 & PC @ 5 t/ha	6.1	12.95	0.320	024	0.065	0.061	1.28	120	0.24	0.15
N80, K40 & PC @ 10 t/ha	6.3	13.52	0.338	0.26	0.070	66	121	1.15	0.27	0.17
SE	0.41	0.58	0.023	0.025	0.0031	00025	0.029	0028	0.018	
CD at 5%	1.82	2.15	0.058	0.053	O,()O48	00053	0.062	0059	0.033	

sufficient to meet the need of the crop and luxury consumption resulted in increased root growth, plant growth, enzyme activation, better resistance in plant to insect-pests and diseases as compared to a P deficient crop (Phongpan et al. 2002).

No significant variation in protein content of rice and wheat grain unlike yield was evidenced when exposed to different treatment combination of phosphor-compost alone or in combination with inorganic N&K fertilizer. However, the protein content was significantly higher (31.37 and 21.81%) in crop when treated with N, K recommended + phosphor-compost @10t/ha and compared with the treatment control i.e. only compost @ 5t/ha. A significant variation in P content and no variation in N content either in grain or in straw was evidenced across the applied treatments under which the crop grown. The result indicated that the protein content in rice grain was improved significantly only when the nutrients available in the labile pool crossed a minimum threshold value for ready uptake by the crop (Rahman et al., 2003).

Effect of phosphor-compost on soil nutrients status

There was a build up in soil-nutrient status in succeeding crop under treatments where phosphor-compost was added @ 10t/ha in combination with inorganic fertilizers (Table-5). The nutrient balance sheet for available N, P and K was marginally on positive side with supplementation of phosphocompost @ 5t/ha plus half of recommended N&K. A negative nutrient balance was evidenced when the crop was grow under lone application of compost @ 5t/ha and /or phosphocompost @10t/ha or combined application of 1/3rd recommended N&K with phosphocompost @5t/ha. The organic carbon content in soil was

Table 4. Nutrients in soil after harvesting of rice-wheat

Treatments details	pH	Organic carbon (%)	Nitrogen (kg/ha)	Phosphorus (kg/ha)	Potash (kg/ha)
Compost @ 5 t/ha	7.4	0.54	80.15	19.15	213.64
PC @ 10 t/ha	7.2	0.58	118.97	15.87	226.85
N P K @ 120:60:60	7.2	0.60	130.52	15.95	237.58
N120, K60 & PC @ 5 t/ha	7.3	0.67	135.98	22.31	244.62
N120, K60 & PC @ 10 t/ha	7.1	0.73	161.54	24.65	252.31
N60, K60 & PC @ 5 t/ha	7.2	0.63	128.83	21.00	235.41
N60, K60 & PC @ 10 t/ha	7.3	0.66	137.48	22.41	238.64
N40, K20 & PC @ 5 t/ha	7.1	0.62	121.94	15.32	229.81
N40, K20 & PC @ 10 t/ha	7.2	0.62	123.51	16.52	231.94
N80, K40 & PC @ 5 t/ha	7.2	0.66	138.46	21.85	240.68
N80, K40 & PC @ 10 t/ha	7.5	0.69	142.12	23.96	248.10
LSD 0.05	0.31	0.52	10.11	0.28	15.21

increased under addition of phosphocompost @ 10t/ha over the recommended N&K level. These findings are agreement with the earlier works of Mishra et al., 2002, and Manna et al., 2003.

ACKNOWLEDGEMENT

We are thankful to Dr. Nirmal De, IAS, BHU for providing technical help.

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J. Farming Systems Research & Development **19** (1) : 51-54 (2013)

ON FARM EVALUATION OF BALANCE NUTRITION EFFECT ON PRODUCTIVITY AND PROFITABILITY OF MENTHOL MINT (*MENTHA ARVENSIS*) IN MID WESTERN PLAIN ZONE OF UTTAR PRADESH

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ABSTRACT

On Farm trials were conducted at farmer's fields at different locations in Budaun district of Uttar Pradesh during three consecutive *Zaid* seasons of 2009 to 2011. The trial were conducted in Randomized Block Design with 3 doses of fertilizers *viz.*, Farmers' practice (N-100, P_2O_5-50 kg ha^{-1}), Recommended dose of NPK (N-120, P_2O_5-60 and K-60 kg ha^{-1}) and Recommended dose of NPK + Zinc sulphate (20 kg ha^{-1}) replicated five times. The soil of the experimental fields was sandy loam in texture, with slightly alkaline in reaction (pH 7.8) and were low in organic carbon (0.27%) and medium in phosphorus (41 kg P_2O_5 ha^{-1}) and low in potassium (132 kg ha^{-1}). The results indicated that the growth, green foliage and oil yield of mentha were significantly affected due to application of recommended dose of fertilizers as compared to farmer's practice. Application of recommended dose of NPK along with Zinc sulphate (20 kg ha^{-1}) being at par with recommended dose of NPK, produced highest and significantly higher green foliage yield (244 qha^{-1}), oil yield (99.5 kg ha^{-1}) as well as net return (Rs. 42961 ha^{-1}) and cost benefit ratio (2.17) as compared to farmers' practice (216 qha^{-1}, 82.7 kg ha^{-1}, Rs. 31194 ha^{-1} and 1.89, respectively). Further recommended dose of NPK also gave significantly higher green foliage yield (235 qha^{-1}), oil yield (95.4 kg ha^{-1}) as well as net return (Rs. 40436 ha^{-1}) and cost benefit ratio (2.13) as compared to farmers' practice.

Key Words: Aromatic, Bergamot mint, Essential oil, Medicinal, Mentha, Menthol, Mint, Peppermint, Perennial herb, Spearmint, Quality.

Japanese Mint (*Mentha arvensis var piperascense*) is an aromatic perennial herb, grown as an annual in sub-tropical parts of north India. The over-ground herb (foliage) on distillation yields an essential oil, containing high (75 – 80%) menthol content. The oil has a bitter cooling taste, harsh odour and is the principal source of menthol. It is used in combating cold, used as an ingredient in cough drops and related pharmaceuticals, dentifrices, cosmetics, mouth washes, scenting of tobacco products and flavouring of beverages. Synthetic menthol has also come in market but its volumes are meagre due to high cost of production. Besides, natural menthol is preferred in food and flavour industry.

Mints belong to the genus *Mentha*, in the family Labiatae (Lamiaceae) which includes other commonly grown essential oil-yielding plants such as basil, sage, rosemary, marjoram, lavender, pennyroyal and thyme. Within the genus *Mentha*, there are several commercially grown species, varying in their major chemical content, aroma and end use. Their oils and derived aroma compounds are traded world-wide. The four most commonly cultivated species are Japanese Mint/Menthol Mint (*M.arvensis*), Peppermint

(*M.piperita*), Spearmint (*M. spicata*) and Bergamot mint (*M. citrata*). All are herbaceous plants, readily sending out runners (rainy season) and stolons (winter), which develop new roots and shoots at the nodes and form plants. The entire aerial shoots together with foliage is a source of essential oil rich in menthol, carvone, linalool and linanyl acetate having use in pharmaceutical preparations and flavour industry.

For the past four decades, mints are commercially cultivated in India. Of these, the Japanese Mint, yielding menthol is grown extensively in northern India especially in Uttar Pradesh and Uttrakhand States. At present, Japnese mint is cultivated in India on about 60,000 hactare area of land with estimated production of 12,000 tonnes of mint oil which accounts for about 75% of total menthol mint production in the world. Other major producing countries are China and Brazil and to a smaller extent Thailand and Vietnam. The cultivation of Japanese or corn mint originated from Brazil and China. Subsequently, China and India overtook Brazil and more recently India has taken the leading position in cultivation of this essential oil yielding plant.

A large part of the country's oil production is exported. It meets fierce competition in trade with China. The crop has of late involved a large sector in processing and trade activity in several small towns of Uttar Pradesh (Rampur, Sambhal, Chandausi, Badaun, and Barabanki). A large number of farmers, traders, distillers and exporters are associated with this activity. The investment in the industry is estimated at Rs.350 crores.

India has attained position of primary and dominant source of mint oil and menthol in the world market, replacing China to a great extent due to (lower) price structure and comparable quality. The rising input cost and expensive labour in South China, its cultivation there could presumably shrink and consequently Indian mint may find increasing larger market in next several years. There can be significant increase in area of cultivation due to this. The country has evolved a number of new high yielding varieties which has helped to maintain India in a lead position.

Mentha is heavy feeder of nutrients spatially NPK including micronutrients. However, little work has been done on balanced nutrition for the crop to get maximum yield at farmer's fields for obtaining higher profit to the farmer in actual farm situations. Keeping this in view, an On Farm Trial were conducted at farmer's fields to evaluate the effect of balanced nutrition of productivity and profotability of Menthol Mint (*Mentha arvensis*) in Mid Western Plain Zone of Uttar Pradesh

Materials and Methods

On Farm trials were conducted at farmer's fields at different locations in Budaun district of Uttar Pradesh by scientists of *Krishi Vigyan Kendra, Budaun* during three consecutive *Zaid* seasons of 2009 to 2011 to evaluate the effect of balance nutrition on productivity and profitability of Menthol Mint (*Mentha arvensis*). District Budaun comes under Mid Western Plain Zone of Uttar Pradesh having light soils suited for pearlmillet, wheat, potato, sugarcane as well as mentha cultivation. The temperature ranges from 4.5 ^{0}C to 45.4 ^{0}C. Rainfall in this region is received during mid June to mid October with annual average rainfall 882 mm.

The soils of the experimental fields were sandy loam in texture, with slightly alkaline in reaction (pH 7.9) and were low in organic carbon (0.27%) and medium in phosphorus (41 kg P_2O_5 ha^{-1}) and low in potassium (132 kg ha^{-1}). The trials were conducted with 3 doses of fertilizers *viz.*, Farmers' practice (N-100, P_2O_5-50 kg ha^{-1}), Recommended dose of NPK (N-120, P_2O_5-60 and K-60 kg ha^{-1}) and Recommended dose of NPK + Zinc sulphate (20 kg ha^{-1}) in Randomized Block Design replicated five times.

Mentha variety "Shivalik" was planted by roots (rhizomes) at the rate of 4.5 quintals per hectare in first week of February during all the years of conducting trials. The planting was done in furrows opened by bullock drawn plough '*desi hal*' at 50 cm spacing with 4-5 cm depth covered with loose soil. One third of nitrogen and full dose of phosphorus, potash and zinc sulphate were applied as basal according to need of different treatments. A light irrigation was given immediately after planting of roots. Remaining amount of nitrogen was applied in two splits at 30 and 60 days after planting of crop. All other recommended practices like weeding, irrigation, plant protection measures were followed as per the requirement of the crop. The fresh foliage of the crop was harvested in first week of June during all the years and essential oil was extracted in mentha oil extraction plant situated near the trial field and obtained the quantity on unit area basis. Statistical analysis of pooled data of three years was done following the procedure depicted in Panse and Sukhatme (1976).

Results and Discussion

The results (Table-1) indicated that the plant height, green foliage and oil yield of mentha were significantly affected due to application of recommended dose of fertilizers as

Table 1. Effect of balance nutrition on growth, green foliage/fresh matter yield, oil yield and economics of mentha

(Pooled of 03 years)

Treatment	**Dose (kg/ha)**	**Plant height harvest (cm)**	**Green foliage/ fresh matter yield (q ha^{-1})**	**Oil (q ha^{-1})**	**Gross return**	**Cost of cultivation (Rs ha^{-1})**	**Net return (Rs ha^{-1})**	**B:C ratio (Rs ha^{-1})**
Farmers practice	N-100, P_2O_5-50	58.9	216	82.7	66180	34986	31194	1.89
Recommended dose	N-120, P_2O_5-60 and K-60	64.1	235	95.4	76340	35904	40436	2.13
RD + ZnSO4	N-120, P_2O_5-60, K-60 kg & Zinc sulphate (20)	66.0	244	99.5	79640	36679	42961	2.17
CD (P=0.05)		4.92	17.4	11.3	9869	4752	4179	0.22

Note – Sale price for mentha oil was Rs. 800/- per Kg.

compared to farmer's practice. Application of recommended dose of NPK (N-120, P_2O_5-60 and K-60 kg ha^{-1}) along with 20 kg ha^{-1} Zinc sulphate being at par with recommended dose of NPK (N-120, P_2O_5-60 and K-60 kg ha^{-1}), produced highest and significantly higher green foliage yield (244 qha^{-1}) and oil yield (99.5 kg ha^{-1}) as compared to farmers' practice *viz,* N-100, P_2O_5-50 kg ha^{-1} (216 and 82.7, respectively). The increase in green foliage and oil yield with the application of recommended dose of NPK along with 20 kg ha^{-1} Zinc sulphate was 12.96 and 20.31 percent as compared to farmers' practice and 3.83 and 4.30 percent over recommended dose of NPK (N-120, P_2O_5-60 and K-60 kg ha^{-1}) only. Further, recommended dose of NPK (N-120, P_2O_5-60 and K-60 kg ha^{-1}) also gave significantly higher green foliage yield (235qha^{-1}) and oil yield (95.4 kg ha^{-1}) as compared to farmers' practice. The percent increase in green foliage yield and oil yield due to application of recommended dose of NPK was 8.80 and 15.36, respectively over farmers' practice. These results are in conformity with those of Anwar *et al.* (2002, 2010) and Patra *et al.*(1998) who observed the highest fresh foliage and oil yield at Lucknow and Pantnagar conditions with the application of NPK (150:60:60 kg ha^{-1}).

Similarly, economics of mentha cultivation also affected significantly due to application of higher doses of fertilizers as compared to farmers practice because returns from a crop directly related to its yield (Table-1). Significantly higher gross return (Rs.79640 ha^{-1}), net return (Rs.42961 ha^{-1}) as well as B: C ratio (2.17) were obtained with the application of recommended dose of NPK (N-120, P_2O_5-60 and K-60 kg ha^{-1}) along with Zinc sulphate (20 kg ha^{-1}) as compared to farmers' practice (Rs.66180 ha^{-1}, Rs.31194 ha^{-1} and 1.89, respectively). However, recommended dose of NPK also gave significantly higher gross reture (Rs.76340 ha^{-1}), net return (Rs. 40436 ha^{-1}) and cost benefit ratio (2.13) as compared to farmers' practice.

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J. Farming Systems Research & Development **19** (1) : 55-60 (2013)

ROLE OF FENVALERATE ON GROWTH AND YIELD OF COTTON (*GOSSYPIUM HIRSUTUM* L.)

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Abstract

Cotton is the most important cash crop. Cotton constitutes more than 70% of the total world consumption of fibres. Cotton is reported to be a host for about 166 different species of insect pests throughout its growth cycle. The major pests of cotton are causing considerable economic losses to the crop production. The cotton farmers incur heavy losses on the crop due to these factors. Saubhagya variety of *Gossypium hirsutum* was selected to carry out the research work during the period of 2004-2007. Variety LRK 516 is used as a check variety with known characters. Cotton crop is highly susceptible to various insects' pests. About 166 different species of insects' pests are reported to attack cotton at various stages of its growth. Amongst these the cotton bollworm *Helicoverpa armigera*, the Whitefly *Bemisia tabaci, Jassids, Aphids*, *Empoasca devastans* and the pink bollworm (*Pectinophora gossypiella)* have been causing economic damage to cotton crop all over the country. However, by the end of the first 60-75 days, Fenvalerate treated cotton fields were looking as good as those which were unsprayed. This elicited a strong positive response. Fenvalerate is a synthetic compound primarily used as an insecticide. It acts as a fast-acting neurotoxin in insects. It is easily degraded on soil and plants.

Keywords : *Gossypium hirsutum,* Fenvalerate sprays, morphological characters and yield

Cotton *(Gossypium hirsutum)* is one of the main cash crops and a major contributor to financial stability and economic viability of India. A number of sucking insect-pests are associated with American cotton *(Gossypium hirsutum L.)* in India. Cotton is reported to be a host for about 166 different species of insect pests throughout its growth cycle. The major pests of cotton are causing considerable economic losses to the crop production. Amongst these the cotton bollworm (*Helicoverpa armigera)*, the Whitefly (*Bemisia tabaci), Jassids*, *Aphids*, *Empoasca devastans* and the pink bollworm (*Pectinophora gossypiella)* have been causing economic damage to cotton crop all over the country. It has developed a high degree of resistance against several chemical classes (Denoholm *et al.*, 1998; Elbert and Nauen, 2000). Therefore, in an effort to find an effective chemical against this pest, Fenvalerate (10 EC), a synthetic pesticide, was evaluated to assess the response of pest population.

Cotton crop is highly susceptible to various insects' Pests. Because insecticides had been recognized universally as easy, convenient and effective pest control options, farmers were enthusiastically using them to reap good benefits. Overuse and misuse of insecticides led to problems of harmful residues, pest resurgence, development

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insect resistance to insecticides and ecological upheavals. Because of insect problem, cotton is also known to be consuming half of the total pesticides used in this country. (Elliot, M., Janes, N. F., & Potter, C., 1992).

The pest population has to be curtailed to a minimum biological activity to avoid economic loss to crop fields. The objective of Fenvalerate application, besides keeping the pest population under check should also be to avoid the pollution and damage to the non-targets. Keeping in view the importance of this treatment, the present study was carried out to assess the effects of Fenvalerate on growth and yield of cotton.

MATERIAL AND METHOD

The experiment was carried out in fields at Institute of Science, Nagpur University, Nagpur during 2005-2007. A randomized complete block design, replicated three times, was used. Individual plots consisted of ten rows, 5 m long and 50 cm apart. Plants within the rows were 20 cm apart maintaining 25 hills/row. Block to block and plot to plot distance were 3 m and 2 m, respectively. Saubhagya variety (*Gossypium hirsutum)* was used as planting material. Variety LRK 516 was used as a check variety with known characters. Seeds were sown at the rate of 3-4 seeds/hill. Watering was done immediately after sowing. Plots were hand-weeded at 14, 28 and 42 DAP (days after planting). Thinning to two plants per hill was done at 14 DAP. Compost was applied as basal treatment at the rate of 15.9 t/ha before land preparation. Side dressings were applied at 15, 30 and 45 DAP with NPK of 15-15-15, 12-24-12 and 13-21-13 at the rate of 312.5, 187.5 and 187.5 kg/ha, respectively.

The experiment consisted of three insecticidal treatments including control. Insecticide used was Fenvalerate 10 EC. Insecticide applications were made at 30, 60 and 90 DAP using a knapsack sprayer. The rate of applications were 1 l/ha, in 400 liters of water for Fenvalerate. Adjuvant (IBA spreader) was added to spray volume at the rate of 0.5 ml/liter for better adhesion of insecticides on plant surface.

Data were collected on second day after application of each spray. For this purpose, 20 plants per plot were randomly selected for counting larvae and adults and observing the morphological characters and yield. The efficacy of insecticide Fenvalerate was calculated by comparing them with the untreated control plot.

The following morphological characters and fiber properties were taken in consideration for these two varieties. These are - plant height, number of nodes on the main stem, monopodia and sympodia, number of leaves per plant, boll number per plant, boll weight, and yield. The monopodia, sympodia and number of leaves were counted separately in five tagged plants and average number was recorded at the time of harvest. The average plant height in cm of five tagged plants was recorded at harvest from the base of the plants to the growing tip.

RESULTS AND DISCUSSION

The efficacy of Fenvalerate was investigated in the field for controlling insect pests of *Gossypium hirsutum* variety Surabhi in two growing seasons. It was observed that the Fenvalerate significantly reduced population of bollworm, (*Helicoverpa armigera)*, and the Whitefly (*Bemisia tabaci), Jassids, Aphids*, *Empoasca devastans* and the pink bollworm (*Pectinophora gossypiella)* compared to control.

Fenvalerate showed the highest growth and yield and reduction of pests population among the treatments. Fenvalerate showed significant difference over all treatments on 90 DAP and significant difference was observed among the others controlled plants. All treated lines were found on par with each other and significantly superior to the control on 90 DAP. On the other hand, all treatments significantly suppressed the pests population and increase the growth and yield over the control on 90 DAP but no significant difference was observed in control lines.

It is estimated that the plant height in Saubhagya plant ($SauT_1R_1F$) was found to be high (112 cm.) by treatment with insecticide Fenvalerate. The number of monopodia and sympodia were higher in treated variety Saubhagya. The results obtained were compared with check variety LRA- 516, which are presented in Table 1.

Yield and yield parameters like boll weight, seed index, ginning out turn, lint index, 2.5% span length, uniformity ratio, micronaire value, fiber strength were found higher and promising in treated lines. In Saubhagya variety ($SauT_2R_2F$) treated with Fenvalerate, the average yield was found to be as high as 16.25 g which also has higher boll weight (4.31 g), seed index (8.53g), GOT (40.98%), lint index (4.58 g) (Table. 2).

The traits 2.5% span length, Uniformity ratio, micronaire value and

Table 1. Mean value showing variation in growth characters under study by treatment with Fenvalerate

Name of treatments	Plant Height (cm)	No. of monopodia	No. of sympodia
$SauUT_1R_1$	92	2	13
$SauUT_2R_2$	96	1	11
$SauUT_3R_3$	95	1	10
$SauT_1R_1F$	112	4	18
$SauT_2R_2F$	110	5	16
$SauT_3R_3F$	98	5	15
$L\ UT_1R_1$	92	1	10
$L\ UT_2R_2$	98	3	11
$L\ UT_3R_3$	110	2	12
$L\ T_1R_1F$	123	5	15
$L\ T_2R_2F$	134	6	16
$L\ T_3R_3F$	137	5	14

Sau - Saubhagya; L – LRK 516; UT – Untreated controlled plant; T – Treated with insecticides; F- Fenvalerate; R – No. of replication

Table 2. Mean value showing variation in yield and yield parameters under study after treatment with Fenvalerate

Name of treatments	Boll Weight (g)	Seed index (g)	Ginning Out Turn (%)	Lint Index (g)	2.5% span length (mm)	Uniformity Ration	Micronaire	Fibre Strength	Yield per plant (g)
$SauUT_1R_1$	2.32	5.45	30.81	3.23	24.27	43	3.8	18.1	7.04
$SauUT_2R_2$	3.41	4.25	32.52	3.43	24.18	46	3.6	18.5	5.62
$SauUT_3R_3$	3.71	5.36	36.25	3.21	25.30	47	3.3	17.5	6.25
$SauT_1R_1F$	4.28	8.36	40.52	4.56	25.43	52	4.3	22.3	15.23
$SauT_2R_2F$	4.31	8.53	40.98	4.58	26.57	49	4.7	23.9	16.25
$SauT_3R_3F$	4.08	8.2 6	40.50	4.65	24.05	51	4.8	21.7	15.25
$L\ UT_1R_1$	4.25	7.36	40.26	4.29	23.52	44	2.6	17.8	9.63
$L\ UT_2R_2$	4.28	7.52	32.25	4.38	23.54	43	2.8	17.9	8.56
$L\ UT_3R_3$	3.61	7.58	38.45	4.59	26.58	48	3.3	18.6	10.25
$L\ T_1R_1F$	4.51	8.36	42.25	5.32	25.75	51	4.9	25.5	11.23
$L\ T_2R_2F$	4.42	8.52	41.26	4.58	26.54	53	4.6	24.6	15.21
$L\ T_3R_3F$	4.32	8.42	41.85	4.62	27.85	51	4.8	25.8	15.85

Sau - Saubhagya; L – LRK 516; UT – Untreated controlled plant; T – Treated with insecticides; F- Fenvalerate; R – No. of replication

fibre strength was found to be higher as compared to untreated lines of Saubhagya.

In all the treated plants, insecticides treatment provided significantly better control over the pest population at 30, 60 and 90 DAS after sprays. Plants sprayed with Fenvalerate generally continued to maintain significantly low population of the pest than the control. Pest population on the crop was quite low and in several plots it reached zero after spray. Fenvalerate suppressed the pest for a longer duration and showed promising growth and yield in Surabhi variety.

Russell, and Kranthi, (2006) also made similar observations who stated that whitefly; thrips population was low at a faster rate in insecticide treated plots than untreated control plots. Other workers have reported that Fenvalerate was effective against these pests – *bollworms, Bemisia tabaci, thrips, aphids* etc. (Attique and Ghaffar, 1996). Highest yield was recorded in Fenvalerate treated plot which differed significantly from controlled lines.

It was obvious from the experiment that Fenvalerate provided better control by reducing insect pests in and increase in the growth and yield. Reduced population of bollworm, *Helicoverpa armigera*, the Whitefly *Bemisia tabaci, Jassids*, *Aphids*, *Empoasca devastans* and the pink bollworm *Pectinophora gossypiella* were observed at all sampling days in Fenvalerate treated plots. Field and green house studies were conducted by Jiang *et al.* (1999) and they reported that alpha-Fenvalerate 5% EC was effective in controlling *Helicoverpa armigera, Jassids* and aphids and increasing the yield and morphological characters. A field evaluation of some insecticides was made by Uddin *et al.* (1993) and Slosser, *et al.* (2000) for the control of spotted pod borer in the field of cowpea in Bangladesh. They reported that the best control of this pest was achieved by three sprays of Fenvalerate (0.007%).

Our investigation also showed less number of infested pods caused by *Empoasca. zinckenella* in Fenvalerate treated plots. The effect of contact as well as systemic insecticides on pests population of *Ophiomyia phaseoli* (Tryon) (Diptera: Agromyzidae) in soybean was investigated by Gohokar *et al.* (1985). The effectiveness of some insecticides against the *H. armigera* on gram (*Cicer arietinum*) was evaluated in the field studies in Maharastra, India by Gohokar *et al.* (1985) and Russell and Kranthi, (2006). They observed that the application of 0.009% Fenvalerate was made at 50% flowering and 15 days later reduced the incidence of *H. armigera*, followed by 0.006% Fenvalerate and the highest yield was obtained from plots treated with 0.006% Fenvalerate, followed by controlled lines.

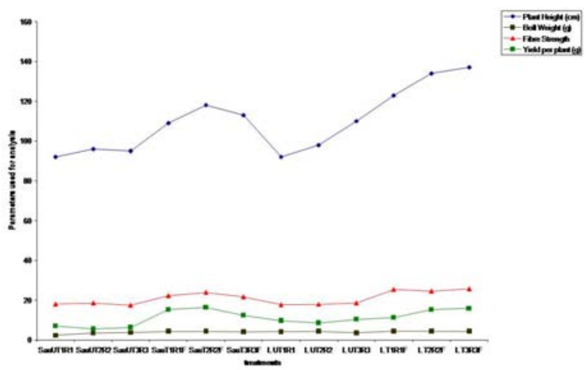

Fig. 1. Showing effects of fenvalerate on plant height, boll weight, fiber strength and yield of cotton plants

It was concluded that insecticides treatments had overall adverse effects on plant growth, yield and fibre quality. Therefore, it is always essential to recommend proper dose of Fenvalerate for increasing the yield and keeping the pests population under control. From this study it was revealed that Fenvalerate had better efficacy in controlling major insect pests of *Gossypium hirsutum* resulting the highest yield.

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J. Farming Systems Research & Development **19** (1) : 61-66 (2013)

IMPACT OF DIVERSIFICATION OF RICE WITH PIGEON PEA IN RICE-WHEAT CROPPING SYSTEM ON PERFORMANCE OF WHEAT UNDER DIFFERENT TILLAGE AND CROP ESTABLISHMENT METHODS

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ABSTRACT

The wheat plants grew significantly taller after pigeon pea than after rice. The wheat plants had more tillering after pigeon pea than after rice under all the tillage and establishment methods. The average spike length, number of grains/spike and grain yield as well as straw yield and harvest index of wheat crop were significantly more after pigeon pea than after rice under all the tillage and crop establishment methods. Thus inclusion of pigeon pea in R-W cropping system proved better in increasing the wheat yield than growing rice in kharif season under all the tillage and crop establishment methods.

Keywords :

A number of RCT's are under development and evaluation for rice-wheat and other cropping systems under the umbrella of rice-wheat consortium (RWC) for Indo Gangatic Plains with the goals of increasing profitability of farmers, with higher food production and its nutritive value to match population growth and environmentally sustainable. Besides the RCT's related to improved cultural practices (zero tillage, FIRB etc), the need to diversify away from rice – wheat cropping system is now being recognized. A number of crops other than rice and wheat are being grown in rotation with rice and wheat in NW India but their total production is very small. The crops grown in small area of land are maize, pigeon pea, chick pea, oil seed crops, green gram, vegetables and fodder crops. Crop diversification (cropping sequence / cropping systems) is location specific which is alternate remunerative and sustainable cropping system and also reduces problems of diseases, pests and weeds, there by reducing the pesticides and herbicides needs and improves nutrient use efficiency. The RW cropping system can be diversified by growing legumes as substitute crop like pigeon pea – wheat and rice – chick pea etc. instead of rice – wheat cropping system. The legume crops fix atmospheric N and enrich soil fertility and improve soil structure. In view of this, the present experiment was conducted to grow pigeon pea in place of rice to know the crop diversification opportunities in rice-wheat cropping system.

MATERIALS AND METHODS

The present field experiment was conducted at agricultural farm of J.V. College, Baraut, Distt. Bagpat located in western boundary of U.P. about 55 Km. to the north of Delhi, the NCR of India, on Delhi-Saharanpur road. The soil of the experimental field is of loam texture,

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nearly neutral in reaction (pH 7.2), moderately fertile and well drained. The soil contains nearly 0.54 % organic carbon and1.55 mg/m^2 bulk density.

The experiment was laid out in split plot design by dividing the experimental plot into four main plots (replications) and each main plot was subdivided into 6 subplots. Thus there were 6 different treatments with 4 replications, making 24 total numbers of subplots. The details of the experimental treatments were 3 tillage and crop establishment methods and 2 cropping systems. The different tillage and crop establishment methods were conventional tillage (CT) with flat bed planting, CT with raised bed planting (furrow irrigation) known as FIRB and the reduced tillage (RT) with flat bed planting. In conventional tillage, 4 ploughings were done with tractor whereas in reduced tillage only 2 ploughings were done. In furrow irrigated raised bed (FIRB) method, the crops were sown on ridges or beds. The two cropping systems were rice-wheat and pigeon pea- wheat and both cropping systems were repeated for two consecutive years in the cropping sequence of pigeon pea –wheat - pigeon pea- wheat and rice-wheat-rice-wheat.

The variety of pigeon pea shown was ICPl 88039. This variety was developed by pedigree selection at ICRISAT, Hyderabad, recognized for yield evaluation in 1988 and it matures in about 120-145 days. The variety of rice sown was Pusa Basmati-1, developed at IARI, New-Delhi by crossing Pusa 150 with Karnal local variety. The sowing dates for rice and pigeon pea were in the month of June. The variety of wheat shown was PBW 343 developed and released from PAU, Ludhiana in 1996. The wheat crop was sown in the month of October. The details of different field/ cultural operations performed during the course of experiment from land preparation to harvesting and data recording have been given by Amit (2008).

The crop diversification opportunity by adopting the pigeon pea-wheat cropping system in place of rice- wheat cropping system under different tillage and crop establishment methods were evaluated for enhancing the productivity and sustainability of wheat by inclusion of pigeon pea in place of rice. The experimental findings on growth and production potential of wheat crop after pigeon pea (Pigeon pea- Wheat cropping system) have been compared with the growth and production potential of wheat after rice (R-W cropping system) under different tillage and crop establishment methods. The analysis of variance was conducted to test the effect of replication, treatments and cropping systems on growth and yield attributes of wheat.

RESULTS AND DISCUSSION

The data on average values of growth characters of wheat grown under two cropping systems have been presented in Table 1 whereas the average value of yield contributing characters and grain yield of wheat under two cropping systems have been presented in Table 2 in relation to different tillage and crop establishment methods.

Growth potential of wheat: The perusal of data on plant height of wheat after pigeon pea (Table 1) have indicated that plants attained their full height up to 90 days after sowing as no increase in height was observed thereafter. The wheat plant attained the full height of

Table 1. Growth performance of Wheat under R-W cropping system and Pp-W Cropping system.

Characters	Cropping	Tillage and cropestablishment methods			CD 5%	
Plant Height (cm) at Days	Systems	C T	RT	FIRB	CS*	TCEM*
30	1*	7.6	7.1	7.9	0.096	0.128
	2*	7.8	7.6	8.2		
60	1	44.4	43.0	45.4	0.136	0.37
	2	44.9	43.5	46.0		
90	1	89.9	88.8	93.0	0.90	0.48
	2	91.9	90.2	94.0		
Maturity	1	91.0	88.6	93.0	0.80	0.48
	2	91.9	90.2	94.0		
Total Tillers atDays						
30	1	71.1	72.2	74.7	1.02	1.09
	2	73.0	74.0	75.9		
60	1	81.3	83.8	84.3	0.68	0.84
	2	82.0	85.1	86.1		
90	1	97.5	99.0	100.0	0.91	0.80
	2	98.6	100.5	102.0		
Maturity	1	104.5	106.4	109.0	0.56	0.77
	2	111.5	114.6	116.7		
Effective Tillers	1	96.8	98.2	99.0	0.51	0.87
maturity	2	98.4	100.2	102.3		

1*= Rice-Wheat cropping system 2*=Pigeon pea-Wheat cropping system
CS*= cropping system TCEM*=Tillage&crop establishment method

92.0, 90.3 and 94.0 cm under CT, RT and FIRB planting systems, respectively, in the first year crop and almost similar height under these respective tillage and crop establishment methods were attained in the second year up to 90 days of sowing. The plant height did not differ significantly by two tillage practices whereas the plants attained significantly more height under FIRB planting than under flat bed planting. Secondly, the wheat plants grew significantly taller after pigeon pea compared to that after rice (Tables 1). This was true for the wheat plants of both the years and at all stage of growth. The growth rate of wheat plants following pigeon pea was maximum during third month of age (60 -90 days after sowing) as was observed in case of the height of wheat plants after rice.

The average number of total tillers emerged up to one month of age were 73.0, 74.0 and 76.0, respectively, under, CT, RT, and FIRB planting in the first year crop after Pigeon pea. The total tillers in the second year were also same in number as those in the first year crop. The tillering also continued after 90 days of age and at maturity the numbers of total tillers were found to be

114.0, 116.2 and 119.5 under CT, RT, and FIRB system, in the first year, respectively. The year of crop did not influence the number of total tillers at any stage of growth. The wheat plants after pigeon pea emerged significantly more number of tillers per square meter area compared to the wheat plants grown after rice (Table 1).

The number of effective tillers (spike bearing) /m area averaged to be 98.7, 100.7 and 102.2 in the first year following pigeon pea crop. Almost similar number of effective tillers was observed in the second year. The perusal of the total numbers of tillers and effective tillers indicated that the number of effective tillers were nearly equal to the total number of tillers observed at 90 days after sowing (Table 1). This indicated that the tillers which emerged after or around 90 days failed to mature and bear spikes. The average numbers of effective tillers were maximum (102.2) under FIRB planting followed by the numbers under reduced tillage (100.7) and minimum under conventional tillage (98.7) in the first year. The same was true in second year crop following pigeon pea. On comparing the number of effective tillers under two cropping scheme viz. rice-wheat and pigeon pea - wheat, it was observed that the effective tillers were significantly more in number after pigeon pea than after rice. This was true under all the tillage and crop establishment method and in both the years (Table 1).

Wheat yield and its contributing characters: The average spike length was found to be longer by 0.8, 0.4 and 0.9 cm for the wheat plant after pigeon pea than after rice in first year whereas in second year the length of spikes after pigeon pea were more by 0.9, 0.6 and 1.4 cm compared to those after rice under CT, RT and FIRB planting, respectively. Statistically the differences due to cropping scheme were highly significant. Thus inclusion of leguminous crop (pigeon pea) in rice-wheat cropping system was found to increase the spikes length. The numbers of grains / spike in wheat crop following pigeon pea were found more by about one grain than those after rice. This was true for all the tillage and crop establishment method in both the years (Table 2). Statistical analysis of data had indicated significant improvement in the character due to cropping scheme.

The test weight of 1000 grains of wheat crop after growing pigeon pea was found to be 40.5, 41.2 and 42.5 gm under Ct, RT and FIRB planting systems, respectively. On comparing the test weight of wheat grains in the crop after rice, it was observed that the grains were heavier in the crop after pigeon pea. The test weight was higher by 0.6, 0.4 and 0.5 gm under CT, RT and FIRB planting for the crop after pigeon pea than after rice, in the first year. The test weight of wheat after pigeon pea was also higher than after rice in second year under all the methods of tillage and crop establishment.However, the differences were not found significant due to cropping sequence. The average grain yield of wheat crop following pigeon pea was recorded to be 44.8, 45.2 and 47.3 q / ha under CT, RT and FIRB planting in the first year and the corresponding values in the second year were 45.1,45.3 and 47.4 q / ha under these tillage and crop establishment methods. These values of grain yield of wheat following pigeon pea were higher by 1.8, 1.9 and 1.9 q/ha in the first year and 2.1, 2.2 and 2.1q / ha in the second year compared to that after rice crop. The

Table 2. Average values of yieldand its contributingcharacters of Wheat grown under R-W cropping system and Pp-W Cropping system

Characters	Cropping	C T	RT	FIRB	CD 5%	
					CS*	TCEM*
Spike length	1*	8.1	8.0	8.5	0.18	0.11
	2*	9.0	8.4	9.6		
Grains/Spike	1	31.9	31.1	33.2	0.54	0.75
	2	33.0	32.0	35.0		
Test weight	1	39.8	40.5	41.9		0.65
	2	40.2	41.0	42.3		
Grain yield	1	43.0	43.1	45.6	0.20	0.44
	2	45.0	45.2	47.3		
Straw yield	1	71.5	71.3	72.3	0.06	0.17
	2	71.8	72.4	72.8		
Biological yield	1	114.5	114.5	117.7	-	-
	2	116.7	117.6	120.0		
Harvest Index	1	37.3	37.6	38.5	0.21	0.50
	2	38.5	38.3	39.3		

1*= Rice-Wheat cropping system 2*=Pigeon pea-Wheat cropping system
CS*= cropping system TCEM*=Tillage &crop establishment

grain yield of wheat increased significantly in both the years after pigeon pea than after rice. This showed that induction of pigeon pea (legume crop) in rice- wheat cropping system has increased the wheat yield under all the tillage and crop establishment methods. This was attributed to significantly longer spike length, more number of grains/spike and little heavier wheat grains. Similar results have been reported by Tripathi et al (2002), Dahiyaetal (2002), Singh et al (2005), Pandeetal (2006) and Singh and Dwivedi (2006) who reported that inclusion of pigeon pea in rice – wheat cropping system increased wheat productivity.

The data on straw yield of wheat following pigeon pea crop have indicated that it was higher by 0.2, 1.2 and 0.4 q/ha in first year and 0.4, 1.0 and 0.5q/ha in the second year compared to the straw yield of wheat after rice under CT, RT and FIRB planting method, respectively. Statistically, the differences due to crop sequence were significant only for first year crop. The increase in biological yield of wheat following pigeon pea was observed to be 2.0, 3.0 and 2.3 q/ha in the first year and 2.5, 3.2 and 2.6 q/ha in the second year under CT, RT and FIRB planting than biological yield of wheat after rice. This has again showed the beneficial effect of inclusion of legume crop (pigeon pea) in rice – wheat cropping system.

Comparing the data on harvest index of wheat crop following rice and pigeon pea, it was evident that the harvest index of wheat following pigeon pea was higher from 0.6 to 0.9 in the first year and from 0.7 to 1.3 in the second year under different tillage and crop establishment methods. The differences due to cropping sequence were highly significant. More increase in harvest index of wheat crop following pigeon pea was recorded under conventional tillage and this was attributed to the reason that increase in straw yield compared to grain yield following pigeon pea was less under this tillage practices than reduced tillage and FIRB planting.

Water productivity: This pigeon pea-wheat cropping system had maximum water productivity compared to rice-wheat cropping systems. This was attributed to less water used in pigeon pea compared to rice. The cropping system under conventional tillage required 4110 m^3water/ ha which was higher by about 20 % compared to reduced tillage (3280 m^3 / ha) and also higher by about 28 % compared to FIRB planting (2991 m^3 / ha). The water productivity of this system was found to be minimum (1.47 kg grain) under conventional tillage followed by the reduced tillage which produced 1.87 kg grain / m^3 water given to the system. The FIRB planting system proved to be superior for water productivity producing 2.18 kg grain / m^3 water. Pande et al (2006) showed that the water productivity was markedly better in raised bed planting as compared to flat bed planting.

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J. Farming Systems Research & Development **19** (1) : 67-73 (2013)

EFFECT OF CROP ESTABLISHMENT TECHNIQUES AND WEED MANAGEMENT PRACTICES ON THE PRODUCTIVITY AND PROFITABILITY OF HYBRID RICE (*ORYZA SATIVA*) - WHEAT (*TRITICUM AESTIVUM*) CROPPING SYSTEM

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ABSTRACT

A field experiment was conducted at Modipuram, Meerut during the *kharif* and *rabi* season of 2007-08 and 2008-09 to study the effect of crop establishment techniques and weed management practices on the productivity and economics of hybrid rice (*Oryza sativa* L.) - wheat (*Triticum aestivum* L. emend Fiori Paol) cropping system. In this investigation four rice establishment techniques *viz;* puddled transplanting, unpuddled transplanting, puddled drum seeding and direct sowing (line sowing) and six weed management practices *viz.*, weedy, weed free, pendimethalin PE @ 1.0 kg a.i./ha, pendimethalin PE @ 1.0 kg a.i./ha + hand weeding at 30 DAS, pendimethalin PE @ 1.0 kg a.i./ha + almix PoE @ 4 g a.i./ha and pendimethalin PE @ 1.0 kg a.i./ha + fenoxaprop-p-ethyl PoE @ 70 g a.i./ha were tested in split plot design with three replications. The study revealed that puddled transplanted rice, being at par with puddled drum seeding recorded significantly highest yield of rice in terms of biological yield (146.3 and 149.2 q/ha) and grain yield (59.9 and 61.4 q/ha). However, in subsequent wheat significantly highest grain yield (47.5 and 50.5 q/ha during 2007-08 and 2008-09, respectively) was recorded after direct seeded rice. The highest net returns and B:C ratio of rice-wheat cropping system were recorded under direct seeding of rice. Pendimethalin @ 1.0 kg a.i./ha + hand weeding followed by pendimethalin @ 1.0 kg a.i./ha + almix @ 4 g a.i./ha recorded significantly highest grain yield (59.8 and 62.5 q/ha), straw yield (83.4 and 85.6 q/ha) and harvest index of rice, which was significantly higher than weedy check and pendimethalin @ 1.0 kg a.i./ha alone. However, in subsequent wheat, significantly highest grain yield (47.3 and 49.9 q/ha during each year, respectively) was recorded under pendimethalin @ 1.0 kg a.i./ha + almix @ 4 g a.i./ha over weedy check. The gross returns, net returns and B:C ratio of rice-wheat cropping system were recorded highest with pendimethalin @ 1.0 kg a.i./ha + almix @ 4 g a.i./ha during both the years.

***Key words*:** Crop establishment techniques, Economics, Productivity, Rice-wheat cropping sequence, Weed management practices

Sustainability of rice-wheat cropping system, vital in providing food security and livelihood to hundreds of millions of people around the globe, is under question due to various environmental, economic and management problems (Fujsaka *et al.*, 1994). Hybrid rice is one of the viable and proven technologies available at present to enhance the rice productivity and production in the India. Since, rice is mostly taken as manually transplanted crop under puddled condition the yield is high and water losses through deep seepage and percolation are reduced compare with unpuddled condition, but it has its own

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limitation and ill effect on soil health. This technique is cumbersome, labour intensive and requires continuous pounding of water creating a compacted layer (plough pan) which restrict the percolation of water and creates temporary water logging resulting poor root penetration and growth of succeeding crops (Tomar *et al.*, 2006). Direct seeding of rice in rows, under dry condition; offer a useful option to reduce the adverse effect of puddling. Besides, this also aids in quick establishment and early harvest of rice thereby, early sowing of wheat (Singh *et al.,* 2007).

However, the direct seeded rice culture is subjected to greater weed competition than transplanted rice. Yield reduction due to weeds have been reported to the extent of 25 % in transplanted rice, 32 % in puddled broadcasted rice and 52 % in direct sown rice (Manna, 1991). Hence to avoid yield losses, weed control in direct seeded rice becomes an immensely important practice. Traditionally weed control is done by hand weeding but now a days weeding becomes rather difficult due to costly and scarce labour. Application of herbicides with hand weeding may be a good option to control the weeds. Hence, the present investigation was undertaken to study the effect of sequential application of pre and post-emergence herbicides on yield and economics of rice and wheat under different rice establishment techniques.

MATERIALS AND METHODS

A field experiment was conducted during rainy and winter season of 2007-08 and 2008-09 on sandy loamy soil at Crop Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modiouram, Meerut. (29^0 05' 19" N latitudes, 77^0 41' 50" E longitudes and 237 metres above mean sea level). The rainfall during cropping seasons from July to April was 429.5 mm and 480.5 mm during 2007-08 and 2008-09, respectively. The soil at site was sandy loam with organic carbon 0.47 and 0.42, available N 224.1 and 225.6 kg/ha, available P 13.5 and 13.7 kg/ha and available K 176.5 and 177.3 kg/ha, during 2007 and 2008, respectively. The experiment was carried out in split plot design with three replications. The treatments include four rice establishment techniques *viz;* puddled transplanting, unpuddled transplanting, puddled drum seeding and direct sowing (line sowing) and six weed management practices *viz.*, weedy, weed free, pendimethalin PE @ 1.0 kg a.i./ha, pendimethalin PE @ 1.0 kg a.i./ha + hand weeding at 30 DAS, pendimethalin PE @ 1.0 kg a.i./ha + almix PoE @ 4 g a.i./ha and pendimethalin PE @ 1.0 kg a.i./ha + fenoxaprop-p-ethyl PoE @ 70 g a.i./ha to rice. The succeeding wheat was raised on the residual effect of previous crop with recommended package of practices.

Hybrid rice 'PRH-10' was sown on 6 and 10 June and; transplanted on 1 and 3 July during 2007 and 2008, respectively. After harvesting of rice, wheat (UP-2338) was sown on 20 and 24 November, 2007 and 2008 and harvested on 5 and 8 April during 2008 and 2009, respectively. Half dose of N was applied at the time of sowing of rice and wheat and the remaining amount of N was top dressed at first and second irrigation. All the treatments were applied to rice as per the standard methods and data on yield attributes and yield were recorded. The economics of rice, wheat and rice-wheat cropping system was recorded based on the prevailing market price of inputs and outputs. Soil samples up to the depth of 30 cm were collected at the end of cropping cycle and analyzed for organic carbon, available NPK content, bulk density, infiltration rate and water holding capacity by following standard laboratory procedures.

Results and Discussion

Effect on rice

The perusal of the results (Table 1) reveals that the rice transplanted in puddled condition gave significantly more yield than other methods. Puddled transplanted rice, being at par with puddled drum seeding recorded significantly highest biological yield (146.3 and 149.2 q/ha), grain yield (59.9 and 61.4 q/ha) and straw yield (86.3 and 87.9 q/ha) of rice during 2007 and 2008, respectively, while the significantly lowest yields were recorded with direct seeding of rice. The grain yield of puddled transplanted rice was 4.9, 10.5 and 8.7%, respectively more over puddled drum seeding, unpuddled transplanting and direct seeding during 2007 and 1.15, 7.91 and 6.04% more during 2008. It could be due to favourable soil physico-

Table 1. Biological, grain and straw yield (q/ha) and harvest index of rice as influenced by crop establishment techniques and weed management practices

Treatment	Biological yield		Grain yield		Straw yield		Harvest index	
	2007	2008	2007	2008	2007	2008	2007	2008
Crop establishment techniques								
Puddled transplanting (PT)	146.3	149.2	59.9	61.4	86.3	87.9	0.41	0.41
Puddled drum seeding (PDS)	138.2	144.6	57.1	60.7	81.1	83.5	0.41	0.42
Unpuddled transplanting (UPT)	132.9	137.1	54.2	56.9	78.4	80.2	0.41	0.41
Direct seeding (DS)	128.5	134.2	55.1	57.9	73.8	76.2	0.42	0.43
SEm±	2.28	2.29	0.49	0.47	1.92	1.93	0.005	0.005
CD (P=0.05)	7.9	7.9	1.7	1.6	6.6	6.7	NS	NS
Weed management practices								
Weedy (W_0)	114.9	119.3	41.7	44.3	73.3	74.9	0.36	0.37
Weed-free (W_1)	151.1	156.2	66.2	69.2	84.9	87.0	0.44	0.44
Pendimethalin (PE) (W_2)	133.3	137.6	56.3	58.8	77.0	78.9	0.42	0.43
Pendimethalin + HW at 30 DAS/ DAT (W_3)	142.1	146.8	59.8	62.5	83.4	85.6	0.42	0.43
Pendimethalin +Almix at 25 DAS/ DAT (W_4)	141.3	146.1	58.9	61.3	81.6	83.6	0.41	0.42
Pendimethalin + Fenoxaprop at 25 DAS/DAT (W_5)	136.1	141.7	56.8	59.9	79.2	81.8	0.42	0.42
SEm±	1.97	1.91	0.49	0.51	1.91	1.87	0.01	0.01
CD (P=0.05)	5.6	5.5	1.5	1.5	5.5	5.3	0.02	0.03

chemical properties and low initial weed competition for crop growth under puddle conditions. Puddling as a means of improving the productivity of rice through land submergence and weed control is well documented (Singh *et al.*, 1995). Puddled transplanted method also had positive effect on size of grain, ear weight and numerically positive effect on grains/ panicle, panicle length, productive tillers which cumulatively resulted in significant increasing in the grain yield. The extent of increase in straw yield of rice due to rice sowing in puddled condition over direct sowing and unpuddled transplanting was attributed to better tiller production and height of plant. The results are in conformity with the findings of Singh *et al.* (2006). The significantly maximum values of harvest index (0.42 and 0.43) were noticed in direct seeding, while the minimum harvest index (0.41 and 0.41) was recorded with puddled transplanted rice during 2007 and 2008, respectively.

Results (Table 1) make it clear that all the weed management practices increased significantly the yield of rice over weedy check. The application of pendimethalin @ 1.0 kg a.i./ha + hand weeding followed by pendimethalin @ 1.0 kg a.i./ha + almix @ 4 g a.i./ha recorded significantly highest biological yield (142.1 and 146.8 q/ha), grain yield (59.8 and 62.5 q/ha), straw yield (83.4 and 85.6 q/ha) and harvest index (0.42 and 0.43) during 2007 and 2008, respectively as compared to rest of the treatments, while the minimum yield and harvest index was recorded with weedy check. The possible reason for this might be effective suppression of weeds without phytotoxicity and consequent higher values of yield contributing characters (panicles/m^2, effective spikletets/panicle and test weight). This result can also be attributed to marked improvement in dry matter accumulation, plant height and leaf area index under pendimethalin @ 1.0 kg a.i./ha + hand weeding. Lowest grain yield was recorded under weedy check attributed to vigrous weed growth and consequent reduction in growth of crop plants. The results are in agreement with the findings of Mohan *et al.* (2005).

Effect on wheat

The crop establishment techniques of rice had a significant residual effect on yield of subsequent wheat (Table 2). Significantly low yield was obtained in plots where rice was grown in puddled condition compared to unpuddled conditions. This was mainly attributable to relatively greater compaction of soil under puddled condition and its carry over effect to the disadvantage of succeeding wheat. The significantly highest biological yield (111.0 and 117.5 q/ha), grain yield (47.5 and 50.5 q/ha) and straw yield was (63.1 and 67.1 q/ ha) recorded under direct seeded rice during 2007-08 and 2008-09, respectively, which found at par with unpuddled transplanting, while the lowest yield was recorded under puddled transplanted rice. Though the well puddled condition provides congenial conditions for rice, it also creates hard pan below the surface restricting the root growth and proliferations of winter season crops in deeper layers. This in turn limits nutrients and moisture availability thus reduction in the grain yield. After direct seeded rice succeeding wheat had greater yield advantage due to favourable soil physical environment as evident by shoot dry matter accumulation, leaf area index and overall growth of crop plants.

Table 2. Biological, grain and straw yield (q/ha); and harvest index of wheat as influenced by residual of crop establishment techniques and weed management practices in rice

Treatment	Biological yield		Grain yield		Straw yield		Harvest index	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Crop establishment techniques								
Puddled transplanting (PT)	97.8	102.3	41.8	43.9	55.8	58.4	0.43	0.43
Puddled drum seeding (PDS)	104.4	109.5	45.3	47.6	59.1	60.9	0.43	0.43
Unpuddled transplanting (UPT)	108.9	115.1	47.1	49.7	61.8	65.4	0.43	0.44
Direct seeding (DS)	111.0	117.5	47.5	50.5	63.1	67.1	0.43	0.43
SEm±	1.04	1.24	0.60	0.72	0.59	0.67	0.03	0.05
CD (P=0.05)	3.6	4.3	2.1	2.5	2.0	2.3	NS	NS
Weed management practices								
Weedy (W_0)	98.0	103.3	40.0	42.4	58.0	60.9	0.41	0.41
Weed-free (W_1)	111.6	116.8	48.8	51.2	62.8	65.7	0.44	0.44
Pendimethalin (PE) (W_2)	99.3	104.8	42.8	45.3	56.5	59.5	0.43	0.43
Pendimethalin + HW at 30 DAS/ DAT (W_3)	106.6	112.1	46.4	48.9	60.2	63.2	0.44	0.44
Pendimethalin +Almix at 25 DAS/ DAT (W_4)	108.6	114.6	47.3	49.9	61.2	64.3	0.44	0.44
Pendimethalin + Fenoxaprop at 25 DAS/DAT (W_5)	108.1	113.5	47.2	49.8	61.0	64.1	0.44	0.44
SEm±	1.03	1.11	0.55	0.59	0.64	0.70	0.03	0.04
CD (P=0.05)	2.9	3.2	1.6	1.7	1.8	2.0	NS	NS

The weed management practices of previous rice had significant effect on yield of wheat during both the years (Table 2). The highest biological, grain (108.4 and 114.1 q/ha) and straw yield of wheat were recorded under pendimethalin @ 1.0 kg a.i./ha + almix @ 4 g a.i./ha during both the years. This might be due to a lesser nutrients removal by weeds, which in turn, made more nutrients available to succeeding wheat crop.

Economics of rice-wheat cropping system

The highest cost of cultivation of rice-wheat cropping system (₹40945 and 43148/ha) was recorded under puddled transplanted rice, the highest gross returns (104527 and 116357/ha) was recorded under puddled drum seeding, while the highest net returns (65557 and 75812/ha) and B:C ratio (1.76 and 1.95) were recorded with direct seeding of rice during 2007-08 and 2008-09, respectively (Table 3). It might be because of more man-days engaged in puddled transplanted rice.

In rice-wheat cropping system, the highest cost of cultivation (39953 and 41948/ha) was recorded under pendimethalin @ 1.0 kg a.i./ha + hand weeding, while the highest gross returns (107014 and 118537/ha), net returns (69201 and 78926/ha) and B:C ratio (1.83 and 1.98) of rice-wheat cropping system were recorded with pendimethalin @ 1.0 kg a.i./ha + almix @ 4 g a.i./ha, except weed free, 2007-08 and 2008-09 (Table 3). This might be owing to high weed control efficiency (90.24 and 90.82% at harvest) with least man-days engagement and higher grain yield of both rice and wheat under this treatment. The lowest cost of cultivation net returns and B:C ratio were obtained in weedy check treatment because of poor grain yield under severe competition from weeds in rice and the carry-over effect on nutrient exhaustion by perennial weeds in rice to wheat.

Thus, it is imperative from above study that adoption of puddled transplanted rice along with the application of pendimethalin @ 1.0 kg a.i./ha + hand weeding is best agronomic practice to ensure higher yield, maximum net return and B: C ratio of rice. However, the highest yield, net return and B: C ratio of succeeding wheat were recorded under direct seeded rice crop applied with pendimethalin @

Table 3. Economics of rice-wheat cropping system as influenced by crop establishment techniques and weed management practices

Treatment	Cost of cultivation (₹/ha)		Gross return (/ha)		Net return (/ha)		B:C ratio	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Crop establishment techniques								
Puddled transplanting (PT)	40945	43148	101622	111846	60677	68698	1.49	1.60
Puddled drum seeding (PDS)	39595	41448	104527	116357	64932	74909	1.64	1.66
Unpuddled transplanting (UPT)	39545	41608	100240	110659	60695	69051	1.54	1.66
Direct seeding (DS)	37195	38908	102751	114720	65557	75812	1.76	1.95
Weed management practices								
Weedy (W_0)	36233	38018	83720	93375	47487	55357	1.31	1.42
Weed-free (W_1)	45833	48418	114295	126290	68462	77872	1.50	1.56
Pendimethalin (PE) (W_2)	37553	39348	98961	109725	61408	70377	1.64	1.76
Pendimethalin + HW at 30 DAS/DAT (W_3)	39953	41948	105363	116459	65410	74511	1.64	1.74
Pendimethalin +Almix at 25 DAS/DAT (W_4)	37813	39608	107014	118537	69201	78929	1.83	1.98
Pendimethalin + Fenoxaprop at 25 DAS/DAT (W_5)	38533	40328	104357	115988	65824	75660	1.71	1.84

1.0 kg a.i./ha + almix @ 4 g a.i./ha, which also recorded highest net return and B: C ratio of rice-wheat cropping system.

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J. Farming Systems Research & Development **19** (1) : 74-80 (2013)

GROWTH AND YIELD OF WHEAT (*TRITICUM AESTIVUM* L.) UNDER NORMAL AND LATE SOWN CONDITIONS

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ABSTRACT

A field experiment was conducted during Rabi season of 2008-9 and 2009-10 at Janta Vedic College, Baraut (Baghpat), U.P. Experiment was sown on 25th November as normal sown and 5th January as late sown during both the years with twelve varieties. Among the different varieties PBW-502 was recorded maximum grain yield under normal and late sown conditions however, it was recorded at par with the varieties Raj-3765, DBW-16 and HD-2922 and HD-2643 under late sown conditions during both the years. Among the different varieties PBW-343 was recorded highest membrane stability and found at par with the varieties RAJ-3765 and PBW-550 under late sown conditions during both the years. It was found that varieties RAJ-3765, HD-2643 and PBW-343 showed higher yield stability under late sown conditions. It can be concluded from the studies that higher test weight, grain weight / spike and membrane stability were associated with stability in yield of adapted varieties exposed to heat stress under late sown conditions.

Key Words : Varieties, Terminal heat stress, wheat, yield, Traits

The intensive cultivation of rice and wheat for 2-3 decades in rice-wheat cropping system, without growing pulses and green manuring crops, resulted in yield pleatue and sustenance of productivity. In this rotation, where rice varieties having comparatively longer duration (both basmati and non basmati) type) late sowing of wheat is very common. Late sowing of wheat is common in India in the region where rice – wheat and sugarcane - wheat crop rotations are followed year after year. Under such conditions wheat is sown under late sown conditions and crop is exposed to high temperature (exceeding 35 ^{0}C) during grain filling stage. The yield loss of wheat in India due to rising temperature has been projected as 4-5 million tones per year with every degree rise in temperature throughout the growing period even after considering the benefits of carbon fertilization (Aggarwal 2007). Heat stress is a major detrminenant of growth and yield of wheat and its yield is decreased by 3to 5% per 1^{0}C increase above normal conditions (Gibson and Paulson 1999). High temperature after anthesis up to maturity adversely affects fertilization and grain development.

The identification of suitable traits associated with terminal heat tolerance is also important to initiate trait based screening of germplasm and to identify the stable genotypes. The research efforts in this direction were mostly aimed at heat stress avoidance by developing medium and short duration varieties for late sown conditions. However using this strategy the increase was not substantial due to non flexibility of duration of crop growth. Keeping in view the requirement to identify adaptive genotypes along with adaptive physiological traits.

Materials and Methods

Field experiments were conducted for two years, at Janta Vedic College, Baraut (Baghpat), U.P during Rabi season of 2008-2009 and 2009 – 2010. The wheat experiment was preceded by paddy during both the years. Twelve varieties (PBW-564, PBW-343, PBW-547, Raj-3765, DBW-16, HD-2922, PBW-550, HD-2643, HD-2329, PBW-502, WH-542, HD-2687) under normal and late conditions. Experiment was sown on 25th November as normal sown and 5th January as late sown during both the years. The varieties were tested using R.B.D design in three replications under both the conditions. A total of five irrigations were applied under both conditions. Recommended doses of NPK were 120:60:40. Require NPK as per treatment were supplied through urea, diammonium phosphate (DAP) and murate of potash. Half of required nitrogen and full dose of phosphorus and potassium was band placed as basal while rest half amount of nitrogen was applied in two equal split at CRI and tillering stages.

Leaf membrane stability index (MSI) was determined according to the method of Sairam *et al* (1997). The data recorded during the course of investigation were subjected to statistical analysis using analysis of variance technique (ANOVA) for randomized block design as prescribed by Cochran and Cox (1959).

Results and Discussion

The average plant height was 90.19 and 77.29 cms under normal and late sown conditions respectively during 2008-09. It was 92.05 and 79.0 cms under normal and late sown conditions during 2009-10. Such results shows that heat stress reduced plant height during both the years compare to normal sown conditions.

Among the different varieties PBW-547 was recorded tallest and found at par with PBW-343, PBW-550, PBW-502 and HD-2687 during both the years. Under late sown conditions Raj-3765 was recorded tallest and found at par with HD-2687, PBW-550 and PBW-502 during 2008-09. However, during 2009-10 varieties HD-2687 was found tallest (85.88) and it was at par with PBW-547, PBW-502, PBW-550 and Raj-3765 (Table-1). In current studies it was observed that high temperature reduced stem elongation and overall growth and limits plant height. Similar results on reduction in plant height due to heat stress at terminal stage were also reported by Siddique *et al.* (1999).

The number of tillers per meter row length varied significantly at harvest among different varieties under normal and late sown conditions. Heat stress at terminal stage reduced the number of tillers as compared to normal sown conditions during both the years. Among the different varieties PBW-547 was recorded maximum number of tillers and found at par with all the varieties except PBW-564, under normal and late sown conditions during both the years (Table-1). Reduction in tiller number due to heat stress can be associated with reduction in current photosynthesis and limited amount of carbohydrates can not support the tiller growth at reproductive stage as developing grains acts as a strong sink for current photosynthates. Delay in sowing often reduces the growing season which adversely effects the growth including reduction in number of tillers. Similar results were also reported by Siddique *et al.* (1999).

Table 1. Plant height (cm) and number of tillers per meter row length at maturity under normal and late sown condition of wheat.

S.N.	Variety	Plant height (cm)				Number of tillers (per meter row length)			
		2008-09		2009-10		2008-09		2009-10	
		Normal sowing	Late sowing	Normal sowing	Late sowing	Normal sowing	Late sowing	Normal sowing	Late sowing
1	PBW-564	91.50	78.44	93.11	80.71	72.28	66.58	74.39	67.31
2	PBW-343	93.00	76.54	95.18	77.89	75.54	69.88	78.14	70.12
3	PBW-547	96.50	79.50	97.42	81.51	100.28	68.87	103.11	69.92
4	Raj-3765	90.00	83.50	91.82	85.34	75.28	70.69	77.14	72.17
5	DBW-16	85.50	74.00	87.51	75.45	99.28	96.88	101.12	97.12
6	HD-2922	84.12	74.98	86.12	76.10	99.87	70.58	101.27	73.14
7	PBW-550	94.25	79.99	96.23	81.22	88.90	86.88	91.12	90.10
8	HD-2643	86.21	75.58	89.12	77.21	96.25	90.58	97.72	92.22
9	HD-2329	85.21	70.88	86.14	72.34	80.87	68.98	81.92	70.12
10	PBW-502	95.00	79.88	97.12	81.42	83.54	81.28	86.53	84.11
11	WH-542	86.75	70.88	88.46	72.92	98.28	88.29	101.14	90.32
12	HD-2687	94.25	83.25	96.34	85.88	91.58	85.88	93.34	87.23
	Mean	90.19	77.29	92.05	79.00	88.50	78.78	90.58	80.32
	CD at 5 %	4.21	3.65	4.57	4.13	4.98	3.75	4.32	3.81

The membrane stability varied significantly among different varieties under normal and late sown conditions. The average membrane stability was 51.89 and 53.34 under late sown conditions during 2008-09 and 2009-10. Among the different varieties PBW-343 was recorded highest membrane stability and found at par with the varieties RAJ-3765 and PBW-550 under late sown conditions during both the years (Table-2). The minimum membrane stability was recorded in variety WH-542 under normal and late sown conditions during both the years. Temperature stress results in the leakage of ions and organic solute movements across membranes, which disrupts photosynthesis and respiration (Christiansen, 1978). Many procedures for the assessment of electrolyte leakage have been reported and these procedures are the criterion to develop heat tolerant wheat cultivars .Electrolyte leakage is a measure of cell membrane thermo stability (Sullivan and Ross, 1979). In current studies also varieties with high yield stability maintains the higher cell membrane stability. Such results clearly indicate that membrane stability can be used as selection criteria to screen wheat varieties for terminal heat tolerance.

The grain weight per spike varied significantly among different varieties under normal and late sown conditions. The average grain weight per spike reduced due to high temperature under late sown conditions in both the years. Among the different varieties Raj-3765 was recorded maximum grain weight per

Table 2. Membrane stability index (%) and grain weight per spike (gram) at maturity under normal and late sown condition of wheat

S.N.	Variety	Membrane stability index (%)				Grain weight per spike (gram)			
		2008-09		2009-10		2008-09		2009-10	
		Normal sowing	Late sowing	Normal sowing	Late sowing	Normal sowing	Late sowing	Normal sowing	Late sowing
1	PBW-564	73.00	60.32	76.12	62.61	1.71	1.33	1.78	1.36
2	PBW-343	77.00	68.80	79.14	69.77	1.79	1.71	1.82	1.75
3	PBW-547	74.56	48.50	75.15	49.41	1.60	1.25	1.69	1.30
4	Raj-3765	70.25	67.50	72.42	69.32	1.99	1.96	2.10	2.04
5	DBW-16	57.77	50.88	59.11	52.57	1.69	1.58	1.72	1.61
6	HD-2922	62.50	54.88	64.41	55.14	1.61	1.59	1.65	1.62
7	PBW-550	82.32	64.55	85.36	65.67	1.49	1.39	1.54	1.43
8	HD-2643	65.28	40.28	67.13	41.98	1.82	1.80	1.84	1.84
9	HD-2329	67.37	38.88	69.14	40.36	1.78	1.58	1.84	1.62
10	PBW-502	79.14	40.25	80.12	42.38	1.75	1.38	1.76	1.41
11	WH-542	56.24	38.98	57.14	40.22	1.58	1.49	1.62	1.43
12	HD-2687	81.32	48.80	82.63	50.61	1.77	1.70	1.80	1.71
	Mean	70.56	51.89	72.32	53.34	1.72	1.56	1.76	1.59
	CD at 5 %	3.11	6.54	3.62	7.14	0.19	0.21	0.21	0.26

spike under normal and late sown conditions during both the years. The reduction in grain weight per spike was recorded highest in PBW-547 under late sown conditions during both the years (Table-2). The result clearly shows that reduction in grain yield under heat stress is due to reduction in both the source availability and the sink realization. These results are in close conformity with the results obtained by Viswanathan and Khanna-Chopra (1996). Heat wave for 3 or 4 days at 35-36º C reduced grain size in wheat (Wardlaw and Wrigley 1994). With the prevalence of rice – wheat cropping system, late sowing of wheat is generally practiced which pushes grain development further to high temperature regime (Zhang – hu and Raja Ram 1994).

The average test weight reduced from 40.43 to 33.54 during 2008-09 and from 41.19 to 34.20 grams during 2009-10 under late sown conditions as compared to normal sown conditions. Among the different varieties Raj-3765 was recorded maximum test weight and found superior over rest of the varieties under normal sown conditions during both the years. Varietal variation for test weight was observed and it was found that Raj-3765 recorded maximum test weight compared to other varieties under normal and late sown conditions during both years. The minimum test weight was recorded in variety WH-542 under normal and late sown conditions during both the years (Table-3). The result clearly shows that test weight reduced significantly due to heat stress. As test

Table 3. Grain yield (q/ha) and test weight (gram) under normal and late sown condition of wheat.

S.N.	Variety	Grain yield (q/ha)				Test weight (gram)			
		2008-09		2009-10		2008-09		2009-10	
		Normal sowing	Late sowing	Normal sowing	Late sowing	Normal sowing	Late sowing	Normal sowing	Late sowing
1	PBW-564	41.42	25.25	43.15	27.82	43.52	31.25	44.12	31.98
2	PBW-343	45.15	30.60	47.13	31.70	38.32	32.58	39.37	32.96
3	PBW-547	37.66	20.21	39.51	22.22	36.15	32.28	37.01	33.10
4	Raj-3765	42.22	35.11	43.25	37.12	48.25	42.88	48.95	43.12
5	DBW-16	50.12	34.55	53.12	37.14	42.14	40.28	43.12	41.26
6	HD-2922	53.24	35.88	55.16	38.12	43.28	31.88	44.10	32.00
7	PBW-550	44.64	27.88	45.79	29.54	36.58	26.54	37.00	27.31
8	HD-2643	47.25	34.58	49.28	36.42	40.21	36.58	40.92	36.92
9	HD-2329	55.5	25.58	56.52	27.62	39.98	32.58	40.98	33.38
10	PBW-502	63.66	35.88	64.71	38.66	39.58	30.25	40.33	31.12
11	WH-542	47.49	24.58	49.32	26.45	33.92	26.54	34.20	27.12
12	HD-2687	58.69	28.88	59.84	30.10	43.28	38.88	44.14	40.12
	Mean	48.92	29.92	50.57	31.91	40.43	33.54	41.19	34.20
	CD at 5 %	6.99	3.88	7.12	4.31	4.72	2.58	5.01	2.95

weight is one of the important yield contributing attribute its reduction will ultimately reduce the grain yield of crop. Wheat is particularly susceptible to yield losses as a result of high-temperature-induced heat stress at terminal stage affecting grain mass and grain number (Mullarkey and Jones 2000) leading to almost 75% loss in the yield (Zhong-Hu and Rajaram 1993). The main effect of high temperature after anthesis can reduce the grain size. It has been reported that single grain weight falls by 3-5% for every 1º C rise in temperature above 18º C (Wardlaw *et al* 1989). Rise in temperature decrease grain size due to high respiration rate and decrease in rate of starch synthesis, which reduces grain weight because of forced grain development (Warrington *et al* 1977).

Grain yield is a function of several yield building characteristics along with the time of grain filling period particularly under heat stress conditions. The average grain yield reduced from 48.92 to 29.92 during 2008-09 and from 50.57 to 31.91 during 2009-10 under late sown conditions compared to normal sown conditions. Among the different varieties PBW-502 was recorded maximum grain yield under normal sown conditions during both the years however, it was recorded at par with the varieties Raj-3765, DBW-16 and HD-2922 and HD-2643 under late sown conditions during both the years (Table-3). The minimum grain yield was recorded in variety PBW-547 under normal and late sown conditions during both the years. Heat-induced yield reductions were associated with shortening of grain growth period (Stone and Nicolas, 1995). Current studies are also in conformity with the earlier published that wheat is particularly susceptible to yield losses as a result of high-temperature-induced heat stress at terminal stage affecting grain mass and grain number (Mullarkey and Jones 2000). High temperature above 32^0C has been reported reducing grain yield and grain weight (Gibson & Paulsen, 1999). There is an average yield loss 1.7% per day, when sown beyond optimum time is practiced (Mohammadi, 2002). These yield reductions can be largely attributed to the twin effects of increased developmental rate and shortened developmental duration, which occur as a result of high temperature stress (Wardlaw and Wrigley, 1994). It was also reported that wheat yield declined approximately by 3 to 4% for each 1 C rise in the average temperature above normal temperature under field conditions (Wardlaw and Wrigley 1994). Even when water supply is non - limiting, as in irrigated wheat, yields of late plantings have been found to be low, with hastened crop development due to high temperatures during grain filling being a contributing factor (McDonald *et al* 1983).

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J. Farming Systems Research & Development **19** (1) : 81-84 (2013)

EVALUATION OF MUNGBEAN (*VIGNA RADIATA* L. WILCZEK) VARIETIES FOR YIELD ATTRIBUTES IN FLOOD PRONE EASTERN PLAIN ZONE OF RAJASTHAN

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ABSTRACT

Genetic variability was estimated among 10 genotypes of mungbean for eight quantitative characters. High magnitude of Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (GCV) recorded for seed yield/plant followed by number of pods/ plant and 100 seed weight indicate the presence of sufficient amount of variation for these characters. The estimation of heritability for number of pods/plant exhibited high values and also possesses high genetic advance as percent of mean, indicating probabilities of greater amount of additive gene action for the character. Moderate magnitude of heritability and genetic advance estimates were observed for 100 seed weight, days to maturity and plant height, suggesting probabilities of smaller gain upon selection.

Key words: Mungbean, genetic variability, heritability, genetic advance.

Pulses have a special role in meeting the nutritional security of population and sustainability of various cropping system. The mungbean is one of the most important pulses in India as well in Rajasthan and is suitable for cultivation under different agro-ecological situations in zone IIIb of Rajasthan. It is a prerequisite in order to improve yield level through breeding techniques, a thorough understanding of variability exist and in hand of breeders. The present experiments was aimed to study the quantum of variation present and expressed in existing genotypes for various yield parameters, which may prove useful in future breeding programmes.

MATERIALS AND METHODS

The present study comprised of 10 genotypes of mungbean and the experiment was conducted at Agricultural Research Station, Navgaon during *kharif* 2010. The experiment was conducted in randomized block design with three replications of 10 square meters plot size and 30 cm and 10 cm inter and intra-row spacing, respectively with adopting recommended package of practices to raise the crop. Observations were recorded on ten randomly selected plants for each genotype in each replication for plant height (cm), no. of primary branches/plant, no. of pods/ plant, pod length (cm), no. of seed/pod, 100 seed weight (g), days to maturity and seed yield/plant (g). Means were computed and data were analyzed for variance as suggested by Burton (1952) and heritability (broad sense) as the ratio of genotypic to phenotypic variance. The expected genetic advance and genetic advance as percent of mean was calculated as suggested by Johnson *et al* (1955).

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RESULTS AND DISCUSSION

Analysis of variance revealed that the genotypes were differed significantly for almost all the characters except pod length, indicating the existence of considerable amount of variation amongst genotypes (Table 1). The estimates of Phenotypic coefficient of variation (PCV) and Genotypic coefficient of variation (GCV) exhibited variation for most of the characters studied (Table 2). The magnitude of GCV and PCV were highest in the case of seed yield/plant followed by 100 seed weight, no. of pods /plant, Plant height and primary branches/plant, indicating presence of substantial amount of variation for these traits. Seed yield and no. of pod/ plant showed high genotypic coefficient of variation as reported by Eswari and Rao, (2006) and Sirohi and Kumar (2006). Number of primary branches/plant, days to maturity and no. of seeds/pod possesses moderate magnitude of GCV and PCV. Malik *et al* (1986) reported that the no. of pods, primary branches/plant, seeds/pod and early maturity were the most important yield components and accounting for 80-93% of variability in yield among various genotypes of mungbean. Differences in the estimates of GCV and PCV were minimum for pod length, days to maturity and 100 seed weight and suggested little role of environment in the expression of these characters. However, seed yield/plant, no. of seeds/pod, no. of primary branches/plant showed high magnitude of differences between GCV and PCV, this suggesting greater role of environment in the expression of these traits.

Heritability is the index of transmissibility of characters from plants, need to be studied in order to determine the extent to which the observed variations is inherited. High heritability estimates were observed for no. of pods/plant (88.7%), 100 seed weight (69.1%), days to maturity (63.8%) and plant height (63.3). According to Panse and Sukhatme (1957) such traits governed predominantly by additive gene action and could be improved through individual plant selection. Low estimates of heritability was found for seed yield/ plant and no. of primary branches. plant

Table 1. Analysis of variance of yield contributing traits

Characters	Mean sum of square			CD (P=0.05)
	Replication	Treatment	Error	
Plant height cm	10.674	143.967	24.845	7.64
Primary branches/plant	2.652	2.362	0.468	1.09
Pods/plant	1.485	216.867	8.842	4.84
Pod length cm	0.006	0.583	0.073	0.39
No. of seeds/pod	1.759	4.845	1.532	1.86
100 seed weight g	8.126	78.931	9.852	4.89
Days to maturity	23.731	133.625	19.363	7.02
Seed yield/plant g	18.459	94.370	29.783	8.75

*,** Significant at 0.05 and 0.01 level

Table 2. Estimation of various genetic parameters.

Characters	Mean	PCV	GCV	Heritability (broad sense)	Genetic advance as % of Mean
Plant height cm	50.64	15.34	12.95	62.74	21.26
Primary branches/plant	5.89	15.76	11.97	56.7	19.74
Pods/plant	40.1	19.48	18.68	88.2	37.37
Pod length cm	6.34	5.86	4.59	63.8	7.85
No. of seeds/pod	10.32	13.09	8.46	42.1	11.27
100 seed weight g	3.07	17.24	14.41	69.3	24.72
Days to maturity	67.94	11.53	9.57	62.6	16.11
Seed yield/plant g	15.72	42.02	26.38	39.1	33.89

indicated that these traits are highly influenced by environmental fluctuation. But heritability alone does not provide real picture of genetic improvement. It is the genetic gain, predict the pace of genetic improvement to the effected by selecting a particular portion of the population. Association of high heritability with high genetic advance was reported for 100 seed weight, days to maturity, no. of pods/plant and plant height indicates that these traits were controlled by additive gene effects and suggests that the phenotypic selection for these characters may likely to be effective Manivannan and Rammoorthi (1996), Eswari and Rao, (2006) and Sirohi and Kumar (2006) also reported that high estimates of heritability, along with high estimates of genetic advance were observed for plant height, 100 seed weight, pods/plant and seed yield.

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J. Farming Systems Research & Development **19** (1) : 85-90 (2013)

EFFECT OF IRON FERTILIZATION ON GROWTH YIELD OF RICE-WHEAT CROPPING SYSTEM

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ABSTRACT

The rice-wheat is a major cropping system in the Indo-Gangetic plain region of India. It is grown in about 13.5 million ha area in the Indo-Gangetic plain and provides food for 400 million people. Effect of micro nutrients like Zinc and Iron were studied in individual crop of rice & wheat separately but in the system, a few ones have conducted the study. Besides the major nutrient micronutrients, like Zinc & Iron also play critical role in rice and wheat. Deficiency of micronutrients has become a major constraint on productivity, stability and sustainability in the production and soil characteristics. Although, wide spread use of micronutrients has been observed in the soils of Northern India, The information with respect to nutrient availability vis-a-vis characteristics is lacking. Therefore, an attempt has been made in the present study to correlate Iron micronutrient contents of the soil under rice-wheat cropping sequence.

Key words:

MATERIALS AND METHODS

The experiment was conducted during 2004-05 to 2005-06 at Agricultural Farm of A.S. College, Lakhaoti, Bulandshahar. The soil of the experimental plot was sandy loam in texture having pH 8.00, organic carbon 4.1 g kg^{-1}, available N (177.5 kg/ha), available P (8.8 kg/ha) and available K (143 kg/ha). The experiments were laid out in R.B. Design with 4 replications. Plots were fertilized with 5 levels of zinc (0, 10, 20, 40 & 60 kg ZnSO4 ha^{-1}) to and 5 levels of Feso4 ha^{-1} (0, 14, 28, 56 and 112 kg $FeSO_4$ ha^{-1}) in rice crop only.

Basal dose of 120 kg N, 60 Kg P_2O_5 and 60 Kg K_2O ha^{-1} was applied to rice as well as wheat in the form of urea, DAP and MOP, respectively. The crops were irrigated at the proper time as judged by the appearance of soil and the crop. The source of irrigation was canal. Rice variety Pant-10 and wheat variety PBW-343 were used for the study. The present market prices of rice-wheat crops were used to workout the net returns. The data obtained during 2 years were pooled and subjected to statistical analysis. The content and uptake of phosphorus by rice (Table-4.17) and content and uptake of Iron by rice were computed (Table 4.20). The total uptake kg of N, P & K was computed by summing up the nutrient uptake by grain as well as straw. After harvesting, separate, soil samples were collected from each part for estimation of available N, P and K in the soil.

RESULTS AND DISCUSSION

Iron fertilization up to 56 kg ha^{-1}significantly increased the yield in both years (Table-1). The application of FeSO4 at 56 kg ha^{-1} enhanced the grain yield in the systems significantly as compared to

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Table 1. Grain Yield of rice and wheat (qha^{-1}) at different level of Iron

$FeSO_4$ level (kg ha^{-1})	Rice			Wheat		
	Year			Year		
	2004	2005	Mean	2004	2005	Mean
0	51.33	47.54	49.435	43.6	42.87	43.235
14	55.9	50.8	53.35	44.8	44.07	44.435
28	59	53.94	56.47	46.8	46.9	46.85
56	59.58	54.6	57.09	47.1	47.18	47.14
112	59.37	54	56.685	44.9	44.8	44.85
SEM ±	1.11	1.4	1.255	0.42	0.35	0.385
CD at 5%	2.4	3	2.7	0.88	0.76	0.82

28 kg FeSO4. But there was no significant increase in yield at the application of FeSO4 at 120 kg ha^{-1}. The increase in yield might be attributed to the fact that the initial status of available Iron in the soil was low. The findings are in agreement with the results obtained by Pathak *et al.*, (1975), Tiwari *et al.* (1976), Sakal *et al.*, (1982), and Kulandaivel *et al.*, (2003).

A perusal of data presented in Table-2 shows that application of Iron sulphate enhanced the nitrogen content in rice grain. The highest increase in nitrogen content was obtained at 112 kg FeSO4 ha^{-1} followed by 56 kg ha^{-1}. There was significant difference among Iron sulphate levels in respect of N content. The addition of FeSO4 at 112 kg ha^{-1} slightly increased nitrogen content from 2.09 to 2.10 percent[1]which was insignificant. The Iron uptake by rice grain increased from 460.6 to 489.1 mg^{-1}with 112 kg FeSO4 ha^{-1}applied in rice crop. Higher values of nitrogen uptake were observed with increasing levels of Iron Sulphate by Samui *et al.*, (1981).

Table 2. Effect of Fe level on total nutrient uptake (qha^{-1}) and nutrient status in soil by rice (pooled over year)

$FeSO_4$ level (kg ha^{-1})	Nutrient content (%)				Nutrient uptake (kg ha^{-1})			
	N	P	K	Fe (mg kg^{-1})	N	P	K	Fe (mg kg^{-1})
0	2.015	0.21	0.595	59	101.585	10.55	30	298.1
14	2.045	0.225	0.6	68	109.065	12	32	363.15
28	2.07	0.225	0.625	75	116.865	12.65	35.3	423.8
56	2.09	0.2	0.645	80.65	119.295	11.65	36.8	460.6
112	2.1	0.19	0.655	86.25	119.01	11	37.15	489.1
SEM ±	0.012	0.007	0.0075	1.05	1.21	0.29	0.42	5.775
CD at 5%	0.026	0.0145	0.017	2.24	2.58	0.625	0.9	12.315

Application of higher levels of iron to the soil tended to decrease the concentration phosphorus .At par increase in the amount of Iron sulphate up to 28 kg ha^{-1} increased the P content of rice grain. There is no difference significantly from 0.225 to 0.225 kg ha^{-1}but there after it declined with increase on the application of Iron sulphate up to 56 kg ha^{-1}. The reduction in P content at higher 28 and 56 kg FeSO4 ha^{-1} was also reported by Yadav *et al.*, (2003). The application of FeSO4 up to 28 kg ha^{-1} increased the P uptake by rice grain over control. A reduction in P uptake by rice crop was recorded at higher levels of FeSO4 at 56 and 112 kg ha^{-1}.

The potassium content of paddy grain was in increasing trend up to 112 kg ha^{-1} application of FeSO4. Thereafter, a reduction is K content in rice grain was noticed from 112 t0 14 kg ha^{-1} of FeSO4. The uptake of potassium by rice grain was in increasing trend up to 112 kg/ha^{-1} application of Iron sulphate.

The doses of Iron sulphate increased the Iron content of rice grain up to 112 Kg ha^{-1} application. The results revealed that incremental increase in Iron level increased the Iron content of rice as compared to its preceding lower dose. This increase in Iron content may be as ascribed to increased availability of Iron in soil due to its addition. Similar findings were reported by A.K. Singh *et al.*, (1995).

Residual effect of Iron sulphate content:

The effect of different levels of FeSO4 at 14, 28, 56 and 112 kg ha^{-1} were found to be significant on grain yield of Rice (Table-1). Residual effect of Iron sulphate up to 56 kg FeSO4 ha^{-1}significantly increased the grain yield of both years but in 2004 significantly increased the grain yield up to112 kg FeSO4 ha^{-1}. It could be attributed to improve fertility status of the experimental fields in terms of available Iron which could act as catalyst in most of the physiological and metabolic processes and metal activator of enzyme, resulting into higher rice grain yield. It corroborates the findings of Kulandaivel *et al.*, (2003) .

The yields of grain and straw of wheat increased significantly with every increase in the level of iron up to56 kg FeSO4 ha^{-1} applied in preceding rice crop in both crop seasons. The highest yield of grain in both years (2004-5 & 2005-6) 47.10 and 47.18 kg were recorded with 56 kg FeSO4 ha^{-1} .The wheat grain yield tended to decrease with higher level of iron sulphate (112kg ha^{-1}). Similar results were reported by Khurana *et al.*, (2002) and Kulandaivel *et al.*,(2003).

Nutrient content and uptake

The Table-3 shows the residual effect of Iron on N, P and K content (%) and their uptake. The residual effect of Iron enhances the nitrogen content in rice grain significantly over control. It was maximum under residual effect of 112 kg FeSO4 ha^{-1}. It may be due to the favorable effect of residual Fe on metabolic process. Singh and Varun (1989) and Yadav *et al.*, (2003) also reported increased nitrogen content of grain with Iron application. The phosphorus content in wheat grain remained almost static with the application of different doses of Iron sulphate applied in preceding rice crop. Potassium content in wheat grain yield increased significantly with the application of graded level of ferrous sulphate from 0 to 112kg ha^{-1} applied in preceding rice crop in both years. The doses of iron sulphate applied in

Table 3: Effect of Fe level on total nutrient uptake (qha^{-1}) and nutrient status in soil by wheat (pooled over years)

$FeSO_4$ level (kg ha^{-1})	Nutrient content (%)				Nutrient uptake (kg ha^{-1})			
	N	P	K	Fe (mg kg^{-1})	N	P	K	Fe (mg kg^{-1})
0	2.075	0.225	0.515	48.35	89.7	9.75	22.3	209.05
14	2.09	0.215	0.53	56.1	92.9	9.55	23.5	249.35
28	2.115	0.205	0.545	63.8	99.05	9.55	25.5	298.9
56	2.14	0.185	0.56	71.1	100.9	8.7	26.4	335.2
112	2.165	0.165	0.575	77.05	97.1	7.4	25.75	345.55
SEM ±	0.0065	0.0045	0.013	0.39	0.91	0.115	0.335	5.45
CD at 5%	0.014	0.01	0.027	0.835	1.94	0.25	0.725	12.14

preceding rice crop tended to increase the Iron content in wheat grain as compared to control. In wheat it increased from 48.35 t 77.05 mg ha^{-1}with residual amount of 112 kg FeSO4. The results obtained are in agreement with those of Sakal *et al.*, (1982) and Sahu *et al.*, (1996).

Wheat fertilized with increasing level of FeSO4 ha^{-1}significantly increased N uptake. It increased N by 12.48 percent over control. The increase in N uptake may be due to increase in the wheat yield as well as N content in the grain. Samui et *al.*, (1997) also reported similar results. The mean uptake of P by wheat grain was adversely affected with residual iron sulphate .Similar results were reported by Yadav *et al.*, (2003). Further FeSO4 had significantly beneficial effect on the K uptake by wheat grain up to 56 kg ha^{-1} applied in preceding rice crop. The K uptake by grain increased from 22.3 kg ha^{-1} at control to 26.4 kg ha ^{1} at 56 kg FeSO4 ha ^{1} which is in agreement with the findings of Samui *et al.*, (1981).

The Fe uptake by wheat increased significantly with increase in FeSO4 level uptake 112 kg ha^{-1}. Iron content in wheat grain increased from 48.35 gm ha^{-1} to 77.05 gm ha^{-1}with residual amount of 112 kg FeSO4. The mean values of iron uptake by wheat increased from 209.0g ha^{-1} to 345.5g ha^{-1} with residual amount of 112 kg ha^{-1} .Similar results were reported by Yadav *et al.*, (2003).

Net returns of rice wheat cropping system

The economic analysis of rice-wheat cropping systems pooled over years (Table-4) exhibited maximum net return of Rs. 27257.0 ha^{-1} when 28 kg FeSO4 ha^{-1} was applied in rice crop as followed by net return of Rs. 29995.5. Similarly B.C. ratio was highest with 28 kg FeSO4 ha^{-1} from rice-wheat cropping system as a whole. It may be concluded that maximum return (Rs ha^{-1}) and B: C ratio could be obtained with 28 kg FeSO4 ha^{-1}.treatment. This may be practiced by the farmers of the region as a general practice under rice-wheat cropping system.

Table 4: Economic returns of rice-wheat cropping sequence (Rs ha^{-1})

FeSo4 level	Gross returns		Net returns		B:C ratio		
(kg ha^{-1})	Rice	Wheat	Rice	Wheat	Rice	Wheat	Pooled
0	38310.60	42651.9	23768.6	27609.9	2.63	2.83	2.73
14	40630.2	43608.9	25458.2	27936.9	2.67	2.78	2.72
28	43029	46255.5	27257.0	29995.5	2.72	2.83	2.77
56	43636.8	46699.2	26574.8	29137.2	2.56	2.66	2.61
112	42757.8	44523.0	23175.8	24441.0	2.18	2.22	2.20

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J. Farming Systems Research & Development **19** (1) : 91-97 (2013)

INSECTISIDE RESIDUE IN FISH LABEO ROHITA FROM DIFFERENT WATER RESOURCE IN DHAMTARI DISTRICT

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Abstract

The insecticide residues were measured in fish *Labeo rohita* from selected water bodies (Mahandi river, Ravishankar reserviour, Urbon pond Amatalab, Rural pond Matatalab) in dhamtari districts. The insecticide analyzed include all insecticide using the farmers in this districts. The analysis was done applying the method suggested by Nasr *et al* (2009) and final determination was done by GCMS QP 2010 (Gas Chromatography Mass Spectrophotometer) Chloropyrifos (18%) is the most commonly used insecticide followed by endosulfan (16%), cypermethrin (16%), imidachloprid (11%), phorate (7%) and carbryl (5%) by crop growers of Dhamtari district. In most of the water bodies studied insecticide residues were either not detected or were below detectable limit or in traces, because the experimental period was in summer season the possibility of insecticides coming through monsoon run off was least. Due to high temperature, the process of volatization and degradation was also at its peak. This fact is further justified by the results of residue analysis of edible portion of fish, where none of the insecticide was found in detectable limit.

Key words: Insecticide, fish, water, GCMS, water bodies.

The aquatic environment is continuously being contaminated with toxic chemicals from industrial, agriculture and domestic activities. Pesticides/insecticides are one of the major classes of toxic substances used in India for management of pest in agriculture and control of insect vectors of human diseases. The runoff from treated area enter the rivers and aquaculture ponds that are supplied by river (Begum Ghousia, 2004).In many cases, animals near the top of the food chain are most affected because of a process called biomagnifications. Many of the most dangerous toxins settle to the seafloor and then are taken in by organisms that live or feed on bottom sediments. Because these compounds aren't digested, they accumulate within the animals that ingest them, and become more and more concentrated as they pass along the food chain as animals eat and then are eaten in turn. This is biomagnifications, and it means that higher-level predator-fish, birds, and marine mammals-build up greater and more dangerous amounts of toxic materials than animals lower on the food chain. (Nowell *et al* 1999).India ranks second in the world in inland fish production and Chhattisgarh state is one of the largest producer of inland fishery. The rivers and reservoirs occurring in Chhattisgarh are the major source of fish. At the same time these rivers may also act as a sink of the effluents generated from the house holds (Chowdhury *et al.*, 1994). As a consequence there is a likelihood of bioaccumulation of organic and inorganic pollutants like heavy metals and

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pesticides in fish and other aquatic organisms are also affected (Aktar *et. al.*, 2009).Dhamtari district was chosen for the study purpose as the farmers undertake intensive cropping of paddy and vegetable therefore the use various insecticides and pesticides in their fields for plant protection measures and some of these pesticides drain out into the water bodies of Dhamtari district.

MATERIALS AND METHODS

General description of the study area

Chhattisgarh is situated between 17 46' N - 24 80' N latitude and 80 15' E - 84 24' E longitude. The state is blessed with a number of natural resources including productive water areas in the form of rivers, tanks and reservoirs etc. About 55,584 number of water bodies covering an area of 1, 54,741 ha are available for fish production, out of which 83,894 ha water area fall under reservoirs and the remaining are village ponds covering an area of 70,847 ha.

Site of sampling-Site selected for the study are as follows:

Mahanadi River

Ravishankar Reservoir

Rural pond (Matatalab) in achota village

Urban pond (Amatalab) in amapara of Dhamtari

Mahanadi river system

Mahanadi is the principal river of this district and Its originates in the hills of Sihawa (near village Pharsia) flows in an easterly direction into the Bay of Bengal. The fertility of lands of Dhamtari District can be attributed to the presence of this river. The chief crop of this region is paddy. The total length of about 857 km in Chhattisgarh and Orissa state where the catchment area is about 141,600 km2.

Ravishankar reservoir

Ravishankar reservoir is located in Chhattisgarh built across Mahanadi river by damming which is located 15 km from Dhamtari. The length of the dam is 1246m and the reservoir covers total area 6935 ha with a depth of 75 meters. Due to this dam farmers get continuous water supply for their crops of rice hence they even take crops twice a year.

Rural pond (Matatalab)

Matatalab is situated in Achota village of Dhamtari district. Total area of the pond is 1.75 ha with a maximum water depth of 5 feet. This pond is perennial in nature with low anthropogenic pressure. Because of rural location in summer, water is being maintained or recharged through groundwater.

Urban pond (Amatalab)

Amatalab is situated in Amapara of Dhamtari city covering 1.97 ha water area with maximum 4.5 feet water depth mostly used for domestic purposes. It is a perennial pond.

Insecticide residue study

Fish: Healthy and vigorous fishes around 1kg were collected through the fishermen from various landing sites at the times of water sampling. The soft parts of fish samples was removed and muscle tissue sample (10g) taken from the dorsal muscle. It were wrapped in an aluminum foil and kept in deep freezer until analysis.

Sample preparation for insecticide residue analysis -Fish and water sample collected from different water resources were prepared by applying the standard protocol of extraction and cleanup as suggested by Nasr *et al.* (2009) and final determination was done by GCMS-QP 2010(Gas Chromatography Mass Spectrophotometer).

Extraction of Fish sample-Fish sample (10 g wet weight) were homogenized along with anhydrous sodium sulphate (30g) in ceramic mortar. The mixture was extracted with 200 ml of 50% methylene chloride in n-hexane for 8 hours in a soxhlet apparatus. The extracted solvents were concentrated with rotatory evaporator to about 1 ml.

Cleaning of fish sample-Water and fish extracts were cleaned and fractionated using 20g of 0.5% deactivated florisil topped with 1g anhydrous sodium sulfate in order to avoid re-suspension of the top layer while pouring solvents into the column. The column was then washed with 50 ml n-hexane before the loading of sample. The fraction was eluted with 60 ml of 30% methylene chloride in n-hexane. Fraction transferred to rotatory vaccum evaporator adjusted at 35°C temperature and evaporated until the volume reached 2-3 ml. The residue were dissolved in 2 ml of n-hexane and transferred to GCMS – QP 2010 for qualitative study of different insecticides.

Results and Discussion

In the present study, water samples were collected from May to June 2011 from Ravishankar reservoir, Mahanadi river, rural pond Matatalab and urban pond Amatalab for assessing the status of insecticide residues in Dhamtari district

A study was conducted for assessment of most commonly used insecticides for crop cultivation by the crop growers of Dhamtari district. The data comprising the information about such insecticides, along with their consumption rate in percentage is given in Table 1.

The most frequently used insecticide was chloropyrifos (18%), followed by cypermethrin (16%), endosulfan (16%), and imidacloprid (11%). These observations are quite similar to the findings of Khan (2005) and Katekar (2010), who reported most commonly used insecticides for fruit and vegetable cultivation to be cypermethrin, followed by chloropyrifos, endosulfan, and imidacloprid.

Chlorpyrifos is an organophosphate insecticide and can be used on a variety of vegetables and fruits, cotton and ornamental plants. Chlorpyrifos has no residential uses. Crops with the use of active ingredient 20 EC, 4% WP quantity use of per ha 1250-2500 ml, 15-20 kg included apple, cotton, pear, potato and tomato. Mode of action is by contact & through stomach for control of all types of larva, stem borers, termites and soil insects (Howard, 1989).

Endosulfan an organochlorine insecticide, first registered in the 1950s, is used on a variety of vegetables and fruits, cotton and ornamental plants. Endosulfan is mainly released into the environment as a consequence of its use as a pesticide. Its environmental persistence and its long-range environmental transport have resulted in its becoming a ubiquitous

Table 1. Insecticide concentrations in fish flesh (*Labeo rohita*) from selected water bodies of Dhamtari district

S. no	Insecticide	Concentrations in fish flesh from selected water bodies			
		Ravishankar reservoir	Mahanadi river	Matatalab Rural pond	Amatalab Urban pond
1.	Chloropyrifos	ND	ND	ND	ND
2	Endosulfan	ND	ND	ND	ND
3	Cypermethrin	ND	ND	ND	ND
4	Imidacloprid	ND	ND	ND	ND
5	Malathion	ND	ND	ND	ND
6	Phorate	ND	ND	ND	ND
7	Dimethoate	ND	ND	ND	ND
8	Dichlorvos	ND	ND	ND	ND
9	Carbofuran	ND	ND	ND	ND
10	Carbryl	ND	ND	ND	ND

ND- Not detected

contaminant of atmosphere, soil, sediments, fresh and marine water worldwide. Crops with the use of its active ingredient include apple, cotton, cucurbit (cucumber, pumpkin, summer squash, and winter squash) pear, potato and tomato etc. Mode of action is contact & stomach for control of all types of larva and stem borers. Use of endosulfan has decreased significantly over the past decade due in part to regulatory actions taken by authorized bodies (Farm Chemical Handbook, 2000).

Cypermethrin insecticide with soil and foliar uses for the control of sucking insects including rice hoppers, aphids, thrips, termites, turf insects, soil insects and some beetles is most commonly used on rice, cereal, maize, potatoes, vegetables, sugar beets, fruit and cotton it is especially systemic when used in seed or soil treatment. It is effective on contact and via stomach action (Farm Chemical Handbook, 2000).

Imidacloprid is a systemic, chloro-nicotinyl insecticide with soil, seed and foliar uses for the control of sucking insects including rice hoppers, aphids, whiteflies, termites, turf insects, soil insects and some beetles. It is most commonly used on rice, cereal, maize, potatoes, vegetables, sugar beets, fruit and cotton .It is especially systemic when used as a seed or soil treatment. It is effective on contact and via stomach action (Farm Chemical Handbook, 2000).

Phorate and carbryl are used in crops like rice, chilli, cereal and vegetable for control of borer, cutworm and pod borer etc. in Dhamtari district.

In the present study it was found that crop and vegetable cultivation of Dhamtari district is receiving most common insecticide chloropyrifos, followed by endosulfan, cypermethrin, imidachloprid, phorate and carbryl.

Fish are valuable source of high grade protein and they occupy an important position in the socio-economic condition of the South Asian countries by providing the population not only the nutritious food but also income and employment opportunities. India ranks second in the world in inland fish production. West Bengal is the largest producer of inland fish and consumes 11.67 lakhs tons of it annually, the highest among all the States in India. The rivers occurring in West Bengal are the major source of fish. At the same time these rivers are the sink of the effluents generated from the industries and the usage of households (Chowdhury et al. 1994). As a consequence, there is a likelihood of bioaccumulation of organic and inorganic pollutants like heavy metals and pesticide in fish and other aquatic organisms and without proper monitoring programme for the safety evaluation to consumers the situation may raise to an alarming level. (Amorastt *et al.* 1983, Jinha *et al.* 1993).

In the present investigation,fish (*Labeo rohita*) samples collected from different water resources (Ravishankar reservoir, Mahanadi river, rural pond Matatalab and urban pond Aamatalab) of Dhamtari district in June 2011,were subjected to insecticide residue analysis. Out of ten insecticides selected, none was found in the edible portion of fish body. Insecticides were found in traces or at below detectable level in some water bodies but not at all detected in fishes of any of the water body. Presence of insecticides in any water body depends upon physico-chemical properties of aquatic environment. Different factors affect the presence of insecticide like temperature, pH etc. and so the insecticides were not present in the fish body.(Table 2)

Similar results were reported by other researchers also in their studies. Yang naiqing *et al.* (*2008*) analyzed the concentrations of polychlorinated biphenyls (PCBs) and organochlorine pesticides (OCPs) and concentrations of PCBs in samples collected from Dalian, Tianjin and Shanghai ranged from 1.11 to 8.04 ng/g, 1.26 to 5.60 ng/g and 0.83 to 11.4 ng/g on wet weight basis respectively. These concentrations were lower when compared to those in developed countries such as Japan and Italy. Average concentrations of HCB, HCHs, CHLs and DDTs were 0.38, 0.92, 0.47 and 28.9 ng/g on wet weight basis, respectively. David *et al* (2008) measured the organochlorine pesticide (OCPs) in three species of fish *Tilapia jill* (Red belly Tilapia), *Ethmalosa fimbriata* (Bonga Shad) and *Chrysichthys nigrodigitatus* (cat fish) and found to be not detected or below detected of organochlorine pesticide in some fish samples. Begum, Harnataka and Infanulla (2009) reported the concentration of different organochlorine residues in different fish species. The residues were not detected or below detection limit (0.01 µg/L) in different stations of Cauvery river. Endosulfan and p,p'DDD was not detected in *Etroplus suratensis, Channa marulius, Hypophthalmichthys molitrix and Hetropneustes fossilis* in Cauveru River. Acquaah and Frimpong observed that the residues of endosulfan were not detected in the fish samples during 1993-1994.

The insecticides like chloropyrifos, endosulfan, cypermetherin and imidachloprid, are quite frequently used in Dhamtari district for insect and pest management ,but these were not detected in edible portion of fish *Labeo rohita* caught from various selected water bodies,may be because they were not found in the water samples of these water bodies also. Similarly less frequently used other insecticide residues were also not found in *Labeo rohita* fish of Dhamtari district.

Bakar *et al*. (2010) studied three species of fishes namely *Oreachromis sp*., *Clarias spp* and *Pangasius sutchii*. The fish were analyzed for chemical hazards, including pesticide residues and antibiotic residues. The results revealed that there were low chemical hazards in freshwater aquaculture fish. Pesticide and antibiotic residues were detected only in 2.9% and 5.8% of farm fish samples, respectively. The two insecticides,diazinon and fenitrothion were detected in the pale chub at their high concentrations in the water but were not detected in common carp and crucian carp (Tsuda *et al*, 2009).Chlordane residue could not be detected by Salem (2003) in *Clarias lazara* fish in Upper Egypt. Thus, the results obtained in the present investigation are in tune with other works done by other scientists.

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J. Farming Systems Research & Development **19** (1) : 98-102 (2013)

EFFECT OF ORGANIC MANURES AND BIO- PESTICIDES ON COTTON PRODUCTION

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Abstract

A field experiment was conducted for three consecutive *Kharif* seasons of 2005-06, 2006-07 and 2007-08 at All India Coordinated Cotton Improvement Project, Khandwa (M.P.) to evaluate the effect of organic manures and bio-pesticides on cotton production. The results revealed that except 2005-06 the treatment of recommended plant protection practices (IPM) recorded significantly higher mean yield of 1353 kg seed cotton yield per hectare over the treatment of bio- pesticides (organic plant protection) used for plant protection (1120 kg/ha). The increase in yield was to the tune of 233 kg/ha. The yield attributing characters were also affected in the same manner. Among the various nutrient management treatments application of recommended dose of NPK alone (120:60:40kg/h) recorded highest (1493 kg/h) average yield of seed cotton closely followed by application of 50% RDF+FYM 10 t/ha (1406kg/h). It is interesting to note that application of FYM or Vermi compost alone or in combination with NPK enhanced number of bolls/plant and there by seed cotton yield per hectare over control (977 kg/ha) and also over application of crop residue alone @ 5 t/h (1068 kg/ha) and recommended dose of phosphorus alone @ 60 kg/h (1122 kg/h).

Key words: Organic cotton, Growth, Yield

Organic cotton technology has been widely accepted by Indian farmers across the country since its commercialization in 2002. Organic cotton crop is the product of intense scientific research involving high costs and efforts indeed represents the state of art in pest management technology. Apart from the likelihood of reduction in insecticide use by at least 50 to 75 per cent, it is also expected to ensure favourable ecological, economical and sociological returns in contrast to the harmful effects due to large scale use of insecticides {Kranti, 2002}. Efficient crop production packages from the modern agronomy of cotton explore the avenues for realizing the potential crop yields. Looking towards increase in area of Organic cotton, it was felt worthwhile to study the agronomic requirements of Organic cotton in Madhya Pradesh Therefore, the present study was undertaken to evaluate the effect of organic manures and bio-pesticides on cotton production

Material and Methods

A field experiment was conducted for three consecutive *Kharif* seasons of 2005-06, 2006-07 and 2007-08 at All India Coordinated Cotton Improvement Project, Khandwa (M.P.). The Treatments comprised of two Plant Protection – treatments in main plots viz.. (1) Recommended Plant protection Practices (2) Bio pesticides whereas sub plot comprised of 12 treatments viz.. T_1-FYM 10t/ha, T_2-VC 2.5t/ha, T_3-CR 5t/ha, T_4- FYM 5t+VC 1.25t, T_5- FYM 5t+CR

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2.5t, T_6-VC 1.25t+CR 2.5t, T_7-FYM 3.35t+VC 0.8t+CR 1.25t, T_8-RDF(120:60:40 kg NPK/ha), T_9-50%RDF+FYM 10t, T_{10}-RD of N, T_{11}-RD of P, T_{12}-Control with three replications on cotton Variety JK-4. The experimental design was factorial RBD the spacing between plant to plant and row to row was 60x60cm and Plot size was 9.00 x 6.00m. the three year data on yield attributes and yield were analyzed and presented in table-1. Rainfall dada-3years.

Results and Discussion

Effect of Recommended plant protection practices and Bio-pesticides

Perusal of data presented in Table-1 revealed that in case of recommended plant protection practices yield, parameters viz... boll number/plant significantly, boll weight/Plant non significantly, plant height significantly and seed cotton yield significantly. The data further indicated that resulted in non-significant effect on plant height

Growth characters

The Pooled data of ancillary characters and seed cotton yield are presented in Table 2. Effect of different treatments of organic and inorganic source of nutrients of plant, number of bolls significantly, boll weight were non significantly and plant height significantly, affected by different nutrient combinations. The number of boll per plant significantly increased from 15.93 (FYM 3.25t+VC 0.8t) to 24.63 (RDF+NPK). The plant height varied from 36.9 (50% RDF+ FYM 10t) to 41.33 cm (FYM 3.25t+VC 0.8t). When RDF+NPK (T_8) was applied than number of bolls per plant significantly increased over the 50% RDF+FYM 10t (T_9) and RD of N

Table 1. Meteorological data (June 2006-07 January2007-08)

S. No.	Particulars	June				July				August				Sept.			
		2007-08	2006-07	2005-06	Mean	2007-08	2006-07	2005-06	Mean	2007-08	2006-07	2005-06	Mean	2007-08	2006-07	2005-06	Mean
1	Max. Temp.(° C)	31.2	36.6	44.2	37.1	26.5	33.3	31.9	30.6	26.9	29.2	32.2	29.5	26.7	34.4	35.1	32.1
2	Minim. Temp.(° C)	27.5	27.2	26.5	27.7	25	25.3	21.4	23.9	25.5	23.2	23.5	24.1	25.6	26.4	23.6	25.2
3	Rainfall (mm)	80.2	78.7	20	59.7	691.5	236	319	415.5	158	80	66	101.3	104	189	247	180
4	No, of Rainy days	2	3	3	2.67	21	23	17	20.3	11	11	13	11.7	5	7	17	9.67
5	Relative humidity (%)	64	60.8	67	63.3	83	79	77	79.7	82	85	86.2	84.4	87	78.6	79.8	81.8
6	Evapo-transpiration rate (mm/day)	6.98	6.51	5.8	6.43	4.51	4.12	4.41	4.35	4.67	4.55	4.21	4.48	4.42	4.31	3.97	4.23

S. No.	Particulars	Oct.				Nov.				Dec.				Jan.			
		2007-08	2006-07	2005-06	Mean	2007-08	2006-07	2005-06	Mean	2007-08	2006-07	2005-06	Mean	2007	2006	2005	Mean
1	Max. Temp.(° C)	21.1	25.4	34.9	27.1	21.1	23.3	33.7	26.1	26.4	26.3	29.2	27.3	22.3	24.2	33.4	26.7
2	Minim. Temp.(° C)	19	17.7	18.1	18.2	18.7	16.6	10.7	15.3	13.5	11.1	7.05	10.6	8.64	6.8	6.3	7.25
3	Rainfall (mm)	0	0	3	1	0	0	0	0	0	0	0	0	0	0	0	0
4	No, of Rainy days	0	0	1	0.33	0	0	0	0	0	0	0	0	0	0	0	0
5	Relative humidity (%)	63	58.7	67.1	62.9	49.8	65.2	74.1	63	46.8	45.6	48.2	46.9	44	45.4	48.2	45.9
6	Evapo-transpiration rate (mm/day)	1.75	1.11	1.58	1.48	1.65	1.16	14.1	5.64	1.61	1.77	1.56	1.65	0.74	0.61	0.58	0.64

Table 2. Growth and yield attributes of organic cotton

Treatments	SCY Kg/ha				Bolls/ plant				Boll wt (g)				Plant Height (cm)			
	2007-08	2006-07	2005-06	Mean	2007-08	2006-07	2005-06	Mean	2007-08	2006-07	2005-06	Mean	2007-08	2006-07	2005-06	Mean
Recommended Practices	1472	1130	1455	1353	21.87	14.16	15.63	17.22	2.67	2.83	2.97	2.82	38.42	55.03	63.88	52.44
Bio pesticides	1340	745.6	1303	1130	19.24	12.43	14.36	15.34	2.73	2.62	2.87	2.74	35.05	59.57	63.1	52.57
SEm±	32.4	27.4	43.1	—	0.503	0.405	0.39	0.43	0.082	0.09	0.06	0.08	0.57	1.01	0.97	0.85
CD 5%	92.4	78.2	NS	—	1.435	1.16	NS	0.87	NS	NS	NS	0.00	1.627	2.9	NS	1.51
FYM 10 t/ha	1409	982	1442	1278	22.97	15.83	15.73	18.18	2.66	2.3	2.81	2.59	39.73	64.67	62.57	55.66
Vermi compost 2.5t/ha	1435	899	1482	1272	19.2	11.77	14.57	15.18	2.61	3.19	2.76	2.85	38.2	56.3	58.23	50.91
Crop residue 5t/ha	1324	728	1153	1068	21.77	12.8	10.73	15.10	2.61	2.41	2.85	2.62	37.03	53.73	64.27	51.68
FYM 5t+VC 1.25t	1453	942	1572	1322	21.47	13.43	18.43	17.78	2.72	2.65	3.1	2.82	34.23	59.97	68.9	54.37
FYM 5t+CR 2.5t	1411	930	1519	1287	20.67	13.8	15.2	16.56	2.7	2.85	3	2.85	37.57	49.12	64.07	50.25
VC 1.25t+CR 2.5t	1386	787	1388	1187	20	13.53	14.37	15.97	2.99	2.32	3.04	2.78	34.1	55.3	59.87	49.76
FYM 3.25t+VC 0.8t	1440	810	1285	1178	15.93	12.37	13.93	14.08	2.96	2.69	2.58	2.74	41.33	64.53	59.47	55.11
RDF of NPK	1698	1173	1608	1493	24.63	12.83	18.57	18.68	2.52	2.88	3.22	2.87	32.1	54.77	67.3	51.39
50% RDF+FYM 10t	1513	1118	1588	1406	18	11.97	18.3	16.09	2.71	3.1	2.85	2.89	36	56.83	61.73	51.52
RD of N	1336	1108	1465	1303	20	12.8	16.17	16.32	2.56	3.47	2.84	2.96	36.03	59.3	66.15	53.83
RD of P	1281	1013	1072	1122	21.13	12.93	12.3	15.45	2.7	2.47	2.91	2.69	37.57	55.13	63.5	52.07
Control	1187	768	978	977	20.93	15.43	11.63	16.00	2.67	2.39	3.09	2.72	36.9	57.97	65.83	53.57
SEm±	79.3	67.0	61.3	—	1.232	0.993	0.83	1.02	0.2	0.22	0.16	0.19	1.397	2.484	4.18	2.69
CD 5%	226.4	191.6	175.4	—	3.516	2.84	2.37	2.91	NS	0.63	NS	0.21	3.987	7.1	NS	3.70
CV %	13.8	17.50	11.35	—	14.68	18.29	13.59	15.52	18.17	19.88	13.43	17.16	10.2	10.62	14.4	11.74

(T_{10}), however, effect was statistically on the par with the 10t FYM/ha (T_1) and crop residue 5t FYM/ha (T_3). This may be due to more retention of bolls with the RDF of NPK application which fulfils the nitrogen demand of growing plant. Application of different treatment combinations significantly increased the boll weight over the control. However, it was non-significant with respect to different nutrient combinations.

Yield

The seed cotton yield was significantly increased with application of different treatment combinations from 1068 kg/ha (crop residue 5t\ha.) to 1493kg/ha (T_8). Application of FYM@ 10 t/ha alone (T_1) increased the seed cotton. Yield about 1.3 per cent over the control. Similarly, about 1.2 and 1.1 per cent higher seed cotton yield was obtained with the application of Vermicompost 2.5t\ha (T_2) and crop residue 5t\ha. (T_3) over the control, However, with the combined application of FYM 5t +CR2.5t (T4), 1.35 per cent higher seed cotton yield was obtained over the control. The effect of FYM 5t\ha. +CR 2.5t\ha. (T_4) on seed cotton yield was statistically on the par with the FYM 5t\ha (T_1) which indicates the non significant effect of V.C 1.85t\ha application on seed cotton yield. This is because of experimental soil which was not more effect by CR1.25t\ha., similarly, when R.D. of N (T_{10}) was then effect on seed cotton yield was statistically on the par with FYM 5t +CR2.5t (T_4). This was probably due to the fact that crop residue improved the physico-chemical properties of the soil and nutrients were available at proper time (Raskar, 2004). The effect of FYM 5t +CR2.5t (T_4) on seed cotton yield was also statistically at par with of RD of NP(T_{10}) and yield was about 1.30 per cent higher than control, which indicates that 5 t FYM/ha can be applied along with RD of N in place however, if the FYM is in sufficient quantity than 5t FYM/ha should be applied and recommended dose of N should be reduced to 50 per cent (T_9) and for getting the higher seed cotton yield (1.4 per cent higher than control). The highest seed cotton yield under this treatment (T_8) may be due to the balanced use of chemical fertilizers. The results of present study are in conformity with the findings of Nehra *et al.* (2004) and Raut *et al.* (2006).

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J. Farming Systems Research & Development **19** (1) : 103-106 (2013)

EFFECT OF GRADED DOSE OF S, FE AND MO ALONG WITH RECOMMENDED DOSE OF N, P, K ON YIELD ATTRIBUTES AND ECONOMICS OF PEA (*PISUM SATIVUM*)

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Abstract

Input-output data on farm trails of three most popular pea varieties of eastern Uttar Pradesh cultivated under different inorganic nutrient combination were collected during 2002-05 from the experimental field of the Indian Institute of vegetable Research Varanasi, The highest yield and benefit ratio per unit input ratio was found when the crop was cultivated under under recommended dose of NPK with S@20 kg/ha plus Fe and Mo @ 50ppm foliar spray. A return ratio of 3.6 rupees per rupee invested was realized in fresh vegetable pea and pea seeds under this package, which accounted a net profite of 63-to131.4%. Maximum net return and cost benefit ratio 1: 3.4 was realized in Arkel when market as fresh vegetable. Maximum net return and cost benefit ratio was obtained when pea grain was marketed.

Key word:-yield, Economics of green pods and grain

Pea (Pisum sativum L) is one of the important vegetable crops grown all over the world. It contains high percentage of digestible proteins, carbohydrates, sugar, vitamins and minerals and hence is considered vital for country like India where majority of the people are vegetarian. The increasing demand of vegetable pea in eastern Uttar Pradesh has lead to a mega scale cultivation of the crop for the last couple of years. The growers' preference mostly restricted in three varieties viz. Arkel, Azad P-1and Azad P-3. An attempt has been made in this paper to test the effect of graded dose of sulphur iron and molybdenum along with recommended dose of N.P.K.on yield and cost benefit ratio.

The production of vegetable peas adapted to commercial purpose. Knowledge for this of nutrient requirements for become increasing yield by less expensive to become a significant proportion of crop production neither more use of fertilizer gain more profit. Therefore use of any fertilizers care mind effect was synergistic but no antagonistic. Thus the present investigation was undertaken view to find out the effect of graded dose of sulphur iron and molybdenum along with recommended dose of N P K on yield and cost benefit ratio.

Materials and Method

A field experiment was conducted to evaluate the impact of sulphate, molybdate and iron along with recommended dose of NPK application on yield and biochemical constituents of vegetable pea seeds at Indian Instituent of Vegetable Research. Varanasi (U.P).The soil used for the basic properties of the soil were as fallows pH

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7.6, EC 0.41 dSm^{-1}, available N 270 kg ha^{-1}, P_2O_5 18 kg ha^{-1} and K_2O 180 kg ha^{-1} sulphur 10 kg ha^{-1}, organic carbon 0.38% and (Ca^{+2} + Mg^{+2}) 6.42 meq/100 g soil and Just before sowing. The treatment combination viz., T_1 (N_0, P_0, K_0 kg/ha), T_2 (N N_{30}, P_{60}, K_{80} kg/ha), T_3 (N_{30}, P_{60}, K_{80} + S_{20} kg/ha), T_4 (N_{30}, P_{60}, K_{80} + S_{40} kg/ha), T_5 (N_{30}, P_{60}, K_{80} +Fe 10kg/ha T_6 (N_{30}, P_{60}, K_{80} kg/ha +Fe @ 100 ppm spray (15, 30,and 45 days after sowing), T_7 (N_{30}, P_{60}, K_{80} + Fe 10 kg/ha + S_{20}kg/ha) T_8 (N_{30}, P_{60}, K_{80} +Fe @ 50 ppm spray) T_9 (N_{30}, P_{60}, K_{80} + S_{20} kg/ha + Fe @ 100 ppm spray) T_{10} (N_{30}, P_{60}, K_{80} + S_{20} kg/ha + Fe @ 50 ppm spray) T_{11} (N_{30}, P_{60}, K_{80} + S_{20}+ Fe 10kg/ha) T_{12} (N_{30}, P_{60}, K_{80} + S_{20} kg/ha + Mo @ 50 ppm spray (15, 30 and 45 days after sowing. Nitrogen, Phosphorus, Potash and Sulphur applied as basal dose through, Urea, DAP, murate of potash and sulphur respectively, whenever micronutrient iron and molybdenum through ferrous sulphatase and sodium hepata molybdate @ 50 and 100 ppm spraying of crop at fifteen days interval. Were evaluated in split plot design with three replication. The size of each plot was $5m^2$.The crop was planted in16november2002-2003to2003-2004 and recommended Agronomic practices and plant protection measures were fallowed. The crop was irrigated at active growth stage and pod initiation stage. Observation of fresh pod yield at physiological maturity. Pea fruits were harvested at breaker stage from each subplot and marketable fruits only weighed for yield determination. In addition to yield and yield contributing traits, the data were also recorded on marketable yield and price fetched by the crop. The costs of cultivations in general (table-1) vis-à-vis net returns and cost: benefit ratios were worked out for all the varieties (table 2).

Table 1. Effect of graded dose of S, Fe and Mo along with recommended dose of N P K on yield attributes and economics of pea.

Treatment.	Cost of cultivation	Yield g/ha		Gross return		Net return		Return/ rupee invested	
		Grain	Fresh	Grain	Fresh	Grain	Fresh	Grain	Fresh
T1	11180	6.5	48.3	32550	33810	21370	22630	1.9	2.1
T2	13648	9.9	68.7	49350	48090	35702	34442	2.6	2.5
T3	14948	10.7	85.3	53685	59710	38737	44762	2.6	3.0
T4	17548	10.8	91.3	54045	63910	36497	46362	2.1	2.6
T5	14548	9.8	80.7	48760	56490	34212	41942	2.4	2.9
T6	14580	9.4	79.8	47130	55860	32550	41280	2.2	2.8
T7	15548	9.9	80.7	49305	56490	33757	40942	2.2	2.6
T8	14220	10.1	84.9	49995	59430	35775	45210	2.5	3.2
T9	15448	10.6	87.7	52985	61390	37537	45942	2.4	3.0
T10	15348	10.9	90.1	54860	63070	39512	47722	2.6	3.1
T11	15848	10.6	93.4	53105	65380	37257	49532	2.4	3.1
T12	14148	11.5	95	57440	66500	43292	52352	3.1	3.6
LSD=0.5		0.92	7.6						

Table 2. Genotypic variation of economics impact

Treatment.	Cost of cultivation	Yield g/ha		Gross return		Net return		Return/ rupee invested	
		Grain	Fresh pod	Grain	Fresh pod	Grain	Fresh pod	Grain	Fresh pod
Arkel	13648	8.5	75.9	42290	60720	28642	47072	2.1	3.4
AP-1	13648	11.3	85.2	56500	59640	42852	45952	3.1	3.3
AP-3	13648	9.42	74.9	47095	52430	33447	38790	2.5	2.8
$LSD_{0.05}$		0.58	7.4						

Result and discussion

Fresh pod and Grain yield

Fresh pod and grain yield was significantly higher as compared to control. Treatment T_{11}, T_9, T_3, T_2 were found significantly superior compared to rest of the treatment at par to recommended dose of NPK (Table-1). The application of sulphur @ 20 kg/ha and M_o @ 50 ppm on foliar spray along with recommended dose of NPK. Yielded maximum grain and fresh pod yield (1148.8 kg/ha which was 76.3% and 102 q/ha 166.3%) respectively higher yield as compared to control treatment. Greater availability of nutrients lead to increased assimilation of photosynthates per unit leaf area resulting in more plant vigor, which ultimately gave higher yield. Tripathi and Mishra (1997) Kumawat and Khongarot (2002) Singh et al (2002) Prasad and Prasad (2003) Chitdeshwari and Poongothai (2004). Legumes are known to respond favorable to application of Fe and Mo on yield of pea because Fe and Mo may be influencing the nitrogenase and hydrogenase enzyme activity. The 'Azofer' and Azoferm i.e. Fe and Fe Mo protein constituents, are influenced by the application of Fe&Mo foliar spray along with S and recommended dose of NPK.Higher nitrogenase activity leaded by Mo/Fe application enhanced N-Fixation which in turn had positive effect on photosynthetic organs and rate resulted on great increase in yield, (Srivastava and Ahlawat 1995 Srivastava et al 1998).Sulphur and molybdenum gave the maximum yield which play a role on synthesis of chlorophyll, active center of some enzyme and affects various metabolic process which ultimately help in growth and development of plants. The synergistic relation between Mo and S also added an edge for higher yield Singh et al (2002).

Economic impact on treatments

The maximum net return and cost benefit ratio was found rupees fifty two thousand three hundred fifty two and (1:3.6) respectively under treatment T_{12} followed by T_{11} (fourty nine five hundred therty two and cost benefit ratio 1:3.6) in case of fresh pod sailing. Whenever maximum net return and cost benefit ratio fourty three thousand nine hundred twenty two and (1:3.1) obtained under treatment T_{11} in case of dry seed sailing. It may be concluded over all treatment tested found the fresh pod sailing is more profitable compared to grain sailing.

Varietal performance on yield

The grain and fresh pod yield was significantly higher in Azad P-1 followed by Azad P-3 and Arkel.All the three varieties were differ in contrast to flowering, fruiting and seed yield (Table-2). Genotype Arkel performance first flowering and fruiting in nature its early maturity fresh pod of vegetable (15-20 days before) and its sailing to market for vegetable purpose and obtained more market prize fallowed by AP3 and AP1.Genotype AP1 and AP3 gets more production of grain and fresh pod yield other than Arkel &because late flowering and fruiting in nature then let maturity of fresh pod which is let sailing for vegetable consumption of market for humans beings then obtained poor market prize in comparison to Arkel .Cultivar AP1 more fresh pod and grain yield in comparison to AP3 and provide Arkel.But market prize obtained lower in contrast to Arkel and AP3.

The grain yield was significantly higher Azad P1 fallowed Azad P3 and Arkel. Because of grain yield was significantly higher in Azad P1 level of seed its value significantly higher fallowed by Azad P3 and Arkel in this place Azad P1 acquire higher place fallowed by Azad P3 and Arkel.

Economic impact on variety

Variety Evaluation data indicated significantly lowers Arkel of grain and fresh pod yield compared Azad P-1 and AzadP-3 (table-2). The maximum net return of rupees and cost benefit ratio of fifty seven thousand two hundred fifty two rupees and cost benefit ratio (1:4.2) evaluated by Arkel at par Azad P3 compared to Azad P1 (1:3.9) in case of fresh pod sailing. When ever the maximum net return and cost benefit ratio of rupees fourty seven thousand seven hundred sixty seven rupees and cost benefit ratio was realized by (1:3.4C:B ratio) respectively found in Azad P1 followed by Azad P3 (1:2.5) in case of dry seed sailing.

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J. Farming Systems Research & Development **19** (1) : 107-112 (2013)

DIVERSIFICATION OPPORTUNITY OF WHEAT WITH CHICK PEA IN RICE-WHEAT CROPPING SYSTEM IN RELATION TO PERFORMANCE OF RICE UNDER DIFFERENT TILLAGE AND CROP ESTABLISHMENT METHODS

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ABSTRACT

The results obtained on rice-chick pea cropping system have indicated that growth performance of rice crop was better following chick pea crop compared to that after wheat crop. This was evident from significantly more number of total tillers and effective tillers in rice crop after chick pea compared to that after wheat crop and this was true under all the tillage and crop establishment methods. The average length of panicle of rice crop, number of grains/panicle and test weight of rice after chick pea were little better than after wheat under all the tillage and crop establishment methods .The grain yield of rice after chick pea was significantly more than after wheat crop but the harvest index was nearly equal under rice – wheat and chick pea – rice cropping systems.

Key word:-yield, Economics of green pods and grain

The rice – wheat cropping system is predominant in IGP. Continuous cropping of rice – wheat system for long has caused decline in soil and crop productivity (Nambiar and Abrol, 1989). Some long term experiments show stagnation and even decline in yields in the rice – wheat system of South Asia (Daweetal 2000, and Duxbury etal, 2000). Total productivity is declining and farmers have to apply more fertilizer to obtain same yields. Soil organic matter is declining, new weeds, pests and diseases are creating more problems, irrigation water is less available and farmers are complaining about high input costs and low price for their produce (Hobbs and Gupta, 2003) .Some other causes for the decline in the sustainability of RW system have been the late onset of monsoon, labour shortage, delayed and excessive tillage, shortage of draft energy resulting in late sowing of wheat. Keeping in view the decline in soil and crop productivity and other problems under continuous RW cropping system, it has now been recognized to diversify away from RW cropping system by inclusion of leguminous crops in this cropping system.

MATERIALS AND METHODS

The present field experiment was conducted at agricultural farm of J.V. College, Baraut, Distt. Bagpat located in western boundary of U.P. about 55 Km. to the north of Delhi, the NCR of India, on Delhi-Saharanpur road. The soil of the experimental field is of loam texture, nearly neutral in reaction (pH 7.2), moderately fertile and well drained. The soil contains nearly 0.54 % organic carbon and1.55 mg/m^2 bulk density.

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The experiment was laid out in split plot design by dividing the experimental plot into four main plots (replications) and each main plot was subdivided into 6 subplots. Thus there were 6 different treatments with 4 replications, making 24 total numbers of subplots. The details of the experimental treatments were 3 tillage and crop establishment methods and 2 cropping systems. The different tillage and crop establishment methods were conventional tillage (CT) with flat bed planting, CT with raised bed planting (furrow irrigation) known as FIRB and the reduced tillage (RT) with flat bed planting. In conventional tillage, 4 ploughings were done with tractor whereas in reduced tillage only 2 ploughings were done. In furrow irrigated raised bed (FIRB) method, the crops were sown on ridges or beds. The two cropping systems were rice-wheat and chick pea- rice. The two cropping systems (chick pea- rice and rice-wheat) were repeated for two consecutive years in the cropping sequence of chick pea – wheat - chick pea- wheat and rice-wheat-rice-wheat.

The variety of chick pea shown was ICCV- 10. This variety is high yielding cultivar, developed from cross of P_{1231} x P_{1265} at ICRISAT, Hyderabad (A.P.) and released by the name "Bharti". The variety of rice sown was Pusa Basmati-1, developed at IARI, New-Delhi by crossing Pusa 150 with Karnal local variety. The sowing dates for rice were in the month of June. The variety of wheat shown was PBW 343 developed and released from PAU, Ludhiana in 1996. The wheat and chick crops were sown in the month of October. The details of different field/ cultural operations performed during the course of experiment from land preparation to harvesting and data recording on different characters have been given by Amit (2008).

The feasibility of the crop diversification opportunity of rice - wheat cropping system under different tillage and crop establishment methods was tested by inclusion of chick pea in place of wheat.This cropping system (Chick pea - rice) was followed and tested for two consecutive years with the crop sequence as: chick pea – rice - chick pea-rice. The analysis of variance was conducted to test the effect of replication, treatments and cropping systems on growth and yield attributes of wheatunder different tillage and crop establishment methods.

RESULTS AND DISCUSSION

The data on average values of different growth characters of rice grown under two cropping systems (rice –chick pea and R –W) with different tillage and crop establishment methods have been presented in Table 1 whereas the average values of yield contributing characters, grain yield and harvest index of rice crop under two cropping systems have been presented in Table 2.

Growth potential of rice: The average plant height of rice plants following chick pea was found to be more than height of rice plants under rice-wheat cropping system (Table 1). This was true for the plants at all stage of growth and under all tillage and crop establishment methods. However, the differences due to cropping systems were found significant only at 30 days of age. Moreover, the plants attained greater height under FIRB system than on flat at all stage of growth. The growth rates were found maximum during third month of age (60-90 days after sowing).

Table 1. Growth performance of Rice under R-W and R-Cp Cropping system

Characters	Cropping	Tillage and cropestablishment methods			CD 5%	
Plant Height (cm) at Days	**Systems**	**C T**	**RT**	**FIRB**	**CS***	**TCEM***
30	1*	7.1	6.9	8.0	0.31	0.27
	2*	7.5	7.3	8.3		
60	1	45.7	44.8	47.0		0.40
	2	46.0	45.1	47.3		
90	1	91.8	91.0	92.8		0.45
	2	92.0	91.5	93.0		
Maturity	1	91.8	91.0	92.8		0.45
	2	92.0	91.5	93.0		
Total Tillers at days						
30	1	105.0	104.7	116.0	1.39	0.63
	2	110.0	108.0	119.0		
60	1	188.0	186.0	195.2	1.28	1.80
	2	191.0	192.0	197.0		
90	1	370.0	370.0	377.2	2.38	2.35
	2	380.0	375.0	383.0		
Maturity	1	370.0	370.0	377.2	2.38	2.35
	2	380.0	375.0	383.0		
Effective Tillers at maturity	1	363.0	358.2	364.5	2.75	2.00
	2	377.0	374.6	380.0		

1*= Rice-Wheat (R-W) cropping system 2*=Rice-Chickpea (R-Cp) cropping system
CS*= cropping system TCEM*=Tillage&crop establishment method

It was also evident that the plants attained full height up to 90 days as there was no increase in height of plants thereafter.

The data on number of total tillers / m^2 area have indicated that the tillering in rice crop after chick pea was more than under rice – wheat cropping system (Table1). Statistically the cropping sequence had highly significant effect on this character. This holds good at all stage of growth and under all tillage and crop establishment methods. It was also found that total numbers of tillers were more under FIRB planting system and minimum under reduced tillage and that there was no tillering after 90 days after transplanting the rice under either method of tillage and crop establishment and thus the tillering was completed upto 90 days after transplanting.

Comparing the data on effective numbers of tillers /m^2 area in rice crop after chick pea to that under rice-wheat cropping system, it was evident that effective tillering (panicle bearing tillers) was more under rice-chick pea cropping system (Table 1) under all tillage and crop establishment techniques. This difference due to crop sequence was found to be highly significant statistically at all stages of growth.

Moreover, the numbers of effective tillers were less than the number of total tillers emerged up to 90 days after transplanting. Thus it was clear that some of the tillers (0.7, 0.3 and 0.7. % of the total tillers under CT, RT and FIRB planting) emerged up to 90 days could not bear the panicles.

Rice yield and its contributing characters: It was observed that the average length of panicle of rice crop following chickpea were little longer (0.3 to 0.4 cm) under different tillage and crop establishment methods than under rice-wheat cropping system (Table 2). However, these differences were not found significant due to cropping systems. The panicle length under FIRB planting was 2.3 cm significantly longer than under conventional tillage. Perusals of data presented in Table 2 have indicated that numbers of grains/ panicles following chickpea were little more compared to that under rice-wheat cropping system. But these differences could not approach statistical significance. The number of grains per panicle were found to be maximum (52.0) under FIRB planting and minimum (49.0) under reduced tillage in the crop following pigeon pea and this difference of 3.0 grains between FIRB planting and reduced tillage was found significant.

The average test weight of rice after chick pea was found to be 25.1, 26.1 and 26.3 gm, for CT, RT and FIRB planting, respectively. This test weight was little higher than the test weight of rice under rice-wheat cropping system, under all the tillage and crop establishment methods. The differences in test weight under two cropping systems varied from 0.2 to 0.4 gm under different methods and it was not found significant. The

Table 2. Average values of yield and its contributing characters of Rice under R-W and R-Cp Cropping system.

Characters	Cropping Systems	Tillage and cropestablishment methods			CD 5%	
		C T	RT	FIRB	CS*	TCEM*
Panicle length	1*	21.7	22.8	24.0		0.32
	2*	22.0	23.2	24.3		
Grains/Spike	1	49.0	49.0	51.2		1.25
	2	50.5	49.0	52.0		
Test weight	1	24.9	25.7	26.8		
	2	25.1	26.1	26.3		
Grain yield	1	52.0	52.9	55.7	0.20	0.32
	2	53.2	53.6	56.7		
Straw yield	1	75.2	75.1	76.3		0.56
	2	76.0	75.0	76.1		
Biological yield	1	127.2	128.0	132.0		0.54
	2	128.9	128.6	132.8		
Harvest Index	1	41.1	41.3	42.1		
	2	41.2	41.6	42.7		

1*= Rice-Wheat (RW) cropping system 2*=Rice-Chickpea (R-Cp) cropping system
CS*= cropping system TCEM*=Tillage &crop establishment method

grain yield of rice after chick pea averaged 53.2, 53.6 and 56.7 q/ha under CT, RT and FIRB planting system. The average grain yield under FIRB planting was found to be statistically higher than on flat bed planting, whereas it did not differ significantly between two tillage practices. It was further observed that grain yield of rice after chick pea was significantly higher compared to the grain yield under rice-wheat cropping system and it was found true for all the tillage and crop establishment methods. This was attributed to the combined effect of little longer panicle length, more number of grains / panicle, little higher test weight and more number of panicles per square meter area of the crop due to residual effect of chick pea. Hedge (1992) showed consistently better productivity from rice – pulse than R-W system. Singh et al (2002) in a study for diversification of rice- wheat system also reported that cropping system having leguminous components (Chick pea) performed better in all respect compared to cereal – cereal system.

The straw yield of rice after chick pea varied from75.0 q/ha under reduced tillage to76.1 q/ha under FIRB planting method and conventional tillage .The straw yield was significantly less under RT than CT and FIRB planting for chick pea – rice cropping system. On the other hand, the straw yield following chick pea did not differ significantly compared to the straw yield obtained under rice-wheat cropping system. The biological yield of rice after chickpea was significantly higher under FIRB planting compared to flat bed planting. However, it did not differ significantly due to tillage practices. The harvest index of rice crop following chick pea was nearly same under two tillage practices but higher under FIRB planting. These values of harvest indices of rice crop were also nearly equal to that of the rice-wheat cropping system. However, the harvest indices did not differ significantly either due to cropping systems or the tillage and crop establishment methods.

Water productivity: The water requirement of rice-chick pea cropping system was lesser than rice –wheat cropping system, whereas the water productivity was less than rice-wheat cropping systems. This was attributed to low yield of chick pea compared to wheat. Under conventional tillage and reduced tillage the water used to irrigate the crops was nearly equal (10385 and 10313 m^3 water / ha) but it was less (8283 m^3 / ha) under FIRB planting system. Thus FIRB planting saved about 20 % water than flat bed system. The water productivity of this system under two tillage practices were also found to be nearly equal (0.67 and 0.68 kg grain / m^3 water used) whereas it was higher under FIRB planting system (0.90 kg grain).

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J. Farming Systems Research & Development **19** (1) : 113-130 (2013)

RECENT ADVANCES IN INDIAN AGRICULTURAL FARM MECHANIZATION

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Abstract

Since more than 66% population are associated and 22% directly engaged in agriculture as worker. The traditional tools and implements relied mostly on human and animal power. The Indian farmers however, orthodox, he/she may be has only to be assured of the relevance of technique and machinery to induce him to accept them. Equipments for tillage, sowing, irrigation plant protection and threshing have been widely accepted by the farmers. Even farmers with smell holding utilize select the improved farm equipments through custom hiring to increase productivity and reduce the cost of production. The adoption of technology depends upon the resource available with the farmers the paper highlights the trend of agricultural mechanizations in adoption of the engineering inputs. Although the efforts were made to include technologies/data developed by various agencies. The main aim is to project the status of mechanization and currently used agricultural implements by the farmers.

Key word:

An alternative approach would be to use available information technologies to automate these processes to the point where they do not need a human operator. By removing the person from he immediate control of the system, it offers new opportunities but also creates new problems. Once the person is outside the control loop, then the economies of scale that applied to the larger manned tractors does not apply and alternative smaller smarter systems can be developed. Work rates (per day) can be kept high by working longer hours and using multiple machines.

The productivity of Agriculture can be increased by the use of well-designed machinery, which contribute to increase in command area of power sources, better quality of work, reduction in fatigue of operator and considerable improvement in overall economy of production and processing system. A number of institute, Agricultural universities and private firms are rigorously and contributory working in the refinement, improvement and up gradations of farm machinery which enhance the human comfort and also reflect the, would be future trend of mechanization in India.

Most new machines brought to the market are bigger than the previous model. When discussing this issue with equipment manufacturers, this trend is likely to continue into the future. The driving force for this growth would seem to be to take advantage of the economies of scale that larger machines bring with them. This is easily demonstrated if the cost of the operator is taken into account. As most operators are paid by the hour, a larger machine that can increase the work rate over a smaller one can have a significant economic advantage. This size increase does not

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only bring benefits. Large machines are only viable when working in large fields as turning, positioning and transport are all non productive activities. Although many farms have removed field boundaries to take advantage of the larger machines, many smaller farms cannot follow suite due to environmental concerns and suffer economically because of it. As this equipment becomes larger, it also becomes very capital intensive with new tractors and combines becoming prohibitively expensive for the small and medium sized farm. Reliability also becomes an issue as all processes are carried out in series. If one part of the mechanisation system breaks down then all field operations stop

As we all, are aware that modernization of agriculture requires appropriate machinery for ensuring timely field operations and effective application of various crop productive input utilization human animal and mechanical power sources. It also requires machinery for reducing fatigue and drudgery in agriculture practices beside cost effective and eco-friendly. After 70 significant contributions have been made in production of agriculture through mechanization of

(a) Lifting irrigation water with diesel and electric pumps.

(b) Mechanization of other energy intensive farm operation like seed bed preparation and sowing, intercultural operation and plant protection equipment harvesting and threshing equipments, transplantation etc. using tractor and power tiller draft animal, engines and motor along with matching implements and machinery.

Agriculture Development Scenario in India

Total geographical area of the country is about 328 million ha, of which 142 million ha is under cultivation (43.3%). The gross cropped area , however, has increased to more then 189 million ha. Although the farmers have adopted improved seed, fertilizer, plant protection measures, irrigation water and energy which have help them in increasing the food grain production (Table-1). Table – 2 shows the trend of crop production in India.

Table 1. Food grain

Year	Area, million hectares				Cropping intensity	Grain production million tonnes
	Net cropped area	Grossed cropped area	Net irrigated area	Gross irrigated area		
1950-51	118.75	131.89	20.85	22.56	111	50.8
1960-61	133.20	152.77	24.66	27.98	114	82.0
1970-71	140.27	165.79	31.10	49.78	118	108.4
1980-81	140.00	172.63	38.72	49.73	123	129.6
1990-91	143.00	185.91	47.78	62.47	130	176.4
1999-2K	142.80	189.55	53.51	71.51	133	208.8

Source : Agricultural Statistics at a Glance (2001)

Table 2. Trend in crop production

Food crops	1950-51	1960-61	1970-71	1980-81	1990-91	2000-01
Food grain, m tons	50.8	82.0	108.4	129.6	176.4	192.4
Yield kg/ha	522	710	872	1023	1380	1600
Oilseed, m tons	5.2	6.98	9.63	9.37	18.61	24.2
Yield kg/ha	481	507	579	532	771	930

Source: Economic Survey 1998-99

Ecological diversity in soil, rainfall, and temperature, cropping system are very important aspect of Indian agriculture. The rainwater flows through 14 major, 44 medium and 55 miner rivers. About 210 billion m^3 water is estimated to be available as ground water. The Indian agriculture is characterized not only by small fragmented land, but also hill farming, shifting cultivation. Table –3 shows the trend in distribution land holding, operational area and average size of holding.

Farmer preferred to get first ploughing done by tractor and other operation is performed by animal power (Table –4).

The adoption of modern cultivation technology can increased the productivity up to 12 to 34%. The advantage of adoption of modern technology for modernization of is listed in box.

Increased in productivity up to	12-13%
Seed cum fertilizer drill facilitates	
Saving in seed	20%
Saving in fertilizer	15-20%
Enhancement in cropping intensity	5-22%
Increasing in gross income	29-49%

Table 3. Trend in distribution of land holding (Average size of holdings, hectors)

Year	Marginal < 1 ha	Small 1-2 ha	Semi medium 2-4 ha	Medium 4-10 ha	Large > 10	All India
			Farm holding million numbers			
1970-71	36.20	13.43	10.78	7.93	2.67	71.01
1976-77	44.52	14.73	11.67	8.21	2.44	81.57
1980-81	51.20	16.07	12.45	8.07	2.17	88.88
1985-86	56.15	17.92	13.25	7.92	1.92	97.16
1990-91	62.10	19.97	13.91	7.63	1.67	105.29
			Average size of holdings			
1970-71	0.40	1.44	2.78	6.08	18.76	2.28
1976-77	0.39	1.42	2.98	6.05	17.56	2.00
1980-81	0.39	1.44	2.78	6.01	17.38	1.84
1985-86	0.39	1.43	2.77	5.95	17.19	1.60
1990-91	0.40	1.44	2.76	5.91	17.33	1.57

Source: Agricultural Statistics at a Glance (2001)

Table 4. The Level of mechanization (1996)

Operations	Used device/crop	(%)
Tillage	Tractor	15.6
	Animal	24.7
Sowing with seed drill	Tractor	8.3
	Animal	20.6
Irrigation		37.0
Threshing	Wheat	47.8
	Paddy & others	4.4
Harvesting	Reaper	0.56
	Combine	0.37
Plant protection	Plant protection equipment	34.2

Source: Report of Sub group of Agriculture implements and machinery for formulation of 9th five year plan, Govt. of India

Mechanization Scenario

Mechanization has become necessities to reduce drudgery, insuring timely and effective operations of various crops. The use of farm machinery depends upon the Farm and source of available tractive and stationary operations. As seed, fertilizer and chemicals (Pesticides) are the costly inputs and there is a great need to develop farm equipment that bring precision in metering and placement and at the same time timeliness in field operation.

To reduce undue dependence on the labour, R&D efforts required in mechanization are relatively more complex in nature. Here a brief discussion and relevant data are listed with respect to all engineering and technological aspect in agriculture like farm power, comprises with Human power, Animal power, Electrical power etc.

Used Human Power for Completion of Various Agricultural Operation

Various agriculture operation like digging, clod breaking, sowing, inter-culture, harvesting, threshing, cleaning and grading are still performed by the human power. In 2000-01 contribution from animated power has reduced 16.38% and the share of mechanical increased to 83.62% (Table-5).

According to Agricultural Statistics at Glance 1998, the agricultural worker population in India increased from 90.72 million in 1951 to 186.5 million in 1991 with a average growth rate of 2.1% (Table–6).

The worker availability has increased from 0.82 to 1.44 workers/ha. However, the human power used hour/ha in crop production decreased in recant year for different crops. Human power

Table 5. Share of farm power source

Power Source million kW	1971-72	1996-97	2000-01
Human Power	6.29(14.2)	10.12(7.4)	11.12(6.49)
Animal Power	20.19(45.8)	19.23(14.1)	19.17(9.89)
Mechanical and electrical	17.57(40.0)	107(78.5)	112.94(83.62)
Total farm Power	44.05	136.35	143.23

Note : The value in the parenthesis indicate the percentage of total farm power

Table 6. Human energy used in crop production (Human- hours/ha)

Crops	1971-72	1975-76	1981-82	1985-86	1991-92	1996-97
Paddy	889	871	959	859	933	783
Wheat	490	708	538	529	354	468
Jowar	404	458	454	380	391	458
Bajara	477	497	450	397	319	331
Maize	669	678	670	592	572	585
Gram	338	317	342	331	354	305
Arhar	630	630	630	546	540	490
Groundnut	624	574	712	594	729	686
Mustard	367	423	367	395	355	342
Soyabean	443	443	443	347	383	431
Sugarcane	1533	1478	1294	1509	1551	1461
Cotton	770	787	812	715	745	720
Jute	1336	1410	1440	1538	1302	1477
Potato	1336	1007	1487	1354	1326	699
Onion	—	2511	3536	1961	1754	1299
Average	643.5	729	734.9	617.8	739	549.8

Source : Live Stock Census Report, Agricultural Statistics at Glance 1998

availability also increased from 4.86 million kW in 1950-51 to 11.12 million kW in 2000-01.

Drought Animal Availability in India

The country 77.69 million draught animal as per 1991-92 Census (Table-8) This is equivalent to 18.0 million kW. Even today it is estimated that more than 57% area is commended by draught area, with 2.5 ha command area per animal pair. However, the use of draught animal have gradually declined from 182 to 58 animal pair – hour/ha on all India average basis. The state such as Punjab, Gujrat, Haryana , Rajasthan, and Kerla have lower intensity (Table-9).

Table 7. Trend in availability of draught animal

Animal	1971-72	1976-77	1981-82	1986-87	1991-92
Total pairs*, million	4.38	41.25	34.19	35.18	38.85
ha/pair	3.47	3.39	4.09	4.00	3.64

Source Singh G.(2000) Agriculturel Situation in India , Janualry, 2000

Table 8. Trend in animal energy utilization (Animal pair hour/ha)

Crops	1971-72	1975-76	1981-82	1986-87	1991-92	1996-97	Growth
Paddy	225	197	193	143	138	92	3.51
Wheat	190	211	127	98	43	38	6.22
Sorghum	128	106	102	107	109	53	3.45
Pearl millet	89	82	70	57	37	17	6.39
Maize	146	123	138	116	100	83	2.03
Gram	138	110	108	113	88	48	4.67
Pigeon pea	146	102	116	108	87	81	2.37
Groundnut	117	127	124	101	136	82	1.38
Rapeseed	105	105	112	82	81	39	5.56
Soybean	145	145	109	108	93	60	3.39
Sugarcane	135	140	89	103	76	—	7.04
Cotton	113	78	140	120	54	10	10.28
Jute	241	242	264	203	216	147	2.12
Potato	162	155	164	150	133	47	5.52
Onion	173	173	218	141	12	64	8.14
Average* (Aph/ha)	181.68	170.80	147.10	112.10	112.00	58.00	4.48

*Source: Cost of cultivation o Principal crops in India(*animal pair – hour/ha)*

Table 9. Average area per drought animal (Ha/pair)

States	1987	1992
A. High draught animal power intensity states		
1. Himanchal Pradesh	1.29	1.40
2. Manipur	1.65	0.80
3. Bihar	1.79	1.75
4. West Bangal	2.70	1.92
5. Assam	3.06	1.62
6. Jammu & Kashmir	3.16	1.50
B. Medium draught animal power intensity states		
1. Uttar Pradesh	2.50	2.89
2. Orissa	2.51	2.22
3. Tamil Nadu	3.36	3.32
4. Madhya Pradesh	3.96	3.36
5. Andhra Pradesh	4.87	3.90
6. Karnataka	6.79	4.29
C. Low draught animal power intensity states Himanchal Pradesh		
1. Maharashtra	5.35	5.10
2. Gujrat	7.17	6.47
3. Haryana	8.62	9.30
4. Rajasthan	5.60	10.05
5. Panjab	6.07	10.66
6. Kerla	14.00	10.59
All India	3.87	3.67

Source : Cost of cultivation of Principal crops in India

Use of Mechanical and Electrical Power in Indian Agriculture:

There were only 8635 imported tractors in use in 1951. Today more than 282000(2000-01) are manufactured by 13 leading manufacturers with total estimated population of more than 2.24 million (1999-2000) contributing, 49.28 MkW (Table-10). Mostly smell size, general purpose tractors manufactured in India ranging from 15 kW to 37.5 kW (Table –11).

Power Tiller Manufacturing in India started since 1961 with Japanese collaboration. Few models were also imported from China about 17000 units were now produce every year. The population of Power tiller estimated 1.2 Lakhs (Table-12).

Pump Availability

In India 88% of the Total ground water is being used in agriculture. Presently around 5.84 million diesel engine pump set and 11.85 million electric motor operated pump set are used for lifting the water from various sources (Table-13). They consume 90 billion kWh of electricity and 3.6 billion liters of diesel annually (Table-12).

Table 10. Population growth trends in tractors (No in million)

Tractor	1951	1961	1971	1981	1991	1997	Growth rate since in 1970, %
Population	0.008	0.031	0.148	0.518	1.31	2.0	10.3
ha/tractor	14844	4297	948	270	108	470	

Source : Live Stock Census, Report Automobile Association of India

Table 11. Power range of tractors manufacturer in India

P to Power KW	Models	No. of models
Less than 15	Mahindra 225 DI(12), Eicher 242 NC(14.1), Mitsubishi MT 180 D(11.6)	3
15-22.5	Mahindra 365 DI (21.9), Swraj 724 FE(16), Escorts 325 M (16.6), Escorts 335 M (209), TAFE25 DI(17.7), Eicher241 NC(15.1), Eicher 3-12 (20.3), HMT 2522Edi(16.1), HMT 3522(22.5), Hindustan G312(18.7)	10
22.5-30	Mahindra 265 DI (22.8), V B275 DI(23.3), V 475D(29), Swaraj 735 FE(25.1), Escorts 340 M (29.6), TAFE(25.1), Escorts 340 M (29.6), TAFE 1035 (24.9), Eicher 364 NC (22.9), Sonilika (24.5), Tempo OX45(29)	12
30-37.5	Mahindra 575DI(31.2), Swaraj 855(33.9), Farm Trac 50(31), Farm trac 60 (33.3), Escorts 335 M (33.2), TAFE 245 (30.5), HMT 4511(30.5), HMT 5911 (37.2), Hindustan G453 DI (32.3)	9
Above 37.5	Hindusttan G 614(39.2), Hindustan Super G 614(48.9)	2
Power tiller	Kamco, Kubota 290(6.2 kW), Mitsubishi CT85(5.3 kW), Mitsubishi VM 120 (5.8 kW), Mitsubishi 130 DI (8.6 kW), Shrachi Dong Feng(10.7 kW), Khazana S 1100(9.6 kW), Rajada Tong Yong (8.4 KW)	7

Source : Live Stock Census, Report Automobile Association of India

Table 12. Growth in power tiller in India (in .000 numbers)

Source	1971-72	1981-82	1991-92	1995-96	2000-01
Power Tiller	16.418	32.4	60.324	82.13	122.488

Source : TERI, Data directory and year book 2001

Table 12. Population growth trend in stationary farm power source in India (In million)

Mechanical Power	1961-62	1971-72	1981-82	1991-92	1996-97	1997-98	Growth rate since 1970 (%)
Electric Pumps	0.1	1.63	4.33	9.34	11.57	11.85	8.2
Diesel pump	0.23	1.55	3.1	4.59	5.58	5.84	4.89

Source : Status and Future Need of Farm Mechanization

Energy Utilization Scenario in Indian Agriculture

The availability of commercial energy source in India and their use are indicated in Table 13 and 14. It was estimated that 304 million tones of Coal 480 billion kWh of electricity 34.79 million tons of diesel and 5.735 million tones of Kerosene are available in India (Table – 13).

It is estimated that 66-80 % of the total energy for the rural sector is used mainly for rural home management and 16-25% of agricultural production. The rural electrification Programme launched by Govt. in mid sixties, undertaken through the Rural electrification Corporation has helped in making availability electricity to 85% of total village by 95-96 (Table-23) Eleven states have provided electric supply to their all rural areas. With increased level of Mechanization the share of agriculture (based on volume sale through rural outlets) has ranged between 9 to10% of total consumption Since 1980. The availability of HSD in agriculture has increased at an annual growth rate of 8% during the period of 1980-81 to 1999-2000. The total diesel consumption in the country has increased from 1034.5 thousand tones 1980-81 to 3928.7 thousands tones in 1999-2000 at an annual consumption growth rate of 7.28% (Table –17).

Table 13. Net Availability of commercial energy 1999-2000 (mtoe*)

Source	Quantity	Share (%)
Coal	70.31	34.90
Petroleum products	19.87	45.10
Natural gas	12.49	6.20
Electricity	27.80	13.80
Total	201.47	100

*Source : AICRP on ERAS(*energy equivalent to metric ton of coal)*

Based on used pattern of diesel, electricity, human and animal power in Indian agriculture the trend in use operational , direct energy and its projection for the year 2000 is presented in table 18 the average specific energy on all India basis with the present growth rate would be order off 5860 MJ/ Ton of food grain as compared to previous situation of 1996-97 i.e. 5480 MJ.

Table 14. Sectoral consumption of commercial energy in mtoe (million tons of coal)

Sector	1999-2000	Share, %
Agriculture	10.49	5
Industry	90.17	49
Transport	44.88	22
Residential	20.86	10
Others	28.29	14

Source: TERI, Energy Data Director and Year Book 2000-01

Table 15. Monthly per capita consumption of energy in domestic sector (1993-94)

Energy Source	Rural	Urban
Fire wood (kg)	17.27	6.09
Electricity (kWh)	2.27	9.67
Kerosene (liter)	0.68	1.4
LPG (kg)	0.04	0.8

Table 16. Rural energy need

Home management and Rural industries	66-80 %
Agriculture production	16-25 %
Post harvest activities	2-4 %
Animal husbandry and dairying	2-5 %

Source: TERI, Energy Data Director and Year Book 2000-01

Table 17. HSD, Used in agriculture (in .000 tonnes)

Diesel in Agriculture	1970-71	1980-81	1990-91	1996-97
Total HSD consumption used	3837	10345	21139	35200
HSD consumption in Agriculture	153.5	1034.5	2113.9	3520
Share in Agriculture, %	4	10	10	10
Total HSD Need	2084.6	4737	8400	13497
Availability /need (%)	7.4	11.1	25.2	26

Source : TERI, Energy Data Director and Year Book 2000-01
Assumed Annual Use: Tractor 1000 hr.; Power tiller 500 hr.; Stationary engine 1250hr

Use of Energy Conservation Technology for Mechanization

The following aspects need critical analysis and better effective utilizing measure for energy conservation technology for mechanization for Indian agriculture.

1. Better utilization of Natural Resources like solar, wind

2. Water conservation technologies

3. Reduced cultivation practices using combination machinery like minimum/Zero tillage, till planter, roto-planter, Sugarcane set cutter planter, efficient harvesting threshing etc.

4. Efficient fuel utilization of mechanical power sources through better design and maching machinery

Saving of 68% in time in sowing 33% in labour, 62% in diesel could be achieved through use of no till drill over the conventional practice in Wheat crop. (Table –19).

About 10-20% of total energy is used in seed bed preparation which varied from1100 to 3850 MJ/hr.

About 50% saving energy was estimated using the improved implements (Mb plough, disc harrow) over the conventional equipments etc. Tractor drawn rotavator saves time and energy to the extent of 30-35% in heavier soils (42 l/ha diesel compared to with 62 l/ha) with conventional practices). Line sowing whether with bullock drawn or tractor drawn seed cum fertilizer drill; facilitate proper application of seed and fertilizer and saving energy up to 15-20%. About 30% loss of fertilizer may also be prevented at the same time.

The share of energy in harvesting and threshing varies from 10-30% The combine harvesting cost Rs. 800/ha – 500/ha in Northern India. About 1500-1700 combines are introduced every year with estimated population of less then 10000 units in country. Manual harvesting followed by power thresher requires about 1500 MJ/ha compare to 1000 MJ/ha with combine.

Adoption of Improved Categories

Land leveling and grading equipments are generally of multipurpose type, although same of the

Table 18. Operational energy use pattern in India

Energy, Source	1970-71	1975-76	1980-81	1985-86	1990-91	1996-97	2000-01
Diesel energy MJ/ha	23	78	148	190	288	480	550
Electric energy MJ/ha	322	668	1002	1563	32333	5308	7720
Total Mechanical energy MJ/ha	345	746	1150	1753	3521	5788	8270
Animal energy MJ/ha	1606	1485	14004	1293	1101	980	907
Human energy MJ/ha	1331	1363	1401	1348	1409	1525	1607
Total energy in agriculture MJ/ha	3282	3594	3955	4394	6031	8773	10784
Mechanical over total energy, %	11	21	29	40	58	71	76

** Estimated Capacities : Diesel , 63.27 MJ/Kg, Electricity, 11.93 MJ/kWh, Bullock Pair 10.10 MJ , Human 1.84 MJ, (Male – 70% , Female-30%)*

Table 19. Energy saving through use of no till drill in wheat crop

Parameters	Conventional practice	No-trill drill	% saving
Labour requirement man-h/ha	12	8	33.3
Fuel consumption, l/ha	31.6	12	62
Total operational energy, MJ/ha	6687	5777	13.7

Source : AICRP on FIM Research highlight 2000 equipments is designed for earth moving purpose. Indigenously manufactured bullocks drawn equipment requires for the farm development on irrigation project are given in Table 20. Self propelled or automatic type equipments excavator, shovel, draglines, bulldozer, motor grader and scraper are used.

For seed bred preparation Desi plough, bakher and plough (Henga) is still in practice. However, with an annual growth rate of 9-17% of farm machinery cultivator, disc harrow, MB plough, puddler, disc harrow cum puddler, peg tooth harrow, spring time harrow, rotavator and plate harrow are used by the farmers (Table 21 and 22).

Various institutes like CIAE various universities like TNAV, GBPUA&T, PAU etc are rigorously involve in design and

Table 20. Detail of the bullock drawn equipments required for farm development for proper irrigation project areas. (Power requires hauling: a pair of bullocks)

Type of Equipment	Output per day of 8h	Recommendation for Use
Leveling Karaha 1.0 to 1.5 m wide	40-60 cum	Leveling small fields with lead less than 30 meter and cut less than 15 cm
Buck scrapper (2m long and 30 cm wide)	60-75 Cum	Leveling small fields with lead less than 30 meter and cut less than 15 cm. Does better leveling than Kherha
Wooden float (1.5 m wide and 4.5 m long)	1-2 ha	For smoothening land after rough leveling by other equipment
Bund former	2-3 has	Making bunds for irrigation before and after sowing of crop
A frame ridger	5-6 ha	Making ridges for border strip and check basin of width 60 cm and height 30 cm
V ditcher	5-6 ha	Construction and cleaning field change channel and field rain of 75cm width and 25 cm depth
Double mould board type ridger	½ to 1 ha	For making rideges and furrow

Table 21. Trends in growth of population of bullocks drawn implements

Implements	1966-67	1970-72	1981-82	1991-92	2000-01
Steel plough	3.52	5.36	6.69	9.60	11.70
Cultivator	—	-	4.26	5.79	6.54
Puddler	2.71	1.69	2.32	2.37	2.81
Sowing devices	1.14	4.09	5.62	6.74	8.26
Cane Crusher	0.65	0.68	0.69	0.75	0.73
Sprayer & Duster	0.21	1.44	1.55	1.79	1.86

Source: G. Singh (2000), Agriculture situation in India, Jan, 2000

Table 22. Trend in growth of power operated agriculture machinery (in hundreds)

Power Source	1971-72	1976-77	1981-82	1986-87	1991-92	2000-01
Power sprayer/duster	448	851	1239	1853	2771	3110
M.B & Disc Plough	573	925	1429	2392	4989	12431
Disc harrow	556	1292	1892	3574	5456	28814
Cultivator	815	1766	3105	5956	11558	28115
Seed drill/ seed fert. drill	246	640	1606	2777	7301	27405
Planter	85	244	305	443	643	1090
Thresher	2058	4841	10250	13638	13793	30900

Source : G. Singh (2000), Agriculture situation in India, Jan, 2000

developments of agricultural implements. Some of successfully developed equipments for seedbed planter listed in table –23.

The meeting devices type of furrow openers and power transmission train in sowing and ploughing equipment are the major design features. CIAE, HAU, PAU, IISR and other institutions and agriculture universities have developed different type of sowing and planting equipments which, basically developed for particular soil and climatic conditions (Table –24).

The crop yield is effected by 20-30% of weed is not controlled in time. The khurpi is the most variable hand hoe for removal of weeds but it takes 300-700 man/hr to cover one hr. Use of long handle hand hoe and beg type weeders, reduce this weeding time to 100-125 man hours/ha. Same of the weeding and inter culture equipment are tabulated in table –25.

Table 23. Farm equipment for seed bed preparation

Name of equipments	Power source	Where developed	Work capacity ha/h	Unit manufactured (manufacturers)
CIAE animal drawn multipurpose frame	Bullock Pair	CIAE	0.06-0.12	50(3)
Animal drawn harrow cum puddler	Bullock Pair	PAU	0.14-0.20	1000(2)
Animal drawn helical blade puddler	Bullock Pair	TNAU	0.12	1000(3)
Tractor drawn pulversing roller attachment	35 hp tractor	PAU	0.62-0.75	2000(2)
Tractor drawn spiked clod crusher	35 hp tractor	GBPUAT	0.4-0.6	50(3)
Tractor hydraulically leveler	35 hp tractor	ANGRAU	0.4	40(1)

Source: Commercialization Source: AICRP on FIM

Table 24. Different type of equipment developed for sowing and planting

Name of equipments	Power source	Where developed	Work capacity ha/h	Unit manufactured (manufacturers)
Manually operated mustard drill	2 person	PAU	0.05	2500(2)
Manually operated garlic planter	2-3 person	PAU	0.04	200(4)
Manually operated low land rice seeder	2 person	TNAU	0.12	1000(3)
Animal drawn Joyti multi crop planter	Bullock pair	MPKV	0.1	200(2)
CIAE animal drawn planter	Bullock pair	CIAE	0.12	5000(5)
Power tiller operated till planter	10-20 hp engine	NDUAT	0.15	
TNAU tractor mounted seed planter	35 hp tractor	TNAU	0.63	800(4)
Tractor mounted till planter	35 hp tractor	PAU	0.2	50(2)
Tractor mounted planter	35 hp tractor	MPKV	0.5	5(1)
Tractor mounted inclined plate planter	35 hp tractor	CIAE	0.5	15
Tractor mounted no till drill	35 hp tractor	GBPUA&T	0.46	1000(8)
Tractor mounted raised bed planter	35 hp tractor	PAU	0.25	50(2)
Manually operated six row rice transplanter	1 person	PAU	0.4	1000(7)
Self propelled rice transplanter	6 hp engine	CIAE/KAU	0.12	60(1)
Sugarcane set cutter planter	35 hp tractor	IISR	0.25	500(2)
Sugarcane stubble saver cum fertilizer applicator	35 hp tractor	GBPUA7T	0.53	46(2)
Tractor mounted multi crop planter	35 hp tractor	MPKV	0.5	
Self propelled riding type rice transplanter	5 hp engine	PAU	0.2	
Self propelled vegetable seed planter	5 hp engine	TNAU	0.09	
HAU animal cum fertilizer seed drill	Bullock pair	HAU	0.2	200(3)
Animal drawn vegetable cum planter	Bullock pair	ANGRAU	0.15	10
Power tiller operated multi crop planter	10-12 hp engine	HPKV	0.5	4
Tractor mounted multi crop planter	35 hp tractor	PAU	0.6	

Source : AICIP on FIM

Table 25. Weeding and inter-culture equipments

Name of equipments	Power source	Where developed	Work capacity ha/h	Unit manufactured (manufacturers)
Grubber	One person	CIAE	0.01	2000(4)
Twin wheal hoe	One person	CIAE	0.01	30000(3)
CIAE single wheel hoe	One person	CIAE	0.01	150(4)
PAU wheel hand hoe	One person	PAU	0.4	5000(3)
Self propelled weeder	2hp engine	CIAE	0.13	3
Self propelled weeder	3 hp engine	TNAU	0.09	50
Tractor mounted 2 row sugarcane stubble shaver	35 hp tractor	IISR	0.35	40
Self propelled boom sprayer	6.5 hp tractor	ANGRAU	0.5	3
Power tiller operated tall tree sprayer	10-12 hp engine	TNAU	30 tree/ha	—
TNAU star weeder	One person	TNAU	0.01	500(4)
Self propelled high clearance sprayer	20 hp engine	PAU	1.6	40(1)

Source : AICRP on FIM

The design of harvesting and threshing equipments are basically motivated from economic consideration, social realities, reduction in cost of production as well as operation and economics considerations A in India Sickle is still most widely tool used for harvesting. However Tractor operated and sell propelled harvesters are commercially manufactured in India. The growth rate of harvesting and threshing machines are sown in table – 26.

The Govt. of India allowed to import of few models of combine harvester. The central Farm machinery-training institute Budhani is govt. Body to evaluate the combine for their suitability for Indian condition. Major combine were evaluated and their performance has been summarized in table-27.

Table 26. Trend in growth of harvesting & threshing machines (In thousands)

Power source	1971-72	1991-92	2000-01
Combine (Tractor)	3.5	61.5	216
Harvestor (Self propelled)	4.5	35	82.58
Thresher	2058	13793	30521
Wheat	1825	10757	23363
Paddy	136	1353	3190
Others	97	1683	3968

Table 27. Technical specification and performance of major combines with respect to wheat crop

Combine	Max power (kW)	SFC (gm/ kWh)	Cutter bar width (m)	Minimum fuel consumption (liter/h)	Rate of work (ha/h)	Grain (kg/ha)	Crop (Ton/ha)
Swaraj 8100 SPI	73.3	283	4.28	9.16	0.91-2.62	1864-3849	3.81-7.68
ESPI 614	57.8	298	4.28	7.6	0.92-1.90	2707-7723	5.26-13.0
IC 616 Delux	72.5	295	4.28	3.68	0.58-1.4	1929-26177	4.48-16.57
Standard S 8300	75.3	271	4.85	7.6	0.67-1.55	3503-4215	6.20-13.39
Bharat 730Delux	71.1	264	4.28	7.08	0.81-1.50	2824-6250	5.96-11.98
Axia 6-514	75.3	258	4.24	7.57	0.56-1.43	1124-7785	2.29-14.22
Dashmesh 9100	63.6	239	4.28	7.08	0.89-1.27	2226-6021	5.27-9.30
Preet 987	62.5	240	4.28	6.75	0.76-1.23	2059-5411	5.01-11.95
Standard C 514	71.7	258	4.28	6.55	0.63-1.36	2356-10348	4.64-15.73
Standard C 412	52.5	256	3.63	6.33	0.49-1.00	2462-6006	4.21-10.70
Kartar 4000	55.0	318	3.92	5.47	0.58-0.98	2747-7520	4.29-11.49
Kartar 3500	28.7	329	3.26	6.76	0.70-1.00	1461-3989	2.56-7.38
Class Crop trigger	45.0	235	2.08	6.35	0.38-0.6	1333-2762	2.07-5.7

Source: AICRP on FIM

Design of equipments for harvesting and threshing has been developed specially for rice and wheat crop. They are very much suitable for Indian condition. The grain losses are minimum compared to previous machines. The equipment developed for harvesting and threshing operations are given in Table 28 & 29.

Conclusion

It is well known that Indian agriculture is the backbone of Indian economy contributing approximately 25% of the Gross Domestic Products (GDP) of the country. It provides livelihood to the weaker section of the society and also the raw material for small and cottage industries situated in semi- urban and rural areas. Agricultural mechanization in the country has made significant progress during last five decades and presently India has approximately 126 lacs tractors, 9650 combined harvesters 38.8 lacs threshers , 168 lacs irrigation pumps. The growth of agricultural mechanization has been observed in the field of various farm operations like ploughing, sowing, plant protection, and threshing as 41%, 30%, 35 %, and 38% respectively. India is the second food grain producer after China. However India holds second position in the production of tea, fruits, vegetables and cereals crops. Therefore, in view of the above, plastic culture, green house construction, utilization of solar energy are the specific R & D area of Indian agriculture. As far as process industry

Table 28. Harvesting and threshing equipments

Name of equipments	Power source	Where developed	Work capacity ha/h	Unit manufactured (manufacturers)
Naveen sickle	One person	CIAE	0.018	1200000(2)
Vaibhav sickle	One person	MPKV	0.011	100000(2)
TNAU animal drawn groundnut digger	Bullock pair	TNAU	0.1	300(5)
Udaipur animal drawn groundnut digger	Bullock pair	AUU	0.16	—
PAU animal drawn single row potato digger	Bullock pair	PAU	0.12	100(2)
Self propelled vertical conveyor reaper	5 hp engine	CIAE	0.20	700(3)
PAU tractor front mounted vertical conveyor reaper	35 hp tractor	PAU	0.3	10000(5)
Tractor mounted groundnut harvester	35 hp tractor	TNAU	0.28	10(2)
Tractor mounted 2 row potato digger	35 hp tractor	PAU	0.3	500(2)
Tractor mounted potato digger elevator	35 hp tractor	PAU	0.14	150(3)
Tractor mounted fodder harvester	Tractor 35 hp	PAU	0.2	—
Tractor mounted trash shredder	Tractor 35 hp	MPKV	0.23	—
Tractor mounted hoist	Tractor 35 hp	TNAU	25 min/tree	—
Tractor mounted rice straw chopper	Tractor 35 hp	PAU	0.5	—
Riding type self propelled vertical conveyor reaper	6 hp engine	CIAE	0.28	60(1)

Source: AICRP on FIM

Table 29. Threshing equipments

Name of equipments	Power source	Where developed	Unit manufactured (manufacturers)
Tabular maize Sheller	One person	CIAE	125000(5)
Pedal operated thresher	Two person	IIT	500(4)
CIAE groundnut cum castor decorticator	One person	CIAE	20000(5)
Single ear head thresher	0.5 hp motor	CIAE	105(3)
Multicrop plot thresher	1 hp motor	CIAE	250(3)
CIAE multicrop thresher	5 hp motor	CIAE	140(3)
High capacity multicrop thresher	20 hp motor/ 35 hp motor	CIAE	2(1)
APAU multicrop thresher	5 hp motor	ANGRAU	1000(4)
PAU Axial flow rice thresher	35 hp tractor	PAU	100(3)
Groundnut pod stripper	2 hp tractor	ANGRAU	500(3)
PAU Axial flow groundnut thresher	25 hp tractor	PAU	20(1)
TNAU groundnut thresher	5 hp motor	TNAU	10(2)
PAU Axial flow sunflower thresher	7.5 hp motor	PAU	8000(30)
Flow through rice thresher	8 hp engine/7.5 hp motor	KAU	300(4)

Source: AICRP on FIM

is concerned, India is far behind in comparison to developed countries. Thus, it is very important to create awareness for modern agriculture mechanization technology among the ultimate beneficiaries i.e. rural people . To achieve the goal, extension functionaries have to work to hard to convenience the farmers for adopting the recent technology and to increase the their productivity and reduce the input cost.

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J. Farming Systems Research & Development **19** (1) : 131-135 (2013)

RESPONSE OF CHICKPEA (*CICER ARIETINUM L.)* TO ORGANIC FARMING PACKAGE UNDER DRYLAND CONDITIONS

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Abstract

An experiment was carried out at AICRP Project on Dryland Agriculture, JNKVV, Kuthulia Farm, Rewa (M.P.) during *Rabi* season of 2005-06. The experiment was laid out in Randomized block design with four treatment comprising four replications. The chickpea variety JG- 322 was grown. Although the organic farming package T_3 having 1/3 recom. N as FYM+ vermicompost+ linseed oil cake+ intercropping with mustard gave the maximum yield- attributes and yield but the net return was highest up to Rs. 18642/ha (B:C ratio 1: 3.86) from package T_2 having the same inputs as in T_3 except intercropping. Thus, the best organic farming package T_2 was 2t FYM/ha (i.e.1/3 reco.N) +1 .6 t vermicompost/ ha +8.33 kg linseed oil cake/ha for securing highest net income from chickpea grown under dryland conditions of Kymore plateau region. The soil moisture tended to decrease with the increase of crop growth period till crop maturity and tended to increase with the increase of soil depth from 0 to 45 cm under each growth stage of observation. It is interesting to note that intercropping of mustard though increased the yield but the cost of intercropping reduced the net returns.

Key words: Chickpea, Organic farming, Dryland

Material and Methods

A field experiment was conducted at, Kuthulia Farm, college of Agriculture Rewa (M.P.) during rabi season of 2005-06. The experiment was laid out in Randomized block design with four replications The chickpea variety JG 322 was sown on during 2005 Rabi season keeping a seed rate of 100 kg/ha at the row distance of 25 cm. In T_3 intercropping of mustard var. Pusa Bold was done at the seed rate of 5 kg/ha. The crop was harvested on 8 March 2006.The soil of experimental field was clay-loam having pH 7.5. The treatments comprised of eight organic farming packages i.e. T_{1-} 50 % recom. NPK ($N_{10}P_{20}K_0$) + 50 % N as 3 t FYM/ha, T_{2-} S! recom. N each from 2 t FYM/ha 1.6 t vermicompost/ha + 8.33 kg linseed oil cake/ha.,T_{3-} T_2 + intercropping of mustard with chickpea,T_{4-} T_2 + organic practices for weed & pest control (no pesticides), T_{5-} 50 %N as 3 t FYM/ha + 1 kg/ha Rhizobium + 160 kg rock phosphate + 0.8 kg PSB/ha, T_{6-} T_2 + 1 kg/ha Rhizobium + 0.8 kg PSB/ha, T_{7-} 100 % NPK ($N_{20}P_{40}K_0$) +25 kg $ZnSO_4$/ha , T_{8-} Control . The periodical observations, including statistical computation were performed for each character/parameter studied. The economics of the different treatments was also worked out.

Results and Discussion

Growth characters

The plant population/m row length did not deviate significantly. The plant height, in general, increased by more than two-fold between 30 and 45 days growth period, thereafter the increase was slow till maturity, the primary and secondary branches/plant, in general, increased steadily till maturity of crop.

However, the dry biomass/plant increased rapidly between 30 and 60 days growth period. The growth characters viz. plant height, primary and secondary branches/plant, dry biomass/plant were influenced significantly due to different organic farming packages. The package (T_3) having S! recom. N as FYM + vermicompost + linseed oil cake + intercropping with mustard gave maximum growth characters of every stage of observation.

Yield attributes

The second best package was T_7 having 100 % NPK ($N_{20}P_{40}K_0$) +25 kg $ZnSO_4$/ha.The yield-attributes viz. pods/ plant, seeds/pod, 1000-seed weight and

Table 1. Growth and yield-attributes of chickpea as influenced different organic farming packages.

Treatments	Plant height (cm)	Primary branches/ plant	Secondary branches/ plant	Dry biomass/ plant	Pods/ plant	Seeds/ pod	Test weight (g)	Seed yield/ plant
T_1 50%Recom. NPK($N_{10}P_{20}K_0$) +50%N as FYM(3t/ha)	29.50	3.76	9.12	42.55	21.42	1.95	120.75	8.76
T_2 S!Recom. N(FYM2t/ha) +vermicompost 1.6 t/ha. +linseed oil cake (8.33 kg/ha)	31.05	3.40	9.15	41.12	21.70	1.75	117.75	8.92
T_3 S!Recom. N(FYM2t/ha) +vermicompost 1.6 t/ha. +linseed oil cake (8.33 kg/ha) + intercropping with mustard	32.25	4.12	10.90	43.44	25.85	2.00	125.75	10.90
T_4 S!Recom. N(FYM2t/ha) +vermicompost 1.6 t/ha. +linseed oil cake (8.33 kg/ha) + HW 35 DAS + bird perching + trench digging for pest control	31.10	3.82	8.37	42.81	20.35	1.90	117.25	8.42
T_5 50%N as FYM (3t/ha) + Rhizobium (1kg/ha.) + rock phosphate (160 kg/ha.) +PSB (0.8 kg/ha)	31.42	3.55	9.22	41.53	21.87	2.00	122.50	8.57
T_6 S!Recom. N(FYM2t/ha) +vermicompost 1.6 t/ha. +linseed oil cake (8.33 kg/ha) + Rhizobium (1kg/ha.) + PSB (0.8 kg/ha)	31.27	3.30	9.65	42.07	21.45	1.75	116.75	9.25
T_7 100 % NPK ($N_{20}P_{40}K_0$) + 25 kg Zn SO_4/ha	29.97	3.62	10.10	42.71	22.97	1.90	123.50	10.38
T_8 Control	29.20	3.02	7.92	41.10	19.22	1.65	116.50	8.37
S.Em ±	0.56	0.18	0.56	0.18	1.21	0.07	2.22	0.57
C.D. *5 %	1.65	0.54	1.66	0.54	3.55	0.23	6.54	1.69

Table 2. Yield and net-return from chickpea as influenced by different organic farming packages

Treatments		Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Net income (Rs/ha)	B:C ratio
T_1	50%Recom. NNPK($N_{10}P_{20}K_0$)+50%N as FYM(3t/ha)	12.00	13.35	47.34	17834	6.10
T_2	S!Recom. N(FYM2t/ha)+vermicompost 1.6 t/ha. +linseed oil cake (8.33 kg/ha)	11.96	12.25	49.40	**18642**	5.04
T_3	S!Recom. N(FYM2t/ha)+vermicompost 1.6 t/ha. +linseed oil cake (8.33 kg/ha) + intercropping with mustard	12.72	14.63	45.98	17289	5.43
T_4	S!Recom. N(FYM2t/ha)+vermicompost 1.6 t/ha. +linseed oil cake (8.33 kg/ha) + HW 35 DAS + bird perching + trench digging for pest control	12.00	14.85	44.69	17090	4.97
T_5	50%N as FYM (3t/ha) + Rhizobium (1kg/ha.) + rock phosphate (160 kg/ha.) +PSB (0.8 kg/ha)	12.00	14.85	44.69	17739	5.97
T_6	S!Recom. N(FYM2t/ha)+vermicompost 1.6 t/ha. +linseed oil cake (8.33 kg/ha) + Rhizobium (1kg/ha.) + PSB (0.8 kg/ha)	11.27	13.27	45.92	16287	4.29
T_7	100 % NPK ($N_{20}P_{40}K_0$) + 25 kg Zn SO_4/ha	12.54	13.63	48.27	18078	**5.02**
T_8	Control	8.72	10.75	44.80	12276	4.72
	S.Em ±	0.053	0.044	0.145	—	—
	C.D. *5 %	0.456	0.130	0.427	—	—

seed yield/plant were increased significantly due to organic farming packages. The package T_3 having S! recom. N as FYM + vermicompost + linseed oil cake + intercropping with mustard recorded the maximum yield-attributes i.e. 25.85 pods/plant, 2.0 seeds/pod, 1000-grain weight 125.75 g and seed yield 10.90 g/plant. The second best package was T_7 having 100 % NPK + 25 kg $ZnSO_4$/ha, the values being 22.97 pods/plant, 1.90 seed yield. Both these packages were at par to each other.All the seven organic farming packages (T_1 to T_7) resulted in significant increase in grain and straw yield of chickpea over control (T_8). The best package was T_3 having S! recom. N as FYM + vermicompost + linseed oil cake + intercropping with mustard which produced significantly higher grain (12.72 q/ha) and straw (14.63 q/ha) over rest of the organic farming packages. The second best package was T_7 having 100 % NPK + $ZnSO_4$ yielding 12.54 q/ha grain and 13.63 q/ha straw. The increase inn grain yield from both these packages i.e. T_3 and T7 was 4.00 and 3.82 q/ha over control (T_8). The harvest index was also increased significantly in packages like T_1 (47.34 %), T_2 (49.40 %), T_3 (45.95 %), T_4 (49.69 %) and T_7 (48/27 %) as compared to control T_8 (44.80).

Table 3. Soil moisture depletion pattern during the growth and development period of chickpea.

Crop growth period	Soil Depth (cm)		
	0-15	15-0	30-45
At sowing	18.75	19.98	20.74
At 15 DAS	17.49	18.62	19.70
At 30 DAS	16.48	17.74	18.78
At 45DAS	15.47	16.77	17.66
At maturity	14.05	15.42	16.18

Economics

Amongst the different packages T_2 (S! N as FYM + vermicompost + linseed oil cake) gave the maximum net return of Rs.18642/ha (B: C ratio 3.86), however, the grain yield was maximum in package T_3 (T_2 + intercropping), with the lower net return of Rs.17289/ha (B:C ratio 2.79). The second best package was T_7 having 100 % NPK + 25 kg $ZnSO_4$/ha, the net return being up to Rs.18078/ha (B: C ratio 3.16). The packages like T6 and T4 gave lower net return which may be because of non-effectiveness of biofertilizers and additional cost involved in the hand weeding, respectively.

Effect of soil moisture

The soil moisture was found to increase with the depth of soil at every stage to observation. A sowing of chickpea it was 18.75 % at 0-15 cm depth which increased up to 20.74 at 32-45 cm depth. Finally, at maturity stage, the soil moisture remained only up to 14.05% at 0-15 cm depth and 16.18% up to 30-45 cm depth. The overall picture indicates that the soil moisture increased with the increase of crop growth period till maturity of chickpea crop. Secondly, the soil moisture increases with the increase of soil depth.The beneficial influence of similar type of organic farming packages (including FYM and vermicopost) on plant growth have been reported by, Vasanthi and kumaraswamy (1999), Jha et al. (2002), Jat and Ahlawat (2002), Shrivastava et al. (2002), Saini et al(2002), Vyas et al. (2002) and Maruthi et al, (2002).

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J. Farming Systems Research & Development **19** (1) : 136-146 (2013)

VARIABILITY IN CROP PRODUCTIVITY IN ORISSA-CAUSES AND CONSEQUENCES

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Judicious blend of technology, seed, input services, credit, and institutional support and price policies put the Indian agriculture on high growth curve after independence. However, the country is still considered in the group of low-income countries as the sizeable proportions of people are below poverty line. The reason behind that the agriculture performance widely differ across the country due to considerable heterogeneous in agro-climate, resource endowments, dissemination of technology and other production constraints This has caused a great inter-state and inter-district variation in crop yield, which in turn influence the food grains productivity at national level. Mukherjee, C and Vaidyanathan (1980) and Ray, S. K. (1983) studied the nature and causes for growth and instability in Indian Agriculture. In Orissa, rice alone covers 54.4 percent of the gross cropped area. However, the average productivity of rice during 2005- 06 was recorded 1.4 t/h compared to 2.6, 2.9 3.1 and 3.9 t / ha in West Bengal, Haryana, Andhra Pradesh and Punjab. The productivity of coarse cereals that has sizeable area in the state was noted 0.6 t/h as against 2.0 and 2.5t/h in neighboring states of West Bengal I:', and Bihar. Besides, a wide variation in crop yield was also observed within the state. For instance, the productivity of rice was noted to 1.25, 1.04 and 1.03 t/h in districts Bhadrak, I Koraput and Ghazipati as against 0.29, 0.38 and 0.44 t/h in Bolangir, Angul and Boudh. Under coarse cereals, the maize productivity in Balasore and Nawpada was recorded 0.89 and 0.76 t/h while it was 1.3 and 1.5 t/h in Jharasuda and Boudh districts during 2002-03. Similar disparity was also noticed in pulses and oilseeds productivity with different magnitudes in these districts. The slow and inconsistent growth in food grains production recorded 6.6, 4.4, 5.2 and 6.9 million tones during 1993-94, 1996-97, 1999-2000 and 2004-05 in Orissa appears major reason for prevailing poverty in the state.

As variation in crop yield within the state creates instability in food grain production that further influence the growth in poverty, it was thought appropriate to study the inter- district variation in crop productivity, their causes and impact on livelihood and rural economy in various districts of Orissa.

The study results will be of great importance for planners and researchers engaged for poverty alleviation through enhancing the crop productivity in Orissa.

METHODOLOGY

The study is based on secondary data. Out of 3 districts in Orissa, 11 districts namely, Balasor, Bhadrak, Gazipati, Koraput, Khurda, Angul, Bolangir, Deogarh, Jharasugnda, Nawpada and Boudh were selected for the present study. The crops chosen are rice, maize, finger millet, wheat, green gram, black gram, groundnut and mustard. The productivity of these crops were gathered from 1999 to 2002 from various issues of the crop statistics, Directorate of Economics and Statistics, Government of Orissa Besides, fertilizer consumption and rainfall pattern from 1999-2002, irrigated area 1995- 1999, area under HYV and credit distribution during 2002-03 were also collected for the respective districts from different sources. The per capita availability of cereal, pulses and oil seeds were worked out based on the total production of these commodities during 2002-03. Further, per capita distributions of animal products were calculated taking into account the total production of milk, meat, fish and eggs in the study area. The total food grains and oil seeds produced in the study districts during 2002-03 formed the base for computing the per capita income of the farming community. The procurement price of 2002-03 was used for calculating the gross revenue realized from food grains and oilseeds.

Results and Discussion

Variation in Crop Yield

Rice being staple food occupied 71.3 percent of the total cultivated area allocated to food grains in the state. However, the productivity of rice at district level, which forms the state average yield, showed a wide variation amongst the districts. Further, the productivity of rice was so low that none of the district yield included in the study, was comparable to national average productivity of 1744 kg/h. The highest average yield of rice during 1999 to 2002 in districts Gajapati and Koraput was recorded 1476 and 1247 kg/ha while it was 532, 629 and 669 kg/ha in districts Naupuda, Bolangir and Deoghar Table-I. The productivity of rice in other districts was also on the similar line with different magnitudes. Since

Table 1. Average productivity of major crops in different districts of Orissa

Yield (kg/ha)

Districts	**Average yield (1999-2000 to 2002-03)**							
	Rice	**Maize**	**F.Millet**	**Wheat**	**G.Gram**	**B.Gram**	**G.Nut**	**Mustard**
Balasore	1171	0	0	1661	360	430	1567	353
Bhadrak	1149	0	0	1133	364	305	1621	304
Gajipati	1476	865	989	1667	502	346	1228	472
Koaput	1247	749	570	1260	257	214	1220	208
Khurda	928	679	423	1335	226	205	1044	242
Angul	701	667	281	1376	162	159	892	90
Bolangir	629	756	360	1248	232	157	838	260
Deogarh	669	1025	350	1471	332	245	1048	264
Jharasuguda	914	1235	0	1653	449	83	1102	255
Naupada	532	963	347	983	99	106	670	104
Boudh	818	1278	450	1544	333	250	1019	273
National Average (2002-03)	1744	1681	995	2610	717	536	694	902

F- Finger, G-Green, B-Bengal, G. Groundnut rice cultivation is the main occupation for more than 75 per cent of the state population, low yield coupled with wide inter district variation contributing prime role for growing poverty in the state. The per unit productivity of other cereals, like maize, finger millet and wheat occupying 3.4, 4.0 and 0.30 per cent of the total area allocated for cereals, was also observed much lower than national average in all the districts. Besides, wide gap in productivity of these crops amongst the districts were noticed. For instance, under pulses, the productivity of black gram was recorded 83, 106, 157 and 159 kg/ha in districts Jharasuguda, Naupada, Bolangir and Angul while the productivity of this pulse crop in Balasore, Gajipati and Bhadrak were 430, 346 and 305 kg/ha respectively. However, the yield rate of ground nut was moderate in all the districts. The highest productivity of mustard (472 kg/ha) was recorded in Gajipatti and lowest (104 kg/ha) in Nawpada districts against the national average of 902 kg/ha. Results corroborate with the findings of Bhatia and Singh and Arya and Rawat, (1990). The study results indicated that the productivity of food grain and oilseed crops of the state is greatly influenced by inter-district disparity in crop yield.

Causes of Yield Variation

Inequalities in Fertilizer: Use Fertilizer plays a key role for enhancing food grains production in the country. The fruitful results of green revolution would have never been harvested if the use of fertilizer had not been encouraged. The contribution of fertilizer for boosting the food-grains production has been estimated to be about 50-55 per cent in recent past (Chauhan, 1997). For

Table 2. Disparity and declining trend of fertilizer consumption (2000-2003) in selected districts of Orissa

Districts	Fertilizer (NPK) consumption (kg/ha)			
	1999-2000	2000-01	2001-02	2002-03
Balasore	91	72	77	70
Bhadrak	105	89	102	75
Gajipati	39	35	24	25
Koaput	41	38	33	28
Khurda	15	16	21	16
Angul	23	22	25	20
Bolangir	22	22	23	18
Deogarh	28	21	23	30
Jharasuguda	80	86	82	79
Naupada	20	17	17	14
Boudh	23	22	25	31
National Average (2002-03)	43	38	41	37

Source : Fertilizer Statistics, The Fertilizer Association of India, New Delhi.

increasing the crop productivity, the nutrient removed by the crops must be replenished through chemical fertilizer and manures. But it does not happen and many states uses fertilizer much below the crop requirement resulting poor yield and decline in soil health. The highest (75 kg/ha) fertilizer consumption in Bhadrak and lowest (14 kg/ha) in Nawpada district during 2002-03 (Table-2) clearly indicates the reason for wide variability in crop productivity within the state. Further, while comparing fertilizer consumption, with neighboring states the maximum and minimum dose of fertilizer consumption was recorded 395 and 70 kg/ha in Hawrah and Nadia districts of West Bengal and 193 and 25 kg/ha in Begusaria and Gopalganj districts of Bihar. These figures elaborating the facts for low crop yield in the respective districts of Orissa state. Besides, declining trend of fertilizer use (Fig-I} was observed in all most all the districts during 1999-2002 that is not a good sign for future crop production in the state. And if the present trend of fertilizer is continued for further more years, the state may face acute shortage of food grains in future. To overcome this problem, three to four fold increases in present dose of fertilizer consumption seems essential for doubling the crop production in the state.

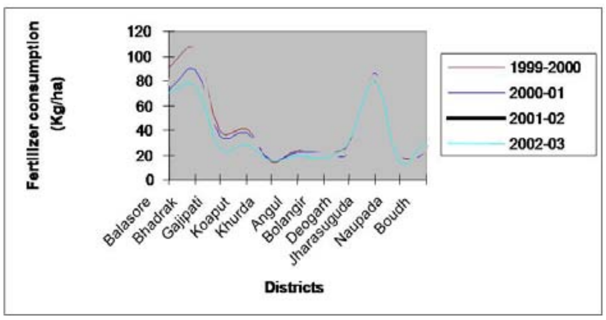

Fig. 1. Trend of fertilizer consumption in districts of Orissa

Insufficient Irrigation Infrastructure

Irrigation facility has great role in crop production after seed and fertilizer. The districts and crops having greater area under irrigation, will certainly give more output than others. Orissa being rain fed state, farmers mainly depend on rainwater for crop production. Since the rainwater is not assured and its distribution is not being equal, government. has created irrigation infrastructure for timely irrigation of the crops. However, the irrigation facilities created by the government. is neither adequate nor its distribution is rational. For instance, districts, Balsore, Bhadrak, Khurd and Boudh are enjoying with gross irrigated area ranging from 41 to 65 per cent, while the share of gross irrigated area in other districts was recorded between 22-25 per cent (Table 3). This unequal distribution of irrigation facility has also promoted disparity in crop yield in the study area.

Rainfall Pattern

The states cultivating rain fed agriculture always suffers from erratic, unequal distribution and variation in rainfall intensity besides drought and floods. The data on rainfall pattern presented in (Table-4) revealed that none of the districts included in the study received normal rains during the year 1999 to 2002. Further, unequal distribution r of rains was observed in the districts that emphasized disparity in crop yield. Besides, the states like Assam, Orissa, Bihar and eastern part of Uttar Pradesh, always suffers from drought and flood. Flood creates water logging which brings down the crop yield while the drought restricts the plant growth in absence of sufficient soil moisture. Pandey et. al., (1979) reported

Table 3. Unequal distribution of irrigation area during 1995-2000

Districts	Percentage of the Gross Cropped Area		
	1995-96	1997-98	1999-2000
Balasore	45.7	47.6	47.8
Bhadrak	45.8	54.8	65.8
Gajipati	25.9	32.7	35.3
Koaput	25.7	20.3	39.8
Khurda	50.6	52.4	56.9
Angul	26.6	31	28.1
Bolangir	17.2	21.2	21.8
Deogarh	26.8	28.6	26.8
Jharasuguda	18.7	25.6	22.8
Naupada	16.6	20	22.2
Boudh	39.6	42.1	40.8

Source : Directorate of Economics and Statistics, Govt. of Orissa.

Table 4. Rainfall pattern during 1999, 2000 and 2002 in different districts of Orissa

Districts	Normal rainfall (mm)	Deviation from normal rainfall		
		1999	2000	2002
Balasore	1568.40	(+) 686.6	(-) 45.4	(-) 231.5
Bhadrak	1568.40	(-) 98.6	(-) 611.4	(-) 510.6
Gajipati	1295.60	(-) 246.6	(-) 352.6	(-) 347.2
Koaput	1521.80	(-) 40.8	(-) 408.0	(-) 388.3
Khurda	1521.80	(-) 644.8	(-) 617.8	(-) 487.5
Angul	1421.10	(-) 68.1	(-) 430.1	(-) 521.0
Bolangir	1443.50	(-) 492.5	(-) 637.5	(-) 636.5
Deogarh	1527.00	(-) 87.0	(-) 711.0	(-) 644.5
Jharasuguda	1527.00	(-) 401.0	(-) 821.0	(-) 515.3
Naupada	1378.00	(-) 317.2	(-) 672.2	(-) 728.3
Boudh	1997.10	(-) 972.1	(-) 1055.1	(-) 419.0

that damage of crop due to submergence was more at flowering stage than at post fertilization and maturity stage. These facts proved that low and unequal distribution of rainfall coupled with drought and flood make subsequent contribution in inter-district variation in crop yield.

Use of Local Cultivars

The crop varieties grown in rain fed states are mainly subsistence oriented and thus very little emphasis is given to their suitability for the prevailing moisture availability situations. Further, the varieties that are grown are of long duration, tall and have low harvest index with low input response. Though, the data shown in (Table-5) indicated that HYV of rice covered 58 to 90 per cent of the cultivated area in the study districts during 1999-2000. However, the existing rice productivity do not support this facts. It appears that farmers are not really using high yield variety of rice and exploiting their potentialities. Further, HYV's may not do better than traditional varieties in the years of poor rainfall or under waterlogged conditions and with insufficient use of plant nutrient. The distribution of high yielding varieties of rice, wheat, jowar and maize were also not rational in the respective districts resulting variability in crop yield.

Inadequate and Improper Distribution of Credit

No doubt, technological innovation is of great importance, but to utilize them, capital is needed for both off-farm and on-farm investment. The farmers practicing rain fed I agriculture are poor resource based and their low crop income does not allow to purchase sufficient farm inputs. Better credit supply system may help the farmers for timely purchase of farm inputs. However, insufficient and unequal distribution of

Table 5. Districtwise area under HYV of different crops during 1999-2000

Districts	Percentage to the cultivated area			
	Rice	Wheat	Jowar	Maize
Balasore	72.00	92.20	0.00	22.40
Bhadrak	78.30	60.00	0.00	20.00
Gajipati	86.20	95.50	0.00	81.70
Koaput	90.10	47.60	70.30	58.30
Khurda	58.20	72.00	11.00	63.70
Angul	75.20	61.90	0.00	73.70
Bolangir	74.70	68.70	56.50	82.00
Deogarh	78.80	87.70	40.00	88.00
Jharasuguda	66.90	85.40	0.00	96.00
Naupada	96.00	96.30	37.50	44.60
Boudh	70.00	98.00	0.00	47.80

Source : Directorate of Economics and Statistics, Govt. of Orissa.

Table 6. Credit distribution pattern in study area

Districts	Credit given by all scheduled commercial banks as on March, 2003 (Rs.)	No. of holdings	Holding wise credit distribution (Rs.)	Per ha credit availability (Rs.)
Balasore	50826	2100	2420	21
Bhadrak	16002	1467	1091	9
Gajipati	4615	565	817	8
Koaput	20615	1383	1490	9
Khurda	25856	1226	2109	23
Angul	26135	1365	1914	16
Bolangir	16737	1940	863	6
Deogarh	2023	386	863	3
Jharasuguda	13760	476	2891	23
Naupada	5490	728	754	4
Boudh	3564	563	633	4

Source : Directorate of Economics and Statistics, Govt. of Orissa.

credit was observed in the targeted districts. For instance, in Bhadrak, Naupuda and Bolangir 1 districts, credit was given Rs.I091, 754 and 863 as per holding size of 1467, 728 and 1940 while in Jharasurgudia, Deoghar and Khurda, the credit was distributed Rs.289l, 863 and 2109 as against 476, 386 and 1226 holding size respectively during 2002-2003. Besides, insufficient and wide variation in credit supply systems was also observed. For example, the disbursement of credit (per unit of gross cropped area) in Deogarh and Boudh was noted Rs.3 and 4/ha as against Rs.21 and 23/ha in Balasore and Khurda districts, Shukla et. al (2001) observed similar variability in distribution of crop loan in western and eastern part of Uttar Pradesh. The study suggest that since better credit facility improves the economic condition of the f~ers by enhancing the farm output, there is great need to provide sufficient loan to the farming community in rain fed states in general and Orissa in particular to enable the poor farms to make their best use for purchase of farm inputs and raise the crop yield. Further, rational distribution of crop loan is equally important to narrow down the inter-District variation in crop yield. It is presumed that if government pays proper attention towards capital investment in agriculture, the crop production in Orissa may be increased two fold or more and poverty prevailing in the state may be eliminated up to some extent.

Impact of Yield Disparity

Improper Distribution of Food Articles

Variation in crop yield always affects the total production that in turn influences the per capita availability of food and non-food grain crops to state/ district population. The per capita availability of cereals calculated to be

435.1, 591.4 and 517.7 g/day in Balasore Bhadrak and Korapute compared to 116.7, 150.4 and 212 g/day in Khurda, Angul and Nawpada districts, clearly indicates the effect of yield variation in food grains distribution (Table- 7). Though, district Gajipati ranked first in average productivity of rice, wheat and finger millet during 1999-2002, however, it appears that crops grown in the district during 2002-03 might have adversely affected by natural clematises resulting low production and less distribution., It is further, added in this context that the availability of cereal at national level was 456.3 gram per capita, per day during 2002-03 and considering that figure in view, the population of all the districts of the study area except Bhadrak and Koraput, seems to be below the poverty line. With regard to pulses consumption, the highest and lowest figure was recorded 14.9 and 1.6 g/day in Balsore and Nawpada as against All India average figure of 34.4 g/day. The availability of edible oils ranged from 0.2 to 5.7 g/day in the study zone. These figures showed basic facts behind poverty prevailing in Orissa state.

Variation in Per Capita Consumption of Livestock Products

Livestock production is also linked with crop production. And because of this, the animal productivity of high productive zone is always higher compared to low (productive regions like rain fed and dry land. The reason behind that low productive zone does not provide sufficient dry and green fodder to the cattle resulting low productivity of animas. Due to this unequal distribution of livestock products was observed in different districts of Orissa. For example, the per capita availability of milk in Gajipati and Koraput was recorded 126.9

Table 7. Per capita availability of cereal, pulses and edible oil in study districts

Name of Districts	Population 000' No.	Availability (gram/capital/day) during 2002-03		
		Cereals	Pulses	Edible Oil
Balasore	2033	435.1	1.6	1.7
Bhadrak	1332	591.4	2.4	0.2
Gajipati	518	340	3.2	0.96
Koaput	1178	517.7	1.8	0.2
Khurda	1874	116.7	3.2	0.56
Angul	1139	150.4	3.3	5.7
Bolangir	1336	192	7.1	2.7
Deogarh	274	304.4	8.6	2.7
Jharasuguda	510	345.8	6	0.5
Naupada	530	212	14.5	0.86
Boudh	373	338.5	6.4	0.7

Note : Prepared based on total production of cereal, pulses and edible oils during 2002-03.
Source : Directorate of Economics and Statistics Govt. of Orissa.

and 86 g/day as against 31 and 36 g/day in Nawpda and Ahgul districts during 2002-03 (Table-8). Similarly, the consumption of fish at the rate of 5.2 and 56.8 g/day noticed in Gajipatti and Balsore districts again showed wide disparity in distribution of non-food articles. The highest figure for per capita availability of meat was computed 6.2 g/day in Boudh and lowest 1.9 g/day in Bhadrak districts while the corresponding figure for eggs availability was 0.19 and 0.02 g/day in districts Khurda and Jharasugud respectively. Joshi et. al (2004), and Kumar and Birthal (2004) worked out consumption of milk, meat and fishes at the rate of 201, 8.5 and 9.9 g/day at national level during 1999-2000. Keeping these figures in view, the per capita availability of milk and meat is quite low in the study area.

Economic Impact

Since cropping is the main occupation of the farming community, the per capita income was calculated based on the total income realized from crops during 2002-03 in the districts taken for study. Disparity in crop yield greatly influenced the crops revenue (Fig-2), which further made variation in per capita income. The highest per capita, per annum income of rural people was computed Rs.1417 for Balasore and lowest Rs.444 in Ahgul (Table-9). This large gap in crop income clearly indicates the impact of inter- district variability in crop yield in Orissa. Further, these figures show the economic status of Orissa farmers and cropping out put scenario of the state. If the farm income is assumed to be doubled considering the income from other

Table 8. Per capita availability of milk, fish, meat and eggs during 2002-03 (g/day)

Name of Districts	Milk	Fish	Meat	Eggs
Balasore	75.8	56.8	2.8	0.06
Bhadrak	76.1	36.2	1.9	0.1
Gajipati	126.9	5.2	2.8	0.03
Koaput	86	4.5	3.2	0.16
Khurda	55.5	23.3	2.3	0.19
Angul	36.1	12	2	0.04
Bolangir	61.5	18.5	3.5	0.06
Deogarh	60	27.8	3	0.07
Jharasuguda	64.4	18	3.5	0.02
Naupada	31	10.8	3.2	0.05
Boudh	66.1	17.9	6.2	0.05

Note :Prepared based on the total production of milk, fish, meat and eggs produced in the respective districts.
Source : Directorate of Economics and Statistics Govt. of Orissa.

Table 9. Income released from crops by rural people during (2002-03) in selected districts of Orissa

Name of Districts	Total Revenue (million Rupees)	Rural Population (000')	Per Capita / annum income (Rs.)
Balasore	1909.6	1803	1059
Bhadrak	1687	1191	1417
Gajipati	380.4	465	818
Koaput	1294.2	980	980
Khurda	505.4	1069	473
Angul	435.7	981	444
Bolangir	619.6	182	524
Deogarh	194.7	254	767
Jharasuguda	379.1	324	1170
Naupada	249.2	500	498
Boudh	280.6	355	790

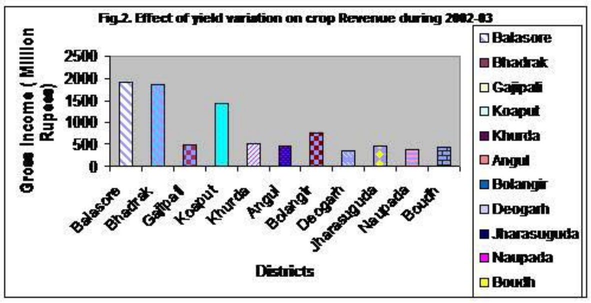

Fig. 2. Effect of yield variation on crop revenue during 2002-03

enterprises, even than it could not meet the basic requirement of the household expenditure of the farm families. Further, with the present farm income, Orissa farmers may not apply sufficient dose of fertilizer and other inputs for raising the crop yield and farm income. Since this chain of low crop income is a continuous process in the state, unless the government makes vigorous efforts to improve the agriculture performance, the Orissa farmers may not : come out from the chain of vicious circle of poverty.

Conclusion and Policy Issues

- The study clearly indicates wide inter-district variation in crop productivity in Orissa. Further, the productivity of all food grain crops of the districts included in the study was much below to the national average.
- Variability in crop yield influenced the total production which in turn created disparity is per capita availability of cereal, pulses and edible oil.
- Since the livestock production is also linked with crop production, the variation in consumption of animal product was also noticed in the selected districts.
- Inter-district variation in crop yield further caused disparity in per capita income realized from crops.

- Low use of fertilizer and its declining trend are playing pivotal role for bringing down the crop productivity in Orissa. Further, inequalities in fertilizer consumption causing regional yield disparity.

- Insufficient and unequal distribution of irrigation infrastructure, rainfall pattern and credit supply are adversely affecting the crop yield and these constraints are mainly responsible for inter-district variation in crop yield.

- Creation of irrigation facility on broader scale by the Government is utmost essential for improving the cropping status of the state. Further, the extension agencies need to be instructed to promote fertilizer use through field demonstration. The assistance from other source of communication like radio, television and newspaper can also be taken up for convincing the farming community for higher use of plant nutrients for boosting the crop yield.

- Evolving high yielding and drought and flood tolerant varieties for all crops in. general and rice in particular is also equally important for doubling the food grain production.

- Establishing food and milk processing units and other agro-industries nearby the village will provide employment opportunity and consequently the household income will be increased which will further encourage the farmers for applying" more dose of fertilizer and other inputs for raising the crop yield.

- As 47.1 per cent of the state population is below poverty line, it seems justified to reintroduce the Small and Marginal Farmer Development Programme, Drought Prone Area Development Programme and Whole Village Development Programme for poverty alleviation of Orissa. Farmers.

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SCREENING OF HEAT TOLERANT GENOTYPES OF WHEAT (*TRITICUM AESTIVUM*) FOR LATE SOWN CONDITIONS IN FLOOD PRONE EASTERN PLAIN ZONE OF RAJASTHAN

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ABSTRACT

A study was conducted for two *rabi* seasons (2007-08 and 2008-09) with 10 diverse genotypes of wheat (*Triticum aestivum* L. emend. Fiori & Paol.), to understand the genetic variation in morph-physiological growth and yield parameters under timely and late sown conditions. Association between these characters and grain yield was also studied to identify physiological traits for selecting genotypes tolerant to terminal heat tolerance. All traits measured showed reduction under late sowing with the exception of harvest index, which registered an increase. Barring days to anthesis and grain growth duration, all other growth parameters viz., spike number and biomass/square meter and yield parameters viz., grain number and weight/spike, harvest index and grain growth rate showed good variability (high CV). Days to maturity and grain growth duration did not show significant association with the grain as well as biological yield.

Key words : *Triticum aestivum* , terminal heat, genetic variability, yield component.

In flood prone eastern plain zone of Rajasthan, guar-wheat cropping system and in north-western India, rice-wheat cropping system has forced wheat to be sown late in a sizeable area. The late sown crop get exposed to mean maximum temperature of about 35^{0}C during grain growth period and causes yield reduction of 270 kg/ha/degree rise in temperature (Rane *et al.* 2000). Genetic variability exists among wheat genotypes for tolerance to high temperature during grain development phase.

Selection for late sown situation is done by screening advance lines along with checks at different locations over years by All India Coordinated Wheat Research Project through IVT and AVT late sown experiments. In these trials the criterion for selection or rejection is only grain yield. However, if some physiological or morphological traits are identified with tolerance to terminal heat. It can be used to screen the early generation material. Many physiological and biochemical traits have relationship with heat stress of wheat plants and are different at different phenological levels of the plants (Dawson and Wardlaw 1989, Shpiler an Blum, 1991). Reduction in crop growth duration (Shpiler and Blum 1991) adverse biochemical changes in the developing grain (Jenner1991a,b) are some of the physiological traits that are affected by heat stress. Hence, the present investigation was undertaken to identify the phenological characters associated with better grain yield under late sown conditions.

MATERIALS AND METHODS

A field trial was laid out during the *rabi* season of 2007-08 and 2008-09 at

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Agricultural Research Station, Navgaon, Alwar (Rajasthan) on sandy loam soil. Randomized block design was followed with three replications. Ten wheat genotypes, including three varieties, were used in the present study. Seed rate 300 seed/ m^2 and fertilizer dose of 120, 60, 40 kg N, P and K/ha were used to raise the crop. Sowing was done both timely and late in the two consecutive years of experiments. Date of sowing for timely sowing wheat was 20 November and the crop was harvested in the second week of April. Late sown wheat was planted on 12 December and the crop was harvested in second week of April. Days to anthesis and physiological maturity were recorded. At harvest, tillers/m^2 biomass/m^2, grain yield/m^2 was measured. Ten plants were selected from each replication to record the data on yield components like grains/spike, grain weight/spike. Heat stress intensity was calculated using the formula 1-X/ X_p , where X represents the mean yield (or other characters) over all genotypes under heat (or late planting) and X_p represent non heat (normal planting).

Pooled analysis of data on growth and yield parameters were carried out. The two year data on growth and yield parameters were pooled for timely sown and late sown conditions separately and the average values are presented in Table 1.

RESULTS AND DISCUSSION

During *rabi* 2007-08 under timely sown conditions, the yield was in general good in all genotypes. The significant differences in grain as well as biomass/ m^2 were recorded among the genotypes (Table 1). Maximum yield was observed in Raj 4160 (496 g/m^2), followed by Raj 3765 (486 g/m^2) and Raj 4037 (473 g/ m^2). The better yields of these genotypes may be owing to their higher number of spikes/m^2 , numbers and harvest index. Very poor yield observed in case of Raj 4161 (336 g/m^2) followed by Raj 4168 (337g/m^2). Genotypes viz. Raj 4135, PBW 373 and Raj 4169 gave less yield due to their reduced spike number/m^2 or poor harvest index. During *rabi* 2008-09, in timely sown wheat, the grain-growth duration was 37 days on an average with extended maturity due to cool weather conditions. The grain yield was good in almost all genotypes. Maximum yield of 659 g/m^2 was recorded in Raj 3765, followed by Raj 4119 (611 g/m^2) and Raj 4160 (590 g/m^2). The high yields may be owing to more number of spikes/m^2 and high harvest index.

Under late-sown conditions, Raj 4037, Raj 3765, Raj 4160 and Raj 4119' gave high yields. Raj 4161 gave least yield, followed by Raj 4168 and Raj 4135. The poor yield of these genotypes may be attributed to poor biomass production coupled with low harvest index. While observing data on variation in phenology, growth and yield components under normal and late sowings have good scope for improvement. The range, mean and coefficient of variation of genotypes during the two sowings in two crop seasons are given in Table 2. Yield and its components were higher in both sowings of second year compared to first year, though the stress intensity was higher for most of the characters in the second year. This may be due to extended winter and subsequent increase in grain-growth duration in second year experiment.

In both seasons, all parameters with the exception of harvest index showed reduction under late-sown conditions. Among the parameters studied, biomass/m^2 and grain weight/spike were the most sensitive to terminal heat,

Table 1. Effect of terminal heat stress on yield and its components in wheat genotypes

Genotype	Days to anthesis		Days to maturity		Grain growth duration		Spike/m²		Biomass (g/m²)		Grain yield (g/m²)		Harvest index		Grains/ spike		Grain weight/ spike (g)		Grain growth rate (g/day)	
	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS	TS	LS
Raj 4128	97	76	129	115	32	39	347	225	1377	1005	378	324	0.27	0.32	43	31	2.15	1.23	14.0	8.3
Raj 4160	92	78	134	112	42	34	295	234	1436	995	439	373	0.31	0.37	48	41	2.31	1.45	11.9	11.0
Raj 4168	94	75	132	116	38	41	270	192	1356	989	337	294	0.25	0.30	42	30	2.19	1.08	10.2	7.2
Raj 4135	93	78	130	116	37	38	287	196	1348	982	368	313	0.27	0.32	44	30	2.22	1.00	11.5	8.2
Raj 4161	100	77	135	114	35	37	289	204	1456	1078	336	288	0.23	0.27	42	31	2.14	0.97	11.2	7.8
PBW 373	100	76	133	116	33	40	335	236	1371	1001	345	293	0.25	0.29	44	34	2.18	1.02	12.3	7.3
Raj 4037	97	78	131	116	34	38	355	253	1434	1079	460	392	0.32	0.36	48	43	2.37	1.43	15.9	10.3
Raj 4169	94	79	129	112	35	33	313	202	1328	983	367	337	0.28	0.34	45	37	2.15	1.06	12.2	10.2
Raj 4119	87	75	126	111	39	36	291	198	1397	895	421	345	0.30	0.39	46	40	2.28	1.21	12.4	9.6
Raj 3765	84	75	129	112	45	37	339	247	1443	1033	443	377	0.31	0.36	47	43	2.26	1.39	11.1	10.2
CD(P=0.05)																				
Genotype (G)	2.78		2.01		2.60		41.8		80.3		33.7		0.033		6.53		0.29		85.8	
Sowing time (S)	1.51		0.92		1.41		26.1		38.2		14.4		0.013		2.67		0.11		58.2	
G X S	4.32		2.28		3.11		64.6		101.4		48.5		NS		9.47		0.39		99.3	

Table 2. Variability for yield and its contributing traits of wheat under timely sown and late sown conditions

Parameters	I Year		II Year		Stress intensity
	Timely sown	Late sown	Timely sown	Late sown	
Days to anthesis					
Mean	93.8	76.6	91.2	75.7	I 0.183
Maximum	101	81	100	80.2	II 0.169
Minimum	86	74	85	73.4	
CV%	3.9	2.9	4.3	5.6	
Days to maturity					
Mean	130.8	108.6	132.3	113.2	I 0.169
Maximum	137	114	138	117	II 0.144
Minimum	124	104	128	110	
CV%	2.1	2.5	2.1	2.1	
Grain growth duration					
Mean	37.1	29.6	40.2	34.7	I 0.202
Maximum	40	33	44	37	II 0.136
Minimum	34	27	36	29	
CV%	5.4	5.4	5.8	8.9	
Spike/m²					
Mean	311.7	228	351	244	I 0.268
Maximum	422	282	400	298	II 0.304
Minimum	235	170	250	201	
CV%	14.8	12.4	13.1	14.9	
Biomass (g/m²)					
Mean	1328	918	1588	1103	I 0.308
Maximum	1576	984	1782	1156	II 0.305
Minimum	1028	848	1290	745	
CV%	14.9	4.3	9.97	10.7	
Grain Yield (g/m²)					
Mean	390.4	331	502	383	I 0.152
Maximum	496	413	659	460	II 0.237
Minimum	231	182	275	260	
CV%	21.4	18.2	18.6	19.4	
Harvest index					
Mean	0.32	0.34	0.37	0.38	I -0.062
Maximum	0.39	0.41	0.42	0.42	II -0.027
Minimum	0.21	0.20	0.23	0.28	
CV%	14.8	16.9	15.6	13.1	
Grains/spike					
Mean	41.4	31.1	51.4	36.4	I 0.248
Maximum	51.5	38.5	56.8	43.1	II 0.291
Minimum	30.6	24.3	40.3	26.7	
CV%	15.3	14.4	13.8	12.7	
Grain weight/spike (g)					
Mean	1.71	1.11	2.28	1.31	I 0.350
Maximum	2.28	1.39	3.0	1.46	II 0.425
Minimum	0.99	0.84	1.58	1.07	
CV%	18.6	13.8	19.1	10.2	
Grain growth rate (g/day)					
Mean	10.4	11.4	13.4	11.2	I -0.096
Maximum	15.8	14.5	19.0	16.0	II 0.164
Minimum	6.9	5.6	8,6	7.1	
CV%	23.7	20.6	21.6	23.2	

followed by grain yield/m^2 and grains/spike. The similar results were also observed by previous workers (Wardlaw *et al.*, 1989, Shpiler and Blum, 1991, Zhong-hu and Rajaram 1994). Also, these investigators except the Zhong-hu and Rajaram (1994) have reported that the rate of grain filling to be relatively stable under high temperature compared with grain-growth duration. Verma *et al* (2006) reported that days taken to maturity and grain growth duration did not show significant association with the grain as well as biological yield. High temperature stress influenced the yield by directly affecting the various yield components (Ferrara *et al*, 1994). So the grain yield on the expression of tolerance to terminal heat stress remains continuous as the most reliable selection criteria.

Variation in phenology was much lower among genotypes in both sowings situations. But other growth and yield components showed good variation. Overall the variation among genotypes was reduced in late-sown compared with normal sown condition. Forced maturity under late heat may be the reason for reduction in the differences among genotypes for growth and yield components.

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EFFECT OF FREUNDLICH AND LANGMUIR ISOTHERMAL STUDY ON ADSORPTION OF LEAD FROM SOIL SEDIMENTS BY IRON OXIDE NANOPARTICLE

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ABSTRACT

Heavy and toxic metal such as lead contaminates to the aqueous streams, which produce from the discharge of untreated metal containing effluents into water bodies, is one of the most important environmental problems. To remedies the problem only Adsorption is the effective techniques for lead removal from wastewater. In the present study, adsorbent is prepared from Ferric chloride and studies are carried out for lead removal. Iron oxide nanoparticles were synthesized from ferric chloride with oleic acid and sodium hydroxide. Batch adsorption studies demonstrate that the adsorbent prepared from iron oxide nanoparticles has a significant capacity for adsorption of lead from aqueous solution. The parameters investigated in this study include contact time, adsorbent dosage, initial Lead concentration and pH. The adsorption process of lead is tested with Langmuir and Freundlich isotherm models. Application of the Langmuir isotherm to the systems yielded maximum adsorption capacity of 127.83 mg/g at a solution pH of 7. The adsorption of Lead was found to be maximum at low values of pH in the range of 2.5-2.8.

Keywords: Adsorption, Lead, iron oxide nanoparticles, Langmuir isotherm. Freundilich isotherm

Lead is used in industries such as Lead smelting, metal finishing, electroplating, leather tanning, paints, and pigments industries etc.,and has the potential to contaminate drinking water sources [Nakada N et al , Tsalev DLet al , Inglezakis et al., 2003; Zhou et al., 2004; Vilar et al.,2007).] due to their high concentration (Dabrowski et al., 2004; Hunsom et al.,2005) As determined by the National Toxicology Program (NTP), the International Agency for Research on Cancer (IARC), lead is a human carcinogen. In general, Lead is removed from waste water by various methods such as chemical precipitation (*Maruyama et al*), electrochemical reduction, sulfide precipitation, cementation, ion-exchange, reverse osmosis, electrodialysis, solvent extraction, and evaporation, etc. [Namasivayam, C]. These methods are,however, cost intensive and are unaffordable for large scale treatment of wastewater that is rich in Lead Adsorption using activated carbon is an effective method for the treatment of industrial effluents contaminated with Lead and quite popular [Sharma et al ,,Jianlong W et al]. Other commercial adsorbents are recently reported to have been used in industries, although their versatility and adsorption capacity are generally less than those of activated carbon [Gupta et al].In the present study, adsorbent is prepared from iron oxide nanoparticles and studies are carried out for Lead removal.. Batch experiments are carried out for kinetic studies on the removal of Lead from

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aqueous solution using the activated iron oxide nanoparticles . The effect of various parameters such as contact time, adsorbent dosage, initial Lead concentration and pH has been studied.

Experimental Work

Preparation of Adsorbent Iron oxide nanoparticles.

Removal of Lead

Batch Experiments

All the chemicals used are of analytical grade. A stock solution of Lead is prepared by dissolving 2.8287 g of 99.9% lead nitrate (Pb $(NO_3)_2$Iron oxide nanoparticles in 1000 ml of distilled water. This solution is diluted as required to obtain standard solutions containing 20, 40, 50, 60, 80, 100, and 200 mg/L of lead. 0.5 N HCl and 0.5 N NaOH solutions are used for pH adjustments. The batch experiments are carried out in 100 mL borosil conical flasks by agitating a pre-weighed amount of the Iron oxide nanoparticles adsorbent with 25 mL of the aqueous lead solutions for a predetermined period at 300C on a water bath-cum-mechanical shaker. The adsorbent is separated with filter paper. Adsorption isotherm study is carried out with different initial concentrations of Lead from 20 to 200 mg/L while maintaining the adsorbent dosage at 10 g/L. The effect of time and pH are studied at 300C with a Lead concentration of 50 mg/L and an adsorbent dosage of 10 g/L. The effect of adsorbent dosage is studied by varying the adsorbent amount from 4 g/L to 24 g/L with a Lead concentration of 50 g/ L.The concentration of Lead ions in the effluent was determined spectrophotometrically by developing a purple-violet color with 1, 5-diphenyl carbazide in acidic solution as an complexing agent. The absorbance of the purple-violet colored solution is read at 540 nm after 20 min

Results and Discussion

In the present study, Iron oxide nanoparticles are activated and used for Lead removal from aqueous solutions.Aquous layer was prepared with 1:2 ratio of soil and DTPA(Lindsay WL,et al,.)(10 gm soil and 20 ml DTPA extractant),and shake up to 2 hrs at 90 rpm shaker and then filter with the help of whatmann filter paper no 42 and then allow to keep for the determination of Pb from the AAS (Atomic Absorption spectrophotometer) DTPA extractant is prepared by dissolving 1.967 diethylene-triamine-pentaacetic acid (DTPA)and 1.470 gm of $CaCl_2.2H_2o$ (AR grade) in about 25 ml distilled water by adding 13.3 ml by triethanolamine (TEA) followed by 100 ml of DDW and transfer into one liter volumetric flask and make up to the mark. extract the help of DTPA extract,The soil D (It is mixture of diethylene tetraamine penta acetic acid and tri Table-1 shows the adsorbent capacity of various adsorbents. When compared with other non-conventional adsorbents, the results of the present study indicate that adsorbent prepared from Iron oxide nanoparticles has better adsorption capacity in many cases (biomass residual slurry, Fe (III)/Cr (III) hydroxide, Waste tea, walnut shell), comparable adsorption capacity with (palm pressed-fibers, maize cob, sugar cane bagasse) and lower adsorption capacity with (activated carbon, saw dust) for Lead ions [3,7,8,9,10,11]. Based on the above results obtained, the effect of various parameters such as equilibrium time, pH, amount of adsorbent etc. has been studied.

Table 1. Summary of adsorbent capacity of various adsorbents

Adsorbent	Maximum Adsorbent Capacity, qm (mg/g)	Reference
Activated Carbon(Filtrasorb-400)	57.7	Huang, C. P et al
Sawdust	39.7	Sharma, D. C et al
Palm pressed-fibers	15.0	9 Tan, W. T et al
Maize cob 13.8	13.8	8 Sharma, D. C et al
Sugar cane bagasse	13.4	Sharma, D. C et al
Iron Oxide nanoparticles	80.34	Yogendra Singh et al
Biomass residual slurry	5.87	Namasivayam, C et al
Fe(III)/Cr(III) hydroxide 1.43 [11] Walnut shell 1.33 [10	1.43	Namasivayam, C et al
Waste tea 1.55 [10]	1.55	Orhan Y. et al

Effect of Contact Time

Fig. 1 shows the effect of contact time for the adsorption of Lead) on Iron oxide nanoparticles. It is evident that time has significant influence on the adsorption of Lead It is apparent from Fig. 1 that till 10 h, the percentage removal of Lead from aqueous solution increases rapidly and reaches up to 65%. After that, the percentage removal of Lead increases slowly till 50 h and reaches up to 71%. A further increase in contact time has a negligible effect on the percentage removal. Therefore, the contact time of 50 h could be considered for adsorption of chromium Lead on Iron oxide nanoparticles for entire batch studies.

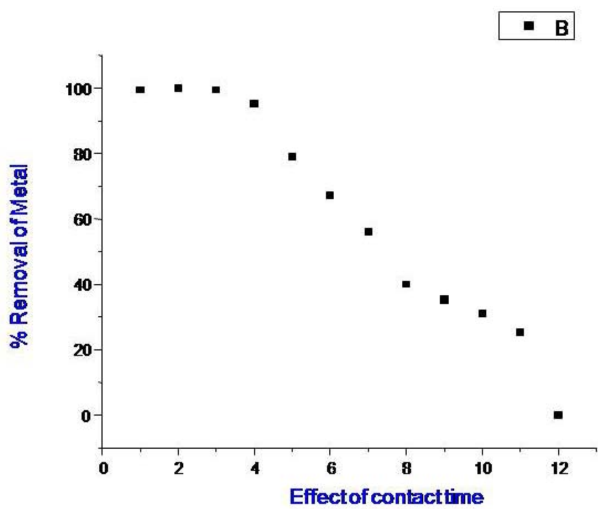

Fig. 1. Effect of contact time on Lead adsorption

Adsorption Isotherm

The equilibrium of sorption is one of the important physico-chemical aspects for the evaluation of the sorption process as a unit operation. The sorption isotherm studies are conducted by varying the initial concentration of Lead from 20 to 200 mg/L and maintaining the adsorbent dosage of 10 g/L. The adsorption isotherm (*q*e versus *C*e) shows the equilibrium between the concentration of Lead in the aqueous solution and its concentration on the solid (mass of Lead per unit mass of Iron oxide nanoparticles). It is evident that adsorption capacity increases with increasing equilibrium Lead concentrations. Fig. 2 shows that the adsorption capacity increases rapidly

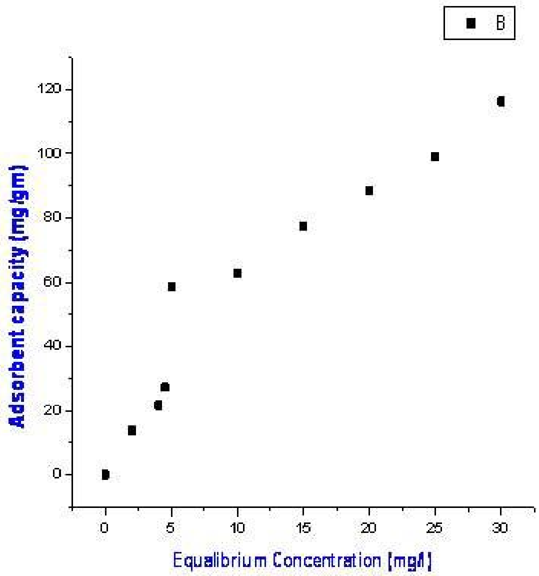

Fig. 2. Effect of Adsorbent capacity on Lead concentration at equalibrium

from 0 to 4.2 mg/g for the equilibrium concentration of 0 to 20 mg/L. Further a gradual increase in adsorption capacity is observed with the increase in equilibrium concentration and it reaches up to 10.5 mg/g for the equilibrium concentration of 102 mg/L. In order to model the sorption behavior, adsorption isotherms have been studied. The adsorption process of Lead are tested with Langmuir and Freundlich isotherm models. Langmuir and Freundlich equations are given in equation (1) and (2), respectively. The isotherm data has linearized using the Langmuir equation and shown in Fig. 3. The regression constants are tabulated in Table-1. The high value of correlation coefficient ($R2$ = 0.93) indicated a good agreement

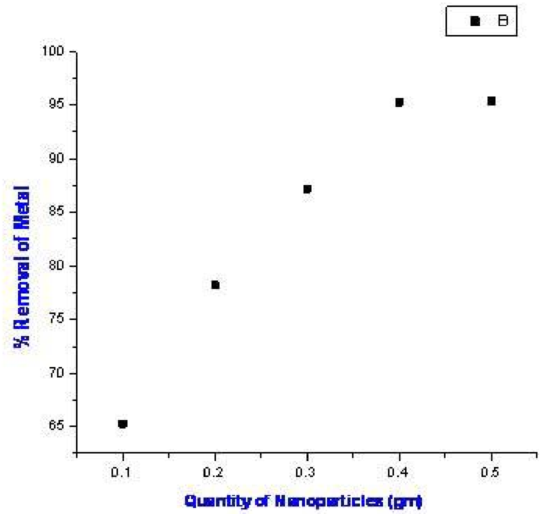

Fig. 3. Effect of Adsorbent doses on Lead concentration at equalibrium

between the parameters. The constant qm, which is a measure of the adsorption capacity to form a monolayer, can be as high as 11.08 mg/g at pH 7. The constant b, which denotes adsorption energy, is equal to 0.049 L/mg. The same data also fitted with the Freundlich equation and shown in Fig. 4. The regression constants are listed in Table-2. The value of correlation coefficient (R^2 = 0.99) showed that the data conform well to the Freundlich equation although the strength of the relationship between parameters is not as good as in the case of the Langmuir equation.

Effect of Adsorbent Dosage

The effect of adsorbent dosage on the adsorption of Lead process is shown in Fig. 5. Removal Lead increases with increase of adsorbent dosage. The percentage removal increases from 49 to 95% by increasing the adsorbent dosage from 4 to 24 g/L. However, the adsorption capacity showed a decreasing

Table 2. Isotherm constants for adsorption of lead on Iron oxide nanoparticles

Langmuir Isotherm			Freundlich Isotherm		
Constants		Correlation	Constants		Correlation
*q*m (mg/g) b (L/mg)	Correlation	Coefficient (*R*2)	*KF*	n	Coefficient (*R*2)
84.9	0.035	0.98	0.996	2.56	0.99

trend with increasing resin dosage. The adsorption capacity dropped from 3.7 to 2 mg/g by increasing the adsorbent dosage from 4 to 24 g/L. The drop in adsorption capacity is basically due to sites remaining unsaturated during the adsorption process.

Effect of pH

The effect of pH on the process is presented in Fig. 6. The percentage adsorption of lead is decreasing from 98% to 45% with increasing pH from 1 to 11. The percentage removal of Lead is maximum and remains constant in the pH range 1-3.

CONCLUSIONS

During the above research the the Adsorbent Iron oxide nanoparticles was prepared from iron chloride is being used for the removal of lead from aqueous solutions.During the study it has been observed The equilibrium time for the adsorption of Lead(II) on the adsorbate prepared from Iron oxide nanoparticles in the present study from aqueous solutions is found to be 50 h.Whereas the adsorption process of Lead(II) can be described by Langmuir isotherm and Freundlich isotherm models. However, Freundlich isotherm model shows a good agreement with the equilibrium data.on the other hand it has also been noticed the Absorption of lead(II) on Iron oxide nanoparticles yielded maximum adsorption capacity of 80.34 mg/g at solution pH of 1.So it is obvious from the result that the Removal of lead (II) increases with increase of adsorbent dosage.therefore The maximum adsorption of lead (II)) took place in the pH range of the order of 1 which is constant up to 1-3.

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J. Farming Systems Research & Development **19** (1) : 158-164 (2013)

TECHNOLOGY INDEPENDENT CMOS OP-AMP

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ABSTRACT

This paper is aimed at understanding the impact of technology scaling and short channel length devices on the performance of analog integrated circuits. The operational amplifier (op amp) is chosen as an example circuit for investigation. The performance of the op amp is studied across different technologies for short channel lengths, and techniques to develop technology-independent op amp architectures have been proposed. In this paper, op amp architectures has been developed whose performance is relatively independent of the technology and the channel length. It is made scalable, and the same op amp circuits are scaled from a 0.35 mm CMOS onto a 0.18 mm CMOS technology with the same components. It is designed to achieve large small-signal gain, constant unity gain-bandwidth frequency constant output referred noise and constant phase margin. This is designed for the application in gas sensor's temperature control circuit.

Keywords: Analysis for parameters calculation, CMOS technologies, op-amp parameters.

Most analog integrated circuits are fabricated in digital CMOS technologies. In the past years, the performance of digital CMOS circuits has improved with advances in the digital technology. The minimum feature size has been constantly getting scaled down, which has imparted the capability to build digital circuits with smaller area, high speed, and reduced parasitic. But, analog circuits are still being made using longer channel length transistors due to the degrading effects of smaller channel length on the circuit performance. Digital circuits are scalable in nature, i.e. with course of time; the same circuit has been scaled onto an improved technology with little re-work [2]. But, in case of analog circuits, when moving from an older to a newer technology, the aspect ratios of most of the transistors need to be redesigned to maintain the desired performance. The research in this thesis is aimed at developing analog circuit design techniques for

- Scalable architectures with technology-independent performance
- Use of all minimum feature-size channel length transistors in the design

Need of Technology independent op-amp

The op-amp is designed for the application in gas sensor's temperature control circuit. In gas sensor, there is a requirement of a constant current at the input terminal. In order to achieve that constant current it is designed. The specifications of op-amp are given in Table 1.

These specifications are decided according to control circuit requirements. Analog circuits are designed using long channel transistors in order to achieve the desired circuit performance. As in the case of the digital

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Table 1.

open loop gain	60 dB
close loop gain	14dB
output referred noise	150mV
UGB	50 MHz
gain error	0.5%,
dynamic range	46 dB
CMRR	60- 80 dB
slew rate	14V/µs

circuits, scaling down of the device geometries in the analog circuits could improve circuit performance in terms of lower area, reduced parasitic, higher speed, low-voltage low-power operation among others. But, the use of all small channel length devices has always been avoided while designing analog circuits. Sometimes, in order to partially achieve the advantages of small channel lengths, a mixed design, which uses a mixture of both small channel length devices as well as large channel length devices, has been used to build analog circuits. Some of the major degrading factors arising as a result of the use of small channel length devices are as follows:

- Small channel length transistors have large channel length modulation effects that reduce the small-signal drain-to-source resistance drastically.

- Decreasing the channel length causes a decrease in the effective channel area below the gate of the MOS transistor. Mismatch and noise are inversely proportional to the effective area, and they become large with smaller channel lengths.

- Smaller channel length transistors are also very difficult to dc bias, and they tend to introduce non-idealities in the conventional dc biasing schemes such as current mirroring. In a current mirror, when the devices are operated in strong inversion, large channel length modulation effects cause a wide variation in the drain current as a function of the output voltage. This becomes even worse in weak inversion due to the exponential dependence of the drain current on the drain voltage.

Technology independent operational amplifier

Initially, a differential input single ended output gain stage was designed for operational amplifier as shown in Figure 1. It is one of the most widely used versions of the op amp. In this section, the performance of this circuit will be verified across two different CMOS technologies. The importance of this exercise is to understand the effect of technology dependent parameters on the circuit performance. If the transistors of this op amp were scaled as it is into different technologies, then its

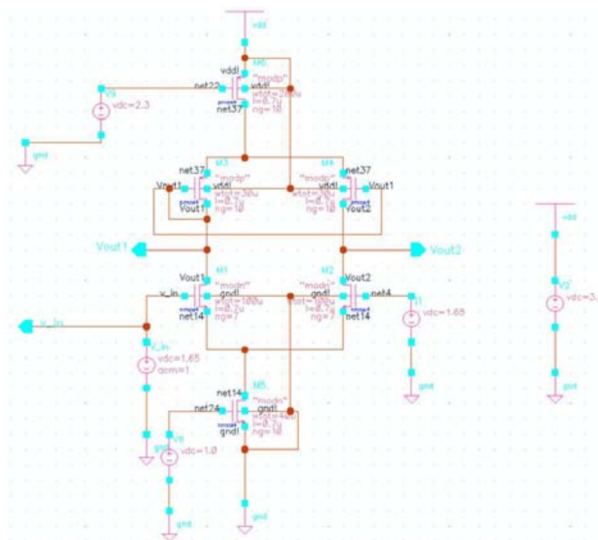

Fig. 1. Differential in single ended output op-amp

performance will be affected. Simulations were performed on this op amp in a 0.35 mm CMOS and a 0.18 mm CMOS technology. The channel length for 0.35µm is 0.7µm and for 0.18µm is 0.7µm.

The aspect ratios of the transistors of op-amp are shown in Table 2.

Table 2.

S1=S2=(100/0.7),S3= S4=(30/0.7)	V_{in1}=V_{in2}=1.65V
S5=(40/0.7),S6=(280/0.7)	V_6=1V, V_9=2.3V

Where, S_i= $(W/L)_i$

AC analysis is done for measuring the open loop gain of operational amplifier. The output open loop gain of operational amplifier stage is 37dB as shown in Figure 2. But the open loop gain of op-

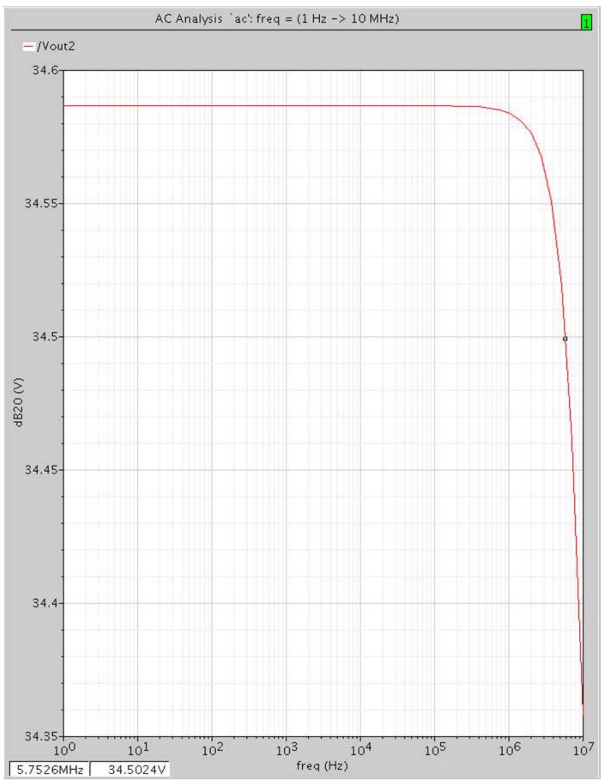

Fig. 2. AC response of op-amp

amp is less than the required gain. So, there is requirement of gain boosting stage. There are various schemes for boosting the gain of operational amplifier. But in this amplifier we used the negative gain stage for gain boosting [2],[3],[4],[5],[6]. Let us first try to develop the negative resistance generation circuit.

So, negative resistance scheme was used along with operational amplifier's gain stage to increase the gain [7].

In this negative resistance gain stage is used for gain boosting of op-amp. The aspect ratios of transistors of op-amp are given in Table 3.

Table 3.

S1=S2=(200/0.7),S3= S4=(70/0.7)	V_{in1}=V_{in2}=V_{12}= V_{13}=1.65V
S5=(40/0.7),S6=(280/0.7)	V_8= V_6=1V
S7=S8=(1000/0.7),S9= S10=(1500/0.7),S11= S12=(20/0.7),S13=S14= (140/0.7)	V_6= V_{11}=2.3V

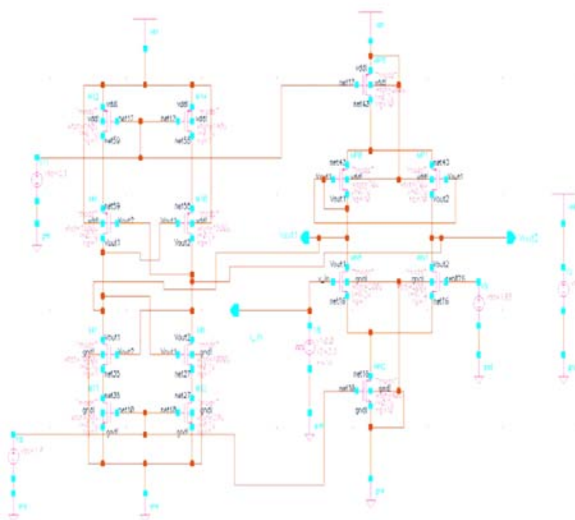

Fig. 3. Op-amp with negative resistance gain stage

The open loop gain of amplifier is now boosted because of this negative resistance scheme. From AC analysis we measured that the gain of the operational amplifier is increased. The AC response of op-amp is shown in Figure 4.

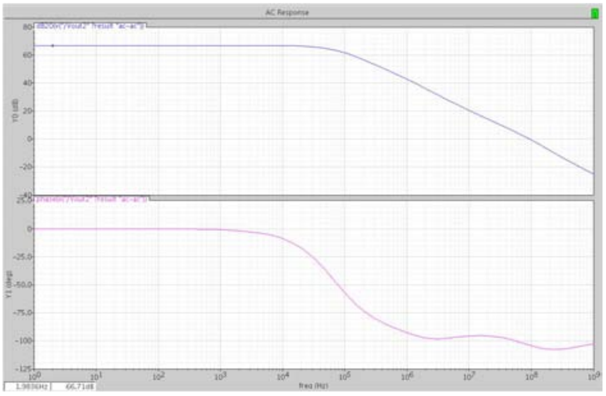

Fig. 4. AC response of op-amp with negative gain stage

From this graph we can analyze the gain and phase of the operational amplifier. The ac open loop gain of the op-amp is 67dB. And the phase margin from the graph we obtained 76º..

Simulation and Performance Analysis

DC analysis of operational amplifier

For measuring the DC response of operational amplifier DC analysis is done. A DC signal is applied at the input of the amplifier. The dc response is shown in Figure 5. From this response curve we can analyze that the dc magnitude of op-amp is 2.3 volt.

AC analysis of operational amplifier

Now, the AC analysis is done for determining the ac gain and phase of the op-amp. The ac analysis is done for the frequency range of 1Hz-100MHz. In this, instead of dc signal ac signal is applied.

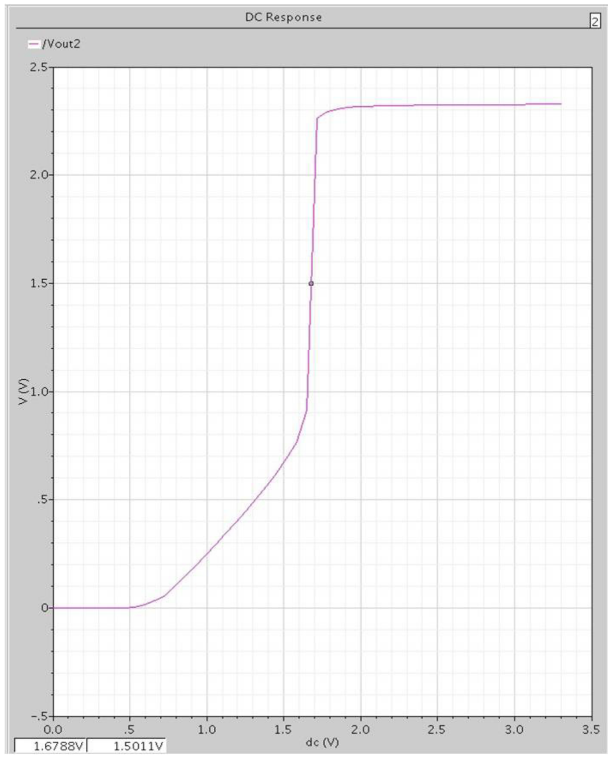

Fig. 5. DC response of op-amp

The simulation plots for this op amp are in the 0.35 um CMOS process with all 0.7 um channel length devices. The parameters of op-amp are also determined by ac analysis like CMRR, ICMR, slew rate, settling time, and input offset voltage.

ICMR

The acronym for ICMR is the input common mode range. It is the input voltage range for which the response of the op-amp remains same for given gain. ICMR of the op-amp is determined in unity gain mode. The inverting terminal of op-amp is connected to the output terminal and biasing voltage is applied at the non-inverting terminal. The ICMR of op-amp is shown in Figure 6. From this figure it can be analyzed that ICMR of the op-amp is 2V (0.1V- 2.1V). The actual lower end of the ICMR for this op

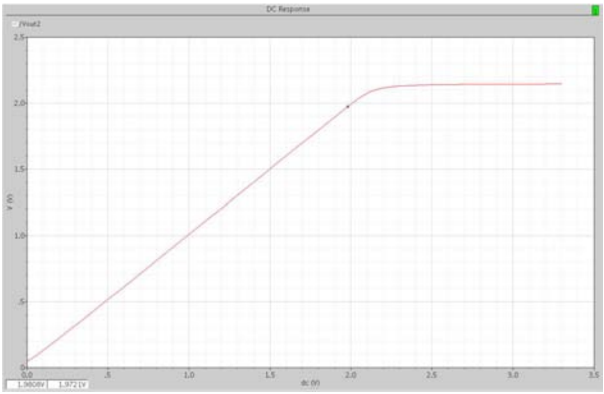

Fig. 6. ICMR response of op-amp

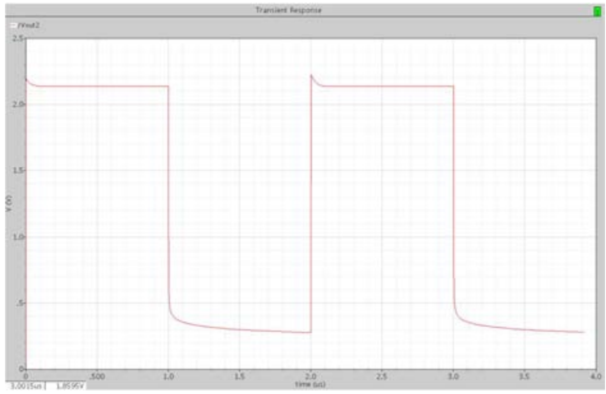

Fig. 7. Simulation result for slew rate

amp was 0.1 V, beyond which the NMOS device in the gain stage went into the linear region of operation [2].

CMRR

The CMRR of op-amp is obtained by subtracting the common mode gain from the differential gain. The differential gain of op-amp is shown by the previous graph. Now, the common mode gain is -1 dB. The common mode gain and differential gain of the op-amp are in dB. So, the CMRR of op-amp is obtained by subtracting the common mode gain from differential gain. The CMRR of op-amp is 68 dB.

Slew rate

The slew rate is the maximum rate at which the output voltage of an op-amp can change and is measured in terms of voltage change per unit of time. The slew rate of op-amp is obtained in unity gain mode configuration. The output response for slew rate is shown in figure 7.

The slew rate of the op-amp is ratio of dVout to dt. The slew rate is given as:

$SR^+ = 18V/\mu s$, $SR^- = -12\ V/\mu s$.

Input offset voltage

The dc voltage that must be applied at the input terminal to force the quiescent dc output voltage to zero or other level, if specified, given that the input signal voltage is zero. The output of an ideal op-amp is zero when there is no input signal applied to it. The input offset voltage of op-amp is 166mV.

Noise analysis of operational amplifier

For determining the noise of the operational amplifier noise analysis is done. In this the output referred noise of the op-amp is determined. The noise analysis is done for the frequency range

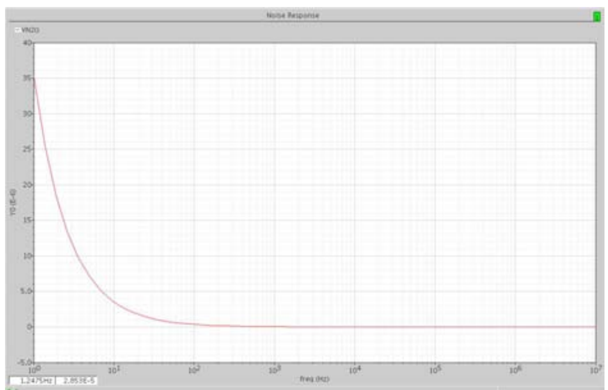

Fig. 8. Noise analysis of op-amp

of 1Hz to 10MHz. The noise response of the amplifier is shown in Figure 8. For this op-amp, the rms value of the output referred noise voltage is approximately 35 μV over a 10 MHz bandwidth.

These analyses are also done with 0.18μm CMOS process. The parameters of op-amp are obtained. The parameters of op-amp are shown in table. Table 4 is for simulated performance of op-amp in 0.35μm and 0.18 um CMOS processes

The Monte Carlo analysis is used for measuring the all parameters of op-amp that are calculated by above analysis. Table 5 is for simulated performance of op-amp by Monte Carlo in 0.35μm and 0.18 μm CMOS processes [1].

Conclusion

The operational amplifier is designed for 0.18μm and 0.35 μm technologies. The circuit is operated at a supply voltage of 3.3 V and 1.8 V. The parameters of op-amp are measured in order to analyze that these are technology independent or not. The parameters like gain, phase margin, output referred noise, gain bandwidth product of op-amp are almost constant for both of technologies. And for this amplifier, instead of small channel

Table 4.

Performance specification	**Simulated value(0.35μm)**	**Simulated value(0.18μm)**
Vdd	3.3 V	1.8 V
Av	67 dB	65 dB
UGBW	50MHz	60MHz
Phase margin	76 deg	75 deg
Slew rate	+18, -12V/μs	+20, -15 V/μs
ICMR	0.1 -2.1 V	0.5- 2.3 V
CMRR	68 dB	58 dB
Output referred noise	35μV/(Hz)$^{1/2}$	40μV/(Hz)$^{1/2}$

Table 5.

Performance specification	**Simulated value(0.35μm)**	**Simulated value(0.18μm)**
Vdd	3.3 V	1.8 V
Av	67 6 69 dB	65 6 70 dB
UGBW	50MHz	60MHz
Phase margin	76-80 deg	75 6 80 deg
Slew rate	+14 6 18, -12 6 -14V/μs	+20 6 25, -15 6 20 V/μs
ICMR	0.1 6 2.1 V	0.5- 2.3 V
CMRR	68 6 70dB	58 6 60 dB
Output referred noise	35 6 40μV/(Hz)$^{1/2}$	37 6 40 40μV/(Hz)$^{1/2}$

length large channel length is used. It means almost double of the minimum feature size.

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J. Farming Systems Research & Development **19** (1) : 165-174 (2013)

EFFECT OF PHOSPHORUS AND SULPHUR FERTILIZATION ON GROWTH, YIELD, NUTRIENT UPTAKE AND QUALITY PARAMETERS OF PIGEONPEA [*CAJANUS CAJAN* (L.) MILLSP.] GENOTYPES

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ABSTRACT

A field experiment was conducted during *kharif* season of 2009 and 2010 to study the effect of phosphorus and sulphur fertilization on growth, yield, nutrient uptake, quality and their economic feasibility on different pigeonpea genotypes. Three genotypes (UPAS 120, Pusa 992 and Pusa 855), four levels of P (0, 30, 60 and 90 kg P_2O_5/ha) and three levels of S (0, 20 and 40 kg S/ha) were tested in Split-Split Plot Design under three replications. Pusa 855 found significantly superior in respect of growth, yield and most of yield attributes as compared to other genotypes and produced 16.71 and 20.14% higher seed yield as compared to UPAS 120 and Pusa 992, respectively. Application of phosphorus up to 90 kg P_2O_5/ha and sulphur up to 40 kg S/ha increased plant height, number of branches, dry weight/plant, pods/plant, 1000-seed weight, seed and stalk yields. 90 kg P_2O_5/ha resulted 46.78% higher seed yield over no phosphorus. However, application of 40 kg sulphur resulted a net yield gain of 21.34% over no sulphur application. Pusa 992 had highest protein content where as, Pusa 855 produced maximum protein yield. Application of 90 kg P_2O_5/ha resulted 7.91% higher content of protein in the seeds. However, application of 40 kg S/ha had 10.64% higher protein content over their respective control. Among different treatment combinations genotype Pusa 855 gave maximum net return (₹39391) with 90 kg P_2O_5/ha + 40 kg S/ha whereas, Pusa 992 gave maximum net return (29265) with 60 kg P_2O_5/ha + 40 kg S/ha. UPAS 120 gave its highest net return (30199) with 90 kg P_2O_5/ha + 40 kg S/ha..

Keywords: Economics, Growth, Nutrient uptake, Pigeonpea genotype, Phosphorus levels, Quality parameters, Sulphur levels, Yield

Among *kharif* grain legumes pigeonpea, occupies first position and is the second most important pulse crop next to chickpea as a whole. Pigeonpea due to its extensive tap root and dense canopy, adds considerable amount of organic matter in the soil in the form of roots and leaves which, in turn, improves the physical condition of soil. The evoluation of short duration pigeonpea varieties of about 130-160 days duration have provided the opportunity for pigeonpea based multiple cropping in irrigated as well as rainfed areas. Besides having high yield potential (20-30 q/ha), they are harvested by end of November. Thus, fit well under double cropping system with wheat. Adequate supply of phosphorus to legume is more important than that of nitrogen, as it has beneficial effect on nodulation, cell division, plays an important role in energy transfer reactions essentially and required essentially as a constituent of RNA and DNA.

Pigeonpea shows special response to phosphatic fertilizers, because of their additional need for multiplication of

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Rhizobia in the nodules. Phosphorus also improves the crop quality and make the crop resistance to diseases. Phosphorus application to pulses not only benefit the particular crop by increased nodulation, but also favorably affects the soil nitrogen content for the succeeding non legume crop thus reduces over all demand for inorganic nitrogen application.

Although sulphur is an important secondary essential plant nutrient, but importance of sulphur in Indian agriculture is being increasingly emphasized and has been considered 4th important nutrient after NPK. Sulphur has a great impact on production of legumes as most of Indian soils are reported sulphur deficient. Sulphur plays important role in many physiological process in plant *viz*; synthesis of sulphur containing amino acids (Cysteine, Cystine and Methionine), synthesis of certain vitamins (Biotine and Thiomine), synthesis of co-enzyme A and in the metabolism of carbohydrates, proteins and fats. Sulphur also promotes nodulation in legumes and is also required as a constituent for the synthesis of chlorophyll. By virtue of disulfide linkage, sulphur application increases drought and cold tolerance in plants. It also helps in the control of diseases and pests. The sulphur deficiency has been recognized as a factor in limiting the yield and quality of grain legumes as around 70% of the S is found in the chloroplast and thus plays vital role in carbon assimilation (Deshbhratar *et al.* 2010).

Therefore, the present investigation was carried out to evaluate the effect of phosphorus and sulphur fertilization on growth, yield, nutrient uptake, quality and economic feasibility of different pigeonpea genotypes.

MATERIALS AND METHODS

The experiment was conducted during the *kharif* seasons of 2009 and 2010 at Agricultural Research Farm of R.B.S College, Bichpuri Agra, (27.2^0 N Latitude and 77.9^0 E Longitude, 168 m above mean sea level). The maximum and minimum atmospheric temperatures during crop period were 30.8 to 48.6 and 9.8 to 27.5^0 C, respectively. Rainfall received during 2009 and 2010 was 536.3 and 630 mm, respectively. The three genotypes (UPAS 120, Pusa 992 and Pusa 855) treated as main plots, four levels of phosphorus (0, 30, 60 and 90 kg P_2O_5/ha) as sub plot and three levels of sulphur (0, 20 and 40 kg S/ha) as sub-sub plots were, tested in split-split plot design under three replications.

The soil was sandy loam, having 7.9 pH, EC 1.86 dS/M, organic carbon 0.34% and available N, P, K and S status of 182.0, 29.50, 253.0 and 15.0 kg/ha, respectively. A uniform dose of nitrogen @ 20 kg N/ha and potassium @ 40 kg K_2O/ha were applied as basal. 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

Growth

The genotypes exhibited significant variation in respect of growth parameters. Pusa 855 grew taller

(200.52 cm) than UPAS 120 (195.45 cm) and Pusa 992 (191.24 cm). Similarly, Pusa 855 produced significantly higher number of branches/plant (25.74) as compared to UPAS 120 (24.73 branches) and Pusa 992 (23.57 branches) and exhibited relatively superior morphological expression under iso-nutritional conditions. Dry matter accumulation also varied significantly from genotype to genotype and recorded highest with Pusa 855 (128.82 g/plant), which was significantly higher than Pusa 992 (117.02 g/plant) and UPAS 120 (112.60 g/plant). Pusa 855 grew 2.60% taller and produced 14.41% higher dry matter over UPAS 120. This might be attributed to superior genetic make up of the genotype. The higher dry matter accumulation was attributed to higher number of branches per plant. The results endorses the finding of Govil *et al.* (2000).

Growth parameters, *viz.* plant height, dry matter accumulation and branches/ plant increased significantly with increasing levels of phosphorus up to 90 kg P_2O_5/ha. Plants fertilized with 90 kg P_2O_5/ha had 24.94, 13.89 and 5.61% taller plants as compared 0, 30 and 60 kg P_2O_5/ha, respectively. The favorable effects of phosphorus application on plant height have also been reported by Parihar *et al.* (2005). 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 and monitored highest with 90 kg P_2O_5/ha (132.98 g/plant), which was significantly higher than 60 kg (124.63 g/plant), 30 kg P_2O_5/ha (109.54 g/plant) and no phosphorus (85.06 g/ plant). Every increase in level of phosphorus brought about a significant increase in the number of branches per plant. Maximum number of branches per plant (26.19 branches) was recorded with 90 kg P_2O_5/ha (Table 1), which was significantly higher than no phosphorus (20.69 branches) and 30 kg P_2O_5 (33.90 branches) and was statistically on par to 60 kg P_2O_5 (25.87 branches/plant). Application of 90 kg P_2O_5/ha resulted 56.34, 21.90 and 6.70% higher dry matter yield, 26.58, 9.58 and 1.24% higher number of branches over 0, 30 and 60 kg P_2O_5/ha, respectively. The higher value of different growth parameters with 90 kg P_2O_5/ha might was due to increased rate of energy metabolism and accelerating effect of P on the synthesis of protoplasm. The result corroborates the finding of Deshbhratar *et al.* (2010).

Sulphur application also had significant influence on different growth parameters. Highest value of Plant height, number of branches as well as dry matter production was recorded with 40 kg S/ha. Significantly higher plant height was noticed with 40 kg S/ha (206.34 cm), which was significantly higher than 0 (171.5 cm). Application of 40 kg S/ha did not exhibited any significant increase over 20 kg S/ha (197.38 cm). Similarly highest number of branches/plant (25.21 branches) was noticed with 40 kg S/ha, which was statistically on par to 20 kg S/ha (24.98 branches/plant) and was significantly higher than no sulphur application (20.81 branches/plant). Dry matter accumulation increased with successive increase in level of sulphur. Significantly higher dry matter produced with 40 kg S (129.75 g/plant) in comparison to 0 kg (91.78 g/plant) and 20 kg S/ha (120.91 g/plant). The increase in dry matter accumulation due to sulphur application was primarily due to increase in number of branches/plant

Table 1. Effect of Phosphorus and Sulphur fertilization on growth, yield parameters, yield and harvest index of different pigeonpea genotypes (Pooled data of two years)

Treatment	Plant height (cm)	Branches/ plant	Dry matter (kg/ha)	Pods / plant	Pod weight (g/plant)	Seed weight (g/plant)	1000- seed weight (g)	Biological yield (kg/ha)	Seed yield (kg/ha)	Stalk yield (kg/ha)	Harvest index
Genotypes											
UPAS 120	195.45	24.73	112.60	192.31	29.23	14.71	73.40	6437	1365	5072	0.213
Pusa 992	191.24	23.57	117.02	180.22	27.83	13.97	70.95	5818	1326	4492	0.229
Pusa 855	200.52	25.74	128.82	197.14	31.15	16.64	78.80	7154	1593	5561	0.226
CD (P=0.05)	6.15	0.98	6.46	6.70	1.32	0.62	2.78	185	52	179	0.007
P levels (kg P_2O_5/ha)											
0	168.45	20.69	85.06	158.73	23.38	10.71	70.53	5570	1103	4468	0.198
30	184.78	23.90	109.54	175.83	28.56	14.85	74.66	6447	1403	5044	0.218
60	199.28	25.87	124.63	191.66	32.54	16.73	76.05	6901	1583	5318	0.230
90	210.45	26.19	132.98	194.32	33.12	17.70	76.29	6994	1619	5375	0.232
CD (P=0.05)	7.10	1.13	7.99	7.25	1.52	0.72	3.21	213	60	207	0.009
S levels (kg S/ha)											
0	171.50	20.81	91.78	158.26	23.56	13.89	72.44	6058	1265	4793	0.209
20	197.38	24.98	120.91	180.42	31.05	15.50	75.13	6657	1488	5170	0.224
40	206.34	25.21	129.75	189.86	32.60	15.94	75.57	6739	1535	5205	0.228
CD (P=0.05)	11.99	1.76	6.64	5.57	1.02	0.48	2.15	171	90	129	0.006

thus plants might maintained higher number of leaves and higher pace of carbon assimilation. The plants receiving 40 kg S/ha grew 20.34% taller, maintained 21.15 higher number of branches and produced 41.37% higher dry matter yield over no sulphur application.

Yield attributes, yield and harvest index

Genotypes recorded significant variation in respect of different yield attributing characters *viz*; number of pods per plant, pod weight per plant, seed weight per plant and 1000-seed weight. Among genotypes Pusa 855 recorded highest pods/plant (197.14 pods), pod weight/plant (31.15 g/plant), seed weight/plant (16.64 g/plant) which stood 2.52, 6.57 and 13.12% higher number of pods per plant, pod weight/ plant and grain weight per plant, respectively over UPAS 120. Genotype Pusa 855 scored significantly highest biological yield (7154 kg/ha), seed yield (1593 kg/ha) as well as stalk yield (5561 kg/ha). Pusa 992 was most short duration genotype. The seed and stalk yield obtained with cv. Pusa 855 was significantly higher than same noticed with Pusa 992 and UPAS 120, which produced 16.71% and 9.64% higher seed and stalk yield over UPAS 120, respectively. The higher, yielding ability of Pusa 855 might was due to its relatively longer duration and was also attributed to relatively higher value of different yield attributing characters. Results corroborate the finding of Govil *et al.* (2000).

Phosphorus application reflected significant impact on number of pods per plant, pod weight/ plant, seed weight per plant and 1000-seed weight. Phosphorus at 90 kg P_2O_5/ha was found to be superior to other levels except 60 kg P_2O_5/ha. The plants enjoying 90 kg P_2O_5/ha had 22.42, 29.40 and 3.95% higher pods/pant, pod weight/plant and seed yield/plant over no phosphorus application, respectively. Albeit, Biological (6994 kg/ha), seed (1619 kg/ ha) as well as stalk yields (5375 kg/ha) were noticed maximum with application of 90 kg P_2O_5/ha which was significantly higher than 0 and 30 kg P_2O_5/ha and was on par to 60 kg P_2O_5/ha (Table 1). Application of 90 kg P_2O_5/ha resulted 46.78% higher seed yield over control. The higher yields with 90 kg P_2O_5/ha was due to favorable effect of phosphorus application on different yield attributes. Application of 60 kg P_2O_5/ha resulted 43.52 and 12.84% higher seed yield and 19.04 and 5.43% higher stalk yield over 0 and 30 kg P_2O_5/ha, respectively. Result endorses the finding of Prasad *et al.* (2007), Singh and Ahlawat (2006) and Ansari *et al.* (2011). Phosphorus application also had significant impact on harvest index, which was noticed maximum (0.232), which was statistically on par to 60 kg P_2O_5/ha (0.230) and was significantly higher than 30 kg P_2O_5 (0.218) and no phosphorus application. The greater value of stalk yield at highest dose of P was due to higher pace of growth in the plots enjoying surplus phosphorus. Where as, the higher seed yield was result of favorable effect of phosphorus on different yield contributing characters.

The effect of sulphur application on yield contributing characters *viz.* number of pods per plant, weight of pods per plant and grain weight per plant was also significant. Highest, pods/plant (189.86 pods), pods weight/plant (32.60 g/plant), seed weight/plant (15.94 g/

plant) and 1000-seed weight (75.57 g) were recorded with 40 kg S/ha, which was significantly higher than 0 kg S/ha and were statistically on par to 20 kg S/ha. The plot fertilized with 40 kg S/ha had 19.97 and 14.76% higher number of pods and seed weight/plant, respectively over no sulphur application.

Sulphur fertilization brought about significant improvement in the production of seed and stalk both. Application of 40 kg sulphur had no significant increase over 20 kg S/ha with regard to seed and stalk yield, but the advantageous effects of various doses of sulphur over control was equally significant. Plots receiving 20 kg S/ha (1488 kg seed/ha) and 40 kg S/ha (1535 kg seed/ha) yielded 17.63 and 21.35% higher seed yield over no sulphur application. Whereas application of 20 kg S/ha increased 7.87% straw yield over control. Similarly harvest index also was recorded maximum (0.228) with 40 kg S/ha followed by 20 kg S/ha (0.224). Application of 40 and 20 kg S both bought significant improvement in harvest index over 0 kg S/ha. The difference in harvest index between 20 and 40 kg S/ha was statistically non significant (Table 1).Increase in biological, seed and stalk yield with increasing levels of sulphur was attributed to favorable effect of S application on different growth and yield parameters.

The beneficial effect of sulphur application on seed and stalk yield obtained in the present investigation, endorses the findings of Siag and Yadav (2003) and Deshbhratar *et al.* (2010).

Nutrient uptake and quality

Cultivar Pusa 855 recorded highest N (96.25 kg), P (16.67 kg), K (39.80 kg) and S (12.23) uptake which stood statistically higher than other cultivers. The uptake of N, P, K and S with Pusa 855 was 10.80, 6.38, 8.15 and 11.28%, respectively higher than UPAS 120 which was largely due to the higher seed and stalk yields. The nutrient uptake recorded with UPAS 120 and Pusa 992 was statistically on par to each other (Table 2).

The uptake of N,P,K as well as S also was significantly influenced due to P application and observed maximum with 90 kg P_2O_5/ha (99.15 kg N, 22.02 kg P, 36.62 kg K and 11.92 kg S/ha) followed by 60 kg P_2O_5/ha (96.66 kg N, 18.61 kg P, 32.44 kg K and 11.46 kg S/ha). The plots enjoying 90 kg P_2O_5/ha had 2.57, 18.32, 12.89 and 4.02% higher uptake of N, P, K, and S respectively over 60 kg P_2O_5/ha level. This might was result of favorable effect of phosphorus on root proliferation by stimulating the cellular activities and translocation of certain growth stimulating compounds to the roots. Thus plants might developed extensive rooting patterns even under deeper layers and were able to absorb higher quantity of nutrients. The higher uptake of nutrients was also due to production of higher quantity of biomass. The finding also corroborate with the results of Gupta *et al.* (2006), Sharma and Abrol (2007) and Ansari *et al.* (2011).

Increasing level of P_2O_5 increased the protein content and protein yield. Protein content in seed increased considerably with increase in the level of phosphorus and analyzed maximum with application of 90 kg P_2O_5/ha (22.39%) which was significantly higher than control (20.75%) and was statistically on par to 30 kg P_2O_5/ha (21.82%) and 60 kg P_2O_5/ha. The increase in protein content with increasing P levels might was due

Table 2. Effect of Phosphorus and Sulphur fertilization on nutrient uptake and quality parameters of different pigeonpea genotypes (Pooled data of two years)

Treatment	Uptake (kg/ha)				Protein content (%)	Protein yield (kg/ha)
	Nitrogen	Phosphorus	Potassium	Sulphur		
Genotypes						
UPAS 120	86.87	15.67	36.80	10.99	21.36	291.43
Pusa 992	87.25	15.57	36.60	9.81	22.12	293.22
Pusa 855	96.25	16.67	39.80	12.23	21.96	349.64
CD (P=0.05)	4.82	1.22	1.77	0.43	NS	21.94
P levels (kg P_2O_5/ha)						
0	86.64	10.46	27.47	9.84	20.75	228.73
30	89.03	15.86	29.35	10.98	21.82	305.88
60	96.66	18.61	32.44	11.46	22.31	353.05
90	99.15	22.02	36.62	11.92	22.39	362.46
CD (P=0.05)	4.10	1.26	1.89	0.50	0.92	33.79
S levels (kg S/ha)						
0	83.68	15.26	29.55	10.21	20.47	258.94
20	92.58	16.23	32.46	18.21	21.68	326.87
40	94.11	18.43	39.15	25.60	22.65	347.67
CD (P=0.05)	4.30	1.80	1.54	0.31	1.13	28.29

*NS= Non significant

to maintenance of higher ribosomal activity, extensive rooting and enhancing effect of phosphorus on nodulation. Thus plants enjoyed higher uptake of nitrogen and assimilated higher quantity of protein. The finding corroborate with the result of Kumar and Singh (2006). The production of protein increased significantly with every increasing level of phosphorus up to 90 kg P_2O_5/ha. The plot fertilized with 90 kg P_2O_5/ha maintained 7.90% higher protein in their seeds and produced 58.46% higher protein yield over no phosphorus application. Higher protein yield with 90 kg P_2O_5/ha (362.46 kg/ha) was cumulative effect of higher protein content and respective higher seed yield.

Sulphur showed a synergistic relationship with the uptake of N P K and S. Plots enjoying 40 kg S/ha, had highest uptake of nutrients (94.11 kg N, 18.43 kg P, 39.15 kg K and 25.60kg S/ha). The nitrogen uptake recorded with 40 S level was significantly higher than 0 kg S (83.68 kg N/ha) and was on par to 20 kg S level (92.58 kg N/ha). Almost similar trend of response of sulphur was recorded in respect of phosphorus and potassium uptake (Table 2). However, 40 kg S application resulted significantly higher sulphur uptake over 20 kg (18.21 kg S uptake) and 0 kg S/ha (10.21 kg S uptake/ha). Higher N, P, K and S uptake due to sulphur fertilization was due to higher biomass production. The protein content in seed showed remarkable variation due to various sulphur levels. Highest protein content (22.65%) was registered with 40 kg S/ha, which was significantly higher than 0 kg S (20.47%) and was statistically at par to the 20 kg S (21.68 %). The plots receiving 20 and

Table 3. Economics of different treatment combinations (mean of two years)

Treatment combination	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
UPAS 120 + 0 kg P_2O_5 + 0 kg S/ha	23960	34794	10834	0.459
UPAS 120 + 0 kg P_2O_5 + 20 kg S/ha	25159	39762	14633	0.582
UPAS 120 + 0 kg P_2O_5 + 40 kg S/ha	26359	42966	16607	0.63
UPAS 120 + 30 kg P_2O_5 + 0 kg S/ha	25726	44474	18748	0.729
UPAS 120 + 30 kg P_2O_5 + 20 kg S/ha	26925	51258	24333	0.904
UPAS 120 + 30 kg P_2O_5 + 40 kg S/ha	28127	53112	24985	0.888
UPAS 120 + 60 kg P_2O_5 + 0 kg S/ha	26759	49456	22697	0.848
UPAS 120 + 60 kg P_2O_5 + 20 kg S/ha	27960	56458	28498	1.019
UPAS 120+ 60 kg P_2O_5 + 40 kg S/ha	29161	58422	29261	1.003
UPAS 120 + 90 kg P_2O_5 + 0 kg S/ha	27921	50740	22819	0.817
UPAS 120 + 90 kg P_2O_5 + 20 kg S/ha	29101	58634	29533	1.014
UPAS 120 + 90 kg P_2O_5 + 40 kg S/ha	30321	60520	30199	0.996
Pusa 992 + 0 kg P_2O_5 + 0 kg S/ha	23960	31560	7600	0.317
Pusa 992 + 0 kg P_2O_5 + 20 kg S/ha	25159	38426	13267	0.527
Pusa 992 + 0 kg P_2O_5 + 40 kg S/ha	26359	40384	14025	0.532
Pusa 992 + 30 kg P_2O_5 + 0 kg S/ha	25726	42212	16486	0.641
Pusa 992 + 30 kg P_2O_5 + 20 kg S/ha	26925	49849	22924	0.851
Pusa 992 + 30 kg P_2O_5 + 40 kg S/ha	28127	50994	22867	0.813
Pusa 992 + 60 kg P_2O_5 + 0 kg S/ha	26759	46978	20219	0.756
Pusa 992 + 60 kg P_2O_5 + 20 kg S/ha	27960	53832	25872	0.925
Pusa 992 + 60 kg P_2O_5 + 40 kg S/ha	29161	55426	29265	0.901
Pusa 992 + 90 kg P_2O_5 + 0 kg S/ha	27921	50880	22959	0.822
Pusa 992 + 90 kg P_2O_5 + 20 kg S/ha	29101	41490	12389	0.426
Pusa 992 + 90 kg P_2O_5 + 40 kg S/ha	30321	58752	28431	0.937
Pusa 855 + 0 kg P_2O_5 + 0 kg S/ha	23960	39848	15888	0.663
Pusa 855 + 0 kg P_2O_5 + 20 kg S/ha	25159	49034	23875	0.949
Pusa 855 + 0 kg P_2O_5 + 40 kg S/ha	26359	50848	24489	0.929
Pusa 855 + 30 kg P_2O_5 + 0 kg S/ha	25726	51736	26010	1.011
Pusa 855 + 30 kg P_2O_5 + 20 kg S/ha	26925	58610	31685	1.177
Pusa 855 + 30 kg P_2O_5 + 40 kg S/ha	28127	60246	32119	1.142
Pusa 855 + 60 kg P_2O_5 + 0 kg S/ha	26759	57986	31227	1.167
Pusa 855 + 60 kg P_2O_5 + 20 kg S/ha	27960	63492	35532	1.271
Pusa 855 + 60 kg P_2O_5 + 40 kg S/ha	29161	65124	35963	1.233
Pusa 855 + 90 kg P_2O_5 + 0 kg S/ha	27921	59348	31427	1.126
Pusa 855 + 90 kg P_2O_5 + 20 kg S/ha	29101	67596	38495	1.323
Pusa 855 + 90 kg P_2O_5 + 40 kg S/ha	30321	69712	39391	1.299

40 kg S/ha, assimilated 5.91 and 10.65 per cent higher protein in their seeds over no sulphur application. Similarly, maximum protein yield (347.67 kg/ha) was recorded at 40 kg S level followed by 20 kg S /ha (326.87 kg/ha). The protein yield observed under 40 kg S/ha was statistically on par with 20 kg S/ha (326.87 kg/ha) and was significantly higher than no sulphur application (258.94 kg/ha). The results endorses the finding of Tripathi and Verma (2007). The protein production increased significantly with every increase in level of sulphur up to 40 kg S/ha. The percent increase was relatively more with first increment of 20 kg S/ha (3.47) over control as compared to subsequent increment of 20 kg S/ha. It has been well established fact that sulphur is an integral part of several amino acids, which build up the protein in pulses. Due to this fact addition of sulphur increased the protein content in seed over sulphur unfertilized plots.

Economics

Gross return is a function of production of economic material per unit area and price of the produce. Highest gross return (₹69712/ha) was received with $V_3P_3S_2$ (Pusa 855 with 90 kg P_2O_5 and 40 kg S/ha) treatment combination followed by (67596/ha) with (Pusa 855 with 90 kg P_2O_5 and 20 kg S/ha). Similarly highest net return also (39391/ha) was received with $V_3P_3S_2$ (Pusa 855 with 90 kg P_2O_5 and 40 kg S/ha) followed by (38495/ha) with (Pusa 855 with 90 kg P_2O_5 and 20 kg S/ ha).Where as, highest B:C ratio of 1.323 was obtained with Pusa 855 with 90 kg P_2O_5 and 20 kg S/ha. Higher gross return with Pusa 855 with 90 kg P_2O_5 and 40 kg S/ha was due to its respective higher seed and stalk yield. Whereas, higher net return was due to relatively higher level of gross return (Table 3).

On the basis of two years experimental results, it was concluded that the pigeonpea genotype Pusa 855 out performed to UPAS 120 and Pusa 992 in respect of plant growth, yield attributes, seed yield, nutrient uptake and quality parameters. To harness the existing agro-resources and to produce the crop in their higher quantity and quality and to explore maximum net return, pigeonpea (*Cajanas cajan*) should be fertilized with 90 kg P_2O_5 and 40 kg S/ha.

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J. Farming Systems Research & Development **19** (1) : 175-178 (2013)

MORPHO-PHYSIOLOGICAL TRAITS ASSOCIATED WITH RICE (*ORYZA SAIVA* L.) YIELD STABILITY UNDER AEROBIC FIELD CONDITIONS

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ABSTRACT

Field experiments were conducted during wet season for two consecutive years at Meerut. Experiments were direct sown with sixteen genotypes. Genotypes were selected from basmati, non basmati, hybrid and local groups. The major objective of the studies was to test the yield potential of different genotypes under strict aerobic field conditions. Irrigation was applied when any four genotypes starts showing leaf rolling. Mean grain yield for two years was recorded 19.70 q/ha. NDR-359, PHB-71, Pusa Sughandha-2 and Pusa Sughandha-5 yielded more than then 30.00 q/ha and were found promising compare to other genotypes. Grain yield was positively correlated with post flowering dry matter production and relative water content (r = 0.73 and 0.79 respectively). A negative association of grain yield and leaf rolling(r = -0.80) was observed. It was concluded that better adapted genotypes maintains higher plant water status and dry matter production which ultimately reflected in higher grain yield under aerobic conditions.

Key Words : Aerobic, Rice, Yield potencial, Traits

Rice is the staple food in Asia and is the single biggest user of fresh water. It is mostly grown under submerged soil conditions and requires much more water compared with other crops. The declining availability and increasing costs of water threaten the traditional way of growing rice under irrigated conditions. Over 17 million ha of Asia's irrigated rice may experience physical water scarcity and 22 million ha may experience economic water scarcity by 2025 (Tuong and Bouman 2003). Aerobic rice is a new concept of growing rice that is aerobic-soil-adapted and input-responsive. Aerobic rice is crops grown in well-drained, nonpuddled & nonsaturated soils without ponded water (Bouman *et al.*, 2007). Aerobic rice should have combining drought tolerance of upland rice and yield potential of lowland rice. Aerobic rice varieties should also have the ability to maintain rapid growth in soils with moisture content at or below field capacity. Aerobic rice with less water investment can leads to sustainable rice production for future to solve water scarcity along with environmental safety in the scenario of global warming by reduced methane emission.

Keeping the above in view identification of suitable germplasm, development of selection criteria for screening under aerobic field conditions and identification of various traits associated with aerobic adaptation are of crucial importance. The identified traits should have a positive association with yield stability under aerobic conditions.

MATERIALS AND METHODS

The studies were conducted at crop research centre of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut during 2006 and 2007.Crop was direct sown using RCBD design with three replicates. Direct sowing was done with a row distance of 20 cm. The plot size was 5x3 meters during both years. Sowing was done on 17th June and 21st June during 2006 and 2007 respectively with sixteen genotypes. Experiments were strictly maintained under aerobic conditions and irrigations were applied when any four genotypes starts showing leaf rolling. A total of 11 and 14 irrigations were applied during 2006 and 2007 respectively.

Dry matter production was estimated at flowering and maturity. A total of one meter running length was destructively harvested from each plot and oven dried till constant weight. Post flowering dry matter was calculated from the difference of dry matter between maturity and flowering. Dry matter was expressed as gram/m^2 basis. Leaf rolling was measured at midday using 1-5 scale (1- No rolling, 5- leaves completely rolled). Leaf rolling was recorded before every irrigation and mean values were used for analysis. Relative water content was also measured before the irrigation and mean values were used for analysis. RWC was estimated as described by Weatherly (1950) and modified by smart *et al*. (1974). Grain yield was recorded from the 3 m^2 from centre of the plot. Spikelet sterility was estimated from the samples collected for dry matter production at maturity. Statistical analysis was performed using pooled data of two years. Statistical analysis and relationships were performed as per the method described by Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Dry matter production at maturity was found non significant however, post flowering dry matter production was significantly different among genotypes. NDR-359 produced significantly higher dry matter after flowering and it was at par with PRH-10, PHB-71 and Pusa Sughandha-2. Such higher dry matter production after flowering is very crucial for yield stability as the developing grains are the strongest sink during this period. Relative water content was observed highest in NDR-359 and it was at par with PRH-10, PHB-71 and Pusa Sughandha-2. Such results clearly indicate that maintenance of higher plant water status helps these varieties for continuing their photosynthetic rate at a higher rate as compared to other genotypes. Mean leaf rolling differs significantly among genotypes. It was observed that genotypes' having lower relative water content starts folding their leaves earlier.

Effective tillers were observed non significant however, test weight and sterility was significant among different genotypes Such results shows that variation in grain yield under aerobic conditions was build due to higher test weight and lower sterility. Well performing genotypes maintained higher test weight and lower spikelet sterility and vice versa. Grain yield was significantly different among varieties. Grain yield was highest in PHB-71 and it was at par with Pant Dhan-12, PRH-10, Pusa Sughandha-2 and Pusa Sughandha-5. These genotypes can be further tested in multi location mode for their stability under aerobic conditions. Results clearly shows that grain yield is positively correlated with post flowering dry matter production and relative water content (r = 0.73 and 0.79 respectively). Similar results were also reported by Atlin *et al* 2004 under aerobic rice conditions. A negative association of grain yield and leaf rolling(r = -0.80) was observed. It indicates that genotypes

Table 1. Dry matter production, Relative water content and Leaf rolling of various rice varieties under aerobic conditions

Genotypes	Total dry matter at maturity (g/m^2)	Post flowering dry matter (g/m^2)	Relative water content at flowering (%)	Mean leaf rolling (1-5 scale)
Shakkar Chini(Local)	567.34	122.86	68.93	2.86
Balvinder Basmati(Local)	553.22	91.34	81.60	2.12
CSR-30	551.72	75.81	79.07	2.28
Haryana Basmati	568.10	130.08	75.09	1.89
NDR- 359	722.98	337.42	86.37	1.96
Pant Dhan- 10	633.38	103.26	71.25	2.85
Pant Dhan -12	630.78	193.42	80.59	1.62
PHB-71	833.93	230.52	83.23	1.82
PRH-10	593.50	289.69	83.44	1.46
Pusa Basmati-1	501.46	85.68	70.47	2.35
Pusa Basmati-370	583.90	59.44	71.60	2.00
Pusa Suganda- 2	667.42	227.96	86.85	1.90
Pusa Suganda - 4	673.41	126.04	70.13	2.68
Pusa Sugandha- 5	553.68	174.14	82.08	1.85
Satayvir Dharamnagar (Local)	547.51	76.52	74.65	1.45
Tarawdi Basmati	659.33	115.70	76.19	2.35
Mean	615.11	152.49	77.60	2.09
CD (5%)	NS	137.06	6.05	0.36
SED	99.49	66.79	2.94	0.17
SEM	70.35	47.22	2.08	0.12

Table 2. Growth and yield characteristic of various rice varieties under aerobic field conditions

Genotypes	Effective Tillers (%)	Plant height at maturity (cm)	Test Weight (grams)	Spikelet sterility (%)	Grain yield (Q/Ha)
Shakkar Chini (Local)	76.03	86	18.47	66.20	7.22
Balvinder Basmati (Local)	78.08	75	17.98	49.59	13.33
CSR-30	81.40	65	17.61	54.02	12.22
Haryana Basmati	76.28	87	15.61	50.27	11.77
NDR- 359	91.37	66	20.22	37.59	33.00
Pant Dhan- 10	72.27	66	16.09	41.93	5.390
Pant Dhan- 12	92.77	75	19.39	25.01	29.00
PHB-71	88.52	73	20.00	34.82	33.33
PRH-10	78.15	63	22.18	39.83	31.11
Pusa Basmati-1	78.32	59	15.68	58.00	11.66
Pusa Basmati-370	67.13	67	14.85	45.73	21.11
pusa Suganda- 2	74.64	83	24.39	28.62	30.27
Pusa Suganda - 4	78.04	74	18.71	88.02	7.78
Pusa Sugandha- 5	67.90	75	21.30	30.35	32.22
Satayvir Dharamnagar (Local)	79.22	80	17.44	44.69	23.55
Tarawdi Basmati	61.33	83	17.52	67.37	12.22
Mean	77.59	73.56	18.59	47.63	19.70
CD (5%)	NS	3.41	5.41	18.57	7.760
SED	11.31	1.66	2.63	9.05	3.78
SEM	7.99	1.17	1.86	6.40	2.67

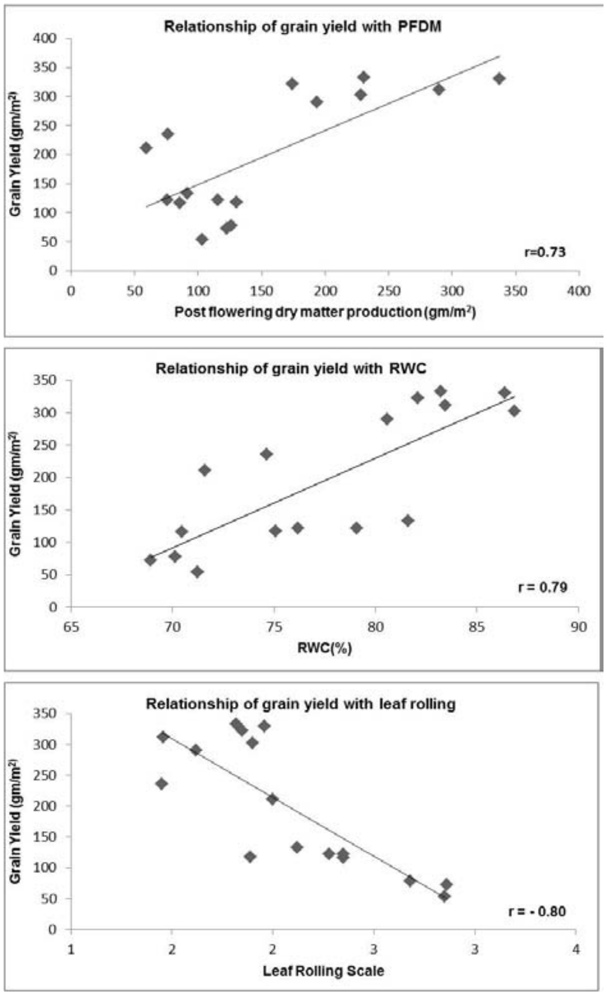

Fig. 1. Relationship of grain yield under aerobic conditions with post flowering dry matter production, relative water content and leaf rolling

suffering from water shortage roll its leaves to save water. Leaf rolling was associated with susceptibility of a genotype under aerobic conditions. It was concluded that better adapted genotypes maintains higher plant water status and dry matter production which ultimately reflected in higher grain yield under aerobic conditions.

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