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Journal of Farming Systems Research and Development

Volume 18 **January - June 2012** **Number 1**

CONTENTS

		Page
Effect of pre-puddling tillage and puddling intensities on growth and yield of rice under rice-wheat system in western Indo-Gangetic Plains	*V.K. Singh, B.S. Dwivedi, Arvind K. Shukla and R.P. Mishra*	1
Impact of resource conservation technologies in trans-gangetic plain in india	*S.P. Singh, B. Gangwar and P. Ramasunderum*	9
Studies on profitability of efficient faming system in mid hills situation of eastern himalaya	*Dhiman Mukherjee*	16
Trend estimation of yield under rice-rice cropping system in different nutrient management under long term experiments	*G.C. Sharma*	22
Experience with managing rice residues in intensive rice-wheat cropping system in Western Uttar Pradesh	*R.K. Naresh, Prem Singh, S.S. Tomar, S.P. Singh, Lalit Kumar, Vineet Kumar and Raj K. Gupta*	28
Alternate to crop establishment practices for higher productivity in maize-based cropping systems in Indo-Gangetic plains of India	*Vipin Kumar, Sandeep Kumar, Prem Singh and R.K. Naresh*	44
Improving productivity and economics of aerobic rice (*Oryza sativa* L.) through crop intensification	*Braja Kishor Samal, A.P. Vishwanath and Andani Gowda*	56
Growth and production potential of pigeon pea under reduced tillage and raised bed planting	*Amit Kumar, O.P. Singh and M.L. Jat*	60
Effect of bio-compost enriched poultry waste on productivity of wheat	*A.K. Katiyar and A.S. Jat*	65
Soil test based fertilizer recommendation for maximum economic yield of potato and sustainable soil health in nubbra valley	*Ashok Kumar, B.P. Singh and R.B. Srivastava*	69
Effect of sulphur on productivity, profitability and sulphur dynamics under urdbean (*Vigna mungo*)-Indian mustard (*Brassica juncea*) cropping system	*B. Ram, S.S. Punia, V.R. Meena and P.R. Raiger*	74
Weed dynamics and weed control efficiency in wheat (triticum aestivum l.) under different tillage methods and weed control options in rice- wheat system.	*Divakar Dev, Vivek, Sheesh Pal Singh and Ravindra Kumar*	79
Effect of different farm holding size on soil characteristics of farmer's field of Meerut district.	*M.P. Sharma, J.P. Singh and Prem Singh*	87

Effect of organic residue on growth, yield and quality of greengram in maize-sunflower–greengram cropping system of conservation agriculutre	*Tejeswara Rao K., Upendra Rao and Srinivasula Reddy D.*	93
Effect of threshing on seed quality of indian mustard crop	*Shiv Kumar Lohan and R.P.S. Kharb*	102
Effect of nitrogen and potassium on growth and yield of French bean and potato grown in intercropping system	*S. Sherawat, O.P. Singh and Jaiveer Singh*	110
Performance of wheat (*Triticum aestivum*) - based cropping systems in southern Rajasthan	*S.K. Sharma, N.K. Jain and S.L. Mundra*	117
Impact of improved technology on soybean productivity in frontline demonstration	*Upesh Kumar and Shirish Kumar*	122
Effect of bio-fertilizers on biomass partitioning pattern and yield of vegetable pea	*Rajiv Kumar Singh, Nirmal De, Saurabh Sharma and Surendar Kumar*	127
Nutrient use efficiency, growth and yield of wheat (*Triticum aestivum* l.) Under different nutrient options in rice wheat system.	*Sheesh Pal Singh, Vivek and Ravindra Kumar*	133
Impact of front line demonstrations on pigeon pea productivity in relay cropping system in Gujarat	*T.C. Poonia, M.S. Pithia and A.D. Raj*	139
Effect of zinc fertilization on growth yield of rice-wheat cropping system	*Komal Singh, Harendra Singh, Sandeep Singh, Vinod Kumar, G.C. Sharma and Prem Singh*	144
Effect on excess amount of aluminum discharge by industrial effluents with interaction of iron oxide nanopaarticles	*Yogendra Singh, Inderjeet Singh, Prem Singh and Salu Tomar*	150
Effect of PGPR and micro-nutrients on biochemical characteristics of two cultivars of *Cajanas cajan*	*Madhu Malik*	157
Effect of rice residue, tillage and nitrogen management on productivity, N use efficiency and soil properties in rice-wheat cropping system	*Arvind Kumar, Sudhir Kumar, M.L. Jat, Sudhir and Vipin Kumar*	163
Influence of reduced tillage and raised bed planting on production and water productivity of chick pea	*Amit Kumar, O.P. Singh, M.L. Jat and Sudhir Kumar*	171
A digital education initiative in agriculture	*Shashi Dahiya, K.K. Chaturvedi, Seema Jaggi, Anshu Bharadwaj and Cini Varghese*	175
Short Communication		
Strengths of SHG – Bringing Women Together	*Seema Tyagi*	180
Constraints experienced by women beneficiaries in effective functioning of SHGs	*Seema Tyagi*	183

J. Farming Systems Research & Development **18** (1) : 1-8 (2012)

EFFECT OF PRE-PUDDLING TILLAGE AND PUDDLING INTENSITIES ON GROWTH AND YIELD OF RICE UNDER RICE-WHEAT SYSTEM IN WESTERN INDO-GANGETIC PLAINS

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ABSTRACT

Field experiment was conducted on a sandy loam (Typic Ustochrept) soil of Modipuram to study the interactive effects of pre-puddling tillage and puddling intensity on crop growth and yield of rice and its residual effect on succeeding wheat crops. Treatments included 03 levels of pre-puddling tillage- discing followed by a tine-cultivation and planking (T_1), discing followed by 2 tine-cultivations and planking (T_2), or discing followed by 4 tine-cultivations and planking (T_4); and 3 puddling intensities i.e., 1, 2 or 4 passess of puddler in ponded water (P_1, P_2 and P_4, respectively), each followed by planking. Growth parameters viz., dry matter accumulation and leaf area index (LAI) measured at 30 and 60 days after transplanting (DAT) and yield attributes viz., number of ears m^{-1}row, number of grains ear^{-1} and grain weight ear^{-1} measured at maturity in rice revealed a significant increase with increasing pre-puddling tillage or puddling intensity and treatment combination T_2P_2 was found significant over T_1P_1. Increasing pre-puddling tillage from T_1 to T_4 and puddling intensity from P_1 to P_4 increased rice grain yield by 459 to 801 kg ha^{-1} and 821 to 1058 kg ha^{-1}, respectively. On the other hand, intensive puddling (P_4) led to decreased succeeding wheat grain yields. A combination of two dry tillage operations followed by two passes of puddler (T_2P_2) found optimum with respect to rice as well as rice- wheat system productivity.

Keywords: pre-puddling tillage; puddling; leaf area index; dry matter; yield; yield attribute; rice-wheat

INTRODUCTION

Adoption of Green Revolution Technologies (GRTs) since mid-1960s has resulted in significant expansion of area under rice and wheat, giving rise to the most important rice-wheat annual crop rotation. Presently, over 10.5 m ha area in India is managed under this crop rotation, and a major share of this area lies in the Indo-Gangetic Plain region (IGPR). In the IGPR, Upper Gangetic Plain (UGP) representing western parts of Uttar Pradesh are considered high productivity zones, where annual productivity (rice + wheat) often exceeds 6.0 t ha^{-1}. In most of these areas, wet land tillage for rice puddling has become very common, as apart from reducing percolation losses, it helps to control weeds and creates a soft medium for easy transplantation of rice seedlings (De-Datta, 1981). The process of rice field preparation consists of pre-puddling tillage (dry tillage) and wet tillage (puddling) operations. The quality of puddling depends on initial soil conditions created by pre-puddling tillage (Gajari *et. al.,* 1999) which ultimately regulate the percolation losses in rice. Surveys made under major rice-wheat

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growing areas of IGPR by Sharma *et. al.*, 2004 shows that 65% of the farmers apply 4 to 8 pre-puddling tillage operations to bury wheat stubble, restrict weed population and provide favorable soil tilth for puddling and followed by 3 to 5 wet tillage operations using puddler or cultivator plus a wooden plank. On the other hand, excessive puddling has several negative effects like it is a labour, capital and energy intensive operation and also repeated puddling deteriorates soil physical conditions (Kukal and Aggarwal, 2003), affecting adversely root growth and yield of subsequent crops (Tripathi, 2003). Thus, it is imperative to know the optimum number of pre-puddling tillage operations and puddling intensity for optimum growth and productivity of rice and its subsequent effect on succeeding wheat under rice-wheat system. We therefore, undertook present investigation to study the effect of pre-puddling tillage (Dry tillage) and puddling (Wet tillage) intensity on growth and yield of rice and subsequent wheat productivity under rice- wheat system.

MARERIALS AND METHODS

The field experiments were conducted at Project Directorate for Farming Systems Research (Earlier PDCSR) Modipuram, Meerut (29° 4² N, 77° 46² E, 237m amsl), comprising three pre-puddling tillage (Dry tillage) treatments in main plot and three puddling (Wet tillage) intensities in sub-plots in rice and compared in a split plot design with four replications for three consecutive years, (2000-03). The pre-puddling treatments were: (i) discing 01 week after wheat harvest + 01 harrowing with a tine cultivator and a planking (01 pre-puddling tillage, T_1); (ii) discing 01 week after wheat harvest + 02 criss-cross harrowing operations with a tine cultivator at weekly intervals after discing, each followed by planking (02 pre-puddling tillage, T_2); and (iii) discing 01 week after wheat crop harvest + 04 criss-cross harrowing operations with a tine cultivator, each followed by planking (04 pre-puddling tillage, T_4). Puddling was done by tractor-mounted puddler, once (01 puddling intensity, P_1), twice (02 puddling intensity, P_2) or four times (04 puddling intensity, P_4) in 8-10 cm pounding water followed by one planking. The plot size was 12 m x 12 m. Study site represents irrigated, mechanized and input-intensive cropping area of Upper Gangetic Plain Zone of IGP. The climate of Meerut is semi-arid subtropical, with dry hot summers and cold winters. The soil of experimental site was a sandy loam (16.5% clay, 18% silt, 65.5% sand) of Gangetic alluvial origin, very deep (>2m), flat (about 1% slope) and well-drained, representing one of the most extensive soil series i.e., Sobhapur series of north-west India.

Twenty-five day old seedlings of rice cv PR-106 were transplanted at 20 x 15 cm spacing during first week of July and harvested in the first wk of November. The succeeding wheat crop (cv PBW-343) was sown in 20 cm apart rows on the same layout, using 100 kg seed /ha with an uniform tillage (02 discing +02 cultivators with tine cultivator). Wheat was harvested in the third week of April during all the years. Both the crops were grown under assured irrigated conditions. At maturity, 11 x 11 m net plot area of rice as well as wheat was harvested manually just aboveground level using sickles. After drying in sun, the total biomass yield was measured, threshed with a plot-thresher and grain yield weighed. At rice harvest, yield attributes of crop viz, number of panicle m^{-2}, grains $panicle^{-1}$, and grain weight $panicle^{-1}$ and panicle length were also recorded. The observations on dry matter accumulation and leaf area index in rice were recorded at 30 and 60 days after transplanting (DAT) in each year. For treatment comparisons in the field experiment the 'F test' was used, following the procedure of split-plot design (Cochran and Cox, 1957).

Results and Discussion

Effect on crop growth

In general, dry matter was accumulated at a slow rate up to 30 days after wheat sowing, and thereafter the accumulation rate increased at faster rate, irrespective of treatments imposed. Data presented in Table 1 reveal that shoot dry weight increased markedly with increments in pre-puddling tillage and puddling intensities. Shoot weight differences due to changes in dry tillage were greater as compared to those due to puddling levels, especially at 60 days after transplanting (DAT). Averaged across pre-puddling tillage treatments, increasing the puddling intensity from one to four passes of puddler raised the dry matter yield by 26% at 30 DAT and by 82% at 60 DAT. Similar increase due to dry tillage option was to the tune of 162 and 236% at 30 DAT and 60 DAT, respectively. Among different treatment combinations, a combination of 02 pre-puddling tillage+ 02 puddling was found optimum. A higher dry matter production due to conjoint use of puddling and dry

Table 1. Leaf area index (LAI) and dry matter yield at 30 and 60 days after transplanting (DAT) during crop growth as affected by pre-puddling tillage and puddling intensities (Data pooled over 03 years)

Pre-puddling	30 DAT				60 DAT			
tillage	P_1	P_2	P_4	Mean	P_1	P_2	P_4	Mean
LAI (m^2 m^{-2})								
T_1	1.31	1.35	1.40	1.35	2.18	2.30	2.76	2.41
T_2	1.35	1.38	1.39	1.37	2.32	2.46	2.87	2.55
T_4	1.36	1.39	1.45	1.40	2.67	2.85	3.14	2.88
Mean	1.34	1.37	1.41	-	2.39	2.54	2.92	-
Dry matter yield (g m^{-2})								
T_1	28.15	34.15	38.15	33.48	70.15	107.65	135.15	104.32
T_2	70.15	77.65	85.65	77.82	182.65	283.15	385.65	283.82
T_4	76.65	90.15	96.15	87.65	259.15	379.65	413.15	350.65
Mean	58.32	67.32	73.32	-	170.65	256.82	311.32	-
CD at 5%								

	30 DAT			60 DAT		
	P	T	PßT	P	T	PßT
Dry matter yield	8.11	10.42	14.83	54.21	70.41	104.82
Leaf area index	0.07	NS	NS	0.14	0.14	0.29

NS= Not significant

tillage interaction may be explained in terms of well-documented role of puddling on increased nutrient availability to crop, reduced weed population and ultimately more photosynthesis via larger and sustained photo-synthetically active leaf surface on account of more and delayed leaf senescence, and prevention of leaf chlorophyll degradation. These results corroborated well with earlier reports (Srivastava and Tripathi, 1999; Singh *et al.,* 2003).

The leaf area index (LAI) values, averaged over tillage levels, increased from 1.34 to 1.41 m m^{-2} at 30 DAT, and from 2.39 to 2.92 m m^{-2} at 60 DAT, when the puddling level was raised from one pass to four passes of puddler (Table 1). Averaging LAI values over puddling intensities showed consistent increase due to increasing dry tillage at 30 and 60 DAT. Although the LAI increased with increasing levels of dry tillage as well as puddling, but the effect of puddling was relatively more spectacular. The advantage of puddling on LAI may be explained in the terms of increase in number and size of leaf (data not shown) due to better nutrient and water availability thereby higher nutrient and water uptake, resulting in increased leaf area of the crop (Singh *et al.,* 2008).

Effect on rice productivity

The grain yield of rice showed a significant increase with increasing dry tillage as well as puddling intensities, though the magnitude of response to dry- and wet-tillage operations varied in accordance to treatment effects (Table 2). The main effects of dry-tillage were significant up to the highest level i.e., four operations, whereas those of

Table 2. Effect of pre- puddling tillage and puddling intensities on the grain yield of rice (Data pooled over 03 years)

Dry- tillage	**No. of puddlings**			**Mean**
	P_1	**P_2**	**P_4**	
Grain yield (kg ha^{-1})				
T_1	4034	4850	5195	4680
T_2	4500	5322	5593	5139
T_4	4894	5729	5844	5489
Mean	4476	5297	5534	
Straw yield (kg ha^{-1})				
T_1	5078	6119	6480	5887
T_2	5666	6570	6920	6385
T_4	6146	7053	7329	6841
Mean	5632	6581	6871	
CD at 5%				

	Puddling intensity (P)	**Dry tillage (T)**	**P ß T**
Grain yield	256	317	411
Straw yield	381	407	444

puddling were significant up to two passes of puddler. When averaged across puddling rates, the yield under one dry-tillage was 4680 kg ha^{-1}, which was increased by 809 kg ha^{-1} in the plots receiving four dry-tillage operations. The effect of puddling was relatively greater, as increase in puddling rate from one pass of puddler (4476 kg ha^{-1}) to four passes of puddler accounted for 1058 kg ha^{-1} increase in grain yield.

The dry tillage x puddling interaction was also significant on grain yield, and a combination of two dry-tillage operations followed by two passes of puddler proved optimum. This combination yielded 5729 kg grain ha^{-1}, and a further increase in puddling did not accrue additional advantage. The reasons assigned for higher procuctivity under two pass of puddler over 01 pass of puddler are improved puddle quality i. e., puddling index (Singh *et. al.,* 2008), restricted N leaching towards lower prpofile (data not shown) and smaller weed count (Kukal and Sidhu, 2004, Kukal and Aggrawal, 2003). The straw yield of rice followed similar trend to grain yield and significant maximum yield was obtained under plots having T_2 P_2.

Effect on yield-contributing characters

Yield-contributing characters viz., number of ears m^{-1}, number of grains ear^{-1} and grain weight ear^{-1} revealed marked effect of dry-tillage and puddling (Table 3). The ear length, however, remained unaffected due to tillage or puddling treatments. Comparing pre-puddling tillage across the puddling intensity treatments, use of 02 or 04 dry tillage operations had 12-19% more ear count, 4-14% more grains ear^{-1} and 2-7% more grain weight ear^{-1} over 01 pre-puddling tillage operation. Similar increase due to P_2 and P_4 across the pre-puddling tillage operations were 10-17%, 4-14% and 2-7%, respectively.

All these parameters increased with increasing puddling levels up to four passes of puddler in the plots having one or two dry-tillage operations. With four dry-tillage operations, the yield-attributes did increase up to two passes of puddler only. The differences between T_2P_2 and T_4P_2 however, remained largely unaffected. By and large here it may argued that under T_2P_2 plots balanced and adequate nutrient supply throughout growth period as indicated by dry matter accumulation and more leaf area index resulted improved plant vigor, as also the yield-attributes.

Grain yield of residual wheat

The succeeding grain yields of wheat, raised with same undisturbed lay-out remained unaffected due to pre-puddling tillage but varied according to puddling intensity given in previous rice crop. The grain yield of wheat was declined with increasing pudding intensity (Table 4). Averaged over pre- puddling tillage treatments, wheat grain yield in P_2 and P_4 plot were 5.0% and 16.2% lesser than that in P_1 plots. The differences for yield reductions were not significant under P_1 and P_2 plots but a significant decline was noticed with P_4 over P_2 plots. Lower wheat yield under intensively puddle plot may be ascribed as increase in soil BD particularly in sub-surface soil results restricted root growth due to increased penetration resistance. Earlier reports of Sharma and De-Datta, 1985 indicated that BD of excessively-puddled soils increase upon drying of the soil after rice harvest, leading to a soil condition that is less favorable for establishment of wheat crop in RWCS. Impaired soil structure of puddled and compacted sub-soil in rice-wheat system is the major impediment for

Table 3. Effect of pre-puddling tillage and puddling intensities on the yield contributing characters in rice (Data pooled for 03 years)

Pre-puddling tillage	Puddling intensity			Mean
	P_1	**P_2**	**P_4**	
No. of panicle m^{-1} row				
T_1	44	47	50	46.5
T_2	48	52	57	52.0
T_4	50	57	58	55.2
Mean	47.0	51.9	54.8	-
Panicle length (cm)				
T_1	21.6	23.4	23.1	22.7
T_2	23.9	22.3	23.5	23.3
T_4	23.8	23.9	22.5	23.4
Mean	23.1	23.2	23.0	-
No. of grains panicle^{-1}				
T_1	99	118	131	115.9
T_2	101	123	138	120.7
T_4	110	137	148	131.6
Mean	103.2	125.8	138.8	-
Grain weight (g) panicle^{-1}				
T_1	3.8	4.2	4.5	4.2
T_2	4.0	4.3	4.6	4.3
T_4	4.1	4.6	4.7	4.5
Mean	4.0	4.4	4.6	-
CD at 5%				

	Puddling intensity (P)	**Dry tillage (T)**	**P ß T**
No. of panicle m^{-1} row	3.0	3.2	4.8
Panicle length	NS	NS	NS
No. of grains panicle^{-1}	13.0	11.8	15.2
Grain weight panicle^{-1}	0.2	0.1	0.3

NS= Not significant

establishment and growth of subsequent wheat crop (Gajri *et. al.,* 1992; Oussible *et. al.,* 1992; Aggarwal *et. al.,* 1995). On the other hand, comparatively better wheat yield under less puddle plots (P_1) confirm the findings of earlier studies of Dwivedi *et. al.*, 2003; Singh *et. al.*, 2005; Singh and Dwivedi, 2006 which revealed that a deep and extensive root system of wheat helps to trap N and P from deeper profile and ensures an increase in wheat productivity. Further relatively greater

Table 4. Effect of pre-puddling tillage and puddling intensity on grain yield of residual wheat yield (kg ha^{-1}) (Data pooled over 03 years)

Pre-puddling tillage	Puddling intensity			
	P_1	P_2	P_4	Mean
T_1	4290	4241	3927	4153
T_2	4375	3871	3858	4035
T_4	4023	3932	2859	3605
Mean	4229	4015	3548	
CD at 5%	P=254, T= NS, P x T= 385			

NS= Not significant

wheat yields under less-puddled treatments could also be explained in the light of greater contact between absorbing root surface and available nutrient pool under an extensive root system (Tisdale *et. al.*, 1993). The interactive effect of pre- puddling tillage and puddling intensities was significant only upto P_2T_2, indicating increasing dry tillage or puddling intensity beyond this level is not beneficial for succeeding wheat productivity.

The results of the present study inferred that both pre-puddling tillage and puddling played a significant role in increasing the grain yield of rice under rice-wheat cropping system. Ensuring a stress-free condition with optimum puddling and tillage combinations at the peak physiological stages in rice, as revealed by the highest values of dry matter accumulation and leaf area index at 60 DAT (i.e., Panicle initiation stage) may further enhance the crop yields. The present study suggested 02 pre-puddling tillage followed by 02 passes of puddler as an optimum tillage combination for rice on the coarse-textured (sandy loam) soils to achieve high annual RWCS productivity.

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J. Farming Systems Research & Development **18** (1) : 9-15 (2012)

IMPACT OF RESOURCE CONSERVATION TECHNOLOGIES IN TRANS-GANGETIC PLAIN IN INDIA

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ABSTRACT

In the present study an attempt has been made to assess the Socio-economic impact of resource conservation technologies in Haryana during 2009-10. The results revealed that Residue Management (RM) plus Zero Tillage (ZT) adopters were highest (35 percent) followed by Green Manuring (GM) plus RM plus ZT (16 percent). About 24 percent farmers were retaining full residue and incorporating it in to the soil for fertility management while about 55 percent farmers were partially retaining it. About 75 percent land preparation cost was saved in zero tillage which is directly related to profit. Similarly, 24 percent farmers were retaining full residue and incorporating it in to the soil for fertility management while about 55 percent farmers were partially retaining it. Partial Budgeting of zero tillage over conventional tillage indicated that as the technology facilitates the timely sowing of crops, the additional yield recorded was 2.30 quintals worth Rs. 2300 and besides saving in tillage cost and reduced seed rate render the net benefit of Rs. 5405/ha in comparison to conventional tillage. The major reasons cited for practicing zero tillage were reduced costs of cultivation, presented as ideal for problem soils and shallow water table areas, saves fuel (diesel) bill and irrigation water, facilitates timely sowing, overcomes labour shortage, facilities line sowing and ensures better germination, less weed intensity, minimized machinery wear and tear and the maintenance and repairing costs. The technology is economical, easy to adopt with reducing labour cost and time saving therefore, offers high potential economic environmental and social gains in the similar conditions.

Key words: Zero tillage, conventional tillage, partial budgeting and profitability

Conservation agriculture is being practiced even before nineteen centuries by Indian rice grower in low land area of Assam, West Bangal, Orissa, Bihar and Eastern part of Uttar Pradesh where traditional rice varieties were grown under rain fed situation. The farmers after harvesting of rice broadcast the lentil, linseeds, lathyrus and other such oilseed crops without ploughing to the land. Since, rice field after harvesting had sufficient moisture, it helps to germinate these crops easily. In some parts of Bihar, Uttar Pradesh (UP), Orissa and Madhya Pradesh (MP), this traditional method of resource conservation is still in practice and farmers are harvesting good yields of pulses, oilseeds and millet crops. Sowing of millets crops like finger millets, maize after making hole in the soil under moisture condition is a long practice by the Indian farmers. However, after green revolution and extension of irrigation facilities, the spread of this technology is declined except certain areas like Diara land of Bihar and some parts of Assam and Uttar Pradesh. Conservation agriculture is a concept for resource-saving agricultural crop production that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. Interventions such as mechanical and soil tillage are reduced to an absolute minimum, and the use of external inputs such as agrochemicals and nutrients of mineral organic origin are applied at an optimum level. This technology is characterized by three principles which are linked to each other. The principles are: (i) Continuous minimum mechanical soil disturbance. (ii) Permanent organic soil cover. (iii) Diversified crop rotations in the case of annual crops or plant associations in case of perennial crops.

The small and marginal farmer which accounts 86% of total households, cultivating less than two hectare of land are not able to feed their family throughout the years and as such 40% of them are below poverty line. Further, declining crop productivity and net return has put them under indebted ness of the land lords and money lenders. If the situation is not improved of these farm groups, the growth in poverty may be accelerated in future. Again due to intensive cropping, the soil health is being deteriorated day by day which influence the crop yield. In addition, the average annual rainfall is declining in many parts of the country. Low rainfall has also caused for sharp depletion of ground water table in all the states. All these problems influence the crop productivity and farm income in one way or other. To overcome these problems, adoptions of conservation agriculture on broad scale in the country is essentially required.

The objective of the zero tillage is to plant seed direct into the soil without ploughing. As per several reports, soil fertility is declining sharply in all part of the country and consequently crop productivity either stagnant or going down, the adoption of zero tillage seems essential by all the farming community of the country. Decomposition of crop residue in the soil in zero tillage technique, which increases the carbon content in the soil, is another benefit from this technology because of depiction of ground water and declining average rainfall. Since water has become kingpin in agriculture production system and in zero tillage practice, irrigation water is saved (20-35%) (Laxmi et al 2007) from normal irrigation, the adoption of this technology on large scale in all parts of the country in general and rain fed areas in particular is utmost essential. The component of agriculture conservation technology are green manuring, laser leveling, direct seeding of rice, bed planting, intercropping in sugarcane, summer plough of moong use of rotavator transplanting of rice through trans planter and zero Tillage in wheat**.** The main objective of the study was therefore; to assess the Socio-economic impact of resource conservation technologies in state of Haryana represented trans- Gangetic Plain in India

Materials and Methods

The study was undertaken in state of Haryana in Panipat, Karnal, Kurukshetra, Kaithal and Yamunanagar districts during 2009-10. Sampling were done at two levels (village and house hold) in consultation with the scientists of KVK Panipat and Kurukshetra, and two types of controls (villages and farmers with respect to adoption and non-adoption) and three forms of comparisons – with, without and across regions and cropping systems. Ninety five farm households were covered across five districts of Northern Haryana and the resources conservation technologies covered were Green manuring, Zero tillage, Laser leveling, Bed planting, Rice Mechanical Trans planter, Bed Planting, Intercropping in

Sugarcane and summer planting of moong. The farm level impact indicators like –yield increase, income augmentation, cost reduction, cropping intensity and resource conservation and aggregate level indicators like – agricultural production and employment were identified. The information on above mentioned resource conservation technologies were from sampled farmers by conducting personal interview using pretested interview schedule. The collected data is then analyzed by simple tabulation method for selected farmers. The results obtained were than compared with the series of experiments on tillage and planting management conducted at different locations in the country and studies done in the past.

Results and Discussion

Adoption profile of resource conservation technologies across sample households has been exhibited in Table 1. It can be observed from the table that the Residue Management (RM) plus Zero Tillage (ZT) adopters were highest (35 percent) followed by Green Manuring (GM) plus RM plus ZT (16 percent). Only green manuring and only residue management were practiced by about 13 percent in each technology. Residue management through rotavator is also being adopted by about 10 percent of the sample farmers in the area. There was a poor adoption in rest of the technologies.

Table 1. Adoption profile of resource conservation technologies across sample households

Technology Particulars	No. of farmers	(%)
Only Green Manuring (GM)	12	12.77
Only Residue Management (RM)	12	12.77
Only Zero Tillage (ZT)	5	5.32
GM+RM	4	4.26
GM+ZT	8	8.51
RM+ZT	33	35.11
GM+RM+ZT	15	15.96
RM+ Rotavator	9	9.57
Laser Leveling +ZT	2	2.13
Use of Rice Mechanical Transplanter	1	1.06
Bed Planting & Intercrops	1	1.06
Total	95	100

Table 2 indicates that about 24 percent farmers were retaining full residue and incorporating it in to the soil for fertility management while about 55 percent farmers were partially retaining it. It is also worth mentioning that about 10 percent farmers burning the residue to clean the field. It has been pointed out that leaving more crop residue as much has implications for both ZT drill functioning and potential trade –off between residue use for livestock feed and conservation agriculture (Erenstein *et al.* 2007).

Table 2. Distribution of zero tillage practitioners as per nature of residue management

Nature of Residue Management	No. of sample households	Percent
Burning	6	9.52
Partial burning	13	20.63
Part retention	35	55.55
Full retention	9	24.29
Total	63	100

It could be seen from the table 3 that the comparative resource use and return recorded in zero tillage vis-à-vis conventional tillage. There was a more

Table 3. Comparative resource use and return in zero tillage vis-à-vis conventional tillage.

Resources/ return	Zero tillage	Conventional tillage	Saving %
Land Preparation time (hr/ha)	1.62	112	98.55
Land preparation cost (Rs/ha)	1500	6000	75.00
Saved rate (kg/ha)	95	117.5	19.15
Fuel consumed (Rs/ha)	5	47.5	89.47
First Irrigation time hr/ha	10	13.5	25.93
Yield realized (t/ha)	4.33	4.10	5.61

than 98 percent saving in zero tillage as compared to conventional tillage. About 75 percent land preparation cost was saved in zero tillage which is directly related to profit. The indirect benefit in terms of fuel savings ranged from 35-40 li/ha. Sharma *et al* (2002) reported that in Haryana ZT saved 59 l/ha of fuel, 8 hr/ha of tractor time (80-88 % saving) and approximately 3000 Maga joules/ha of energy in tractor operation as compared to conventional tillage.

The generally positive yield effect of zero tillage on wheat are mostly due to (i) timely sowing and (ii) efficiency of increased input use and weed control (Mehla *et al.* 2000). Partial budgeting of zero tillage over conventional tillage as given in Table 4 indicates that as the technology facilitates timely sowing, the additional yield recorded was 2.30 quintals worth Rs. 2300 and besides saving in tillage cost and reduced seed rate render the net benefit of Rs. 5405/ ha in comparison to conventional tillage. The studies conducted in the past also revealed that in Haryana the cost saving effect amounted to 6–7% of the total cost of conventional tillage (Nagarajan *et al.* 2002 and Erenstein *et al.* 2007) and in Uttaranchal 16%. On an average, a 280 kg /ha increase in wheat yield was reported in 112 farm trials (46 in 2000-01 and 66 in 2001-02) across five states in the IGP (Dhiman *et al.* 2003)

Table 4. Per hectare Partial Budgeting of zero tillage over conventional tillage in wheat crop in Haryana state.

Added cost in Rs.		Added benefit in Rs.	
• Increase in cost /ha		• Decrease in cost/ha	
• Zero till expenses Rs.	1500	• Saved tillage cost	4500
• Residues management cost	Rs. 0	• Reduced seed rate	225
• Harvesting transport and marketing of added yield	Rs. 120	• Saving in irrigation & weed costs	
Increase in return/ha	Nil	b) Increase in return / ha	2300
Total	Rs. 1620	Total	Rs. 7025
Net return Rs. 5405/ ha /wheat crop			

Table 5 shows the respondents rating of benefits from Zero Tillage. It is evident from the table that 100 percent farmers were in the view that there was saving in time in tillage operations and cultivation expenses. Due to the adoption of ZT technology, the number of field operations for the establishment of the wheat crop (including tillage) decreased from an average of seven to only one (Sharma *et al.* 2002) 81 percent farmers reported less weed intensity. The study confirmed the findings that with the adoption of ZT in rice –wheat system in the IGP, comparatively less weeds in wheat crop (Chauhan *et al.* 2002; Farnk *et al.* 2004; Malik *et al.* 2002; Prasad *et al.* 2002). With the ZT, the early emergence of wheat and no less soil disturbance in the uncropped area resulted in less and late emergence of wheat (especially *Phalaris minor*). Therefore, weed competition to the wheat crop is greatly reduced. However, the population of broad leave weeds reportedly increased like jungli palak (*Rumex retroflex*). Some farmers also feared a drastic yield reduction in the event of a weed out burst (Laxmi *et al.* 2007). More than 44 percent farmers revealed that there was no difference in seed rate and more than 47 percent farmers were in view that the irrigation expenses were same in zero tillage and conventional tillage practices. The saving are generally reported for first irrigation (e.g. 8-10 hr with zero tillage and 13-17 hr with conventional tillage; Hobbs *et al.* 1997). Zero tillage can also imply saving of one irrigation (Hobbs *et al.* 1997; Laxmi *et al.* 2003; Malik *et al.* 2002 ; Mehla *et al.* 2000) and the irrigation saving tends to translate in to immediate cost saving whenever farmers rely on lift irrigation through electric /diesel operated wells. Both on station and on farm highlight significant yield increase from Punjab towards the middle Gangatic plains reflecting the increasing importance of timeliness. Long term monitoring of six sets of farmers' fields over eight years in Haryana has shown that ZT had consistently higher or similar yields to conventional tillage (Malik et al 2005:16)

The major reasons cited for discontinuing of zero technology in case of those who practiced and gave up were lack of timely availability of zero till machine labour skilled and weed intensity. Some farmers also reported that an extra ploughing was required for the subsequent field preparation for rice after ZT wheat. Some farmers reported difficulties in operating ZT drills in fields with loose residues and suggested that the need for straw cutter on the zero till drill to remove the stubbles in the field while sowing. Some farmers using

Table 5. Respondents rating of benefits from zero tillage

Benefits	Less	More	Same
Tillage operations	100	0	0
Cultivation expenses and budget	100	0	0
Seed rate	33.7	21.9	44.4
Irrigation requirement and expenses	24.5	28	47.5
Weed intensity	81.0	8.0	11.0
Yield	6.3	54.8	38.5

rotavator as a substitution of ZT drill machine.

The reasons reported for practicing zero tillage were reduced costs of cultivation, suited for problem soils and shallow water table areas, saves fuel (diesel) bill and irrigation water, facilitates timely sowing, overcomes labour shortage, facilities line sowing and ensures better germination, less weed intensity, minimized machinery wear and tear and the maintenance and repairing costs. Adopters of ZT reported that they were tension free at the time of wheat sowing. The time saving are reportedly utilized in other farming activities. On the other hand ZT reduced the demand for labour and some male and female workers lost seasonal work for land preparation and weeding and other intercultural operations. Some woman estimated they had lost at least 10 day/year because of introduction of ZT (Laxmi *et al.* 2007)

CONCLUSION

Rice–wheat systems need to enhance their cost competitiveness in the context of trade liberalization and rapid non-agricultural growth. Zero tillage potentially includes savings in energy, water, labor, and other inputs. The ZT drastically reduces the use of machinery (less wear and tear and depreciation) and the cost of the tillage operation—a major cost of crop production in the IGP. Compared to broadcasting, the ZT drill potentially saves seed and fertilizer, placing them at the desired depth and vicinity and in the right quantities. Available studies concur in highlighting the profitability of ZT wheat production over CT. Two factors contribute to the overall profitability of ZT: (i) the value of the yield increase (the 'yield effect') and (ii) the savings in production cost (the 'cost saving effect'). Approximately 30% of wheat cultivation is under late sowing in the Indian IGP and zero tillage allows for timelier establishment. The technology is economical, easy to adopt with reducing labour cost and time saving therefore, offers high potential economic environmental and social gains in the Indian IGP. The technology will also be helpful in natural resource saving besides cost saving. Technological intervention needs to be complemented with policy reforms to create an enabling environment for sustainable agriculture. Beyond the farm level, zero tillage opens a new service industry – be it for machinery manufacturer or custom hiring service (Dixon *et al.* 2007). The result of the study in Haryana clearly favours for more concerted efforts on system based conservation agriculture instead of the present focus on resource conservation technologies in entire IGP of India.

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STUDIES ON PROFITABILITY OF EFFICIENT FAMING SYSTEM IN MID HILLS SITUATION OF EASTERN HIMALAYA

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ABSTRACT

The conservation of natural resources in the Himalayan region is an issue of utmost concern for sustainable agricultural development and improving livelihood securities of the local inhabitants. The agro-climatic condition of Kalimpong subdivision of Darjeeling district of West Bengal favours the cultivation of wide range of crops in addition to various farming system components. This adoption was mostly affected by the farmer knowledge levels along with their choice of efficient and profitable farming system. Keeping this aspect a work was conducted during 2008 to 2010 at Regional Research Station (Kalmpong) under Darjeeling district. Studied showed that amongst 60 farmers, most of the farmer had education upto middle school and cosmopolitenes of the farmer was mostly confined to panchayt level only. Further their media exposer mostly confined to radio only. Economics revealed that highest net income of Rs. 1,28,633 was obtained with Crop +Piggery + Poultry +Milch cattle. Amongst the six enterprise combinations highest employment was provided by the Crop + Piggery + Poultry + Milch cattle (116.42 days) followed by Crop +Piggery + Poultry (113.56 days) and Crop + Poultry +Milch cattle (108.46 days).

Key words: Farming system, farmers, economics, education, employment.

To meet the food requirement of its growing population, the country needs to improve the production from the hill and mountain agro-ecosystem. The hill economy is predominantly rural and agriculture oriented. In agriculture 85 percent of the holdings are less than two hectare and the declining trend in the average size of the farm holding, poses a serious problem. The farmers concentrate mainly on crop production which is invariably subjected to a high degree of uncertainty in income and employment. To sustain the income and productivity, the farmer has to integrate ancillary propositions with crop production. Every farmer tries to choose the farm activities/ enterprises depending upon physical and economic conditions prevailing in his ecosystem (Mukherjee and Moktan, 2008). Integration of various farm enterprises in a farm ensures growth and stability in overall productivity and profitability. It also ensures recycling of residues, optimization of resources use, and minimization of risk and generation of employment (Mukherjee, 2010). In hill region of farmers could includes crop production, dairy, poultry, fish farming vegetable and fruit growing, pig farming, mushroom cultivation etc. A judicious mix of enterprises, complementary to cropping and suited to the given farming situation and the farmer's preference would bring prosperity to hill people in rural areas. Farming system approach introduces a change in farming technique for higher production from the farm as a whole with the integration of all the available suitable enterprises. This is a new concept which accounts the components of soil, crops, livestock, labour and other resources with the farm family at the centre managing agriculture and related activities on even non-farm avocations (Ravisankar *et al*, 2007). The farm family functions, within the limitation of the actual farm situation. This is an indication of general recognition for location-specific programme and planning for a farming system approach, which will benefit the hill as a whole, and the resources poor farmers in particular who are toiling under disadvantage conditions

Keeping this aspect in mind present investigation has been conducted to identify existing farming systems in mid hilly area and asses their relative viability, their input use and profitability and to work out income and employment generation and their intensification adoption.

Materials and Methods

The present investigation was conducted at Regional Research Station (Hill zone), Uttar Banga Krishi Viswavidayalay, in Kalimpong I and Kurseong block of Darjelling district during the year of 2008 to 2010. The two blocks from each subdivision of the district were selected for the study because agriculture was mostly concentrated in these two blocks. In these block farming system were more diversified. The soils of this block where divided into two groups: The brown forest soils and the light coarse to fine sandy loam. Soils were moderately to strongly acidic (pH 4.0 to 6.5) with low to moderately high organic matter content (1.2 to 4.7 % organic carbon). Soils are generally low in nutrient content, poor in water holding capacity, when low in organic matter and are considerably eroded where open. For the study purpose the relevant socio-personal and field level primary data were collected from the four villages namely Dalapchand, Bhalukhop, Purbong and Bunklong (Mirik) sub division of Darjeeling district. These villages were selected purposively owing to their greater acquaintance and accessibility on the part of the investigator. Sixty farmers were selected which had average land holding of 1.5 ha randomly following simple random sampling without replacement technique. All necessary information were collected through specially designed pretested schedule following personnel interviewed and by observing the existing land area for crop along with enterprise they have considered. For the convenience the sample farmers were classified on the basis of crop grown along with different enterprises which they took for their optimum economic returns. Simple tabular analysis was adopted for the interpretation. Economics were worked out on average basis.

Results and Discussion

In the study of faming system in the hilly region of Darjeeling district, six enterprises combinations were identified. There were 13 cultivators (21.6%) followed only crop production, 10 cultivator (16.7%) followed Crop + Piggery, 11 cultivator (18.4%) followed Crop + Poultry, 10 cultivator (16.7%) followed Crop +Piggery +Poultry, 8 cultivators (13.3 %) followed Crop + Piggery + Poultry + Milch cattle and 8 cultivator (13.3%) followed Crop + Poultry +Milch cattle (Table 1).

In this investigation of the farming system, certain socio-personal characteristics like education qualification, cosmopoliteness and media exposer of the farmers were studied. The Table 2 shows that the educational qualification level of the farmers were maximum upto middle school (38.3% , Rank I) followed by madhyamik level (28.3%, Rank II) and minimum percentage of qualification level was above graduate level (1.6%, Rank VI).

Table 1. Farming system adopted by the farmers.

Sl.No.	Farming enterprises	No. of cultivators involved in faming enterprises (N =60)	Percentage (%)
1	Crop	13	21.6
2	Crop +Piggery	10	16.6
3	Crop + Poultry	11	18.4
4	Crop +Piggery + Poultry	10	16.7
5	Crop +Piggery + Poultry +Milch cattle	8	13.3
6	Crop + Poultry + Milch cattle	8	13.3

Table 2. Educational qualification of the farmers.

Sl.no.	Education	No.	Percentage	Ranking
1.	Illeterate (0)	Nil	0	VII
2.	Primary (1)	8	13.3	III
3.	Middle School (2)	23	38.3	I
4.	Madhymik (3)	17	28.3	II
5.	Higher secondary (4)	7	11.6	IV
6.	Graduate (5)	4	6.6	V
7.	Above graduate (6)	1	1.6	VI

The cosmopoliteness of the farmer's i.e visit of the farmers to different places or offices in regular interval for their different problem works related to their day to day activities (Table 3). Maximum number of farmer's visits panchayat office (Rank I) which is followed by sub-divisional town (Rank II) which was again followed by B.D.O office (Rank III) and Sub-Divisional Agril. Office (Rank IV), respectively and the minimum visit was with the city (Rank VII).

The use of the media for updating their knowledge and skill regarding farming practices, the farmers most often used Radio (Rank I) for getting information on agriculture, animal husbendary practices, milch cattle etc. followed by Television (Rank II) and newspaper (Rank III), respectively (Table 4). All of these factors affect the farmer knowledge level and which ultimately affect the economy of farming system (Bera *et al*, 2005).

The total income from different enterprises combination indicated that highest income of Rs. 1,28,633 was obtained from Crop +Piggery + Poultry +Milch cattle, followed by Crop + Poultry +Milch cattle (Rs.1,18,927), and Crop +Piggery + Poultry got net income of Rs.1,14,764, while only crops got only Rs. 94,238 (Table 5). Amongst the system, maximum sharing of net return had been observed with crop through out all the farming system approach. In case of

Table 3. Cosmopolitenes of farmers (N=60) involved in farming system.

Sl.no.	Place	Most often (3)	Often (2)	Sometime (1)	Never (0)	Score	Ranking
1.	City	-	-	2	58	2	VII
2.	Dist. Town	3	8	42	7	7	VI
3.	Sub. Town	13	24	33	-	120	II
4.	Panchayat	19	33	8	-	131	I
5.	SAO/ADO office	10	22	26	2	100	IV
6.	B.D.O office	14	25	18	3	110	III
7.	RRS/KVK	8	17	24	11	82	V

Table 4. Media expose of the farmers (N=60) in farming system.

Sl.no.	Mass media	Most often (3)	Often (2)	Sometime (1)	Never (0)	Total score	Ranking
1.	Radio	12	27	20	1	110	I
2.	Newspaper	6	15	31	8	79	III
3.	Farm/Agril. publication	5	13	29	13	70	IV
4.	Film show	3	9	18	30	45	V
5.	Television	10	18	24	8	90	II

Table 5. Economics of faming system practice (Different farming system with share of different enterprises)

Sl.no	Farming enterprises	Crop Produce	Piggery	Poultry	Milch cattle	Total Profit incurred
1	Crop	94,238 (100 %)	-	-	-	94,238 (100 %)
2	Crop +Piggery	92,468 (88 %)	12,564 (12 %)	-	-	1,05,032 (100 %)
3	Crop + Poultry	89,438 (79.8%)	-	22,634 (20.2 %)	- -	1,12,072 (100 %)
4	Crop +Piggery + Poultry	82,986 (72.3%)	10,794 (9.4%)	20,984 (18.3%)	-	1,14,764 (100 %)
5	Crop +Piggery + Poultry +Milch cattle	78,486 (61.0%)	14,984 (11.6%)	13679 (10.8%)	21,484 (16.7%)	1,28,633 (100 %)
6	Crop + Poultry +Milch cattle	84,861 (71.3%)	-	19,468 (16.4%)	14,598 (12.3%)	1,18,927 (100%)

combined system within two enterprises maximum profit was observed with Crop + Poultry, and was followed by Cop + Piggery faming. Further observation revealed that amongst all faming system approach maximum net return was observed with Crop + Piggery + Poultry + Milch cattle. This was mainly due to less labour investment per unit area basis and good marketing opportunity in the hills (Mukherjee 2010 a).

Per farm employment due to different enterprises combination is given in Table 6. Amongst the six enterprise combinations highest employment was provided by the Crop + Piggery + Poultry + Milch cattle (116.42 days) followed by

Table 6. Number of man power involved in different farming enterprises.

Sl.no	Farming enterprises	Hired labour involved in enterprise (Days)			Family labour involved in enterprise (Days)			Gross man power involved (Days)
		Male	Female	Total	Male	Female	Total	
1	Crop	27.30	22.20	49.50	14.98	19.28	34.26	83.76
	Total	27.30	22.20	49.50	14.98	19.28	34.26	83.76
2	Crop	16.50	15.30	31.80	19.98	27.32	47.30	79.10
	Piggery	-	2.20	2.20	3.92	4.31	8.23	10.43
	Total	16.5	17.5	34.0	23.90	31.63	55.53	89.53
3	Crop	16.59	14.20	30.79	17.83	26.34	44.17	74.96
	Poultry	-	-	-	2.95	3.12	6.07	6.07
	Total	16.59	14.20	30.79	20.78	29.46	50.24	81.03
4	Crop	29.3	18.79	48.09	15.92	26.79	42.71	90.80
	Piggery	-	-	-	5.71	3.96	9.67	9.67
	Poultry	1.91	-	1.91	2.92	8.26	11.18	13.09
	Total	31.2	18.79	50.00	24.55	39.01	63.56	113.56
5	Crop	15.32	20.12	35.44	13.96	22.98	36.94	72.38
	Piggery	-	-	-	6.62	11.3	17.92	17.92
	Poultry	-	-	-	2.98	10.5	13.48	13.48
	Milch cattle	3.21	-	3.21	8.53	0.9	9.43	12.64
	Total	18.53	20.12	38.65	32.09	45.68	77.77	116.42
6	Crop	20.24	21.23	41.47	19.56	27.82	47.38	88.85
	Poultry	-	-	-	4.77	3.29	8.06	8.06
	Milch cattle	1.49	-	1.49	5.74	4.32	10.06	11.55
	Total	30.73	21.23	51.96	30.07	42.43	72.50	108.46

Crop +Piggery + Poultry (113.56 days), Crop + Poultry +Milch cattle (108.46 days). This corroborate the early finding of Bahera *et al.* (1998) However, lower of this employment opportunity was observed with only crop system (83.76 days).

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TREND ESTIMATION OF YIELD UNDER RICE-RICE CROPPING SYSTEM IN DIFFERENT NUTRIENT MANAGEMENT UNDER LONG TERM EXPERIMENTS

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ABSTRACT

Various trend equations were fitted to yield data under long term permanent plot experiments in different integrated nutrient management in rice-rice cropping system being conducted since 1987 at Jorhat and Karjat under humid and coastal eco-systems, respectively. Under the study, the different prediction equations to estimate trend yield under different integrated nutrient management have been fitted. For the twelve different nutrient treatments, linear/ non-linear models, i.e. linear, quadratic, cubic, fourth degree polynomial. MMF model, Exponential association, Rational function and Sinusoidal models have been fitted to obtain the predicted equation for evaluating estimated yield over years under rice-rice cropping systems from long term experiments.

Key words: Interpolation, Linear/ Non-linear models, cropping systems, estimation.

Rice-rice production system occupy 6 million hectare of cultivated land in India. It is next to rice-wheat (10 m ha) in different agro-eco systems of the country. Application of integrated nutrient management has played a key role in achieving self sufficiency in food production. The long term experiments provide a system for estimating projection trend in crop yield. Rice alone contribute 41 % to the total food production followed by wheat (35 %). In long term experiments yield dynamics play a major role over time metameter for policy makers to take major steps for sustaining yield through integrated nutrient management practices and pest management. Thus change in crop productivity is a critical parameter for taking decisions in evaluating trends over time. The annual crop yields over years potentially give measure of long term sustainability of cropping systems. The present investigation was, therefore, undertaken to study the yield trend under rice-rice cropping system over years at Jorhat and Karjat under humid and coastal eco-systems respectively. The studies on on statistical yield trend under long term effects of fertilizer application have been studied by Narain *et al*, 1990 and Jenkinson *et al* 1999. Some authors have reported that sustained use of chemical fertilizers have adverse effect on yield stability (Nambiar and Abrol, 1989).

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MATERIALS AND METHODS

The experiment was conducted in permanent plot on integrated nutrient management in rice-rice based cropping system under the All India Coordinated Research Project on Integrated farming Systems at Jorhat and Karjat in humid and coastal eco-systems respectively. The study was conducted during 1987-88 to 2009-10. The experiment was laid out in Randomized Block design having four replications. The data pertaining to yield of kharif and *rabi* in rice-rice system were compiled from the respective annual reports of All India Coordinated Research Project on Integrated Farming Systems. The details of the treatments are as under:

Treatments	*Kharif rice*	*Rabi rice*
T_1	No ferrilizer, no organic manure (control)	No ferrilizer, no organic manure (control)
T_2	50% recommended NPK dose through fertilizers	50% recommended NPK dose through fertilizers
T_3	50% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers
T_4	75% recommended NPK dose through fertilizers	75% recommended NPK dose through fertilizers
T_5	100% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers
T_6	50% recommended NPK dose through fertilizers + 50% N through FYM	100% recommended NPK dose through fertilizers
T_7	50% recommended NPK dose through fertilizers + 25% N through FYM	75% recommended NPK dose through fertilizers
T_8	50% recommended NPK dose through fertilizers + 50% N through straw	100% recommended NPK dose through fertilizers
T_9	75% recommended NPK dose through fertilizers + 25% N through straw	75% recommended NPK dose through fertilizers
T_{10}	50% recommended NPK dose through fertilizers + 50% N through GM	100% recommended NPK dose through fertilizers
T_{11}	75% recommended NPK dose through fertilizers + 25% N through GM	75% recommended NPK dose through fertilizers
T_{12}	Farmer's conventional practice	Farmer's conventional practice

(FYM= Farm Yard Manure, GM = Green Manure)

The missing values of yield were attempted to be evaluated by interpolation formula. The homogeneity of variance for each year data was tested by using the Barlett's test.In case of Homogeneity of variance, pooled analysis was performed to study the overall variability in treatments' response. The different models were fitted by using expert curve software package for each treatment for *kharif* and *rabi* rice yields separately.

Different various linear / non-linear models, such as linear, quadratic, cubic, fourth degree polynomial, rational function, Sinusoidal model, Exponential assocaitin, MMF model have been fitted to all the treatments The equation of models used are as follows:

a) Linear model:
$Y_t = a + bx$

b) Quadratic model:
$Y_t = a + bx + cx^2$

c) Cubic model:
$Y_t = a + bx + cx^2 + dx^3$

d) Fourth degree polynomial:
$Y_t = a + bx + cx^2 + dx^3 + ex^4$

e) Rational function:
$Y_t = (a + bx) / (1 + cx + dx^2)$

f) Sinusoidal fit
$Y_t = a + b \cos(cx + d)$

g) Exponential Association
$Y_t = a(1 - \exp(-bx))$

h) MMF model
$Y_t = (ab + cx^d) / (b + x^d)$

Where Y_t represents the time series garin yield at year 't' and a,b,c,d and e are the parameters of different equations to be estimated. Values of R^2 have been computed for each model to test the adequacy of fit.

RESULTS AND DISCUSSION

The yield data for rice rice cropping systems for a period from 1987 to 2010 has been taken for the study. The linear , quadratic, cubic, fourth degree polynomials, Exponential association,, Sinusoidal, Rational and MMF models have been fitted to all the treatments.. in case of missing observations/ unrecorded yield for particular treatments, it was interpolated by fitting best fitted model having significantly higher R^2 value. The best fitted models for each treatment for *kharif* and *rabi* rice have been presented in Tables 1 and 2. It was observed that in Jorhat kharif rice, quadratic/ cubic were found to be the best followed by Rational function. For treatments T_8 (50% recommended NPK dose through fertilizers + 50% N through straw) and T_{12} (Farmer's conventional practice). R^2 value ranged from 0.8143 to 0.9138. Likewise in *kharif* rice crop in Karjat centre, the cubic / fourth degree polynomial exhibited best fitted model for all the treatments except treatment T_2 (50% recommended NPK dose through fertilizers) and T_3 (50% recommended NPK dose through fertilizers) where prediction equation fitted well with rational function. The R^2 value ranged between 0.7093 to 0.9533.

In case of *rabi* rice at Jorhat centre, quadratic/ cubic degree polynomial were found to be fetted best followed by the Rational function for the treatments T_3 (50% recommended NPK dose through fertilizers) and T_4 (75% recommended NPK dose through fertilizers). The sinusoidal model exhibited the best fitted growth trend over years under treatments T_5 , T_8 and T_{11} whereas under farmers' conventional practice, i.e. treatment $T_{12,}$ the Exponential

Table 1. Trend equation for different treatments under *kharif* rice (Jorhat)

Treatment	Distribution Type	Equation	Predicted equation	R^2
T_1	3rd degree polynomial	Y_t=a+bx+cx²+dx³ → $Y_t=a+bx+cx^2+dx^3$	$702.51+593.20x-53.37x^2+1.23x^3$	0.8871
T_2	Quadratic Polynomial	$Y_t= a+bx+cx^2$	929.99+490.20x-24.75x2	0.8143
T_3	Quadratic Polynomial	$Y_t= a+bx+cx^2$	$1117.94+497.89x-25.53x^2$	0.8214
T_4	Quadratic Polynomial	$Y_t= a+bx+cx^2$	$1011.47+545.02x-27.32x^2$	0.8449
T_5	Quadratic Polynomial	$Y_t= a+bx+cx^2$	$1136.64+539.82x-24.30x^2$	0.8776
T_6	3rd degree Polynomial	$Y_t= a+bx+cx^2+dx^3$	$742.52+814.17x-63.95x^2$	0.9138
T_7	3rd degree Polynomial	$Y_t= a+bx+cx^2+dx^3$	$911.009+744.72x-53.76x^2+1.04x^3$	0.8949
T_8	Rational function	$Y_t= (a+bx)/ (1+cx+dx^2)$	(153.883000.49x)/ $(1+0.56x+0.017x^2)$	0.9206
T_9	Quadratic Polynomial	$Y_t= a+bx+cx^2$	$1098.35+532.30x-22.87x^2$	0.9014
T_{10}	3rd degree Polynomial	$Y_t= a+bx+cx^2+dx^3$	$735.71+895.68x-77.17x^2+1.82x^3$	0.8977
T_{11}	3rd degree Polynomial	$Y_t= a+bx+cx^2+dx^3$	$812.85+919.84x-80.64x^2+1.95x^3$	0.8964
T_{12}	Rational function	$Y_t=(a+bx)/ (1+cx+dx^2)$	$(74.15+3022.87x) / (1+0.86x+0.03x^2)$	0.8655

Table 2. Trend equation for different treatments under *rabi* rice (Jorhat)

Treatment	Distribution Type	Equation	Predicted equation	R^2
T_1	Quadratic polynomial	Y_t=a+bx+cx^2	581.29+261.33x-14.01x^2	0.8167
T_2	Quadratic Polynomial	Y_t= a+bx+cx^2	594.64+631.36x-18.55x^2	0.8056
T_3	Rational function	Y_t=(a+bx)/ (1+cx+dx^2)	(848.92+2.33x)/(1-0.13x+0.006x^2)	0.8458
T_4	Rational function	Y_t=(a+bx)/ (1+cx+dx^2)	(722.57+29.76x)/ (1-0.14x+0.0076x^2)	0.8953
T_5	Sinusoidalfit	Y_t= a+b*Cos(cx +d)	2011.01+0.1272*Cos(0.24x-2.71)	0.8807
T_6	3rd degree Polynomial	Y_t= a+bx+cx^2+dx^3	793.35+230.83x+6.02x^2-0.913x^3	0.8403
T_7	3rd degree Polynomial	Y_t= a+bx+cx^2+dx^3	742.88+220.18x-11.95x^2	0.8876
T_8	Sinusoidal fit	Y_t= a+b*Cos(cx +d)	1959.72+1208.71*Cos(0.253x-2.78d)	0.8822
T_9	Quadratic Polynomial	Y_t= a+bx+cx^2	571.18+468.51x-20.67x^2	0.8867
T_{10}	Quadratic Polynomial	Y_t= a+bx+cx^2	580.46+403.98x-19.39x^2	0.8358
T_{11}	Sinusoidal fit	Y_t= a+b*Cos(cx +d)	1625.96+1234.49*Cos(0.22x-2.416)	0.8828
T_{12}	ExponentialAssociation	$Y_{t=}$ a (1 – exp (-bx))	1623.41(1 – exp(-2.2858x))	0.7915

Table 3: Trend equation for different treatments under *kharif* rice (Karjat)

Treatment	Distribution Type	Equation	Predicted equation	R^2
T_1	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	450.37+1415.75x -302.61x^2+26.22x^3-0.75x^4	0.9522
T_2	Rational function	Y_t=(a+bx)/ (1+cx+dx^2)	(4.17e-05+5.81e10 x)/ (1+26308770x-500193x^2)	0.9531
T_3	Rational function	Y_t=(a+bx)/ (1+cx+dx^2)	(1.84e-05+8.9e10x)/ (1+ 29399010x-678795x^2)	0.9689
T_4	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	886.36+2408.09x -611.21x^2+55.57x^3-1.62x^4	0.9017
T_5	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	991.49+2444.14x-622.60x^2+57.29x^3-1.68x^4	0.9103
T_6	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	899.89+2316.46x-571.44x^2+51.78x^3-1.52x^4	0.8947
T_7	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	960.21+2319.07x-595.23x^2+55.33x^3-1.64x^4	0.8920
T_8	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	980.13+2360.55x-602.7x^2+55.25x^3-1.62x^4	0.8803
T_9	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	994.35+2343.46x-612.66x^2+56.61x^3-1.67x^4	0.8819
T_{10}	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	1918.56+799.15x-101.01x^2+4.49x^3-0.27x^4	0.7093
T_{11}	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	769.69+1794.17x-404.68x^2+35.82x^3-1.04x^4	0.9213
T_{12}	4th degree polynomial	Y_t=a+bx+cx^2+dx^3+ e x^4	536.91+1808.7x-420.92x^2+38.21x^3-1.13x^4	0.9533

association showed growth trend to be fitted well. It has been observed that that in karjat centre for *rabi* rice , the MMF model fitted well for treatments T_1, T_2, T_3 and T_{12} followed by Exponential association for T_4, T_5, T_6, T_9, T_{10} and T_{11} treatments. For T_7 and T_8 treatments, quadratic polynomial observed to be fitted well. The value of R^2 ranged from 0.9793 to 0.9947. The treatment response during *kharif* and *rabi* seasons at Jorhat and Karjat centres are shown in Figures 1-2 for all the twelve treatments.

Table 4. Trend equation for different treatments under *rabi* rice (Karjat)

Treatment	Distribution Type	Equation	Predicted equation	R^2
T_1	MMF Model	$Y = (a*b+cx^d) / (b+x^d)$	$(15.99*47.97+80736.26x^{0.43})/(47.97+x^{0.43})$	0.9898
T_2	MMF Model	$Y = (a*b+cx^d) / (b+x^d)$	$(8.76*5.21+14806.32x^{0.43})/(5.21+x^{0.43})$	0.9862
T_3	MMF Model	$Y = (a*b+cx^d) / (b+x^d)$	$(19.81*4.25+11650.86x^{0.59})/(4.25+x^{0.59})$	0.9869
T_4	ExponentialAssociation	$Y_{t} = a(1 - \exp(-bx))$	$5701.62(1 - \exp(-0.35x))$	0.9793
T_5	ExponentialAssociation	$Y_{t} = a(1 - \exp(-bx))$	$6242.35(1 - \exp(-0.311x))$	0.9873
T_6	ExponentialAssociation	$Y_{t} = a(1 - \exp(-bx))$	$6142.33(1 - \exp(-0.293x))$	0.9857
T_7	Quadratic Polynomial	$Y_t = a+bx+cx^2$	$320.01+1186.02x-66.6837x^2$	0.9884
T_8	Quadratic Polynomial	$Y_t = a+bx+cx^2$	$290.82+1306.6x-80.19x^2$	0.9881
T_9	ExponentialAssociation	$Y_{t} = a(1 - \exp(-bx))$	$5242.94(1 - \exp(0.4201x))$	0.9886
T_{10}	ExponentialAssociation	$Y_{t} = a(1 - \exp(-bx))$	$5928.57(1 - \exp(0.3482x))$	0.9883
T_{11}	ExponentialAssociation	$Y_{t} = a(1 - \exp(-bx))$	$5814.40(1 - \exp(0.3442x))$	0.9840
T_{12}	MMF Model	$Y = (a*b+cx^d) / (b+x^d)$	$(11.11*5.37+11419.15x^{0.56})/(5.3696+x^{0.56})$	0.9947

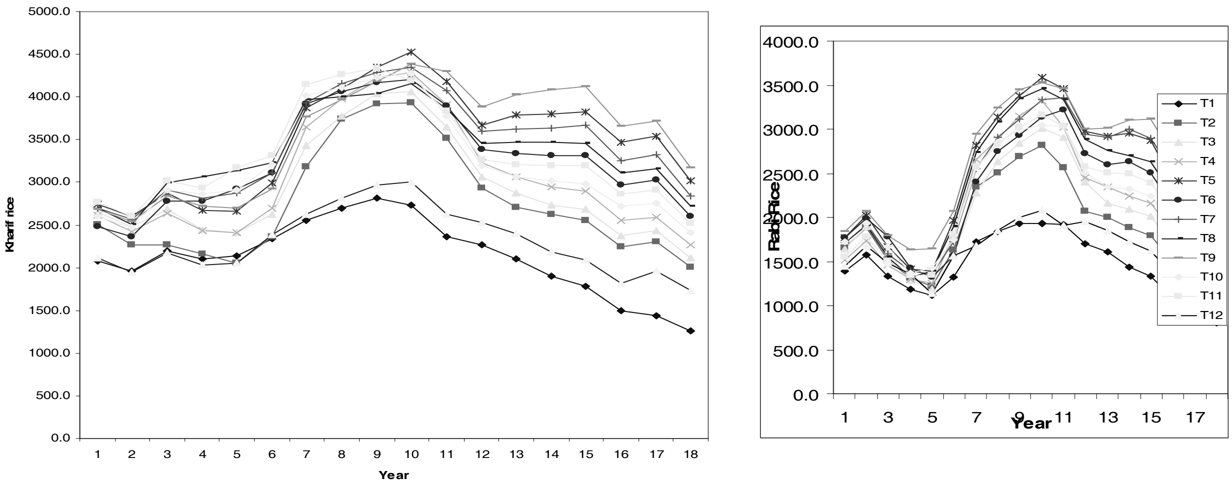

Fig. 1. Trend equation for rice-rice cs at Jorhat

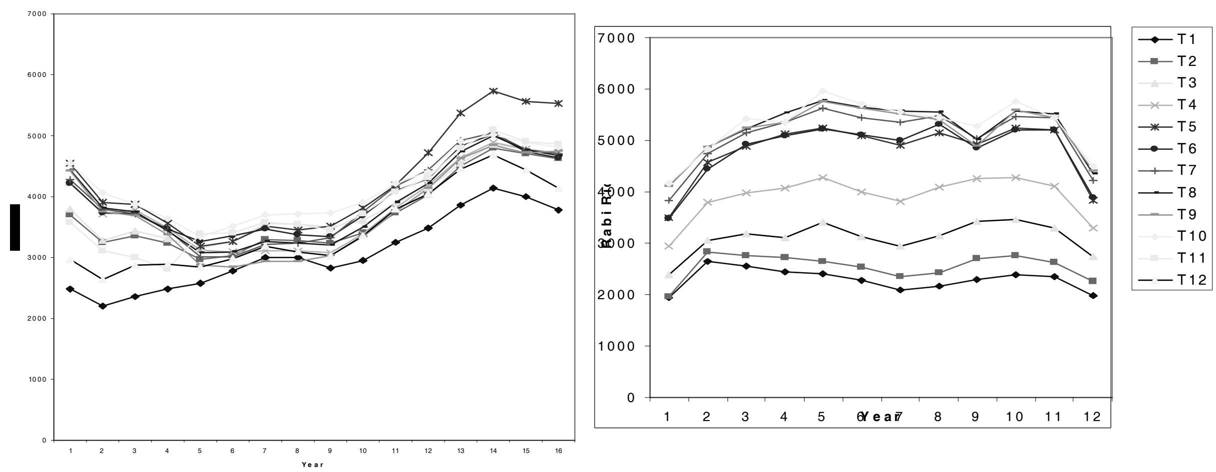

Fig. 2. Trend equation for rice-rice cs at Karjat

It can be inferred from the study that the models fitted as above can be used for predicting yield under long term fertility experiments.

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EXPERIENCE WITH MANAGING RICE RESIDUES IN INTENSIVE RICE-WHEAT CROPPING SYSTEM IN WESTERN UTTAR PRADESH

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Abstract

Rice–wheat (RW) is the dominant cropping system in western Uttar Pradesh and is of immense importance for national food security. However, the sustainability of the RW system is threatened by water shortage and nutrient mining.Zero Till drill RW systems with crop residue retention have been proposed as a means of reducing irrigation water use, improving soil properties and reducing the cost of crop establishment.A field experiment was conducted over 02 years in Sardar Vallabhbhai Patel University of Agriculture &Technology,Meerut,U.P.India,to compare conventional and Zero Till drill RW cropping systems, with and without retention of crop residues,in terms of crop performance and nitrogen use efficiency (NUE). Rice residues are important natural resources, and recycling of these residues improves the soil physical,chemical and biological properties.Management of rice straw is a major challenge as it is considered to be a poor feed for the animals due to high silica content.Disposal of straw in the very short time available between the harvesting of rice and the sowing of wheat is a potential problem for the agriculturists in the rice-wheat cropping system,which is widely practiced in large part of India.Other available options lacks motivation and feasibility and farmers find it easier to opt for burning the residue in the open field.The intensive agricultural practices as a result of green revolution viz. increased use of combine harvester have further added to generation of crop residue left in open field in this cropping system.The combined use of both options does not exceed 10 percent.The farmers are in a hurry to sow the following wheat crop and therefore immediately dispose off the straw by burning.

Constant research efforts are being made to return it to the soil by direct incorporation or through composting.The machinery for direct incorporation and collection has been developed but still is in infancy and not available to the farmers.Even with the use of the latest machinery like happy turbo seeder direct incorporation involves more energy than normal operations after burning the residues.Surface retention of residues increases soil NO_3, N uptak and yield compared to burning.Residue management practices affect soil physical properties viz. soil moisture, temperature, aggregate formation and bulk density.Soil temperature is influenced through the change in radiant energy balance and insulation.Rice straw retention coupled with inorganic fertiliser application with three split doses (50% drilled at sowing + 25% broadcast before the each of the first and second irrigations) resulted in significantly higher grain yield,agronomic efficiency and N recovery efficiency than all other treatments.In the presence of mulch,drilling the urea at sowing gave higher yields and efficiency than broad casting.Zero Till drill for RW seem to have limited potential under the soil and climatic conditions of Western Uttar Pradesh, with current technology, even with full residue retention for both crops.Thus,if residues are managed properly, then it can warrant the improvements in soil properties and the sustainability in crop productivity.

Key words: Rice residue,burning,retention,productivity enhancement,sustainability,tillage

INTRODUCTION

Crop residues, in general are parts of the plants left in the field after crops have been harvested and threshed. These materials at times have been regarded as waste materials that require disposal, but it has become increasingly realized that they are important natural resources and not wastes. The recycling of crop residues has the advantage of converting the surplus farm waste into useful product for meeting nutrient requirement of crops. It also maintains the soil physical and chemical condition and improves the overall ecological balance of the crop production system.

The Indo-Gangetic Plain (IGP), the food basket of India, is of great significance in the food security of the country. It extends over a length of about 1,600 km and a width of 320 km, including the arid and semi-arid environments in Rajasthan and Punjab and the humid and per humid deltaic plains in West Bengal (Shankaranarayana 1982). A decline in land productivity, particularly of the rice–wheat (RW) system, has been observed over the past few years in the northern and north-western IGP despite the application of optimum levels of inputs under assured irrigation (Paroda 1997). Reflecting this, the fertiliser recommendation has been revised upwards for both rice and wheat crops.Agriculture in western Uttar Pradesh has, until now,been focused on achieving food security through increased area under high-yielding varieties of rice and wheat, expansion of irrigation and increased use of external inputs like chemical fertilisers and pesticides (Woodhead et al. 1994; Yadav et al. 1998;Ladha et al. 2000;Naresh et al.2011). The support price system for rice and wheat crops, coupled with subsidies on fertilisers and irrigation water, made the RW system the most profitable option. This enabled rice and wheat crops,covering an estimated area of around 10 million hectares (Mha), to emerge as the major cropping system in the IGP, leading to the Green Revolution. These two crops together contribute more than 70% of total cereal production in India from an area of around 25 Mha under wheat and about 40 Mha under rice. The small states of Punjab and Haryana contribute 20% of the total national grain production and 50% and 85% of the government procurements of rice and wheat, respectively (Singh 2000). With unabated increases in population,more and more land will be required for urbanisation,and productivity needs to be increased to meet the rising domestic and industrial demand.

The indiscriminate use, or rather misuse, of natural resources, especially water, has led to pollution and depletion of groundwater resources (Nayar and Gill 1994). The situation is serious; if it is not improved, India may face water wars in the near future. There are early signs of this already visible in the surface water dispute between Punjab and Haryana, and between some other states in India. Depleting soil organic C status, decreasing soil fertility and reduced factor productivity are other issues of concern (Yadav 1998). This evidence indicates that the RW system, especially residue burning, intensive tillage and injudicious use of water, has weakened the natural resource base. If exploitation of natural resources at the current level continues, productivity and sustainability are bound to suffer. Therefore, to achieve sustainable or higher productivity, efforts must be focused on reversing the trend in natural resource degradation.

Crop residues—a key to sustainability

Crop residues could be an important component of soil fertility management. They are currently burnt, especially rice residues in the high-yielding states like Punjab,Haryana and western Uttar Pradesh leading to degradation of natural resources. Rice residues can be converted to high-value manure of a better quality than farmyard manure, and their use, along with chemical fertilisers,can help sustain or even increase yield (Sidhu et. al.1998;Sharma et al.2006). Inorganic fertilisers have played a highly significant role in intensive cropping systems, bringing about varied increases in crop production. However,with the increased use of inorganic fertilisers alone,often in an unbalanced manner, problems such as diminishing soil health and multiple nutrient deficiencies have started appearing recently in various pockets of the highly productive IGP (Fujisaka et al.1994). Efficient crop residue management can play a vital role in refurbishing soil productivity as well as in increasing the efficiency of inorganic fertiliser.Residue management is receiving a great deal of attention because of its diverse and positive effects on soil physical, chemical and biological properties.Crop residues must be considered a natural resource and not a waste.

Crop residue management options

The management of crop residues must be an integral part of future tillage practices for sustainable RW production systems. There are several options available to farmers for the management of crop residues,including burning—the common practice,baling and removal, incorporation and surface retention.Burning, in addition to promoting loss of organic matter, nutrients and soil biota, also causes air pollution and associated ill effects on human and animal health. Baling is not practised at the farmer level. Removal of crop residues, especially of wheat and scented rice, is a loss of organic sources for soil health but is necessary to feed livestock and sustain mixed farming. Incorporation is a better option but it requires large amounts of energy and time; leads to temporary immobilisation of nutrients, especially nitrogen; and the C:N ratio needs to be corrected by applying nitrogen at the time of incorporation (Pathak and Sarkar 1994; Sharma and Bali 1998). Farmers resort to burning as it is an easier disposal option and allows a shorter turnaround time between crops than incorporation, which is especially important between rice harvest and wheat sowing. Incorporation is also a more costly operation and, until recently, surface retention was not a viable option due to the lack of suitable machines able to seed into the loose residues left after combine harvesting. However, two machines are now available (see below Figure 1 and Figure 2) that are capable of seeding into full,surface-retained rice residues.Deep tillage for incorporation of crop residues has been shown to reduce soil bulk density (Kumar et al.2004a) as well as penetration resistance of the plough layer (Walia et al. 1995). It also helps to decrease soil pH (Sidhu and Beri 1989). Moreover, residue incorporation improved soil fertility by increasing the content of available N, P, K, S, DTPA-extractable Fe and organic C. It also increased the soil water holding capacity (Bhat et al. 1991; Beri et al. 1992;Walia et al. 1998; Prasad et al. 1999). The increased availability of essential plant nutrients with associated improved physio-chemical properties enhanced crop growth and yield (Verma

2001; Das et al. 2002;Kumar et al. 2004b;Singh et al.2010).

Availability of crop residues in the rice–wheat system

A large amount of rice residue is annually produced in the rice growing countries. Moreover, the adoption of mechanized farming has resulted in leaving a sizeable amount of rice straw in the field after harvesting the grain. There is enormous potential of recycling these residues in the crop production systems. Total amount of crop residue produced in India is estimated at 350 x 10^6 kg yr^{-1}, of which wheat residue constitutes about 27% and that of rice about 51%(Lal & Kimble,2002). Another estimate shows that 120 x 10^6 kg yr^{-1} rice residue, out of 180 x 10^6 kg yr^{-1} (assuming that 1/3rd of the residue is used as feed for animals and other purposes) can be returned to the soil to enhance soil quality; it will contribute to soil 2.604 million tonnes of $N+P_2O_5+K_2O$, considering the nutrient contents in rice straw as 0.61% N, 0.18% P_2O_5 and 1.38% K_2O (Tandon, 1996).In rice-wheat cropping system, the residues of rice and wheat amounts to as much as 7-10 t ha^{-1} each year. Both rice and wheat are exhaustive feeders of nutrients, and the double croppingsystem is heavily depleting the soil of its nutrient content. A rice-wheat sequence that yields 7 t ha^{-1} of rice and 4 t ha^{-1} of wheat remove more than N 300, P 30 and K 300 kg ha^{-1} from the soil (Singh & Singh,2001). Another estimate shows that a 10 t ha^{-1} crop removes 730 kg NPK from the soil that is often not returned to the soils (Gupta et al.,2002). If this residue is not returned this may cause mining of soil for major nutrients leading to net negative balance and multi- nutrient deficiencies in crops. This is one of the reasons for the yield decline in the rice-wheat system. Thus, there are urgent needs to manage the residues of these crops for sustainability and stability of the system.

Materials and Methods

Biophysical, demographic, and socioeconomic profile

Two set of experiments on different crop establishment and N fertiliser management techniques involving residue retention or residue removal were conducted under researcher-designed and farmer-managed,with a single replicate, repeated over many farmers.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 (biological yield) in conventional farmers' practices (CTFBP-CTFBS), that is, conventional-tilled,flat beds planted (CT-FBP) and conventional till flat beds seeding (CT-FBS). The study was conducted for two years from June 2009 to May 2011 in 40 farmers' fields at Sardar Vallabhbhai Patel University of Agriculture &Technology meerut sites in the western Uttar Pradesh.Out of 40 farmers 61% had land holdings of <2 ha, 31% had 2 to 4 ha, and 9% had more than 4 ha. 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.The literacy rate was higher for large farmers than for small farmers. The average family size was 5.4 family members for evaluation and promotion of integrated crop and resource management in the rice-wheat system 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 216 family members of the 40 house holds surveyed, 49% were fully engaged in agriculture and 41% partly engaged,whereas 35% were students who also helped with agricultural activities during vacation and/or leisure periods. 35% of the farmers were members of different cooperatives existing in the area.Rice and wheat were the major source of income for 38% of the farmers, followed by sugarcane (48%), vegetables (12%), and oilseeds(9%).

Site characteristics

Fourty farmers were selected to conduct on-farm demonstrations of RCTs in four districts (Meerut, Ghaziabad, Muzaffarnagar and Saharanpur) of western Uttar Pradesh (UP),India (28 402 073 N to 29 282 113 N, 77 282 143 E to77 442 183 E).The climate of the area is semiarid, with an average annual rainfall of 805 mm (75–80% of which is received during July to September),minimum temperature of 4^{0}C in January, maximum temperature of 41–45^{0}C in June, and relative humidity of 67–83% during the year. The soils are generally sandy loam to loam in texture and low to medium in organic matter content. Ground water pumping is the predominant method of irrigation.Western UP has a diversified cropping system, with RW as the dominant cropping system. Wheat is grown by broadcasting after four to five dry-tillage operations and rice seedlings (3–4 weeks old) are transplanted in puddled fields after three to four dry-tillage operations.

Experimental-I: On-farm trials were conducted in the RW system of three districts of western Uttar Pradesh from June 2009 to may 2011 involving 30 farmers.These trials were researcher-designed and farmer-managed,with a single replicate, repeated over many farmers.Therefore,the experimental design was an unbalanced block design in which the number of treatments varied from farmer to farmer, with the farmer as a replicate/block.The main plots consisted of eight layout or crop establishment straw treatments.The sites, treatments and management are briefly summarised here for convenience,together with details of the water and soil water monitoring.

Layout and treatments of replicated small plot experiment

Replicated experiments was established on sandy loam soils to compare eight flat and bed treatments for rice-wheat system over 02 years (Table 1).The width of the narrow beds (mid furrow to mid-furrow) was 67 cm, with 37 cm wide flat tops and 15 cm furrow depth and the width of the wide beds (mid furrow to mid furrow) was 137 cm,with 107 cm wide flat tops and 12 cm furrow depth. Plot size was 15 10 m,with earth bunds around each plot. The depth to the ground water was over 23 m.

Experiment-II: The farmers' participatory trials on crop establishment and N fertiliser management techniques were carried out at ten locations (one farmer at each location) in Ghaziabad district for two years.On farm trials grew rice which was combine harvested prior to wheat establishment.Two straw management treatments were established at—straw retained (mulched) and straw removed (no mulch). In the 'no mulch' treatments the straw was burnt prior to sowing wheat. In the mulched treatments the loose straw in windrows from the combine harvester was distributed evenly across the plots prior to sowing

Table 1 : Treatments in the small plot replicated experiment in rice-wheat crop on sandy loam soil.

Layout	Abbrevations	Layout	Abbrevations
T_1–Rice seeded by Zero-till drill	ZT-DSR	T_1 – Wheat planted by turbo happy seeder	ZT-HS
T_2 -TPR on wide beds + mulch	WBed-TPR + M	T_2 - Wheat on wide beds + mulch	WBedZT-DSW +M
T_3 -TPR on wide beds – mulch	WBed-TPR – M	T_3 – Wheat on wide beds – mulch	WBedZT-DSW – M
T_4 –UP TPR in paired row + mulch	UPTPRPR + M	T_4 - Wheat planted by ZT paired row + mulch	ZT-DSW PR + M
T_5 –UPTPR in paired row – mulch	UPTPR PR - M	T_5 – Wheat planted by ZT paired row – mulch	ZT-DSW PR - M
T_6 –UPTPR in normal spacing + mulch	UPTPR + M	T_6–Wheat planted byZTnormal spacing + mulch	ZT-DSW + M
T_7– UPTPR in normal spacing – mulch	UPTPR – M	T_7. Wheat planted by ZT normal spacing– mulch	ZT-DSW – M
T_8 – conventional practices	CT-TPR	T_8– conventional practices	CT-BCW

with the Turbo Happy Seeder. The wheat (PBW343) was sown at 100 kg/ha with 20-cm row spacings. All treatments were direct drilled into rice residues with the Turbo Happy Seeder except the control (T_8), in which the straw was burnt prior to direct drilling according to recommended practice. Details of the N fertiliser treatments are provided in Table 2. All treatments received a total of 120 kg N/ha as urea in a range of splits (from one to three). All urea applied at sowing was drilled 5–6 cm below the soil surface the day before sowing using a drill,except for T_7 and T_8 which used the recommended practice of broadcasting 60 kg N/ha before sowing. The purpose of drilling the fertiliser the day before sowing was to minimise contact of the seed with high concentrations of urea and so avoid fertiliser damage.Post sowing applications of urea were broadcast immediately before the first and/or second irrigations. A basal dose of 26 kg P/ha as single super phosphate and 25 kg K/ha as muriate of potash was drilled below the seed at the time of sowing on 07 November,2009.An area of 20 m^2 from the centre of each plot was harvested for grain and straw yield. Wheat grain and straw yields are reported on a dry weight basis. Grain and straw sub samples were collected at wheat harvest on April 2011 for analysis of total N.

Results and Discussion

Avoidance of puddling

The impact of puddling (Figure 3) for rice on the performance of wheat after rice appears to be variable,depending on site history, soil type, degree of puddling and management of the wheat crop. Aggarwal et al (1995) showed that the effects of puddling on soil physical properties increase with intensity,depth and history of puddling. It may take one

Table 2 : Details of treatments on N fertiliser management

Treatment	N rate				Treatment details
	Sowing	1st irrigation	2nd irrigation	Straw management	N management
T_1 (No N)	0	0	0	Mulch	No N control
T_2	120	0	0	Mulch	120 kg N drilled at sowing
T_3	90	0	30	Mulch	90 kg N/ha drilled at sowing and 30 kg N/ha topdressed at second irrigation
T_4	60	60	0	Mulch	60 kg N/ha drilled at sowing and 60 kg N/ha topdressed at first irrigation
T_5	60	30	30	Mulch	60 kg N/ha drilled at sowing and 30 kg N/ha topdressed at first and second irrigation
T_6	30	30	60	Mulch	30 kg N/ha drilled at sowing, 30 kg N/ha topdressed at first irrigation and 60 kg N/ha at second irrigation
T_7	90	30	0	Mulch	90 kg N/ha applied as surface broadcast at sowing and 30 kg N/ha top dressed at first irrigation
T_8 (control)	60	60	0	Burn	60 kg N/ha applied as surface broadcast at sowing and 60 kg N/ha top dressed at first irrigation

to several years before this significantly affects the performance of wheat when starting with a soil with no puddling history or a compacted layer. Puddling for rice induces high bulk density, high soil strength and low permeability in subsurface layers (Aggarwal et al 1995), which can restrict root development and water and nutrient use from the soil profile for wheat after rice (Gajri et al 1992; Ishaq et al 2001;Sur et al 1981). The hardpan also leads to aeration stress in wheat at the time of the first irrigation after sowing, resulting in a yellowing of the leaves which is typical of N deficiency,despite the presence of adequate N in the soil.This problem is wide spread in the region and may be associated with subsurface compaction or heavy-textured soils.Naresh et al (2010) found that wheat grain yield decreased by 8% after the third year of puddled transplanted rice (PTR) due to the formation of a dense soil layer at 15–20 cm depth and restricted growth of roots in the lower layers. While avoidance of puddling may help improve soil structure and wheat yield, the implications for rice establishment and water use also need to be considered. However, it is well known that puddling *per se* is not a prerequisite for achieving high rice yields.In changing from puddled flat fields to direct drilled raised beds on soils with a long history of puddling (and therefore a well-developed hardpan),there is also the question of whether the hardpan should be broken by deep tillage prior to bed formation.There may be implications in doing this for water use and performance of both crops. Gajri et al (1992) showed that for a given wheat yield, higher inputs of water and N were required with zero-tilled wheat compared with conventional and deep (40 cm) tillage after puddled rice on a sandy loam. However,there were no differences in wheat yield, water and N use efficiency between conventional and deep tillage. Nor did McDonald et al (2005) find any effect of deep tillage prior to rice on the performance of wheat after rice on a silty loam with deficit irrigation.These findings are difficult to reconcile with other studies which show that wheat yields decline in the presence of a shallow hardpan, and which reinforce the need for further examination of the desirability of deep soil amelioration to remove the hardpan prior to construction of permanent raised beds.

Crop yields

The various tillage and crop establishment techniques had a significant effect on rice yield (Table 3).Yield were similar when rice was conventionally puddled transplanted (CT-TPR) ,transplanted on wide raised beds (WBedTR) unpuddled transplanted in paired rows slits after no tillage(UPTPRPR) and unpuddled transplanted in normal spacing (UPTPR) in all techniques with or without residue retained.This indicated that puddling of soil, for which normally a large amount of water and labour are required can be avoided without anypenalty in rice.TreatmentsUPTPRPR+M,and UPTPR+M were at par with each other, however, they recorded higher grain yield over ZT-DSR treatment which recorded lowest grain yield (4.35 tha^{-1}).On UPTPRPR+M yielded 6 to 11.8 % higher than unpuddled transplanting equal spacing with or without residue retained (UPTPR) and direct seeded rice by turbo happy seeder.

Table 3 : Productivity of rice-wheat system under various tillage and crop establishment techniques

Crop establishment		Grain yield (t/ha)			
		2009-10		2010-11	
Rice	Wheat	Rice	Wheat	Rice	Wheat
ZT-DSR	ZT-HS	4.35	4.95	3.85	5.20
WBed-TPR +M	WBedZT-DSW +M	5.48	5.12	5.07	5.53
WBed-TPR – M	WBedZT-DSW – M	5.20	5.05	4.87	5.15
UPTPRPR + M	ZT-DSW PR + M	4.93	4.70	4.86	4.85
UPTPR PR – M	ZT-DSW PR - M	4.83	4.65	4.59	4.72
UPTPR + M	ZT-DSW + M	4.65	4.61	4.47	4.67
UPTPR – M	ZT-DSW – M	4.52	4.43	4.33	4.50
CT-TPR	CT-BCW	5.65	4.30	5.35	4.45
C D at 5 %		1.05	0.42	1.13	0.38

The wheat grain yield t ha^{-1} resource conserving technologies when practiced as such which includes sowing earlier than conventional tillage resulted in higher wheat yield over conventional tillage over all treatments. Treatment WBedZT-DSW+Mwas found significantly superior to all the treatments,and recorded maximum grain yield. Grain yield increased significantly within various resource conserving technologies with mulch.Treatment ZT-DSWPR+ M was significantly superior to the remaining treatments. ZTWCTM, ZT-HS,ZT-DSW+M,ZT-DSW-M and ZT-DSW–M were at par with each other, however, they recorded significantly higher grain yield over CT-BCW treatment which recorded lowest grain yield.ZT-DSWPR +M or–M (paired rows) seed yields for twin-row plantings were approximately 6 to 8 % greater for equal spacing conventional practices.This observation is similar to that reported by Mascagní et al.(2008) and these data are similar to those reported by Ball et al.(2001),who observed increased soybean yields were related to increased plant densities which increased fertile nodes per m^{-2} and pods per m^{-2}.Under all the tillage and crop establishment techniques, there was yield advantage with surface residue retention compared to removal. The crop residues retained as surface mulch (partially anchored and partially loose) @ 6.0 Mg ha^{-1} that helped in regulating the soil temperature and moisture and more response was mainly due the aberration in weather conditions during the crop growth period.

Water application and water productivity

The input water application includes the irrigation water applied and the rain water during the rice season (634mm) and wheat season (71 mm).The total water application in rice varied markedly due to tillage and crop establishment techniques (Table 4). The conventional puddled transplanted rice consumed more water (3220 mm ha^{-1}) compared to transplanted rice on wide raised beds with residue retained W Bed-

Table 4 : Water application and productivity of rice-wheat system with various tillage and crop establishment techniques

Crop establishment		Irrigation water applied (mm ha^{-1})				Water productivity (kg grain m^{-3})			
		2009-10		2010-11		2009-10		2010-11	
Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
ZT- DSR	ZT- HS	2540	350	2380	305	0.18	1.41	0.17	1.70
WBed-TPR +M	WBedZT-DSW +M	2185	322	2070	280	0.25	1.59	0.24	1.98
WBed-TPR – M	WBedZT-DSW – M	2360	338	2225	294	0.22	1.49	0.22	1.75
UPTPRPR + M	ZT-DSW PR + M	2770	360	2595	320	0.18	1.31	0.19	1.52
UPTPR PR – M	ZT-DSW PR - M	2965	375	2780	335	0.16	1.24	0.17	1.41
UPTPR + M	ZT-DSW + M	2880	335	2698	310	0.16	1.33	0.17	1.51
UPTPR – M	ZT-DSW – M	3085	355	2885	328	0.15	1.25	0.15	1.36
CT-TPR	CT-BCW	3325	425	3115	395	0.17	1.01	0.18	1.13

TPR +M,rice seeded by zero-till drill ZT-DSR and unpuddled transplanted rice in paired rows with residue retained UPTPTPR-+M (2128 mm,2460 mm & 2683 mm).The savings in water use with beds with or without residue retained was28.8to33.9% compared to conventional puddled transplanted rice.Similarly, the water application in wheat was remarkably lower with permanent beds compared to other practices. The higher irrigation water application in wheat under residue removal treatments as compared to residue retain plots. The total system water use was remarkably lower with permanent beds compared to other practices but the maximum water use was recorded with CT-TPR,CT-BCW. The system irrigation water productivity under permanent beds was higher compared to other tillage and crop establishment techniques and lowest system water productivity was recorded with UPTPR-M, CT-BCW.

Total system Productivity

Commonly,conversion from conventional tillage to reduced-till systems with straw retention requires several crop cycles before potential advantages or disadvantages become apparent (Phillips and Phillips,1984).In our trials straw retention increased productivity rapidly,starting from the second crop cycle.We believe this is an important findings because,if repeated on farmers fields,farmers will quickly realize the benefits and be more interested in adopting the technology.Total system productivity increased by 8-13% in straw retention with 80% N placement system over conventional(Table5).Total system productivity of rice-wheat (R-W) was 11.05 t $ha^{-1}yr^{-1}$.For both crops the highest system yields occurred in full straw retained,but the differences between straw burnt and full straw retained were always significant for both the crops.Lower system productivity also occurred from straw burnt due to reduced crop growth.Yields tended to be lower in with lower levels of straw retention for both crops.Similar observations were made by Sayre etal,2005 in Mexico.

Table 5 : Total system productivity under tillage options and straw levels in rice-wheat systems.

Treatment	Crop yield (t/ha)		
	Rice	Wheat	System
T_1	1.36	1.78	3.14
T_2	4.45	4.53	8.98
T_3	4.65	5.15	9.80
T_4	4.35	4.25	8.60
T_5	4.40	4.45	8.85
T_6	4.10	4.15	8.25
T_7	5.65	5.40	11.05
T_8 (burnt)	3.85	4.10	7.95
C D at 5%	1.07	0.56	0.83

N fertiliser management

Grain yields ranged from 1.78 t/ha in the unfertilised treatment to 5.40 t/ha in the treatment (T_7) (Table 6). Agronomic efficiency of N (AE, kg grain/ kg N applied) ranged from 14.8 to 20.4. Recovery efficiency (RE), the difference between N uptake in the fertilised and control treatments as a percentage of the amount of fertiliser N applied, ranged from 35.8 % to 48.7 %.Grain and straw yields and total N uptake were significantly increased with N application over the No N(control), and trends in total N uptake were similar to trends in yield (Table 6). Grain yield, total N

Table 6 : Effect of fertiliser N management on yield, total N uptake, agronomic efficiency (AE) and recovery efficiency (RE) of N in wheat

Treatment	N management	Grain yield (t/ha)	Straw yield (t/ha)	Total N uptake (kg/ha)	AE (kg grain/ kg N)	RE (%)
T_1	0,0,0	1.78	2.91	32.3	-	-
T_2	120,0,0	4.53	5.16	88.4	17.7	44.8
T_3	90,0,30	5.15	5.97	87.8	19.4	47.4
T_4	60,60,0	4.25	4.84	80.2	16.3	39.7
T_5	60,30,30	4.45	5.12	85.6	17.9	38.6
T_6	30,30,60	4.15	4.73	82.3	16.9	35.8
T_7	90,30,0	5.40	6.26	75.8	20.4	48.7
T_8 (burnt)	60,60,0	4.10	4.67	86.9	14.8	43.2
LSD (0.05)	-	0.56	0.92	8.3	2.9	3.1

uptake and RE with the recommended practice (T_8, with straw burnt and 60 kg N/ha broadcast at sowing and before the first irrigation) were significantly lower than with the 90kgN/ha broadcast at sowing and 30kgN/ha before first irrigation in the presence of residues (T_7). However, drilling the 1st 60 kg N/ha at sowing in the presence of rice residues (T_4) restored yield and N uptake to similar values to the control. These data suggest greater immobilisation or N losses from surface-applied N in the presence of straw than when the straw was burnt before sowing, which is consistent with the findings of others (Philips et al. 1980; Rice and Smith 1984; Patra et al. 2004). Drilling part of the fertiliser below the soil surface at sowing may have reduced these losses due to reduction in fertiliser N contact with straw (Rao and Dao 1996). Despite this,Sidhu et al. (2007) found an average 9–15% higher yield of wheat with the Happy Seeder sowing into rice residues, with the fertiliser broadcast at sowing and before the first irrigation, compared with farmer practice (conventional tillage after burning), where as we used zero tillage in(T_8) in the adjacent field. Grain yield of T_3 and T_7 was usually significantly higher than all other treatments. As with grain and straw yield and N uptake, AE and RE were highest in T_3 and T_7 and lowest in T8. There are several possible reasons for the superior performance of the triple split with the last application delayed to the time of the second irrigation. These include greater canopy cover and reduced presence of mulch due to decomposition, and reduction of the potential for N immobilisation and ammonia volatilisation. Drilling all the fertiliser N at sowing (T_2) resulted in grain yield similar to that of the recommended practice of applying N in two equal split doses at sowing and with the first post-sowing irrigation (T_4).When the amount of N drilled at sowing was reduced to 30 kg N/ha, with 30 and 60 kg N/ha before the first and second irrigations, respectively, grain yield was reduced significantly in comparison with T_3 and T_7.These results suggest that delaying half the N fertiliser application until the second irrigation is too late.

CCONCLUSIONS

It has been widely reported that crop residue retention on the soil surface has many benefits. It conserves soil moisture, moderates temperature, suppresses weeds, improves soil physio-chemical properties and helps make the system sustainable. The results from Western Uttar Pradesh,show similar or slightly higher yields with residue retention.The potential benefits in terms of cost reduction, timeliness of planting and similar or higher yield are proving to be of interest to farmers in India's north-western states. The on-farm trials are helping to convince farmers that residue retention is making their soil more friable and productive.In addition, the controlled experiments from research station trials confirm the benefits of residue retention in increasing soil C and reducing soil strength.However, there are still some problems with the capability of the available machines to seed into loose residues after combine harvesting at higher residue loads. The next step will be to further refine the most promising machinery in partnership with farmers and manufacturers. Moreover, further intensive investigations are required on the size of residue load that can be sustained for a long time, as well as the potential effects on insect pests, diseases and weeds, if any. Researchers working with residue retention must remain vigilant and should adopt an interdisciplinary approach to address the issue of residue management in a holistic manner.

Results to date suggest that permanent raised beds have the potential to enable diversification and increase the productivity of cropping systems in western Uttar Pradesh through growing a much wider range of crops in the monsoon season and increasing yields of waterlogging sensitive crops by irrigation.These results also suggest significantly reduced irrigation water requirements for crops on beds, saving costs and energy, although whether this is a real water saving is yet to be determined. Permanent beds offer the additional possibility of direct drilling,with advantages of rapid turn around between crops, reduced tillage and energy costs, reduced greenhouse gas pollution from burning diesel, and improved soil structure due to controlled traffic and reduced disruption of biopores and oxidation of soil organic matter.

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ALTERNATE TO CROP ESTABLISHMENT PRACTICES FOR HIGHER PRODUCTIVITY IN MAIZE-BASED CROPPING SYSTEMS IN INDO-GANGETIC PLAINS OF INDIA

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ABSTRACT

A study was conducted during 2005-06 and 2006-07 at Project Directorate for Farming systems Research, Modipuram Meerut to evaluate the crop establishment method for higher productivity of maize-based cropping systems. Among different cropping systems evaluated, maize-potato-wheat was the most viable system and gave maximum net return (Rs.1,13,586 ha^{-1} $year^{-1}$), B:C ratio (1.65) and chemical energy production (56.06×10^6 kcal ha^{-1}) followed by maize-vegetable pea-green gram. Growing of crops like vegetable pea (as a green pod), green gram and maize on raised bed (FIRB) enhanced yield up to 33, 12.4 and 16 percent, respectively as compared to conventional flat bed planting. Maximum resource use efficiency in term of water consumption and water productivity were recorded with maize-vegetable pea-green gram system followed by maize-potato-wheat system. Farmers adopt generally Rice--Wheat crop rotation due to decline in the productivity and weed infestation. They prefer for alternate cropping sequences *viz.* Maize-Potato-Wheat and Maize-Vegetable Pea-Green gram. Considering the serious threat to the Wheat productivity from weeds in general and *Phalaris minor* in particular under Rice-Wheat system, the diversification of the system by way of introducing short duration crops is one of the options.

Key words: Bed planting, Economics, Energy, Maize-Wheat System, Water productivity

INTRODUCTION

The rice-wheat rotation is the backbone for food security of South Asian countries comprising Pakistan, India, Nepal, and Bangladesh. These crops are being cultivated in 13.5 mha of fertile lands blessed with dependable irrigation facilities developed over the years (Gupta *et al.*, 2002). Over exploitation and injudicious use of chemical fertilizers and irrigation facilities created, the productive soils have gradually started showing the signs of fatigue such as significant decline in soil organic carbon content, increased soil salinity, stagnation of growth in crop productivity in some places with the signs of declining productivity (Ladha *et al.*, 2003). One major school of thought is to follow a two pronged approach where in the resource use efficiency in rice-wheat rotation is improved through alternative tillage and crop establishment practices along with efforts to diversify these systems with more of less resource demanding crops, which offer the needed income and nutritional security to farmers. Our major argument towards crop diversification in general and inclusion of maize in rice-wheat rotation in particular originates from that of Siddiq (2002) who predicts difficulties in furthering production and productivity in rice and wheat crops. He argues that the differences between farm and research plot yields are narrowing down and genetic means of increasing the productivity is no more an easy task for the plant breeders. Maize is the third most important cereal crop in India because it has the higher yield potentiality among the cereals. In North West India there is a need to diversify rice-based systems. Currently rice and wheat are the only two crops used in rotation with each other. Maize will definitely help to diversify the current system and will serve as a valuable addition and also a preferred choice. Maize has several other benefits; it can be grown as fodder, grain for food and feed, roasted and popcorn. It creates greater flexibility because it fits in various intensive cropping systems where sometimes more than two crops are taken during the year. Maize can play a dominant role, along with other important cereals, in meeting future needs of growing population.

Maize-wheat is the 5th predominant cropping system mainly concentrated over 1.13 million hectares of Indo-Gangetic Plains (IGP) of India (Yadav and Subba Rao, 2001). Traditionally, maize and wheat are grown either in row geometry or by random broadcasting, mostly after thoroughly tilling the field till proper tilth is obtained for good field emergence. The traditional practice of growing these crops has limitations such as inconvenient input management when sown by broadcasting, improper plant geometry, and uneven plant population resulting in inefficient utilization of space and plant competition leading to low productivity and input efficiency. Intensive tillage systems results to a decrease in soil organic matter and biodiversity (Biamah *et al*., 2000). The farmers in IGP are yet to grow maize and wheat on flat or raised beds, though it is a common practice in many western countries. Bed planting of maize helps in proper plant establishment, increases input efficiency, increases yields. Adoption of new tillage practice helps in timely seeding either of the crops, hence leads to increase in productivity. With this in views an experiment was framed to evaluate the performance of maize-wheat cropping system under bed planting system at Project Directorate of Farming Systems Research (PDFSR), Modipuram Meerut.

Materials and Methods

To study the effect of crop establishment methods on growth, productivity and profitability of maize-wheat cropping system, a field experiment was conducted during 2005-06 and 2006-07 at the research farm of Project Directorate for Farming System Research (PDFSR), Modipuram, Meerut, U.P., (29 4' N latitude and 77 46' E longitude) at an elevation of 237 m above mean sea level. The region has been characterized by semi-arid sub-tropical climate with average annual rainfall of 862.7 mm. The experimental soil was sandy loam in texture (Typic Ustochrept) with a bulk density of 1.39 Mg m^{-3}, weighted mean diameter of soil aggregates 0.74 mm, pH =8.0, available N=163.1 kg ha^{-1}, available P =18.7 kg ha^{-1}, and available K =140.1 kg ha^{-1} and low in organic carbon 0.44%. The treatments consisted of two crop establishment practices (i) conventional flat bed method and (ii) furrow irrigated raised bed (FIRB) of seeding as sub plot and three crop sequences as main plot viz., T1 Maize-vegetable pea-greengram,T2 Maize-potato-wheat T3 Rice-wheat were laid out in a factorial randomized block design. Each of the treatment was replicated thrice. Maize (HQPM-1), Wheat (PBW-343), green gram (Pusa vishal), vegetable pea (Arkel) and potato (Khufri bahar) were grown as per crop establishment methods. At the time of establishment of the experiment, field was prepared well. Raised beds were prepared by using raised bed planter. Fresh beds were prepared each after the crop harvest. The seeds were sown in rows (dribbled) manually in both beds and flat conventional method. The recommended dose of fertilizer 120-60-40, 150-60-40 and 180-80-100 kg N-P-K/ha in maize, wheat and potato, respectively was applied uniformly to all the establishment methods treatments. One-thirds N and whole P and K fertilizers were applied at final land preparation in the plots with conventional tillage treatment but in the plots with bed planting treatments, the basal doses were applied before sowing on the top of the beds. The remaining two-third N was top dressed. This was followed by irrigation. Recommended practices including irrigation for crops were followed. The quantity of water applied at each irrigation to the crops was measured using parshall flume and the grain productivity per unit of irrigation water was expressed as water productivity (kg grain m^{-3} water). The economics were computed using the prevailing markets prices for inputs and outputs. The energies of various crops and cropping systems were calculated as described by Gopalan *et. al.*, (1978). The physico-chemical properties of soil like; bulk density (Mg m^{-3}), aggregation and mean weight diameter (MWD) of aggregates (mm) and penetration resistance (MPa) soil pH, EC, OC were measured using standard methods at the initial stage and after each crop cycle. Both the crops of the system received all the recommended input level under various tillage practices. The datasets were analyzed using standard statistical techniques.

RESULTS AND DISCUSSION

Yield and yield components

Effect of planting methods on grain yield and yield components of different crops in cropping systems were significant for both the years. In maize raised bed planting method produced significantly higher plant height and leaf area index (3.40 and 3.58) as compared to conventional flat bed (3.23 and 3.35) method during 2005-06 and 2006-07, respectively (Table 1). Significantly higher yield contributors like, number of cobs $plant^{-1}$ (1.3 and 1.4), grains cob^{-1} (384.5 and 406.3) and thousand grain weight (225.9 and 227.6 g) were also recorded on raised bed as compared to conventional flat method (1.2 and 1.3), (364.8 and 383.0) and (222.8 and 225.4) respectively, during both the years. Raised bed method resulted in significantly higher grain yield of maize 5634 and 6002 kg ha^{-1} compared to conventional flat 4892 and 5143 kg ha^{-1}, which was 15.2 and 16.7 percent higher than the conventional flat method during the years of 2005-06 and 2006-07, respectively. Significantly higher stover yield of maize were also observed 7527 and 7919 kg ha^{-1} than conventional flat method 6692 and 7046 kg ha^{-1} in respective years, similarly, harvest index was also found significantly higher on raised bed methods in respective years (Table 2). In agreement, Jat *et al.*, (2005) reported a notable increase (19.2-28.9 %) in economic yield of maize with raised bed (FIRB) planting method as compared to conventional flat planting method. The findings support the observation of Conner *et al.*, (2003). On the contrary, the difference owing to crop sequences was found statistically non significant in both the years on growth, grain yield and yield components of maize crop however, sequence maize-potato-wheat recorded higher plant height (163.1 cm) and leaf area index (3.38) in the year of 2005-06 while; maize-vegetable pea-green gram sequence produced maximum plant height and leaf area index 163.7 cm and 3.53 respectively, during 2006-07 (**Table** 1). Yield attributing characters viz. cob $plant^{-1}$ (1.3), number of grain cob^{-1} (384.3) and 1000-grains weight (225.3 g) were recorded higher in maize-potato-wheat sequence during 2005-06 whereas, maize-vegetable pea-green gram sequence produced more value of these

Table 1. Growth parameters (Plant height and leaf area index) as influenced by various treatments.

	Plant height (cm)											
	Maize		Wheat		Rice		Vegetable Pea		Green gram		Potato	
Cropping system	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**
Rice-wheat			95.2	97.1	93.5	93.3						
Maize-Vegetable pea-Green gram	160.3	163.7					50.8	48.5	53.5	56.0		
Maize-Potato-Wheat	163.1	160.0	90.7	92.2							61.0	58.1
CD (*P*=0.05)	NS	NS	4.3	4.6								
Planting methods												
Conventional Flat bed	157.9	157.9	92.9	95.4	93.9	93.8	46.9	44.0	52.3	54.6	59.6	56.5
Raised bed (FIRB)	165.4	165.8	94.4	97.4	93.2	92.8	54.6	53.0	54.6	57.3	62.3	59.6
CD (*P*=0.05)	7.4	4.9	1.0	0.9								
Leaf area index												
Cropping system												
Rice-wheat			5.65	5.56	5.55	5.64						
Maize-Vegetable pea-Green gram	3.25	3.53					2.40	2.30	3.38	3.39		
Maize-Potato-Wheat	3.38	3.40	5.01	4.98							2.16	2.11
CD (*P*=0.05)	NS	NS	0.66	0.48								
Planting methods												
Conventional Flat bed	3.23	3.35	5.32	5.29	5.60	5.73	2.10	2.00	3.27	3.38	2.07	1.98
Raised bed (FIRB)	3.40	3.58	5.28	5.16	5.49	5.55	2.70	2.60	3.48	3.49	2.24	2.23
CD (*P*=0.05)	0.08	0.15	0.14	0.05								

parameters i.e. 1.4, 401.8 and 229.6, respectively, during 2006-07. Maize-potato-wheat sequence produced maximum grain yield (5307 kg ha^{-1}) than the maize-vegetable pea-green gram (5219 kg ha^{-1}) during 2005-06 while, sequence maize-vegetable pea-green gram recorded higher yield (5665 kg ha-1) during 2006-07 (Table 2). It was quite clear from the data of 2006-07 that inclusion of pluses increased the yield of maize in maize-vegetable pea-green gram sequence as compared to maize-potato-wheat. Ahmad *et al*., (2001) and Ghosh, (2007) advocated that inclusion of legumes as summer crop is generally acted as soil health restorer on account of their capability to fix the nitrogen from the environment and a conspicuous amount of fixed N can also be released to the soil, which is made available to the succeeding crop.

Effect of cropping systems on growth, yield and yield components of wheat were significant for both the years. Maximum plant height (95.2 and 97.1 cm) and LAI (5.65 and 5.56) of wheat was recorded in rice-wheat sequence which was significantly higher than that of maize-potato-wheat (90.7 and 92.2 cm) and (5.01 and 4.98) during 2005-06 and 2006-07, respectively (Table 1). Significantly higher value of all attributing characters of wheat in Rice-wheat sequences i.e. spike length (11.2 cm), grains spike^{-1} (46.0) and thousand grains weight (45.9 g) were recorded than that to maize-potato-wheat sequences. Maize potato-wheat sequence resulted in significantly lower grain, straw yield and harvest index of wheat than the rice-wheat owing to late sowing of wheat after harvesting of potato (Table 2). The main differences were that the wheat crop under maize-potato-wheat sequence was sown relatively late in the season after digging/harvesting of potato crop resulted in lesser duration and decrease the wheat yield in maize-potato-wheat sequence. Planting methods significantly affected plant height, leaf area index, spike length, grains spike^{-1}, Grain and straw yield for both the years. FIRB planting system recorded higher plant height, yield attributes but lower LAI, grain yield as compared to conventional flat bed planting system in both years. Plant height of wheat under raised bed (FIRB) method (94.4 and 97.4 cm) was significantly superior over conventional flat bed (92.9 and 95.4 cm) during the years 2005-06 and 2006-07, respectively (Table 2). Yield contributing characters i.e. spike length, number of grains spike^{-1} and thousand grains weight were also observed significantly higher with FIRB planting methods (Table 2) during respective years. On the contrary, it was observed that FIRB method produced significantly lower LAI, grain and straw yield over conventional flat method over the years. The reduction of about 4.4 and 4.2 percent was observed under raised bed method for grain yield in respective years. Similar yield decrease by bed planting in wheat was also reported by Kumar *et al*., (2004). Significantly higher plant height (54.6 and 57.3 cm) and leaf area index (3.48 and 3.49) of green gram was recorded on raised bed as compared to conventional flat method (52.3 and 54.6 cm) and (3.27 and 3.28) during 2005-06 and 2006-07, respectively (Table 1). Yield contributing characters viz. number of pods plant^{-1} (16.5 and 16.8), seeds pod^{-1} (8.9 and 8.9) and thousand grains weight (43.2 g and 43.5 g) had showed significant improvement owing to planting methods in the years of 2005-06 and 2006-07, respectively. A significant increase in grain yield of green gram was observed with raised bed (FIRB) 12.1 and 12.7% as compared to conventional flat bed during 2005-06 and

Table 2. Yield and yield attributes of maize as influenced by cropping systems and establishment methods.

	Maize											
	Cobs plant^{-1}		Grain cob^{-1}		1000- grains weight (g)		Grain yield (kg ha^{-1})		Stover yield (kg ha^{-1})		Harvest index (%)	
Cropping system	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Maize-Vegetable pea-Green gram	1.18	1.35	365.0	401.8	223.4	229.6	5219	5665	6692	7544	42.3	42.8
Maize-Potato-Wheat	1.27	1.29	384.3	387.5	225.3	223.4	5307	5480	7527	7421	42.8	42.5
CD (*P*=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Planting methods												
Conventional Flat bed	1.18	1.27	364.8	383.0	222.8	225.4	4892	5143	6692	7047	42.2	42.2
Raised bed (FIRB)	1.28	1.37	384.5	406.3	225.9	227.6	5634	6002	7527	7919	42.8	43.1
CD (*P*=0.05)	0.05	0.04	8.4	7.8	3.1	0.9	278	210	325	287	0.3	0.4

	Wheat											
Cropping system	Spike length (cm)		Grains Spike-1		1000 grain wt. (g) (kg ha^{-1})		Grain yield (kg ha^{-1})		Straw yield		Harvest index (%)	
Rive-Wheat	11.2	10.3	46.0	45.9	45.9	45.7	5463	5368	7177	6985	43.2	43.5
Maize-Potato-Wheat	9.7	9.8	43.1	43.1	43.1	44.3	4584	4705	5906	6326	43.7	42.7
CD (*P*=0.05)	1.1	0.7	2.1	3.0	2.3	1.8	560	523	719	484	NS	NS
Planting methods												
Conventional Flat bed	10.2	10.3	44.4	43.9	44.3	45.0	5139	5233	6705	6839	43.4	43.5
Raised bed (FIRB)	10.9	11.0	45.3	45.1	45.3	46.0	4911	5013	6383	6539	43.5	43.6
CD (*P*=0.05)	0.6	0.6	0.3	0.4	0.4	0.1	30	88	125	301	NS	NS

2006-07, respectively. Significantly higher harvest index was also observed with FIRB planting during both the years (Table 3). The effect of bed planting system was evaluated on green gram by Singh *et al.*, (2007) and reported that bed planting exhibited significantly higher grain yield than flat planting. Tripathi and Singh (2008) also reported higher yield and yield attributes under FIRB system as compared to that of flat bed system.

Yields and yield contributing characters of vegetable pea effectively increased owing to bed planting method (Table 3). FIRB planting method resulted in higher yield (as green pod 34.3% and 31.6%) as compared to conventional flat planting during 2005-06 and 2006-07, respectively. growth parameters i.e. plant height and leaf area index were also increase with raised bed. Results are in agreement with Conner *et al.*, (2003) and Tripathi and Singh (2008). Potato crop grown on ridges was not showed remarkable effect during both the years. However, shoot length (62.3 and 59.6 cm) and leaf area index (2.24 and 2.23) were closely higher when potato was planted on ridges in the years 2005-06 and 2006-07, respectively. Similarly, tuber weight g tuber^{-1} was more on ridges. Tuber yield was also higher with ridge planting option during both the years of study. Data revealed that yield contributing characters and yield of mustard were remarkably improved due to planting method during both the years. It was observed that raised bed planting method exhibited higher yield attributes such as primary branch plant^{-1} (17.4 %), secondary branch plant^{-1} (6.2 %), numbers of siliqua plant^{-1} (14.2 %), and thousand seed weight (2.0 percent) as compared to conventional flat bed planting method. Seed yield of mustard increased by 18.2 percent and 20.5 percent on raised bed (FIRB) than that of conventional flat bed (Table 3) during 2005-06 and 2006-07, respectively. Similarly, increase in the yield and yield attributes of mustard was also noticed by Buttar (2006).

Economics

Highest net return of Rs. 1,02,554 and 1,24,618 ha^{-1} year^{-1} was provided by maize-potato-wheat sequence followed by maize-vegetable pea-greengram (Rs.58,714 and 64,130 ha^{-1} year^{-1}) during 2005-06 and 2006-07, respectively, and rice-wheat sequence gave minimum net return (Rs.47,938 and 55,153 ha-1) during both the year (Table 4).It is evident from the data (Table 4) that raised bed (FIRB) gave 10.0 percent more return as compared to flat bed system during both the years of experimentation. The significantly higher benefit: cost ratio was recorded in maize-vegetable pea-green gram sequence (1.71 and 1.81) followed by maize-potato-wheat (1.59 and 1.71) in the years of 2005-06 and 2006-07, respectively. FIRB method gave significantly higher benefit cost ratios of 1.72 and 1.86 as compared to conventional method of crop establishment 1.48 and 1.60 during the years 2005-06 and 2006-07, respectively. Data (Table 4) clearly indicated that FIRB system is beneficial than flat bed system in terms of net return hectare^{-1}. This may be due to potato and vegetable pea based cropping system which gave higher yield and better price resulted in an addition effect for net return in the systems. Biswas *et al.* (2006) had the opinion that cropping systems containing potato resulted in highest levels of yield, net return, benefit: cost ratio and energy productivity.

Energetic

Economic yield of various crop

Table 3. **Variation in yield and yield attributes of Green gram, Vegetable pea, Mustard and potato on raised bed and conventional flat bed method.**

	Green gram											
	Pods plant^{-1}		Seeds pods^{-1}		1000-grans wt. (g)		Grain yield (kg ha^{-1})		Straw yield(kg ha^{-1})		Harvest index (%)	
	Conventional	Raised bed	Conventional	Raised bed	Conventional	Raised bed	Conventional	Raised bed	Conventional	Raised bed	Conventional	Raised bed
2005-06	14.7	16.5	8.6	8.9	42.5	43.2	1363	1528	3331	3549	29.1	30.1
2006-07	15.0	16.8	8.7	8.9	42.8	43.5	1401	1579	3322	3574	29.7	30.6
	Vegetable pea	**Potato**										
	Pods plant^{-1}	Seeds pods^{-1}	1000-grans wt. (g)	Grain yield (kg ha^{-1})	Tuber yield (t ha^{-1})	Tuber weight (g tuber^{-1})						
2005-06	6.3	7.7	5.5	6.0	505.6	528.0	6203	8330	232.1	239	62.5	63
2006-07	6.0	7.3	5.3	5.8	496.9	504.7	5667	7458	227.8	235.8	62	62.2
	Mustard											
	Primary branch/plant		**Secondary branch/plant**		**no. of siliqua/plant**		**No. of seeds/siliqua**		**1000-seeds weight (g)**		**Grain yield**	
2005-06	6.5	7.6	26.6	28.2	342.5	391.2	12.4	12.6	6.0	6.1	1341.0	1585.0
2006-07	6.7	7.9	27.9	29.7	353.2	403.2	13.3	13.6	6.1	6.2	1353.0	1630.0

Table 4. Economics of the treatments

Cropping Systems	Net return (Rs ha^{-1})						B:C ratio					
	Conventional		Raised bed		Mean		Conventional		Raised bed		Mean	
Cropping system	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**
Rice-Wheat	48,955	56,027	46,922	54,279	47,938	55,153	1.50	1.63	1.51	1.69	1.51	1.66
Maize-Veg.Pea-Green gram	49,391	54,359	68,038	73,901	58,714	64,130	1.42	1.52	2.00	2.11	1.71	1.81
Maize-potato-wheat	1,00007	1,20933	1,05100	1,28303	1,02554	1,24618	1.53	1.64	1.64	1.77	1.59	1.71
Mean	66,118	77,106	73,353	85,494			1.48	1.60	1.72	1.86	1.60	1.73
CD(P=0.05) Cropping systems	-	-	-	-	5177	7332	-	-	-	-	0.15	0.20
Planting method	-	-	-	-	957	1135	-	-	-	-	0.02	0.03

sequences was converted into chemical energy (Table 5). Chemical energy differed significantly due to various crop sequences in both the years. Maize-potato-wheat cropping sequence produced significantly higher energy equivalent (55.25 x 10^6 and 56.86 x10^6 kcal ha^{-1}) during respective years. Rice-wheat sequence was also statistically identical with maize-vegetable-green gram. Raised bed produced significantly higher energy equivalent 41.04 x10^6 and 42.07 x10^6 kcal ha^{-1} than the flat bed method 39.16 x10^6 and 39.93 x10^6 kcal ha^{-1} during 2005-06 and 2006-07, respectively. The yield in the systems was higher under FIRB than flat system which, directly increased energy of the system. Sharma *et al.*, (2004) and Chaudhary *et al.,* (2006) also recorded higher total energy under potato based cropping system.

Total water used and water productivity

The total water application in maize varied markedly due to crop sequence and crop establishment techniques (Table 6).The conventional flat beds technique consumed more water as compared to FIRB planting techniques. The savings in water use with beds was 15.95 % compared to conventional flat beds techniques. Similarly, the water application in maize-vegetable pea-green gram crop sequence was remarkably lower with raised beds compared to other practices. The higher irrigation water application in wheat under flat beds as compared to FIRB plots. The system irrigation water productivity under FIRB technique was 26.2 % higher compared to other crop establishment techniques .Among crop sequences, maize-vegetable pea-green gram being at par with maize-potato-wheat sequence received significantly more irrigation water than the other sequences from sowing to till harvest. Sequences rice-wheat produced lowest water productivity (0.554 and 0.555 kg grain m^{-1}) during 2005-06 and 2006-07, respectively. Theses findings support the observation of Chaudhary *et al.,* (2007).

Physico-Chemical properties of soil

After two crop cycles the soil physical properties (bulk density, mean weight diameter of aggregates, infiltration rate, cone index) in the surface (0-15 cm) layer

Table 5. Chemical energy equivalent (k cal x 10^6 ha^{-1}) of the treatments

Cropping Systems	Conventional Flat Beds		Raised bed (FIRB)		Mean	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Rice-Wheat	36.51	36.50	34.87	34.88	35.69	35.69
Maize-Veg.Pea-Green gram	26.83	27.80	31.91	33.10	29.37	30.45
Maize-potato-wheat	54.15	55.50	56.34	58.23	55.25	56.86
Mean	39.16	39.93	41.04	42.07	40.10	41.00
CD(P=0.05) Cropping systems	-	-	-	-	1.85	2.19
Planting method	-	-	-	-	0.38	0.28

Table 6. Water application and productivity of different crop sequences as influenced by conventional flat beds and FIRB methods

Cropping Systems	Irrigation water applied (mm ha^{-1})						Water productivity (kg grain m^{-3})					
	Flat Beds		FIRB		Mean		Flat Beds		FIRB		Mean	
Cropping system	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**	**2005-06**	**2006-07**
Rice-Wheat	2235	2228	1853	1823	2044	2026	0.515	0.512	0.593	0.598	0.554	0.555
Maize-Veg.pea- Green gram	653	785	508	627	581	706	1.991	1.637	3.107	2.496	2.549	2.067
Maize-potato-wheat	1234	1263	1107	1140	1170	1201	2.024	2.164	2.311	2.482	2.168	2.323
Mean	1374	1425	1156	1197	1265	1311	1.510	1.438	2.004	1.859	1.757	1.648
CD (P=0.05)Crop sequence	-	-	-	-	147	83	-	-	-	-	1.15	1.45
CD (P=0.05) Planting Method	-	-	-	-	77		-	-	-	-	0.40	0.44

showed significant treatment differences (Table 7).The mean weight diameter of aggregates (MWD) was significantly higher in the permanent FIRB systems (0.51 mm) than the initial value of 0.35 and declined significantly to 0.29 mm in the conventional tillage systems. However, MWD in the maize-vegetable pea-green gram and maize-potato-wheat crop sequences was in a similar fashion. Infiltration rate in Permanent Raised Beds was more than double that in flat beds, and almost double that in the rice-wheat crop sequence treatments. Infiltration rate with maize-vegetable pea-green gram crop sequences were similar to that with maize-potato-wheat. Bulk density of the surface layer (0-15 cm) under flat beds did not change over the initial value, but under rice-wheat and maize-vegetable pea-green gram crop sequence practices it increased significantly. The mean cone index (0-40 cm) increased significantly in all treatments but by significantly more under the maize-potato-wheat cropping systems.

Conclusion

Inclusion of maize in rice-wheat growing areas is a useful proposition. Ongoing efforts with alternative crop establishment methods and cropping systems proved successful. With bed planting, the crop intensification and diversification is sure to change the way the crop is grown in these areas. Resource use efficiency can be improved and nutritional and income security can be achieved with little more efforts in solving some of the challenges mentioned in this paper. It needs a change in mind-set of farmers towards the way the crops are raised and it might call for radical changes which are possible through linking research and farmers in a harmonious way.

Table 7. Physical properties in different crop sequence and tillage techniques after 02 years

Cropping Systems	Bulk Density (Mg m^{-3})		Infiltration rate (mm/hour)		Cone index		MWD (mm)	
	Flat beds	FIRB	Flat beds	FIRB	Flat beds	FIRB	Flat beds	FIRB
Rice-Wheat	1.66	1.60	33.4	78.3	2.83	2.60	0.29	0.48
Maize-veg.pea greengram	1.64	1.57	36.3	79.8	2.79	2.58	0.37	0.52
Maize-potato-wheat	1.62	1.55	37.6	82.6	2.78	2.57	0.39	0.58
Initial	1.52	1.52	-	-	2.28	2.28	0.35	0.35
C D at 5%	0.07	0.08	1.32	2.03	0.16	0.13	0.09	0.12

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IMPROVING PRODUCTIVITY AND ECONOMICS OF AEROBIC RICE (*ORYZA SATIVA L.*) THROUGH CROP INTENSIFICATION

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ABSTRACT

A field experiment entitled "Improving Productivity and Economics of Aerobic Rice (*Oryza sativa L.*) through Crop Intensification" was conducted at Zonal Agriculture Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore, during *Kharif* 2010. Among the treatments significantly higher grain yield was recorded in Aerobic rice + Amaranthus + 125% RDF (5471 kg ha^{-1}) followed by Aerobic rice + 125% RDF (5197 kg ha^{-1}). The increase in grin yield was in the order of 13.5 and 7.4 per cent in Aerobic rice + Amaranthus + 125% RDF and Aerobic rice + 125% RDF over Aerobic rice + 100% RDF respectively compared to other treatments. Among the different treatments significantly higher rice equivalent yield (REY) was recorded in Aerobic rice + Amaranthus + 125% RDF (17013 $kgha^{-1}$). Significantly lower grain yield was recorded with Aerobic rice + 75% RDF (4029 $kgha^{-1}$). Aerobic rice + Amaranthus + 125% RDF recorded a significantly higher net return (Rs. 43,798 ha^{-1}) and B:C ratio (3.61) as compared to other treatments.

Rice (*Oryza sativa* L.) being the principal food crop to billions of people around the world requires 4000-5000 liters of fresh water to produce one kg of grain, which is three times higher than other cereals (Anon., 2006). Along with high water requirement, traditional system of rice production in the long run leads to destruction of soil aggregates and reduction in macropore volumes (Shashidhar, 2007). Aerobic rice is a new method of growing rice characterized by direct seeding in non puddled condition without standing water. The total water requirement from sowing to harvest is estimated at 850 to 1000 mm under aerobic condition. Introducing intercrops will not only offer the benefit of smothering of weeds but also better utilization of moisture, light, nutrient and space. Expression of genotypic potentiality depends on physiological differences among different genotypes to respond to different levels of nutrients. So the varying nutrient management levels are of particular interest in aerobic rice cultivation. Varying levels of nutrient obviously results into greater variation in growth patterns of a variety leading to different levels of yield.

MATERIALS AND METHODS

A field experiment was conducted at Zonal Agriculture Research Station, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bangalore, during *Kharif* 2010. The Soil of the experimental site was red sandy loam in texture. Moisture content at field capacity was 18.6 per cent at 0-15 cm layer with a bulk density of 1.45 g cc^{-1}. The soil was neutral in reaction (pH 6.4) and electrical conductivity was 0.15 dSm^{-1}. The organic carbon content was 0.61per cent. The available nitrogen was medium (288.24 kg ha^{-1}), phosphorus was medium (16.86 kg ha^{-1}) and potassium (265.25 kg ha^{-1}) was medium. The experiment was laid out in Randomized Complete Block Design with 12 treatment combinations with three replications. The treatments include Rice + Amaranthus + 100% RDF, Rice + French bean + 100% RDF, Rice +

Raddish + 100% RDF, Rice + Amaranthus + 125% RDF, Rice + French bean + 125% RDF, Rice + Raddish + 125% RDF, Rice + Amaranthus + 75% RDF, Rice + French Bean + 75% RDF, Rice + Raddish + 75% RDF, Rice + 100% RDF, Rice + 125% RDF, Rice + 75% RDF. Recommended practices for aerobic rice and inter crops were followed as per package was followed in establishment of crops. Inter crops were sown as additive series.

Results and Discussion

The grain yield was significantly higher in Aerobic rice + Amaranthus + 125% RDF (5471 kg ha^{-1}) followed by Aerobic rice + 125% RDF (5197 kg ha^{-1}). Significantly lower grain yield was recorded with Aerobic rice + Raddish + 75% RDF (3771 kg ha-1). Among different intercrops, Aerobic rice + Amaranthus + 125% RDF recorded significantly higher grain yield of 5471 kg ha^{-1} at harvest (Table 1). Higher grain yield in Aerobic rice + Amaranthus + 125% RDF was due to higher N remobilization efficiency in translocation to the grain. This was due to less competition for nutrient, moisture, light and space making the crop plant to exploit more available resources resulting in higher grain yield. Similar results were reported earlier by Sarkar and Pal (2004) and Singh *et al.* (2004).

Among different treatments significantly higher Rice equivalent yield (REY) was recorded in Aerobic rice + Amaranthus + 125% RDF (17013 kg ha-

Table 1. Grain yield, intercrop yield and rice equivalent yield as influenced by different levels of NPK nutrient under different intercropping system in aerobic rice.

Treatments	Yield (Kgha^{-1})		Rice equivalent
	Rice	Intercrop	yield (kgha^{-1})
T_1:Aerobic rice + Amaranthus + 100%RDF	4458	7024*	15496
T_2:Aerobic rice + French Bean + 100%RDF	3904	976*	4813
T_3:Aerobic rice + Raddish + 100%RDF	3767	4296*	6278
T_4:Aerobic rice + Amaranthus + 125%RDF	5471	7214*	17013
T_5:Aerobic rice + French Bean + 125%RDF	3951	1082*	5033
T_6:Aerobic rice + Raddish + 125%RDF	3922	4480*	6611
T_7:Aerobic rice + Amaranthus + 75%RDF	4342	6980*	15443
T_8:Aerobic rice + French Bean + 75%RDF	3825	924*	4583
T_9:Aerobic rice + Raddish + 75%RDF	3771	4164*	6269
T_{10}:Aerobic rice + 100%RDF	4820		4820
T_{11}:Aerobic rice + 125%RDF	5197		5197
T_{12}:Aerobic rice + 75%RDF	4029		4029
S.Em ±	157		236
C.D. (P = 0.05%)	459		694

Note: *Fresh Biomass yield, RDF: 100:50:50 (kg ha^{-1})

[1]) followed by Aerobic rice + Amaranthus + 100% RDF (15496 kg ha^{-1}). Significantly lower grain yield was recorded with Aerobic rice + 75% RDF (4029 kg ha^{-1}). Among different intercrops, Aerobic rice + Amaranthus + 125% RDF recorded significantly more rice equivalent yield at harvest (17013 ka ha^{-1}) followed by Aerobic rice + Amaranthus + 100% RDF (15496 kg ha^{-1}). This may be due to higher yield of intercrops and its market price coupled with better utilization of the resource by the component crop in intercropping system. These results are in conformity with results of Sanjay Kumar *et al.* (2004) and Rautaray (2005).

Among different treatments, Aerobic rice + Amaranthus + 125% RDF recorded a significantly higher net return (Rs. 43,798 ha^{-1}) and higher B: C ratio (3.61) compared to other treatments (Table 2). These results are in line with the findings of Thakur (1993) who reported that rice + sesame, rice + green gram and rice + jute gave net return 4365.5, 2471 and 2119 Rs ha^{-1}, respectively and were more profitable than rice + fodder sorghum, rice + proso millet.

Based on the above results, it is concluded that aerobic rice intercropped with amaranthus with 125 per cent of recommend fertilizer is help full in achieving higher productivity and economic returns under this crop intensification system.

Table 2. Economics of the system as influenced different levels of NPK nutrient under different intercropping system in aerobic rice

Treatments	Gross returns (Rs. ha^{-1})	Total cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C Ratio
T_1:Aerobic rice + Amaranthus + 100%RDF	48926	11904	37022	3.11
T_2:Aerobic rice + French Bean + 100%RDF	38106	17204	20902	1.21
T_3:Aerobic rice + Raddish + 100%RDF	53632	14404	39228	2.72
T_4:Aerobic rice + Amaranthus + 125%RDF	55945	12147	43798	3.61
T_5:Aerobic rice + French Bean + 125%RDF	39893	17447	22446	1.29
T_6:Aerobic rice + Raddish + 125%RDF	55960	14647	41313	2.82
T_7:Aerobic rice + Amaranthus + 75%RDF	48142	11660	36482	3.13
T_8:Aerobic rice + French Bean + 75%RDF	36877	16960	19917	1.17
T_9:Aerobic rice + Raddish + 75%RDF	52793	14160	38633	2.73
T_{10}:Aerobic rice + 100%RDF	30242	10694	19548	1.83
T_{11}:Aerobic rice + 125%RDF	32389	10937	21585	1.97
T_{12}:Aerobic rice + 75%RDF	25244	10450	14794	1.42
S.Em ±	1267	484	844	0.16
C.D. (P = 0.05%)	3716	1422	2486	0.48

Note: RDF: 100:50:50 (kg ha^{-1})

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GROWTH AND PRODUCTION POTENTIAL OF PIGEON PEA UNDER REDUCED TILLAGE AND RAISED BED PLANTING

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ABSTRACT

The present filed experiment was conducted to study the performance of pigeon pea crop under different tillage and crop establishment methods for two consecutive years (2005-2006). The plants attained more height under conventional tillage (CT) than reduced tillage (RT) whereas number of pods per plant were found more under reduced tillage. The tillage options did not affect the number of branches, number of nodules/plant, their dry weight, number of grains/pod, grain yield, stover yield and harvest index. The pigeon pea crop performed significantly better on FIRB than on Flat bed planting for all the characters under study. Lesser water requirement and higher water productivity of pigeon pea crop under FIRB planting was recorded than flat bed planting.

INTRODUCTION

There had been impressive gains in rice and wheat production through green revolution from 1965 to 1985 but at the cost of grain legumes. Consequently, there was less availability and price rise in grain legumes and this affected the poor to meet requirement of protein, vitamins and mineral due to their limited access to alternate sources of these nutrients that grain legumes provide. The RWC for the IGP has been very successful in sustaining the green revolution through adoption of resource conservation technologies (RCT's). A number of RCT's are under development and evaluation for rice-wheat and other cropping systems.

The RCT's related to improved cultural practices are the reduced tillage and raised bed planting introduced in the mid of 1990. Likewise, the reintroduction of water use-efficient legumes as a break crop in the rice-wheat rotation is an emerging technology. Under crop improvement programmes new genotypes of short duration pigeon pea (SDP) and extra short duration pigeon pea (ESDP) have been developed. The information on the production potential of ESDP genotypes under reduced tillage and raised bed planting are scanty. Therefore, the present field experiment was planned with the aim to know the performance of ESDP variety ICPL 88039 grown under reduced tillage and furrow irrigation raised bed (FIRB) planting technique.

MATERIALS AND METHODS

The present field experiment was conducted during kharib season of two consecutive years (2005-06) at agricultural farm of J.V college, Baraut (Bagpat), U.P. The experimental design was completely randomized block with 3 treatments of tillage and crop establishment methods (conventional tillage, reduced tillage and furrow irrigation raised bed planting) each with 4 replications. The variety sown was ICPL 880 39 which is early maturing,

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developed by pedigree selection at ICRISAT (A.P) and recognized for field evaluation in 1988. The seed rate was kept @ 15 kg/ha. Two light irrigation were given as and when required . Nitrogen and phosphorus were applied @ of 40 kg and 60 kg/ ha, respectively at the time of sowing crop through urea @ 87 kg/ha and single super phosphate @ 375 kg/ha. The observations were recorded on different growth and yield characters, and water used. The data collected on different characters were subjected to statistical analysis using the analysis of variance technique. The significance of differences between treatment means were tested by estimating the critical difference at 5% level.

Results and Dissension

Growth and yield of Pigeon pea

The average value of growth characters viz. plant height, number of branches, number of nodules / plant and their dry weight have been presented in Table 1 whereas the average value of yield characters and yield in Table 2 for two years data.

The height of pigeon pea plants at the age of 30 days averaged to be 9.0 cm under conventional method of tillage and it was more or less same (8.8 cm) under reduced practice of tillage but on raised beds the plants attained more height of 10.5 cm in first year crop with little or no difference in height of the plant in second year under all the tillage and crop establishment methods. The plant height at 60 and 90 days after sowing and at maturity averaged 128, 260.3 and 270 cm under conventional tillage. The average growth rates / day were found to be 0.3, 4.1, 4.4 and 0.3 cm during first, second and third month of age and from 90 days to maturity under conventional tillage. Thus the plants grew more quickly during second and third month of age. Almost same growth rates were observed for reduced tillage and FIRB system for both the years. When the data were subjected to statistical analysis, it was found that the plant height differed significantly due to tillage and crop establishments methods, the plants on raised beds attained more height at all stages of growth. The average numbers of branches at maturity

Table 1. Effect of different tillage and crop establishment methods on growth characters of Pigeon pea(Pooled average of two years.)

T & CE* methods	Plant height (cm) at DAS**				Number of branches/ plant	Number of nodules/ plant	Nodule dry wt (mg)
	30	60	90	Harvest	Harvest	Harvest	Harvest
FIRB	10.4	133.0	267.6	269.5	12.0	10.0	257.4
RT	8.75	126.7	258.6	268.1	10.5	7.5	226.1
CT	8.91	127.7	260.0	268.1	10.0	6.8	223.6
CD 5%	0.40	0.81	0.98	0.76	0.91	0.87	2.74

T & C E*=Tillage and crop establishment Methods, DAS**=Days after Sowing were observed to be 10.0 in both years under conventional tillage, 11.0 and 10.0 under reduced tillage, and 12.0 under FIRB planting system in two years. Thus the number of branches emerged were more under FIRB planting compared to flat bed planting. On statistical analysis of the data, it was found that the number of branches were not significantly different under different tillage options but were significantly more under FIRB planting. The year differences were not significant.

The number of nodules formed on the roots of the plants were found to be 6.7 and 8.0 per plant on flat bed planting under conventional and reduced tillage whereas the number of nodules were 10.0 / plant on raised bed planting in the first year. The number pf nodules formed on the roots during second year crop were nearly equal to first year. The number of nodules per plant on FIRB planting was found to be significantly higher than flat bed planting whereas the tillage practices did not affect the character. The nodules dry weight on FIRB systems averaged to be 260 and 255.7 mg in two years whereas it was less on flat bed planting viz. 225 and 222 mg in two years under conventional tillage. On subjecting the data of nodules dry weight to statistical analysis, it was found that the nodules dry weight was significantly higher on raised beds than on flat bed planting of raising the Pigeon Pea crop, where as the nodules dry weight under conventional tillage and reduced tillage were statistically at par. The results of the present study on number of nodules and their dry weight corroborated with the findings of Annon (2005) who found that these two characters had better values under raised bed planting than under flat bed planting.

The average numbers of pods per plant were found to be 128 under conventional tillage and 130 under reduced tillage which increased to 134 under FIRB planting system in the first year crop. The same trend in the number of pods was observed in the second year with respect to tillage and crop establishment methods. The number of pods per plant differed significantly between conventional and reduced tillage. The numbers of pods per plant under FIRB planting system were found to be statistically more than on flat bed planting. This was true for the crop of both the years. The numbers of grains formed and matured per pod were observed to be 4.0 under conventional tillage as well as under reduced tillage in both the years. On the other hand, FIRB planting system produced more number of grains (5.0 in both yeas) compared to the flat bed planting (Table 2). Statistically the differences in number of grains were found significantly more under FIRB planting than under flat bed planting.

The average grains yield of pigeon pea presented in table 2 have shown that it was 17.6 and 17.1 q / ha under conventional tillage in two years which was less than produced under reduced tillage (18.1 and 17.7 q/ha in two years). The average grains yield was found to be appreciably higher on raised beds viz. 20.0 and 19.5 q / ha in two years than on flat beds. The year differences in grains yield were not found significant for either of the tillage and crop establishment methods. On the other hand, the average grains yield was found to be statistically higher on raised beds than on flat bed and it holds good for both the years. The tillage practices could not produce significant differences in grain yield. Higher yield on FIRB was due to more number of branches, more

Table 2. Effect of different tillage and crop establishment methods on yield characters and yield of Pigeon pea(Pooled average of two years.)

T & CE methods	Number of pods/ plant	Number of grains/ pod	Grain yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	H.I. %
FIRB	133.5	5.0	19.7	68.3	88.1	22.3
RT	129.5	4.0	17.9	66.5	84.3	21.2
CT	127.5	4.0	17.3	66.4	83.7	20.6
CD5%	1.86	0.82	0.95	1.37	2.37	0.52

T & C E*=Tillage and crop establishment Methods.

number of pods per plant and more number of grains per pod. Higher grain yield of pigeon pea on raised bed than on flat bed have also been reported by Jat and Sharma (2005), Annon (2005) and Pande *et al.* (2006). The Stover yield which is the sum of straw of pods and the sticks averaged 67.0 and 65.8 q / ha in two years under conventional tillage whereas it was 66.7 and 66.4 q/ha in two years under reduced tillage. Statistically the differences were not found significant either between years or between tillage practices for this character. The stover yield under FIRB planting system of growing pigeon pea was found to higher (68.6 and 68.0 q/ha in two years) compared to flat bed planting. Statistical analysis of data indicated that stover yield under FIRB planting was significantly higher than flat planting. The average biological yield of pigeon pea crop was found 84.6 q/ha in first year under conventional tillage, 84.8 q/ha under reduced tillage and 88.6 q/ha under FIRB system whereas the average values were found to be 82.9, 83.1 and 87.5 q/ha in second year with respect to these tillage and crop establishment method. The two tillage methods did not influence the biological yield of the crop significantly. However, FIRB planting method of growing pigeon pea resulted into significantly higher biological yield than flat bed planting. The harvest index was found to be 20.7 and 20.6 % in two years under conventional tillage whereas it was 21.4 and 21.0 % in two years under reduced tillage. Statistically, the tillage practices did not influence harvest index significantly. On the other hand, the FIRB planting method had significantly higher harvest index of 22.4 and 22.2 % in two years compared to that of flat bed planting technique of raising the crop.

Water Productivity

The perusal of data presented indicated that FIRB planting required 786 m^3 / ha water which was 15 % less compared to conventional tillage (926 m^3 / ha) whereas under reduce tillage water requirement was 857 m^3 / ha. The water productivity varied from 1.90 kg grain / m^3 water under conventional tillage to 2.54 kg grain produced / m^3 water under FIRB planting. This was due to higher grain yield and low water requirement under FIRB technique. Lesser water requirement and higher water productivity under FIRB planting technique has also been found by Jat and Sharma (2005).

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EFFECT OF BIOCOMPOST ENRICHED POULTRY WASTE ON PRODUCTIVITY OF WHEAT

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ABSTRACT

A farmers participatory field experimental research trial were conducted during two consecutive *rabi* (winter) seasons of 2008-09 and 2009-10 to standardized the best poultry waste decomposed ratio for increasing the productivity of wheat. The treatments comprised of 7 treatments viz., 4 ratio of biocompost enriched poultry waste equivalent to 60 kg N/ ha (1:1, 2:1, 3:1 and 4:1), FYM, Poultry waste raw and urea laid out in ramdomized block design at 10 locations. Results revealed that maximum and significantly higher grains/ spike, test weight, grain and straw yield was recorded in 2:1 ratio biocompost enriched poultry waste remained on par with 3:1 ratio as compared to alone application of FYM, poultry waste raw, urea, 4:1 and 1:1.

Key words: Biocompost, poultry litter, poultry waste, productivity, profitability, wheat yield.

Wheat is a prime staple food of upper Gangetic plains of Uttar Pradesh and grown after harvest of rice and sugarcane in mid or later conditions. Both the crops of rice and sugarcane were heavy feeder of nutrients and create a nutrient mining in the soil. Chemical fertilizer is a leading practice of the farmers and found multiple nutrient deficiencies in the soil. To replenishes the soil through appropriate source of nutrition for building the soil and harvest attainable yield of wheat. Poultry waste have been implicated as potential contributors to source of pollution if not properly used and it may cause water pollution, loss of fertilizer value and negative impact on environment. Poultry industries must use disposal waste. Since long back raw poultry waste and litter has been used as a source of plant nutrients and soil amendments.

Poultry waste treatment enhances quality, increased composition of nutrients and reduces environment pollution if their biomass by composting with straw, plant waste, grasses etc. Composting is being widely adapted for the treatment of solid waste (Goldstein, 1980). Application of composted litter contains nitrogen and phosphorus in organically form and found similar to split applications of commercial fertilizer (Bugbee and Frink, 1989). Further, good compost applied at the correct rate will generally out-perform a similar level of nutrients supplied by synthetic fertilizer (Holden, 1990). Similarly, Gouin (1989) reported that compost could be applied at rates up to 50 tonns per acre without environmental problems. Composting is a biological process in which organic wastes are stabilized and converted into a product to be used as a soil conditioner and organic fertilizer by the degradation of microorganisms. Keeping in view of above facts an experiment was conducted to standardize the biocompost

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poultry waste with optimum ratio for increasing productivity of wheat.

MATERIALS AND METHODS

The field experimental was carried out during two consecutive *rabi* (winter) seasons of 2008-09 and 2009-10 at farmers field of Pilibhit district of Uttar Pradesh. The experiment was carried out in randomized block design comprised of 7 treatments viz., 4 ratio of biocompost enriched poultry waste equivalent to 60 kg N/ha (1:1, 2:1, 3:1 and 4:1), FYM, Poultry waste raw and urea with 3 replications. The soil of the experimental farmers field was loamy sand, neutral in reaction (pH 7.41), poor in organic carbon (3.7 g/kg), low in available nitrogen (189.5 kg/ha) and medium in available phosphorus (21.0 kg/ha) and potassium (205.5 kg/ha). The recommended dose of fertilizers was nitrogen, phosphorus and potash 120:60:60 kg/ha and supplied through Diammonium phosphate (DAP) and muriate of potash (Kcl). Full dose of phosphorus and potash was drilled before sowing uniformly. The poultry litter was collected from Central Avian Research Institute, Bareilly (Uttar Pradesh) and mixed with wheat straw, leaves, grasses in following combinations on dry weight basis viz., poultry litter : wheat straw + leaves + grasses in 1:1, 2:1, 3:1 and 4:1 ratio. These materials were composted aerobically in pits of 2, 4 and 6 feet depth and turned during decomposition. After decomposition, well decomposed materials obtained from 4 feet depth of all combinations were used as organic waste to replace 50 % nitrogen recommendation in wheat production. Similar manner FYM, raw poultry litter and urea were used to replace 50 % nitrogen requirement and rest 50 % nitrogen were supplied by other fertilizers. The half dose of nitrogen was given through biocompost enriched poultry waste @ 60 kg N equivalent and drilled in earmarked plots treatment wise and remaining dose of nitrogen was given through urea after amount of N supplied by DAP and top dressed at the time of first irrigation. Wheat variety 'PBW 226' was sown on 28th November, 2008 & 30th November, 2009 using a seed rate of 100 kg at a row spacing of 22.5 cm apart. The crop was raised by adopting standard package of practice.

RESULTS AND DISCUSSION

Effect on yield attributes

Application of biocompost enriched poultry waste produced higher yield attributes on wheat compared to sole application of urea, raw poultry waste and FYM (Table 1). Maximum and significantly higher grains/spike (45.0 & 39.2) and test weight (46.52 g & 49.41 g) was recorded with biocompost enriched poultry waste (2:1) closely followed by biocompost enriched poultry waste (4:1) as compared to the sole application of urea, raw poultry waste, FYM, biocompost enriched poultry waste (1:1) and biocompost enriched poultry waste (3:1) during 2008-09 and 2009-10, respectively. It was registered per cent increased of grains/spike to the tune of 44.0, 25.9 and 13.2 during 2008-09 and 11.4, 6.8 and 5.3 during 2009-10 over urea, raw poultry waste and FYM, respectively. This was probably due to application of biocompost enriched poultry waste had cumulative apparently higher values of grains/spike and test weight. The decomposition of poultry litter were mixed with straw, leaves and grasses in different combinations as 1:1, 2:1, 3:1 and 4:1. Drozd and Licznar (2000) stated that poultry waste mixed with wheat straw in composting process leads to reduce of N content, increase of C/ N index as well as of the sorption

Table 1. Effect of biocompost enriched poultry waste on productivity of wheat during 2008-09 and 2009-10

Treatments	Grains/spike (No)		Test weight (g)		Grain yield (q/ha)		Straw yield (q/ha)	
	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10	2008-09	2009-10
Biocompost enriched Poultry waste (1: 1)	32.2	38.0	44.08	41.29	41.85	47.75	58.36	64.86
Biocompost enriched Poultry waste (2:1)	45.0	39.2	46.52	49.41	52.81	53.07	78.59	74.95
Biocompost enriched Poultry waste (3: 1)	36.8	37.2	45.16	48.43	45.61	50.68	65.41	62.73
Biocompost enriched Poultry waste (4:1)	41.0	38.7	45.91	47.08	49.91	52.02	75.74	71.65
FYM	39.75	37.2	45.70	47.26	48.25	50.57	68.36	69.47
Raw poultry waste	35.75	36.7	44.62	43.21	47.12	45.05	61.11	64.58
Urea	31.25	35.2	42.64	38.91	44.65	41.68	51.24	59.29
SEm ±	1.01	0.34	0.49	0.90	1.58	0.93	1.70	1.53
CD (P=0.05)	5.01	1.03	1.45	2.67	4.70	2.76	5.05	4.56

capacity of the soil. Mahimiraja *et. al.* (1995) also found in aerobic incubation system, among bedding materials examined wheat straw and peat were found to superior in reducing ammonia. Hence enriched organic wastes were used to replace 50 percent nitrogen recommendation for wheat production on dry weight basis. Turan (2009) reported that poultry litter compost is used as fertilizer having high nutrient content with least release of nitrogen via ammonia volatilization and increased crop productivity.

Effect on yield

A perusal of data (Table 1) further revealed that application of biocompost enriched poultry waste recorded higher grain and straw yield of wheat over sole application of application of urea, raw poultry waste and FYM. Application of biocompost enriched poultry waste (2:1) recorded significantly higher grain yield to the tune of 18.3 & 27.3, 12.1 & 17.2 and 9.4 & 4.9 % over sole application of application of urea, raw poultry waste and FYM during 2008-09 and 2009-10, respectively. While, application of biocompost enriched poultry waste (2:1) remained statistically at par with biocompost enriched poultry waste (4:1) but significantly superior over biocompost enriched poultry waste (1:1) and biocompost enriched poultry waste (3:1). However, biocompost enriched poultry waste (3:1) showed superiority over biocompost enriched poultry waste (1:1). Similarly, maximum and significantly higher straw yields of 78.59 and 74.95 q/ha was recorded with application of biocompost enriched poultry waste (2:1) remained statistically at par with biocompost enriched poultry waste (4:1) but significantly superior over rest of the treatments during 2008-09 and 2009-10, respectively. Biocompost enriched poultry waste (2:1) registered higher straw yield to the tune of 53.4, 28.6 and 14.9 during 2008-09 and 26.4, 16.1 and 5.48 % during 2009-10 over sole application of application of urea, raw poultry waste and FYM. However, biocompost enriched poultry waste (4:1) also found significantly superior over biocompost enriched poultry waste (1:1) and sole application of application of urea, raw poultry waste and FYM. Bijay Singh *et. al.* (1996) observed that poultry waste sustained the grain yield of the rice during the three years while the yield decreases with sole application of urea. Similarly, Feisal *et. al.* (2012) were also observed that application of 5 t/ha produced higher fresh and dry forage at the harvest.

Thus, based on two years experimentation inferred that use of biocompost enriched poultry waste (2:1) equivalent to 60 kg nitrogen as basal application produced significantly higher yield attributes and yield of wheat.

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SOIL TEST BASED FERTILIZER RECOMMENDATION FOR MAXIMUM ECONOMIC YIELD OF POTATO AND SUSTAINABLE SOIL HEALTH IN NUBBRA VALLEY

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ABSTRACT

Field experiment were conducted at the field of Defence Institute of high Altitude Research station Det Partapur during two consecutive year 2009-2010.It s commonly believed that the prevalent soil test recommendation are inadequate to obtain the desired yield target in almost all vegetable crops. The responses of soil test recommendation vis-à-vis farmer's fertilizer practice were tested for NPKS and Zn in potato crop. The final treatment combined with 6 ton FYM ha $^{-1}$. In order to gain precise information on plant height, tuber yield, moister content, and nutrient uptake. The mean range of variation in plant height were 60cm to105cm, tuber yield 26.1 t ha-1, moister content79.3 to81.53 %, N uptake 25.3 kg to 135 kgha^{-1}, P uptake 3.72 kg to 23.65 kgha^{-1} and K uptake 81.62 kg to 189 kgha^{-1}. Treatment T_8 gave highest mean plant height during both the year and increase yield was significant. The tuber yield and uptake of NPK also increase significantly due to different treatment and the treatments giving highest yield also recorded the nutrient uptake value. Application of FYM enhances the tuber quality, reduces input cost and improved organic matter and available nutrient of soil.

Key words: Soil Test, MEY, Soil health and Nutrient uptake.

INTRODUCTION

In the arena of present day agriculture, there is a serious constraint of natural resources like, soil, water, nutrient, variety and plant protection. It is actually this area where judicious management for the various factors of production is most needed. The present day agriculture productivity is fertilizer driven. It becomes more and more relevant in the present context when the continued maximization in the production to meet the food and nutritional Security of teeming millions in face of limited per capita

cultivable land is a subtle agricultural thrust. There was a time when the country had only one imperative producing more and more food & green revolution was started with a fanfare, with spectacular success. Under the present situation the country needs a fresh look on national imperatives, firstly the maximum food production.Secondly, protection of soil health and thirdly the alleviation of biosphere. All these imperatives are interrelated and crop production technology in general and fertilizer management in particular required to be maintained in a sustainable balance. India is now a days in the grip of multi-nutrient deficiency syndrome. The most deficient nutrients in our soil are nitrogen, phosphorus, potash, sulphur & zinc. The deficiencies of magnesium, iron, boron, manganese and other essential macro && micronutrients are appearing in several crops & niches with rapid pace.

Under the situation, have to plan for

a scientific agriculture. The first step in this direction is the balanced nutrition under the umbrella of best management practices. It is commonly believed that the prevalent soil test recommendations are and in adequate to obtain the desired field target in almost crops. The SSNM approach arms to apply nutrients at optimal rates and firms in order to achieve high yield and high efficiency of nutrient use by the crop. The low input high output concept is not practical (Tiwari 2002).Based on soil and other conditions location specific fertilizer recommendation should be made available for the individual almost based on soil test on major secondary & micronutrients for efficient nutrient management & soil health. Potato (*solanum tuberosum* L) is the most important food crop of the world and ranks fourth amongst the food crops of the world. It is short duration crop which produces more dry matter and edible energy protein per unit area. Potato is an exhaustive crop thus it requires higher dose of chemical fertilizer for optimal production, integrated nutrient management is an approach in which all the available resources such as organic, inorganic and bio fertilizers are used in a balanced proportion. It gives quality production without improving soil health and also sustained the physical chemical and biological properties of soil. Cold Arid areas are usually confined to high altitudes. Sixteen percent of total land mass is undercold arid zone. Indian cold arid region come under the trans-Himalayan zone. Such regions areconfined to Ladakh (J&K), Lahual & Spiti (H.P.) and small pockets in Uttranchal (Niti and ManaGarhwal). Ladakh contitutes 87.4 percent of total cold arid zone of India). It is situated at an elevation of 2550 to 8000m amsl along the valley of river Indus. Intensive sunlight; high evaporation rate, strong winds and fluctuating temperature characterize the general climate. Vegetation is sparse, rains are very rare and most of the land is mountainous desert of rocks, sand & dust. Region has a very harsh climate and a short agriculture season (May-Oct.) due to extreme long winter & production of maximum edible biomass is possible only through vegetable cultivation, moreover it plays an important role in balanced diet of human being by providing not only energy rich food but also ensure supply of vital protective nutrients like minerals & vitamins.

MATERIALS AND METHODS

The field experiments were conducted for two consecutive years 2009-2010 at the field of Defence Institute of high Altitude Research station Det Partapur Nubbra valley. The soil was analyzed for different physical and chemical characteristics and experiment was conducted under randomized block design with 8 treatments and 4 replications. The treatments details are given below. The soil of experimental site was analyzed for soil sepr pH, EC, OC available N, P_2O_5, and K_2O. The analysis of EC was done by conductivity bridge pH was measured by pH meter in 1:2 soil water suspensions, organic carbon by Walkley and Blacks method available P by Olsen method, available K by Margans methods. The soil was pH 8.2 EC 0.13 dSm^{-1} organic carbon (0.42%) available N 210 $kgha^{-1}$ available P 10.2 $kgha^{-1}$ available K 220 $kgha^{-1}$soil. Nutrient uptake was calculated by following equation

$$\text{Nutrient uptake kgha}^{-1} = \frac{Nutrientcontet\%}{100}$$

yield $kgha^{-1}$

Table: (A) : Treatments details

Treatments	Corresponding doses kgha^{-1}
T_1 - Control	N 0 + P_2O_5 0 + K_2o 0
T_2 - Farmers fertilizer Practice	N 100 + P_2O_5 40 + K_2o 0
T_3 - State Recommendation	N 100 + P_2O_5 50 + K_2o 40
T_4 - STR100%	N 120 + P_2O_5 60 + K_2o 36+ FYM 6tha^{-1}
T_5 - STR 100%+S+Zn	N 120 + P_2O_5 60 + K_2o 36+ FYM 6tha^{-1} S 15+ Zn 5
T_6 - STR 125%	N 150 + P_2O_5 75 + K_2o 45+ FYM 7.5tha^{-1}
T_7 - STR 125% + S+ Zn	N 150 + P_2O_5 75+ K_2o 45 +FYM 7.5tha^{-1} S 15+ Zn 5
T_8 - STR 125%+S+Zn+5 t FYM	N150+ P_2O_5 75+K_2o 45+FYM 7.5tha^{-1} S15 Zn 5+FYM12.5tha^{-1}

Note : SR =- State Recommendation, FFP = Farmers Fertilizer Practices, STR = Soil Test Recommendation.

Results and Discussion

The results indicated that the increasing effect of nutrient were significant for tuber yield. The average Tuber yield increase from 8.70tha^{-1} to 40.90tha^{-1}and 9.0 tha^{-1} to 41.80tha^{-1} from control to T_8 treatment during both the year respectively. Results indicating that a four fold increase in the tuber yield can be obtained by T_8 treatment over control. The Farmers Fertilizer Practice consisting of N100+$P_20_5$40+K_20 Okgha^{-1}was better than control, but state recommendation of 100:50:40kgha^{-1}NPK was must lower than STR 100% (N.120+$P_20_5$60+$K_20$36kgha^{-1}+ FYM 6tha^{-1}) in respect of tuber yield (Table-1).The highest tuber yield was noted 40.90 to 41.80 tha^{-1} followed by treatment T_7. It was clear that balanced fertilizer based on STR had greater yield and economy, the farmer practice comparatively low cost balance level of fertility. The results of the study are in agreement with several workers. (Sharma & Gupta.1991, Singh *et.al.* 2000, Roy *et.al.*2001, Sasaini *et.al.* 2003, Imas and Bansal 2006, Gupta *et.al.* 2007).

Dry MatterYield: Potato tubers as such were chipped dried to moisture free and variation in data significant statically over-controlled. However, the trends of results were similar to those tubers with moisture. The dry matter yield varied from 1.80 to 7.55 tha^{-1} during Ist year and 1.86 to 7.65 tha^{-1} during IInd years. The lowest and highest yield given by T_1 and T_8 treatments. All the treatments significantly superior to control except treatment T_3. The trends of results were similar during both the years. Treatment T_8 was able to affect a three fold increase in dry matter over control (Table 1). There was no clear cut difference in the moisture content of potato tubers. Under high fertility treatment had some which high moisture content. It varied from 79.3 % to 81.53% during Ist year, 79.32 % to 81.70% during IInd year in control to T_8 treatments. These results are in agreement with(Kate *et.al.* 2005, Imas & Bansal 2006).

Nutrient uptake: The total uptake of nutrients as a function of bio-mass and concentration was recorded under different treatments. N uptake increase from 25.67 kg to 136.38 kg ha^{-1} from control to T_8 treatments on the basis of

Table 1. Effect of different treatments on potato tuber, dry matter yield and moisture content.

Treatments	Tuber yield tha^{-1}		Moisture %		Dry matter yield tha^{-1}	
	2009	2010	2009	2010	2009	2010
T_1 - Control	8.70	9.0	79.30	79.32	1.80	1.86
T_2 - Farmers fertilizer Practice	17.90	18.50	80.09	80.20	3.57	3.66
T_3 - State Recommendation	21.20	22.10	80.39	80.42	4.15	4.33
T_4 - STR100%	26.60	27.50	80.61	80.61	5.14	5.33
T_5 - STR 100%+S+Zn	27.90	29.0	80.98	81.05	5.30	5.50
T_6 - STR 125%	35.40	36.50	81.17	81.30	6.68	6.82
T_7 - STR 125% + S+ Zn	37.70	38.90	81.36	81.40	7.02	7.23
T_8 - STR 125%+S+Zn+5 t FYM	40.90	41.80	81.53	81.70	7.55	7.65
CD 5%	12.28	11.96	-	-	2.27	2.35

Table 2. Effect of different treatments on NPK uptake $kgha^{-1}$

Treatments	N Uptake		P Uptake		K Uptake	
	2009	2010	2009	2010	2009	2010
T_1 - Control	25.30	26.04	3.72	3.72	41.62	42.78
T_2 - Farmers fertilizer Practice	57.81	58.92	9.16	8.78	84.34	84.91
T_3 - State Recommendation	68.06	71.01	11.62	11.69	98.70	104.78
T_4 - STR100%	87.79	90.61	12.83	13.32	125.32	128.98
T_5 - STR 100%+S+Zn	91.19	94.64	13.88	14.30	130.60	135.30
T_6 - STR 125%	118.23	121.39	20.65	20.46	164.60	170.58
T_7 - STR 125% + S+ Zn	124.95	129.41	21.75	21.69	177.40	182.19
T_8 - STR 125%+S+Zn+5 t FYM	135.06	137.70	23.65	23.71	189.00	192.78
CD 5%	37.28	38.27	7.14	6.63	57.05	51.91

average of two years.P uptake varied from 3.72 kg to 23.68 kg ha^{-1} and K uptake varied 42.16 kg to 190.89 kg ha^{-1} on mean basis of two years. The total uptake of NPK increase almost five times due to high fertility treatment (T_8) over control. The highest NPK uptake treatment at (Table 2), these results are in agreement with reported by other workers. (Sharma & Arora 1990, Gupta et.al 2007, Tiwari & Gupta 2006).

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EFFECT OF SULPHUR ON PRODUCTIVITY, PROFITABILITY AND SULPHUR DYNAMICS UNDER URDBEAN (*VIGNA MUNGO*)-INDIAN MUSTARD (*BRASSICA JUNCEA*) CROPPING SYSTEM

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ABSTRACT

A field experiment was conducted during two consecutive seasons of *kharif* and *rabi (*2005-06 & 2006-07) at Agricultural Research Station, Ummedganj, Kota to evaluate the optimum dose of sulphur for increasing the productivity, profitability and sulphur dynamics under urdbean-mustard cropping sequence. The experiment was comprised of 3 levels of sulphur (0, 20 and 40 kg/ha) to each urdbean and mustard and consisted of 9 treatment combinations (U_0-M_0, U_0-M_{20}, U_0-M_{40}, U_{20}-M_0, U_{20}-M_{20}, U_{20}-M_{40}, U_{40}-M_0, U_{40}-M_{20} and U_{40}-M_{40} kg/ha) were tested in randomized block design with four replications. Sulphur fertilization to urdbean 40 kg/ha significantly increased seed yield and net return over no sulphur application while it remained statistically on par with 20 kg S/ha. The respective increase was in the magnitude of 13.6 and 55.0 % over no sulphur. Maximum and significantly higher seed and net return was recorded in mustard with application of U_{40}-M_{40} kg S/ha remained on par with U_{20}-M_{40} and U_{40}-M_{20} kg/ha over no sulphur, U_0-M_{20}, U_0-M_{40}, U_{20}-M_{20} and U_{40}-M_{20}. Treatment U_{20}-M_{40} kg S/ha recorded significantly higher urdbean equivalent yield to the tune of 1107 kg/ha, net return ₹16267/ha, total S uptake 14.21 kg/ha and higher buildup of S 7.49 kg/ha over U_0-M_0 (no sulphur).

Keywords: Cropping system, mustard, nutrient dynamics, sulphur, urdbean, yield

Urdbean-mustard cropping system is a second best important leading cropping system after soybean-wheat cropping system grown mainly South-Eastern Plain Zone of Rajasthan. However, productivity is low as compared to the potential yield of cropping system. Similarly, Tripathi and Rathi (2003) have found significantly higher mustard irrigation and high grade analysis fertilizer i.e. single or two major sources of nutrients are leading to crop production but failed to sustain long term productivity. The Indian soils are becoming deficient in secondary/ micronutrient deficiency particular in sulphur. Sulphur is now being recognized as the fourth major plant nutrient (Morris, 2007). Apart from the secondary nutrients, S had limiting the yield and quality of urdbean and mustard. Sulphur plays a significant role in pulses and oilseed crops particularly where the sink material is largely sulphur containing amino acids. Sulphur has specific vital role in growth, development and quality of pulses and oilseed crops. The maintenance of optimum sulphur levels in fertility is an important consideration for obtaining higher and sustainable yield due to large turnover of nutrients in soil-plant system as compared to prevailed fallow-mustard cropping system. In each season of every year application of sulphur to individual crop is not economical and advisable, because nutrient use efficiency of sulphur is very low and it did not lost

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from soil and had a residual effect on succeeding crop.

Hence, an introduction of pulses in the system was found more beneficial in pulse-oilseed based cropping sequence. Therefore, an attempt was made to evaluate the optimum dose of sulphur for urdbean-mustard cropping sequence on productivity and nutrient dynamics.

Materials And Methods

The field experiment was conducted during *kharif* and *rabi* seasons (2005-06 & 2006-07) at Agricultural Research Station, Ummedganj, Kota. The experiment was carried out in randomized block design comprised of 3 levels of sulphur (0, 20 and 40 kg/ha) to each urdbean and mustard and consisted of 9 treatment combinations (U_0-M_0, U_0-M_{20}, U_0-M_{40}, U_{20}-M_0, U_{20}-M_{20}, U_{20}-M_{40}, U_{40}-M_0, U_{40}-M_{20} and U_{40}-M_{40} kg/ha) with 4 replications. The soil of the experimental field was clay loam, slightly alkaline in reaction (pH 7.6), poor in organic carbon (4.2 g/kg), low in available nitrogen (275.5 kg/ha), phosphorus (20 kg/ha), sulphur (16.5 kg/ha) and medium in available potassium (295.5 kg/ha). The recommended dose of nitrogen and phosphorus 20:40 kg/ha to urdbean and 80:40 kg/ha to mustard were given through urea and Diammonium phosphate (DAP). Full dose of phosphorus and half dose of nitrogen was drilled before sowing and remaining 40 kg nitrogen was given to mustard at the time of irrigation. Sulphur was given through gypsum and drilled before the sowing in ear marked plots treatment wise. Urdbean variety 'RBU 38' and mustard 'Pusa bold' was sown on 14th July, 2005 & 8th August, 2006 and 26th October, 2005 & 11th November, 2006 using a seed rate of 20 kg for urdbean and 4 kg/ha for mustard at a row spacing of 30 cm apart. One hoeing and weeding was done 30 days after sowing. One supplemental irrigation was also given to mustard at the time of flowering stage. Post harvest soil analysis for available S in soil and uptake by plant was analysed by Turbidimetric method as per Williams and Steinberg, 1959.

Results and Discussion

Effect on yield and economics of urdbean

Sulphur fertilization at 40 kg/ha significantly increased seed yield and net return over no sulphur application while it remained statistically on par with 20 kg S/ha (Table 1). Maximum seed yield was recorded with fertilization of U_{40}-M_{40}, U_{40}-M_{20} and U_{20}-M_{40} kg/ha to the tune of 17.1, 16.4 and 14.5 % over no sulphur. Similarly, net return was also fetched maximum under U_{40}-M_{40} to the tune of 1606/ha over no fertilization. However, application of U_{20}-M_{20} also found statistically at par with U_{40}-M40. The incremental growth parameters and yield attributes leads to higher yield and net return compared to no sulphur fertilization. Though, available sulphur status of the experimental field was low (16.5 kg/ha) hence, sulphur application improved nutritional environment of rhizosphere as well as plant system as evident from greater uptake of nutrients (Table 2) and ultimately metabolic and photosynthetic activity, better development of yield attributes and resulting higher yield. The findings corroborate the results of Singh and Kumar, 1996.

Effect on yield and economics of mustard

On the basis of two years pooled mean data (Table 1) revealed that direct application of incremental and residual effect of sulphur on yield and economics were recorded higher values significantly

Table 1. Effect of sulphur on yield of urdean, mustard and economics under urdbean-mustard cropping sequence (pooled mean of 2 years)

Treatment (S kg/ha)	Urdbean		Mustard		Urdbean system equivalent yield	System net return	System benefit: cost
	Seed yield (kg/ha)	Net return (Rs/ha)	(kg/ha) Seed yield (kg/ha)	Rs/ha) (Net return (Rs/ha)	ratio		
U_0-M_0	754	2001	1088	9197	1718	7191	0.97
U_0-M_{20}	772	2269	1796	21131	2363	16784	2.18
U_0-M_{40}	788	2518	1901	22793	2473	18309	2.32
U_{20}-M_0	851	3260	1496	16188	2176	13940	1.71
U_{20}-M_{20}	862	3426	2015	24884	2647	20889	2.57
U_{20}-M_{40}	863	3445	2215	28170	2825	23458	2.87
U_{40}-M_0	868	3381	1697	19637	2371	16769	2.08
U_{40}-M_{20}	878	3536	2113	26561	2750	22316	2.75
U_{40}-M_{40}	883	3607	2322	30007	2940	25063	3.06
CD (P=0.05)	46.95	714	242.2	4154	226.3	3440	0.43

over no application of sulphur. Maximum and significantly higher seed yield and net return were recorded in 40 kg S/ha applied in both the crops over U_0-M_0, U_0-M_{20}, U_0-M_{40}, U_{20}-M_{20} and U_{40}-M_0 levels of sulphur but remained statistically on par with and U_{40}-M_{20}. Which might be owing to gave significantly higher growth parameters, yield attributes, yield and economics over no sulhpur in both the crops. Application of U_{40}-M_{40} treatment recorded higher values to the tune of 1234 kg/ha seed yield and 20810/ha net return over absolute control. It might be due to favourable nutritional environment in rhizosphere crates more mobility of sulphur and increased photosynthetic rate thus increased yield attributes and yield of mustard. The results are in line of Singh *et al.* (1997).

Effect on system productivity and profitability

The maximum urdbean equivalent yield (UEY) was obtained with the highest dose of sulphur U_{40}-M_{40} kg/ha applied in both the crops, which was at par with that realized under the application of U_{20}-M_{40} and U_{40}-M_{20} kg S/ha (Table 1). These 3 treatments U_{40}-$M_{40,}$ U_{20}-M_{40} and U_{40}-M_{20} kg S/ha significantly out yielded over lower dose combinations for urdbean equivalent yield and net return. The highest UEY of 2940 kg/ha was realized with the application of 40 kg S/ha to both urdbean and mustard crops every year. However, the treatment involving the application of sulphur U_{20} kg/ha to urdbean and U_{20}-M_{40} kg/ha to mustard every year performed equally good as reflected in its statistically on par with the highest yield and net return. The treatment U_{20}-M_{40} kg S/ha recorded significantly higher urdbean equivalent yield and net return to the tune of 1107 kg/ha and 16267/ha over no sulphur application in both the crops. The results

Table 2. Effect of sulphur on system use efficiency under urdbean-mustard cropping sequence (pooled mean of 2 years)

Treatment (S kg/ha)	Sulphur uptake (kg/ha) sequence (kg/ha)				Total S uptake by S (kg/ha)	Available
	Urdbean		Mustard			
	Grain	Straw	Grain	Stover		
U_0-M_0	1.19	0.72	2.44	4.02	8.37	12.54
U_0-M_{20}	1.21	0.84	5.38	9.02	16.45	14.87
U_0-M_{40}	1.20	0.86	6.08	9.86	18.00	17.00
U_{20}-M_0	1.36	1.10	4.08	6.62	13.16	14.95
U_{20}-M_{20}	1.40	1.11	6.23	9.96	18.70	17.50
U_{20}-M_{40}	1.47	1.36	7.36	12.39	22.58	20.03
U_{40}-M_0	1.64	1.42	4.97	8.27	16.31	17.60
U_{40}-M_{20}	1.67	1.45	7.07	11.79	21.98	19.80
U_{40}-M_{40}	1.75	1.59	7.58	12.80	23.72	21.25
CD (P=0.05)	0.26	0.30	1.31	1.97	3.30	1.24

Initial soil test values of available S 16.5 kg/ha

corroborate the findings of Tripathi and Rathi (2003).

Effect on S uptake and balance

The maximum sulphur uptake was associated with the highest dose of S application to urdbean and mustard crops i.e. 40 kg/ha compared to no sulphur application (Table 2). The S uptake by urdbean in grain and straw was maximum with application of 40 kg S/ha compared to control however, it remained statistically on par with 20 kg S/ha. The increase was recorded to the tune of 19.04 to 47.05 % in grain and 43.24 to 120.83 % in straw over 20 kg S/ha and control, respectively. In mustard, maximum S uptake was recorded in U_{40}-M_{40} treatment to the tune of 210.65 % in grain and 218.4 % in stover over absolute control (U_0-M_0). However, it remained on par with U_{40}-M_{20} in grain and U_{40}-M_{20} and U_{20}-M_{40} in stover, respectively. The treatment U_{20}-M_{40} also significantly increased S uptake by grain and stover of mustard over absolute control. The per cent increase was 201.6 and 208.7 in grain and stover, respectively.

Maximum and significantly higher total S uptake (23.72 kg/ha) was recorded in treatment U_{40}-M_{40} over rest of the treatments except U_{20}-M_{40} and U_{40}-M_{20} and was found statistically at par with each other. The increase was to the tune of 15.35 kg/ha over absolute control. For better S uptake it is essential to apply 20 kg S/ha to urdbean and 40 kg S/ha to mustard crop and harvest higher yield of these crops. This might be due to incremental increases in the concentration of sulphur in grain and straw/stover. The concentration of nutrients also increase due to S fertilization because of improved nutritional environment in rhizosphere and consequently in plant system. These results are in close conformity with the findings of Varavipour *et al.* (1999).

Higher sulphur rates along with its repeated applications in both the crops resulted in higher S buildup in the soil. The maximum S buildup was found when both the crops urdbean and mustard were adequately supplied with S (40 kg/ha) every year (Table 3). Maximum and significantly higher buildup of S was recorded in treatment U_{40}-M_{40} (21.25 kg/ha) remained on par with U_{20}-M_{40} over rest of the treatments, which was 69.45 % higher over absolute control. Similar result was reported by Varavipour *et al.* (1999).

The two years results inferred that that application of sulphur U_{20}-M_{40} in system mode of urdbean-mustard cropping sequence produced maximum and sustainable seed yield and economics and saved 20 kg of sulphur for the betterment of soil health and ecological system.

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WEED DYNAMICS AND WEED CONTROL EFFICIENCY IN WHEAT (*TRITICUM AESTIVUM* L.) UNDER DIFFERENT TILLAGE METHODS AND WEED CONTROL OPTIONS IN RICE- WHEAT SYSTEM

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ABSTRACT

Wheat (*Triticum aestivum* L.) is the most important cereal among the food grain crop in the world. It is basic component of human diet and the staple food of Indian people meeting the majority dietary requirements next to rice. the present investigation was conducted for 2 years (2005-07) at Crop Research Centre, Sardar Vallabh Bhai Patel University of Agric, & Tech, Meerut (U.P.) during *rabi* season to work out weed management studies in wheat under different tillage options. Two field experiments were separately conducted consisting 15 treatment combinations (3 tillage methods viz. zero, reduce and conventional; and 5 weed management practices viz. weed free, weedy check, sulfofulfuron, isoproturon @ 750g a.i.+ 2,4-D 250g a.i. ha^{-1} and metribuzin @ 250 a.i. ha^{-1}) laid out in Split Plot Design with four replication.

The significantly higher number of yield attributes and yield was found under conventional tillage over reduce tillage and found at par with zero tillage. While, minimum weed density and dry matter accumulation was found under zero tillage Among the weed management practices sulfosulfuron @ 25 g a.i./ha was most effective herbicide followed by isoproturon @ 750 g a.i.+ 2,4-D @ 250 a.i./ha and it gave excellent result to control weeds density and increase in yield attributes and yield.

Key words: Wheat, tillage methods, weed management practices, yield

Wheat (*Triticum aestivum* L.) is the most important cereal among the food grains crop in the world. It is basic component of human diet and the staple food of Indian people meeting the majority dietary requirements next to rice. In general wheat productivity is higher in developed countries than the Asian Countries, where Rice-wheat is a prominent cropping system, that cover 13.5 m ha (10 m ha in India, 2.2 m ha in Pakistan, 0.8 m ha in Bangladesh and 0.5 m ha in Nepal) of land in South Asia (Wood head *et al.,* 1994). This cropping system has now become more fragile, but still the system productivity holds great promises for future to meet the food needs of the ever-increasing population. It is now pertinent that productivity of this cropping system be sustained to support our vast population by 2020 A.D. India will need 109 m tones of wheat with productivity level of 42.9 q/ha (Nagarjan, 1997).

Agronomic practices including tillage practices, crop rotation and weed management (by chemical method) can ameliorate these important constraints and improve the yield sustainability. Zero tillage sowing of wheat has come up as a solution of late sowing, increasing cost of cultivation and severe weed problem. Thus, zero tillage as a resources conservation technology, offers a great potential for sustaining wheat productivity and increasing returns. It significantly reduces the total weed dry matter and also gives higher yield as

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compared to conventional tillage (Mishra *et al.,* 2005). Zero tillage farming is gaining popularity and becomes essential component of rice wheat system in southern region as farmers struggle to making farming profitable (Hobbs, 2002). This system is not only useful in reducing cost of production but is also fuel-efficient. Fuel consumption with zero till drill is 7-8 liters/ha as compared to 60-65 litres/ha with conventional practice (Singh and Singh, 1995). The incentive for a change from conventional to zero tillage has come from three directions viz. improved productivity, improved profitability and sustainability of rice-wheat cropping system. Wheat is generally has problem of both, grassy weed viz. *Phalaris minor, Avena* spp. and broad leaves weeds viz. *Chenopodium album, Fumaria parbiflora, Melilotus indica, Anagalis arbensis* (Malik *et al.,* 1989). Among these species, grassy weeds have comparatively less number as compared to broad leaved weeds in wheat, but their severity is not less anywhere in the wheat growing areas espiecially that of *phalaris minor* (Retz.) and *Avena* spp., because their growth habit is simliar to that of wheat crop. These weeds are responsible for low productivity of wheat by sharing a greater part of nutrients, moisture, space and light with the crop. Besides their direct effect on wheat yield, weeds also lower the market value and hence bring enormous economic losses to the growers (Rao *et al.,* 1992) .

MATERIALS AND METHODS

The field experiment was conducted at the Crop Research Centre of Sardar Vallabh Bhai Patel University of Agriculture & Technology, Modipuram, Meerut 2005-06 and 2006-07. For the several years, rice wheat cropping system has been practiced in experimental field. The crop of rice was raised during the *kharif* season in both years before the experimental crop of wheat. Experiment was conducted in split –plot design having fifteen treatments and each treatment was replicated four times. Tillage methods were taken in main plots and weed control measures as sub plots with randomization of treatments. The Main plot was Tillage practices viz: Zero Tillage (no tillage operations), .Reduced tillage (one harrow +one cultivator) and conventional tillage (two harrow+two cultivator)To control, weeds in sub plot chemically post emergence herbicide viz., sulfosulfuron @25g a.i /ha (Leader 75 WG), isoproturon@750g a.i.+2,4-D@250g a.i. ha^{-1} and metribuzin @250g a.i. /ha (Sencor 70 W P) were applied to plots in an aqueous solution using 800 liter of water per hectare, manually with the help of Knapsack sprayer at 30 days. Weed density was recorded by using a quadrate of 50x50 cm (0.25cm^2) size randomly. The total numbers of weeds falling within quadrate were counted species wise in each plot. All the weeds inside the quadrant were cut close to the ground level in each plot and collected for dry matter accumulation. The samples were first dried in sun and then kept in oven at 70^o C $\pm$ 2 ^{o}C for 48 hours till a constant weight was achieved. The dried samples were weighed and the final dry weight of total weeds expressed in grams per meter square. Weed control efficiency was calculated in relation to total weed dry matter by using the following formula and expressed in percent. Weed control efficiency (W.C.E.): Dry matter of weeds in weedy plot ––– Dry matter of weeds in treated plot/ Dry matter of weeds in weedy plot X 100.

RESULTS AND DISCUSSION

The plant height was significantly higher in conventional tillage than reduced tillage and being at par with zero tillage. At harvest it was 16.3 and 0.82 % higher than zero tillage during 2005 and 2006, respectively. The numbers of tillers per meter row length were 3.89 and 2.34 % higher in conventional tillage as compare to zero tillage, while 6.56 and 4.96 % higher over reduced tillage at harvest stage during 2005 and 2006, respectively. The grain yield was significantly higher in conventional tillage over reduced tillage and being at par with zero tillage during both the years. The grain yield under conventional plot was 3.7, 3.64 and 10.47, 9.46 % higher over zero and reduced tillage during 2005 and 2006, respectively (Table 3). Tillage practices had marked effect on weed density, weed dry matter accumulation and weed control efficiency. The major weed species were found *Phalaris minor, Avena ludoviaciana, Cyprus rotundus and Chenopodium album* in all the tillage practices. The significant effect of different tillage practices on the density of *Phalaris minor* was found during 2005, while in 2006 the effect was non significant. Density of weeds in conventional tillage was significantly higher than zero tillage. The contribution of *Phalaris minor* to total weed population was 15.89, 18.86% under zero tillage. Whereas, in reduced and conventional tillage it was 18.0, 21.01 and 20.0, 19.91%. It might be due to the fact that *Phalaris minor* seeds which were in deeper soil layer comes to upper soil layer due to conventional and reduced tillage and get germinated in conducible environment. The higher dry matter accumulation was noticed under reduced tillage and almost similar to conventional and zero tillage. It may be due to lower density of crop plants and more competition of weed plants and crop. The dominance of *Phalaris minor* in the field suppressed the others weeds. Similar result was also reported by Tomar *et al.* (2002). The highest weed density and dry weight was found under reduced tillage followed by conventional and zero tillage (Table 1& 2). Weed control efficiency was higher in zero tillage followed by conventional and reduced tillage 90 days during both the years. It may be due to higher soil compaction, lower germination of weeds, and Vigorous growth of crop and suppression effect of crop plants on weeds. Sinha and Singh (2005) also reported less weed density and dry matter accumulation under zero tillage as compared to conventional tillage.

Grain and harvest index were affected significantly by various weed management practices. The higher grain yield was observed under weed free treatment. which was 38.38 and 52.56% higher over weedy check. (Table 3). The poor grain yield in 2005 and 2006 in weedy check treatment may be the result of poor yield attributing characters. However sulfosulforon @25 g a.i. /ha was second most effective treatment just after weed free treatment. This may be result of good yield attributing character, lesser number of weeds and better nutrient availability to crop Bisen *et al* (2008) also reported similar effect. Isoproturon @ 750 g a.i.+2, 4-D @ 250 g a.i./ha and metribuzin @250 g a.i./ha treatment were poor performer as compared to weed free and sulfosulfuron @25 g a.i./ha. This may be due to higher weed population and phytototixic effect of herbicides. Similar results were reported by Benga *et al.* (2003). Similarly, higher Harvest index under weed free and sulfosulfuron @25 g a.i./ha treatment may be due to efficient control of weeds, reduced crop-weed competition for nutrient, water, space and light and resulted in better growth, yield attributes and finally yield.

Table 1. Density of *different weeds* / m² at 90 days after sowing as influenced by various tillage methods and weed management practices in wheat.

Treatment	Density of different weeds									
	Phalaris minor		*Avena fatua*		Cyprus rotundus		*Chenopodium album*		other weeds	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Tillage Methods										
Zero Tillage	1.68(3.35)	1.69(3.5)	1.68(3.15)	1.62(3.05)	1.49(2.50)	1.69(3.10)	1.67(3.35)	1.58(2.75)	1.62(2.90)	1.57(2.70)
Reduced Tillage	1.81(3.90)	1.85(4.20)	1.80(3.75)	1.76(3.60)	1.78(3.55)	1.71(3.40)	1.85(4.00)	1.74(3.50)	1.75(3.50)	1.72(3.30)
Conventional Tillage	1.81(3.95)	1.73(3.60)	1.63(3.15)	1.73(3.40)	1.59(2.95)	1.70(3.20)	1.71(3.25)	1.63(3.00)	1.62(3.00)	1.66(3.05)
SEm±C.D (P= .05)	0.13N S	0.07N S	0.09N S	0.07N S	0.14N S	0.04N S	0.04NS	0.06N S	0.14N S	0.07N S
Weed management practices										
Weed Free	3.60(12.58)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.00	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)
Weedy check	1.38(1.58)	3.57(12.41)	3.26(10.83)	3.36(10.91)	3.04(9.33)	3.20(9.91)	3.43(11.41)	3.24(10.16)	3.06(9.55)	3.17(9.66)
Sulfosulfuron@25g.a.i. / Lha at 30 days	1.52(2.00)	1.26(1.33)	1.43(1.66)	1.33(1.50)	1.31(1.50)	1.35(1.58)	1.38(1.58)	1.27(1.25)	1.38(1.66)	1.33(1.50)
Isoproturon@750g.a.i.+ 2,4-D@250 g. /ha	1.62(2.50)	1.52(2.08)	1.47(1.83)	1.49(2.00)	1.48(1.83)	1.59(2.25)	1.58(2.16)	1.44(1.75)	1.52(2.00)	1.43(1.66)
Metribuzin @250 g a.i./ha	0.110.33	1.72(2.75)	1.64(2.41)	1.63(2.33)	1.57(2.33)	1.65(2.41)	1.61(2.50)	1.59(2.25)	1.65(2.50)	1.62(2.25)
SEm± C.D (P= .05)	0.110.33	0.130.38	0.150.44	0.130.37	0.140.42	0.130.40	0.140.40	0100.29	.150.44	0.100.30

(Original value in parentheses)

Table 2. Dry matter accumulation of *different weeds* g / m^2 at 90 days after sowing as influenced by various tillage methods and weed management practices in wheat.

Treatment	Dry matter accumulation of different weeds									
	Phalaris minor		*Avena fatua*		Cyprus rotundus		*Chenopodium album*		other weeds	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Tillage Methods										
Zero Tillage	1.69(2.36)	1.57(1.99)	1.59(2.44)	1.45(2.02)	1.45(1.99)	1.48(2.07)	1.41(1.88)	1.47(2.05)	1.45(2.0)	1.42(1.86)
Reduced Tillage	1.78(2.67)	1.63(2.18)	1.66(2.69)	1.53(2.31)	1.51(2.16)	1.51(2.20)	1.52(2.17)	1.53(2.29)	1.59(2.40)	1.48(2.40)
Conventional Tillage	1.74(2.56)	1.61(2.11)	1.57(2.52)	1.50(2.20)	1.45(2.07)	1.49(2.11)	1.52(2.17)	1.48(2.11)	1.45(2.11)	1.47(1.99)
SEm±	0.09	0.06	0.07	0.04	0.059	0.03	0.05	0.06	0.10	0.03
C.D (P= .05)	N S	N S	NS	NS	NS	NS	NS	NS	NS	NS
Weed management practices										
Weed Free	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)	0.71(0.0)
Weedy check	2.75(7.09)	2.52(5.89)	2.54(6.28)	2.56(6.09)	2.50(5.78)	2.51(5.84)	2.45(5.53)	2.55(6.05)	2.39(5.54)	2.44(5.52)
Sulfosulfuron@25g.a.i. / ha at 30 days	1.51(1.79)	1.32(1.16)	1.51(1.86)	1.31(1.36)	1.25(1.24)	1.32(1.39)	1.39(1.49)	1.33(1.38)	1.39(1.61)	1.28(1.19)
Isoproturon@750g.a.i.+ 2,4-D@250 g. /ha	1.53(1.85)	1.44(1.69)	1.62(2.23)	1.38(1.59)	1.44(1.65)	1.43(1.63)	1.43(1.61)	1.40(1.54)	1.47(1.74)	1.39(1.47)
Metribuzin @250 g a.i./ha	1.56(1.94)	1.49(1.74)	1.68(2.37)	1.51(1.86)	1.43(1.69)	1.49(1.78)	1.42(1.72)	1.48(1.78)	1.52(1.96)	1.45(1.64)
SEm±	0.09	0.07	0.10	0.10	0.08	0.08	0.08	0.07	0.11	0.04
C.D (P= .05)	0.27	0.22	0.31	0.29	0.25	0.23	0.23	0.21	0.34	0.12

(Original value in parentheses)

Table 3. Weed control efficiency, plant height,number of tillers,harvest index and grain yield as influenced by various tillage methods and weed management practices in wheat.

Treatments	Weed control efficiency at 90 days		Plant Height (cm) At harvest		Number of tillers/m. row length at harvest		Harvest index(%)		Grain yield(q/ha)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Tillage Methods										
Zero Tillage	64.76	66.40	90.98	92.51	100.25	102.22	45.04	45.32	43.66	44.19
Reduced Tillage	59.91	62.17	90.42	92.11	97.47	99.50	44.84	45.04	40.59	41.57
Conventional Tillage	62.29	63.92	92.48	93.28	104.3	104.66	45.36	45.48	45.34	45.83
SEm±	-	-	0.49	0.20	2.16	1.46	0.13.	0.09	1.01	0.79
C.D (P= .05)	-	-	N.S.	N.S.	N.S.	N.S.	N.S	0.32	3.51	2.73
Weed management practices										
Weed Free	100	100	92.62	94.68	109.5	110.29	45.66	45.85	47.81	49.24
Weedy check	0	0	90.01	90.75	94.66	92.83	43.80	43.89	34.76	32.42
Sulfosulfuron@25g.a.i. / ha at 30 days	73.59	76.94	92.10	93.29	102.45	105.07	45.47	45.64	45.59	47.04
Isoproturon@750g.a.i.+ 2,4-D@250 g. /ha	70.12	73.13	91.35	92.41	100.8	102.33	45.28	45.56	44.48	46.12
Metribuzin @250 g a.i./ha	67.87	69.64	90.39	92.04	96.66	101.12	45.17	45.44	43.34	44.49
SEm±	-	-	0.55	0.64	1.86	1.54	0.12	0.09	0.92	0.81
C.D (P= .05)	-	-	1.58	1.83	5.35	4.43	0.35	0.28	2.65	2.33

Whereas, in weedy plot the vigorously growing weeds compete with the crop plant for nutrient, moisture, space and sunlight throughout growing period and finally suppress the crop growth. Weed control measures had significant effect on weed population and its dry matter accumulation. The sulfosulfuron treatment was most effective to control the narrow leaves weeds viz. *Phalaris minor*, *Avena ludoviaciana* and Cyprus rotundus. In general weed density reduced after execution of weed control measures as the crop comes in advance stage. Isoproturon @ 750 g a.i.+2, 4-D @ 250 g a.i./ha was next best treatment followed by metribuzin @ 250 g a. i. /ha. The lower weed population and dry matter accumulation under weed free condition and sulfosulfuron treated plots may be the result of time-to-time intercultural operation and effective control of grassy weeds by sulfosulfuron. kumar *et al.* (2005) also reported similar results. Higher weed density and dry matter accumulation found under Isoproturon @ 750 g a.i.+2, 4-D @ 250 g a.i./ha and metribuzin @ 250 g a. i. /ha may be the result of less effectiveness to arresting the weed population. The sulfosulforon @25g a.i./ha was equally effective as in narrow leaves weeds and It was superior over the Isoproturon @ 750 g a.i.+2, 4-D @ 250 g a.i./ha and metribuzin @ 250g a.i./ha (Table 1&2). Reduction in dry weight of weeds as well as weed density might be the reason for lower nutrients depletion under these treatments. These results are in close conformity with those reported by Pandey *et al.* (2007).

Conclusion

It can be concluded that tillage methods and weed management practices affects growth and yield of wheat crop significantly. The highest growth and yield were noticed under conventional tillage followed by zero tillage. While, minimum weed density and dry matter accumulation of weeds was found under zero tillage. Among the methods of weed control, sulfosulfuron @ 25 g a.i. /ha gave excellent result to control the weeds population and higher yield. Thus zero tillage with the application of sulfosulfuron may be recommended for the sustainability of crop yield and soil health

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EFFECT OF DIFFERENT FARM HOLDING SIZE ON SOIL CHARACTERISTICS OF FARMER'S FIELD OF MEERUT DISTRICT

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ABSTRACT

The field survey of farm families was conducted in three villages namely Alipur, Madarpur and Kulanjanpur of Sardhana Tehsil of Meerut district during December 2011 to study the effect of different farm holding size on soil characteristics of farmer's fields. The results indicated that large and medium categories of farmers adopting Sugarcane –Ratoon- Wheat cropping sequence with mechanized farming whereas small and marginal farmers were practicing diversified cropping patterns giving more emphasis on vegetables and fodder crops besides cultivation of cash crop merigold. The Organic Carbon and available N P K of marginal and small farmer's fields are 31.62,20.42,23.56,20.72% and 18.81,28.26, 27.76,03.70% higher then medium and large categories of farmer's fields respectively.

Keywords: Farmers categories, cropping sequences, Holding sizes, and Soil Characteristics.

There are various categories of farmers as per their holding sizes viz marginal having land size < 1 ha. small (1- 2 ha), medium (2- 4 ha) and large category (>4 ha). But the numbers of marginal and small farmers are increasing rapidly year after years due to fragmentation of large families, rapid industrialization, urbanization, and various development activities viz construction of dams, roods and railways. Under such situation, marginal and small farmers are compelled to take up some other secondary and third enterprises such as dairy, fisheries, poultry, piggeries bee keeping, mushroom cultivation, varmicompisting, horticulture and forestry as per their suitability in order to generate employment through out the year and increase the overall income and ultimately adopting diversified agriculture. As these categories farmers are economically and technologically poor, the use of organic sources of nutrient for crop production is a very common practice in their limited land resources.

On the other hand medium and large farmers are taking up remunerating cropping system like sugarcane – ratoon – wheat, rice- wheat – sorghum and maize –wheat etc. with proper crop management practices and improved seeds, fertilizers, irrigation, plant protection measures and mechanized farming. These variations in cultural practices for crops and soil management greatly influence soil health (Sharma at. al. 2002). However, very meager information is available on this aspect. Therefore, there is an urgent need to initiate the study on impact of various cultural practices and fertilizers use adopted by different categories of farmers on their soil health.

MATERIALS AND METHODS

The survey of farm families was conducted in three villages namely Alipur, Madarpur and Kulanjanpur of Sardhana Tehsil of Meerut district during December 2011. The climate of area falls in semiarid subtropical and characterized by hot summer and cold winter. May and June are hottest and

December and January are the coldest months of the year. The area is situated at latitude of 29 09' N and longitude of 77 39' E and at an altitude of 702 feet above mean sea level. The average annual rainfall of the areas is approximately 720 millimetres. The July and August are the main months of maximum rainfall. There were 6 farmers selected randomly from each category viz large, medium, small and marginal from each village and made total number of 72 farmers. All the farmers were systematically interrogated to record the holding size, cropping sequences, fertilizer used and number of animals reared by them and presented in table -1 Besides the above information, 72 composite soil samples were collected from each category of farmers of all the villages. These samples were processed and analyzed for various physico chemical properties.

The pH was determined by following standard methods (Jackson, 1973).

The organic carbon content of the soil was measured by the chromic digestion method (Walkley and Black, 1934). The available N was determined by the method of Subiah and Asija (1956), available P was estimated by the procedure of Olsen *et al.* (1954) and available K was measured by neutral ammonium acetate method. The average value of all the soil properties and available nutrients of each location of all the fields were worked out and presented in table-2.

RESULTS AND DISCUSSION

It was observed from the survey work that 100 % large and medium categories of farmers were adopting fully mechanized farming and 90 % taking Sugarcane- Sugarcane- wheat cropping sequence and rest of the 10 % area was under forage (Lucerne Sorghum and Bajra) and other crops like Potato, Maize, Onion and Marigold. Small and marginal farmers were practicing traditional farming and mostly taking vegetable crops such as Potato, Onion, Peas, Chilies, Bhindi ,Cauliflower Cabbage, cash crop such as Marigold and fodder crops such as Sorghum and Bajra besides Rice, Wheat, Mustard and Greengram for their own consumption in a different cropping sequences (Table-1). Almost all the categories of farmer's maintain 5-6 milch animals and using their excreta as source of manures in an alternative year but quantum of application was higher in categories of small and marginal farmers because of their small holding size in comparison of large number of animals. Application of nitrogenous fertilizer (Urea) @ 150 kg and phosphatic fertilizer (DAP) @ of 60 kg/ Acre was routine fertilization to each crop like Sugarcane, wheat Maize and Rice in Sugarcane-Sugarcane- wheat, Rice-Wheat-Green gram and Maize-Potato Onion cropping sequences where as potato crop was cultivated with 100 kg Urea and 50 kg DAP/Acre along with 250 quintal FYM while hardly 5-10% farmers applied potassium fertilizer (Murat of Potash) @ 50 kg /Acre to Potato crop on an average (Table-1). However, there was no systematic fertilization to any other crops. Anyway, these fodder and other miscellaneous crops (except potato) are being cultivated with variable (50-60Buggi/Acre) application of Farm Yard Manures.

As per soil health of the farmer fields is concerned, the pH value of all the categories of the farmers fields ranged from 6.34 to 7.16 and attains the level of neutral range. The status of organic carbon and NPK of large category of farmers was lowest and varied from 0.21

Table-1 Survey of Farm families of different categories of farmers

Alipur

Parameters	**Large categories**	**Medium categories**	**Small categories**	**Marginal categories**
Holding Size	12.80 Acre	5.02 Acre	4.80 Acre	0.88 Acre
Cropping Sequence	Sugarcane-Sugarcane-wheat Sorghum-Potato-Lucerne.	Sugarcane-Sugarcane-wheat Sorghum-Potato-Lucerne. Maize Potato-Merigold	Maize-Potato-Onion- Chilies. Sorghum -Peas-Merigold. Sorghum-Potato-Bhindi. Rice-Wheat-G.Gram.	Rice-Potato-Onion- Chilies. Sorghum - Peas-Merigold. Rice-Potato-Merigold.
Fertilizers Used	150 kg Urea , 60kg DAP/Acre for Wheat, Sugarcane, Rice and Maize	150 kg Urea, 60kg DAP/Acre for Wheat, Sugarcane, Rice and Maize	100 kg urea, 50.0kg DAP and 250.0 Quintals FYM/ Acre for Potato.150 kg Urea, 60kg DAP/Acre for Rice Wheat, and Maize and 50-60 Buggi F Y M /Acre to other crops	100 kg urea, 50.0 kg DAP and 250.0 Quintals FYM/. Acre for Potato 150 kg and 60kg DAP/Acre for Rice, Wheat and Maize and 50-60 Buggi F Y M /Acre to other crops
Animals Kept.	5.0	5.0	6.0	5.0

Madarpur

Parameters	**Large categories**	**Medium categories**	**Small categories**	**Marginal categories**
Holding Size	9.0 Acre	5.1 Acre	2.9 Acre	1.02 Acre
Cropping Sequence	Sugarcane-Sugarcane-wheat Sorghum-Potato- Lucerne	Sugarcane-Sugarcane-wheat Sorghum-Potato-Lucerne. Maize-Potato-Merigold.	Maize-Potato-Onion- Chilies. Maize-wheat – Bajra.(fodder) Sugarcane-Sugarcane-Wheat. Rice- Potato – Mrrigold. Maize-Potato-Onion.	Maize-Potato-Dhania-Cauliflower. Sorghum - Wheat-Bhindi Rice-Potato-Merigold. Rice-Wheat-Merigold.

Fertilizers Used	150 kg Urea and 60kg DAP/Acre for Wheat, Sugarcane, Rice and Maize	150 kg Urea and 60kg DAP/Acre for Wheat, Sugarcane, Rice and Maize	100 kg urea, 50.0 Kg DAP and 250.0 Quintals FYM /Acre for Potato. 150 kg Urea, 60kg DAP / Acre for Rice, Wheat, and Maize and 50-60 Buggi F Y M /Acre to other crops	100 Kg urea, 50.0Kg DAP and 250.0 Quintals FYM /Acre for Potato. 150 kg Urea, 60kg DAP /Acre for Rice, Wheat and Maize and 50-60 Buggi F Y M /Acre to other crops
Animals Kept.	5.0	6.0	6.0	5.0

Kunjalpur

Parameters	**Large categories**	**Medium categories**	**Small categories**	**Marginal categories**
Holding Size	5.33 Acre	4.22 Acre	2.85 Acre	1.08 Acre
Cropping Sequence	Sugarcane-Sugarcane-wheat Sorghum-Potato-Lucerne	Sugarcane-Sugarcane-wheat Sorghum-Potato-Lucerne Maize-Potato-Onion..	Sorghum-Potato-Marigold Chilies. Maize-Potato-Merigold-Bajra (Fodder) Maize-Mustard Greengram	Sorghum-Potato-Marigold- Chilies. Sorghum-Potato-Merigold.Cabbage. Sorghum -Pea-Marigold- Maize-Potato-Merigold-Bajra (Fodder
Fertilizers Used	150 kg Urea and 60kg DAP/Acre for Wheat, Sugarcane, Rice and Maize	150 kg Urea and 60kg DAP/Acre for Wheat, Sugarcane, Rice and Maize	100 Kg urea and 50.0Kg DAP- and 250.0 Quintals FYM /Acre for Potato.150 kg Urea and 60kg DAP/ Acre for Rice Wheat, and Maize and 50-60 Buggi FYM /Acre to other crops	100 Kg urea , 50.0 Kg DAP/Acre and 250Quintals FYM / Acre for Potato.150 kg Urea and 60kg DAP /Acre for Rice Wheat, and Maize and 50-60 Buggi. FYM /Acre to other crops
Animals Kept.	5.0	5.0	6.0	6.0

Table 2. Soil characteristics of different categories of farmers

Locations	Farmers Categories	Soil pH	O C (%)	Available N (Kg/ha)	Available P2O5 (Kg/ha)	Available K2O (Kg/ha)
Alipur	Large	7.12	0.31	178.0	12.15	128.0
	Medium	7.00	0.45	216.0	12.50	130.0
	Small	6.50	0.46	257.0	13.50	130.0
	Marginal	6.30	0.56	256.0	15.20	145.0
Madarpur	Large	6.80	0.21	137.0	10.24	126.0
	Medium	7.10	0.55	232.0	15.10	138.0
	Small	6.70	0.57	268.0	16.80	140.0
	Marginal	6.40	0.62	291.0	18.10	162.0
Kunjalpur	Large	7.16	0.48	238.0	17.50	149.0
	Medium	6.70	0.56	274.0	18.20	146.0
	Small	6.40	0.58	285.0	20.50	150.0
	Marginal	6.34	0.68	322.0	22.50	192.0

to 0.48 %, 137 to 238 kg/ha, 10.24 to 17.5 kg/ha and 126 to 149 kg/ha followed by medium farmers field which ranged from 0.45 to 0.56 %, 216 to 274 kg/ha, 12.5 to 18.2 kg/ha and 130 to 146 kg/ha and small farmers field varied from 0.46 to 0.58 %, 257 to 285 kg/ha, 13.5 to 20.50 kg/ha and 130 to 150 kg/ha whereas marginal farmers field had higher values of organic carbon ranged from 0.56 to 0.68, available N 256 to 322 kg/ha, availableP_2O_5 15.2 to 22.5kg/ha and availableK_20_5 145 to 192 kg/ha. It may be due to more addition of organic manures into the soil which results higher amount of organic carbon and more availability of N P and K in the soil. These results are in agreement of findings of Sharma and Bali (2000) The village wise nutrient status of the farmers field of large category of the farmers showed that percentage of Organic Carbon and available N P K were higher in fields of village Kulanjanpur followed by Alipur and Madarpur whereas rest of the categories of farmers recorded little bit different trend in respect of organic Carbon and available N P K. The values were higher in farmers fields of village of Kulanjanpur followed by Madarpur and Alipur except in case of small farmers where values of O C was highest in soils of village Kulanjanpur followed by Alipur and Madarpur. These variations in Organic Carbon and available N P K might be due to higher application of organic manures and diversification in cropping sequence. These findings corroborate the observations of Sharma and Bali (2002) and Tolanur and Badanur (2003).

Conclusion

It is revealed from the observations of OC, and NPK that values of these parameters fall in categories of low to medium range and overall soil health of the marginal and small farmer's fields are better than medium and large categories of the farmers.

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EFFECT OF ORGANIC RESIDUE ON GROWTH, YIELD AND QUALITY OF GREENGRAM IN MAIZE-SUNFLOWER–GREENGRAM CROPPING SYSTEM OF CONSERVATION AGRICULUTRE

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Abstarct

Investigations entitled "Studies on organic farming in maize- sunflower- greengram cropping system in relevance to conservation agriculutre "were carried out for two consecutive years (2003-04 and 2004-2005) at S V Agricultural college farm (ANGRAU), Tirupati (Southern Agro-Climatic Zone of AP(or) Southern plateau and Hills of India). . In these investigations,Greengram was raised as residual crop during *summer* in both the years of experimentation after the system sequence of Maize sown in *Kharif* and Sunflower sown in *Rabi* with the imposition of the treatments to the first two crops in the sequence. Six different sources of nitrogen *viz* farm yard manure ,vermicompost , neem leaf, poultry manure, pig manure and fertilizer to supply recommended dose of nitrogen on equal nitrogen basis and one treatment of no manuring through any source were applied to first two crops in the cropping system .Various parameters of Greengram were influenced differently by varied manurial practices tried. However, during both the years of investigation, All the growth and yield attributes, yield (seed as well as haulm), harvest index, gross returns, net returns and benefit-cost ratio of green gram were at their best with the residual effect of poultry manure either with or without the use of *panchagavya*. Nitrogen uptake by greengram crop and protein content of seed was significantly higher with the residual effect of various organic sources either with or without the use of *panchagavya* than with fertilizer either with or without the use of *panchagavya*. The highest phosphorus uptake of greengram was recorded with the residual effect of poultry manure either with or without the spray of *panchagavya*, while the potassium uptake was the highest with vermicompost either with or without the spray of *panchagavya*. The uptake of phosphorus and potassium by greengram crop was significantly higher with the residual effect of various organic sources either with or without the use of *panchagavya* than with fertilizer either with or without the use of *panchagavya*. Gross returns, net returns and benefit-cost ratio of greengram were significantly lesser with the residual effect of fertilizer than with any of the organic sources tried. All the growth and yield attributes, yield, nutrient uptake, harvest index, protein content of the seed and economic returns of greengram were at their lowest with the residual effect of non-manuring through any source to either maize or sunflower, which were statistically similar to those with foliar application of *panchagavya* alone to the preceding two crops.

Intoduction

Organic farming is not a new concept to Indian farmers, because they have practiced it since times immemorial. Organic farming system relies on crop rotation, crop residues, animal manures, legumes, green manures, off- farm wastes and biological pest control. Yields in organic farming are lower than chemical farming during initial years of practice and it takes a few years to stabilize the yields .However, in the long run, if properly followed ,yield with organic farming would be a greater than those obtained with chemical farming . The gravity of environmental degradation has drawn the attention of the scientists and planners towards finding out ecologically sound, viable and sustainable farm technologies, keeping in view of the needs of the future generations. Most of the Indian soils contain less than 0.5 per cent organic carbon. Unless it is raised to 0.9 – 1 per cent level, productivity of the soil can not be optimized (Veeresh, 2002). In view of the resurgence of interest in alternative agriculture in recent years, organic farming has been considered to be sound and viable option in most of the countries. In light of the above, investigations were taken up for two consecutive years, with the objectives of studying the response of maize to different organic manures, to investigate the influence of *Panchagavya* on the productivity and quality of maize ,to trace out the carry over effect of organic manures applied to maize, to work out the dynamics of soil fertility in the cropping system. And to suggest the best organic manurial practice for maize, based on productivity, economic viability and sustenance of soil fertility. It is customary in India, to include short duration pulse crops in high intensive cropping systems, since they are known to sustain with the residual fertility of soil resulting from heavily manured preceding crops of the cropping system, besides enriching the soil with moderate quantities of nitrogen. In the present study, greengram crop was raised succeeding sunflower, without imposing any treatments, with the aim to find out the carry over effect of varied manurial practices adopted to preceding maize and sunflower crops.

Materials and Methods

Investigations entitled "Studies on organic farming in maize- sunflower-greengram cropping system in relevance to conservation agriculture "were carried out for two consecutive years (2003-04 and 2004-2005) at S V Agricultural college farm (ANGRAU), Tirupati (Southern Agro-Climatic Zone of Andhra Pradesh). . In these investigations, Maize is grown in late *Kharif* and Sunflower was grown during late *rabi* during both the years.Greengram was grown in summer without imposition of any treatmental effects as residual crop as a part of studies of conservation agriculture. The experiment was laid out in a randomized block design, replicated thrice and the same lay out was followed during the second year of study. There were fourteen treatments comprising of six different sources of nitrogen *viz* farm yard manure ,vermicompost , neem leaf, poultry manure, pig manure and fertilizer to supply recommended dose of nitrogen on equal nitrogen basis and one treatment of no manuring through any source . All the seven treatments were tried with and without the foliar application of *panchagavya, thus* making the total treatments to fourteen. The test cultivars of Greengram used was LGG-460. *Panchagavya* is a mixture of cow dung (1kg), cow urine (750 ml), cow' s milk (500 ml), cow' s curd (500ml) and cow' s ghee (250ml). In addition to the five products from the indigenous cow , sugarcane juice (750ml), tender coconut water (750ml), pure honey (250ml) and ripe bananas (250g) were also added to accelerate the fermentation process. Plant height from ground surface to top most growing point was recorded from ten labeled plants of net plots, at 15 days interval till harvest and expressed in cm. LI-COR model LI-3000 portable leaf area meter with the transparent belt conveyer (Model LI-3050A) utilizing an electrical display was used for measuring leaf area at 15 days interval till harvest. Leaf area index was calculated by dividing the total leaf area with corresponding land area as per the formula suggested by Watson (1952). Five plants were uprooted from the destructive sampling area at 15 days interval till harvest and the plants devoid of roots were sun dried and later oven dried at 60^{0}C to a constant weight, weighed and expressed in kg ha^{-1}. Total number of pods from ten labeled plants in each of the net plot were counted, averaged and expressed as number of pods plant^{-1}.The number of seeds pod^{-1} from 20 pods taken at random from each treatment was counted, averaged and expressed as number of seeds pod^{-1}.Five seed samples were drawn from net plot yield of each treatment and weight of thousand seeds of each sample was recorded, averaged and expressed as 1000 seed weight in grams.Total seed yield obtained from two pickings from net plot area was sun dried to 8 per cent moisture, weighed and expressed as kg ha^{-1}. The haulms from each net plot area were sun dried to a constant weight, weighed and expressed in kg ha^{-1}. Harvest index is the ratio of seed weight to the total biological yield and is expressed as percentage. Seed samples were taken from each plot and analysed for total N by microkjeldhal method. The N content of the seed was multiplied with 6.25 (Dubez and Wells, 1968) to arrive at the crude protein content and expressed in percent.

Results and Discussion

The tallest plants with largest leaf area and highest dry matter accrual, with the highest number of pods plant^{-1}and number of seeds pod^{-1} as well as thousand seed weight, highest yield (seed as well as haulm), and highest harvest index of greengram were produced with the residual effect of poultry manure either with or without

Table 1. Biochemical Properties of *Panchagavya Stock* Solution

Property	Composition Value	Methodology
Total N (mg kg $^{-1}$)	380	Microkjeldhal – Humphries (1956)
Total P (mg kg $^{-1}$)	258	Triple acid digestion (calorimetry) Jackson (1973)
Total K ((mg kg $^{-1}$)	430	Triple acid digestion (Flame Photometry) Jackson (1973)
Total organic carbon (%)	0.85	Wet digestion Walkley & Black (1934)
Total sugar (μg ml^{-1})	215	Nelson Somogyi's hydrolysis – somogyi
Reducing sugars (μg ml^{-1})	88	(1952)
Glucose (mg/dl)	7.5	Glucose oxidase – Malick and Singh (1980)
Sodium (mg kg^{-1})	105	Triple acid digestion (Flame Photometry)
Calcium (mg kg^{-1})	28	Jackson (1973)
Yeast (CFU/ml)	38 X 10^4	Saborauds agar medium
Actinomycetes (CFU/Mml)	4 X 10^2	Ken Knight's medium Ken Knight and Muncie (1939)
Lactic acid bacteria (CFU/ml)	26X10^6	MRS agar
Zn (mg kg $^{-1}$)	0.28	DTPA extractant (AAS) Lindsay and Norvell (1978)
Fe (mg kg $^{-1}$)	0.87	
Mn (mg kg $^{-1}$)	0.20	
Cu (mg kg $^{-1}$)	0.17	

Table 2. Growth parameters and Yield attributes of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	Plant height at harvest (cm)		Leaf area index at harvest		Dry matter production (kg ha^{-1})		Number of pods plant^{-1}		Number of seeds pod^{-1}		1000 seed weight (g)	
		2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
T_1	No manure	22.8	26.4	1.14	1.23	2014	2085	7	7.2	5.2	5.5	19.4	21.8
T_2	No manure + *panchagavya*	23.5	27.2	1.22	1.32	2032	2102	7.2	7.5	5.6	5.8	20.8	22.5
T_3	Recommended dose of fertilizer	26.2	33.5	1.45	1.56	2086	2175	12.8	13	8.2	9	24.2	25.6
T_4	Recommended dose of fertilizer + *panchagavya*	26.8	34.0	1.47	1.58	2110	2192	13	13.1	8.6	9.2	24.6	26
T_5	Farm Yard Manure	29.5	36.8	1.71	1.82	2186	2304	13.8	14	9.4	9.8	26.2	27.5
T_6	Farm Yard Manure + *panchagavya*	30.2	37.2	1.73	1.84	2234	2336	14	14	9.4	9.8	26.2	27.8
T_7	Vermicompost	30.8	37.5	1.73	1.84	2268	2368	14.2	14.2	9.6	10	26.4	28
T_8	Vermicompost + *panchagavya*	31.5	38.0	1.78	1.86	2332	2382	14.4	14.2	9.6	10	26.6	28
T_9	Neem leaf	34.0	40.8	2.00	2.12	2532	2601	15.2	15.2	10.2	10.6	28	29.5
T_{10}	Neem leaf + *panchagavya*	34.6	41.4	2.03	2.14	2564	2612	15.4	15.6	10.2	10.6	28.2	29.8
T_{11}	Poultry manure	40.4	47.6	2.51	2.65	2706	2792	17.2	17.6	11.2	12	31.3	32.8
T_{12}	Poultry manure + *panchagavya*	41.1	47.9	2.54	2.69	2730	2808	17.3	17.7	11.4	12.1	31.6	33.2
T_{13}	Pig manure	37.2	44.4	2.25	2.38	2620	2685	16.2	16.5	10.6	11.3	29.6	31.2
T_{14}	Pig manure + *panchagavya*	37.8	44.8	2.28	2.40	2644	2721	16.4	16.7	10.7	11.4	30	31.4
	SEm±	0.92	0.85	0.070	0.081	19.0	24.3	0.25	0.28	0.14	0.18	0.42	0.46
	CD (P = 0.05)	2.4	2.6	0.20	0.23	54	69	0.7	0.8	0.4	0.5	1.2	1.3

the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower. The next highest stature of all the above parameters was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher level of all the parameters than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1). All the above mentioned parameters of greengram were at their lowest with the residual effect of non-manuring to both the preceding crops.

Residual effect of various organic manures either with or without the spray of *panchagavya* applied to previous crops of maize and sunflower was comparable, in respect of protein content of

Table 3. Yield (kg ha^{-1}), harvest index and Protein content (%) of greengram as influenced by the residual effect of aried manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	Seed Yield		Haulm Yield		Harvest Index		Protein Content	
		2004	2005	2004	2005	2004	2005	2004	2005
T_1	No manure	380	396	954	992	18.87	18.99	14.8	15.2
T_2	No manure + *panchagavya*	392	412	972	1016	19.29	19.60	14.8	15.2
T_3	Recommended dose of fertilizer	442	462	1204	1268	21.19	21.24	16.5	16.6
T_4	Recommended dose of fertilizer + *panchagavya*	454	476	1225	1294	21.52	21.72	16.5	16.8
T_5	Farm Yard Manure	502	526	1388	1456	22.96	22.83	20.4	20.5
T_6	Farm Yard Manure + *panchagavya*	526	542	1415	1485	23.55	23.20	20.4	20.5
T_7	Vermicompost	546	568	1438	1518	24.07	23.99	20.6	20.8
T_8	Vermicompost + *panchagavya*	568	584	1482	1532	24.36	24.52	20.6	20.8
T_9	Neem leaf	652	672	1586	1648	25.75	25.84	20.6	20.8
T_{10}	Neem leaf + *panchagavya*	665	684	1612	1685	25.94	26.19	21.0	21.4
T_{11}	Poultry manure	784	812	1954	2058	28.97	29.08	21.2	21.6
T_{12}	Poultry manure + *panchagavya*	792	824	1986	2092	29.01	29.34	21.2	21.8
T_{13}	Pig manure	724	742	1825	1872	27.63	27.64	21.0	21.4
T_{14}	Pig manure + panchagavya	732	758	1852	1904	27.69	27.86	21.2	21.6
	SEm±	14.8	17.3	33.8	40.1	0.338	0.381	0.28	0.32
	CD (P = 0.05)	42	49	96	114	0.96	1.08	0.8	0.9

Table 4. Economics of greengram as influenced by the residual effect of varied manurial practices and *Panchagavya* spray to preceding crops of maize and sunflower

	Treatments	Gross returns (Rs ha^{-1})			Net returns (Rs ha^{-1})			Benefit-cost ratio		
		2004	2005	Mean	2004	2005	Mean	2004	2005	Mean
T_1	No manure	7600	7920	7760	3800	4120	3960	2.00	2.08	2.04
T_2	No manure + *panchagavya*	7840	8240	8040	4040	4440	4240	2.06	2.17	2.12
T_3	Recommended dose of fertilizer	8840	9240	9040	5040	5440	5240	2.33	2.43	2.38
T_4	Recommended dose of fertilizer + *panchagavya*	9080	9520	9300	5280	5720	5500	2.39	2.51	2.45
T_5	Farm Yard Manure	10040	10520	10280	6240	6720	6480	2.64	2.77	2.71
T_6	Farm Yard Manure + *panchagavya*	10520	10840	10680	6720	7040	6880	2.77	2.85	2.81
T_7	Vermicompost	10920	11360	11140	7120	7560	7340	2.87	2.99	2.93
T_8	Vermicompost + *panchagavya*	11360	11680	11520	7560	7880	7720	2.99	3.07	3.03
T_9	Neem leaf	13040	13440	13240	9240	9640	9440	3.43	3.54	3.49
T_{10}	Neem leaf + *panchagavya*	13300	13680	13490	9500	9880	9690	3.50	3.6	3.55
T_{11}	Poultry manure	15680	16240	15960	11880	12440	12160	4.13	4.27	4.20
T_{12}	Poultry manure + *panchagavya*	15840	16480	16160	12040	12680	12360	4.17	4.34	4.26
T_{13}	Pig manure	14480	14840	14660	10680	11040	10860	3.81	3.91	3.86
T_{14}	Pig manure + *panchagavya*	14640	15160	14900	10840	11360	11100	3.85	3.99	3.92
	SEm±	276.1	283.8		229.6	244.7		0.049	0.053	
	CD (P = 0.05)	784	806		652	695		0.14	0.15	

greengram seed and nitrogen uptake by the crop, which were significantly higher than with the residual effect of application of recommended dose of fertilizer with or without *panchagavya*, which were statistically superior to those recorded with residual effect of non manuring to previous crops with or without *panchagavya*, which resulted in the lowest protein content of the seed and nitrogen uptake by greengram crop.

Residual effect of poultry manure either with or without the spray of *panchagavya* (T_{12} and T_{11}) applied to previous crops of maize and sunflower was comparable, in respect of phosphorus uptake of greengram, which was the highest. The next highest phosphorus uptake was recorded with pig manure with or without *panchagavya,* (T_{14} and T_{13}), which was significantly higher than with the residual effect of neem leaf manure with or without *panchagavya,* (T_{10} and T_9), which in turn was statistically superior to the residual effect of vermicompost or farm yard

Table 5. Nitrogen,phosphorus and potassium uptake (kg ha^{-1}) of greengram at harvest as influenced by varied manurial practices and *Panchagavya* spray

	Treatments	N uptake		P uptake		K uptake	
		2004	2005	2004	2005	2004	2005
T_1	No manure	17.2	17.6	2.74	3.64	9.8	10.6
T_2	No manure + *panchagavya*	18.6	19.2	2.82	3.82	10.2	11.2
T_3	Recommended dose of fertilizer	31.8	33.8	3.68	4.86	13.8	14.6
T_4	Recommended dose of fertilizer + *panchagavya*	32.9	35.6	3.72	4.98	14.2	15.0
T_5	Farm Yard Manure	55.0	54.5	5.22	6.52	16.8	19.2
T_6	Farm Yard Manure + *panchagavya*	57.0	55.9	5.25	6.54	16.8	19.2
T_7	Vermicompost	54.4	54.2	5.28	6.58	21.4	23.6
T_8	Vermicompost + *panchagavya*	56.0	55.0	5.28	6.58	21.8	24.1
T_9	Neem leaf	54.0	53.6	7.78	7.02	16.5	19.0
T_{10}	Neem leaf + *panchagavya*	55.2	54.8	7.80	7.08	16.6	19.0
T_{11}	Poultry manure	54.2	54.0	8.83	8.02	16.4	18.1
T_{12}	Poultry manure + *panchagavya*	55.8	54.8	8.90	8.10	16.4	18.6
T_{13}	Pig manure	54.6	54.5	8.30	7.52	19.0	21.2
T_{14}	Pig manure + *panchagavya*	56.4	55.2	8.32	7.56	19.4	21.6
	SEm±	1.55	1.41	0.169	0.148	0.63	0.67
	CD (P = 0.05)	4.4	4.0	0.48	0.42	1.8	1.9

manure with or without *panchagavya* (T_8, T_7, T_6 and T_5). Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher phosphorus uptake of greengram than with the residual effect of non manuring to previous crops with or without *panchagavya* (T_2 and T_1).

Residual effect of vermicompost either with or without the spray of *panchagavya* (T_8 and T_7) applied to previous crops of maize and sunflower was comparable, in respect of potassium uptake of greengram, which was the highest. The next higher potassium uptake was recorded with pig manure with or without *panchagavya*, (T_{14} and T_{13}), which was significantly higher than with the residual effect of farm yard manure or neem leaf manure or poultry manure with or without *panchagavya*, (T_6, T_{10}, T_{12}, T_5, T_9 and T_{11}), but comparable among them. Application of recommended dose of fertilizer with or without *panchagavya* (T_4 and T_3) to preceding crops resulted in higher potassium uptake than with the residual effect of non manuring to previous crops with or without *panchagavya*, (T_2 and T_1). The lowest uptake of phosphorus and potassium by greengram crop at different crop growth stages was registered with the residual effect of non-manuring to both the preceding crops.The highest gross and net returns as well as benefit-cost ratio from greengram crop were realized with poultry manure along with *panchagavya* spray (T_{12}), which were however, comparable with poultry manure alone (T_{11}) and significantly higher than with pig manure either with or without *panchagavya* (T_{14} andT_{13}), which were superior to neem leaf manure with or without *panchagavya* ($T_{!0}$ and T_9), which in turn were significantly higher than with vermicompost or farm yard manure with or without the use of *panchagavya* (T_8, T_7, T_6 and T_5). Supply of nitrogen through fertilizer either with or without *panchagavya* (T_4 and T_3) resulted in significantly lower economic returns than with all the organic sources tried either with or without the use of *panchagavya*, but significantly higher than with no manuring with or without *panchagavya* spray (T_2 and T_1). The lowest gross and net returns as well as benefit-cost ratio from greengram crop were realized with the residual effect of non-manuring to both the preceding crops.

The tallest plants with largest leaf area and highest dry matter accrual , with the highest number of pods plant^{-1}and number of seeds pod^{-1} as well as thousand seed weight, highest yield , highest harvest index, highest protein content of seed , highest nutrient uptake and economic returns of greengram were recorded with the residual effect of poultry manure applied to previous crops of maize and sunflower. Application of recommended dose of fertilizer to both the preceding crops could not extend any carry over effect on greengram, as could be noticed from the all the above mentioned parameters of greengram, which were significantly lesser than with any of the five organic manures applied to two preceding crops. Greengram being a legume, it responds to the supply of phosphorus and poultry manure, which was applied to the preceding crops contained high quantity of **P**, which would have left considerable quantity **P** in the soil to be utilized by greengram**,** which might have triggered the growth resulting in higher yield, quality and economic returns. All the other four organic manures have resulted in nearly equal performance of greengram, but significantly superior to fertilizer, indicating that fertilizers can not leave behind residual nutrients to be used by the succeeding crop as compared to organic manures. The results of the present investigation are in agreement with those of Gorodonii *et al.* (1994) and Latha *et al.* (2002).

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EFFECT OF THRESHING ON SEED QUALITY OF INDIAN MUSTARD CROP

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Abstract

A study was conducted to investigate the interacting effects between threshing methods, cylinder speed and concave clearance for assessing the seed quality of Indian mustard (*Brassica juncea*). Three types of threshers were used having three different types of threshing cylinders i.e. hammer mill, spike tooth and rasp bar. Three levels of cylinder peripheral speed of 400, 450 and 500 rpm and three levels of concave clearance i.e. 5, 10 and 15 mm were selected for the study. The data was analyzed on the dependent parameters like seed damage (%), threshing efficiency (%), standard germination (%) and electrical conductivity (m $mhos^{-1}cm^{-1}seed^{-1}$). Highest seed viability and vigor was obtained by threshing Indian mustard with lower cylinder speed (400rpm) and higher concave clearance (15mm), however threshing efficiency was low because of incomplete threshing. Also suggested that for maintenance of seed quality, the cylinder speed and concave clearance appeared to be more important at the time of threshing.

Key words: threshing cylinders, cylinder speed, concave clearance, seed quality, mustard

The most important aspect during the seed production is the maintenance of seed quality. Quality seed should have minimum visible and invisible damage. The invisible damages manifested by germination and vigor of seeds. Among several factors affecting seed quality during production, threshing is the most critical operation for a seed crop. Adopting appropriate threshing mechanisms, cylinder speed and concave clearance can reduce the damage to seeds during threshing. Basic principles employed in threshing are shear, rubbing, impact and their combinations. The force applied by threshing cylinder usually results in removal of seed coats and splitting of cotyledons. Impact forces during threshing process can cause external as well as internal seed damage, which can compromise both germinability and vigor (*Martin et al, 1991*). The threshing mechanism of mechanical threshers utilizes either raspbar or hammer mill or spike tooth as a functional component. The concave clearance and cylinder peripheral speed are the other operational parameters associated with threshing mechanism. Therefore, mechanical threshers utilizing either of the threshing mechanisms, concave clearance and cylinder peripheral speed are to be optimized for maximum and damage free threshing and better physiological seed quality (*Jakhro and Khan 1987*). The purpose of this study was to investigate the interacting effects of threshing mechanisms, cylinder speed and concave clearance during threshing on the seed quality of Indian mustard, the most important oilseed crop of *rabi* season.

Materials and Methods

The study was conducted in the breeder seed production area of the

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Department of Seed Science and Technology, CCS Haryana Agricultural University, Hisar during *rabi* season of 2008-09. Indian mustard crop (cv. RH-30) was harvested manually at maturity, and sun-dried up to the moisture content of 12.5 per cent. Three types of threshers (hammer mill cylinder in hadamba thresher, spike tooth cylinder in hadamba thresher and raspbar cylinder in axial flow thresher) were used in threshing. The cylinder peripheral speed of 400, 450 and 500 rpm and three levels of concave clearance i.e. 5, 10 and 15 mm were used in the study. The experiment consisted of 27 treatment combinations (3x3x3) and each replicated thrice. The duration of experiment was two hours of continuous uniform threshing and every care was taken to ensure constant feed rate. The dried plants were fed manually to the thresher and the threshed seed samples were collected from the main outlet of thresher. Each seed sample was subjected to take observations on seed damage (%), threshing efficiency (%), standard germination (%) and electrical conductivity (m mhos $cm^{-1}seed^{-1}$) as per methods requested by RNAM (1983) and ISTA, (1999).

The visible damaged seeds were separated from the seed sample (100 gm) and the percentage of damaged seed was determined by dividing the weight of total damaged seeds to the weight of total sample seed multiplied by 100. The threshing efficiency was determined by calculating the percentage of unthreshed seeds from all outlets.. Physiological vigor of seed was determined using standard germination and electrical conductivity tests.

The seed germination test was conducted as per procedure given by ISTA, 1999 using top of paper method. About 300 (3 x 100) seeds were placed in petry plates on saturated moistened paper. The petry plates were kept at 20 ^{0}C in seed germinator. After 7 days the seedlings were evaluated and the normal seedlings were counted and expressed as germination percentage. The electrical conductivity of seed leachate was determined by soaking fifty seeds in 75 ml distilled water and kept at room temperature (25-30^0) for 24 hours. The observations were recorded with Elico Electrical Conductivity Meter (Type CM 82T) and calculated as m mhos $cm^{-1}seed^{-1}$.

The data for seed damage, threshing efficiency, germination percentage and electrical conductivity was statistically analyzed according to the factorial completely randomized design (CRD). The coefficient correlations among the dependent parameters were also determined.

Results and Discussion

The data was analyzed with respect to evaluate the effect of different threshing cylinders, cylinder speed and concave clearance on the dependent seed quality parameters like seed damage (%), threshing efficiency (%), standard germination (%) and electrical conductivity. Significant mean sum of squares due to treatment and their combinations showed presence of substantial amount of variation for all the parameters studied except electrical conductivity.

In order to find the optimum adjustment of the thresher and their effect on seed quality parameters, the mean values of different parameters obtained during the study are given in Table. 1

Physical parameters of seed quality

The seed damage increased with the

Table 1. Mean values of dependent characters at various threshing cylinders, cylinder speed and concave clearance in mustard crop.

Threshing Cylinders	Cylinder speed (rpm)	Concave clearance (mm)	Seed damage (%)	Threshing efficiency (%)	Germination (%)	Electrical conductivity (m mhos cm^{-1} $seed^{-1}$)
Hammer Mill Cylinder	400	5	3.70	96.41	86	0.311
		10	3.01	95.01	87	0.259
		15	2.86	92.40	92	0.245
	450	5	4.07	98.12	80	0.310
		10	3.68	96.31	82	0.290
		15	3.18	93.81	86	0.261
	500	5	6.73	98.82	78	0.364
		10	5.08	96.91	80	0.308
		15	4.69	95.41	84	0.302
Spike Tooth Cylinder	400	5	3.39	96.01	86	0.304
		10	2.86	94.71	87	0.245
		15	2.23	92.20	92	0.235
	450	5	4.70	97.22	82	0.319
		10	3.36	95.91	84	0.294
		15	2.90	93.31	86	0.265
	500	5	5.39	97.42	80	0.347
		10	4.90	96.41	82	0.332
		15	3.90	95.21	86	0.304
Raspbar Cylinder	400	5	2.86	95.01	88	0.302
		10	2.47	94.41	89	0.256
		15	2.02	91.40	94	0.230
	450	5	3.86	97.02	84	0.306
		10	3.13	95.41	85	0.269
		15	2.56	92.30	88	0.243
	500	5	5.01	97.72	82	0.337
		10	4.72	95.91	84	0.290
		15	3.66	94.23	88	0.270
CV (%)			3.78	0.77	1.45	10.94
CD (M)			0.074	0.399	0.675	0.001
CD (S)			0.074	0.399	0.675	0.001
CD (C)			0.074	ns	ns	0.001
CD (M xS x C)			0.223	ns	ns	0.003

M= Threshing Mechanisms, S= Cylinder speed, C= concave clearance increased cylinder speed and decreased concave clearance in all the three types of cylinders (Fig. 1). Maximum seed damage (6.73%) was observed when threshing was done by hammermill cylinder with the cylinder speed of 500 rpm and concave clearance of 5 mm. Under the condition of this study a cylinder speed of 400 rpm was found optimum for minimum damage of seed (2.02%), particularly when raspbar threshing cylinder was used at a concave clearance of 15 mm. The results confirm with the findings of *Singhal and Thierstein* (1987). They have reported that the performance for mustard threshing was better with spike tooth threshing cylinder at peripheral cylinder speed of 400 rpm with satisfactory minimum broken seeds.

The maximum threshing efficiency (98.82%) was observed when threshing was done by hammermill threshing cylinder with the cylinder speed of 500 rpm and concave clearance of 5 mm. The threshing efficiency decreased with decreasing the cylinder speed from 500 to 400 rpm and increasing the concave clearance from 5 to 15 mm (**Fig. 2**). This may be due to the resistance of siliquae as well as decrease in impact and frictional forces. It was also noticed that the higher seed damage was along with higher threshing efficiency at these treatment combinations. Reduced rubbing effect between cylinder and concave resulted in to minimum seed damage and low threshing efficiency.

With lower cylinder speeds the threshing efficiency tended to be incomplete, while seed damage became excessive with higher cylinder speed. It was noticed that both seed damage and threshing efficiency in Indian mustard crop increased with cylinder speed because of harder impact expediencies in the threshing mechanisms. These results suggested that for a particular type and size of threshing mechanism, an optimum cylinder speed existed at which seed damage will be minimized. The results confirmed with the findings

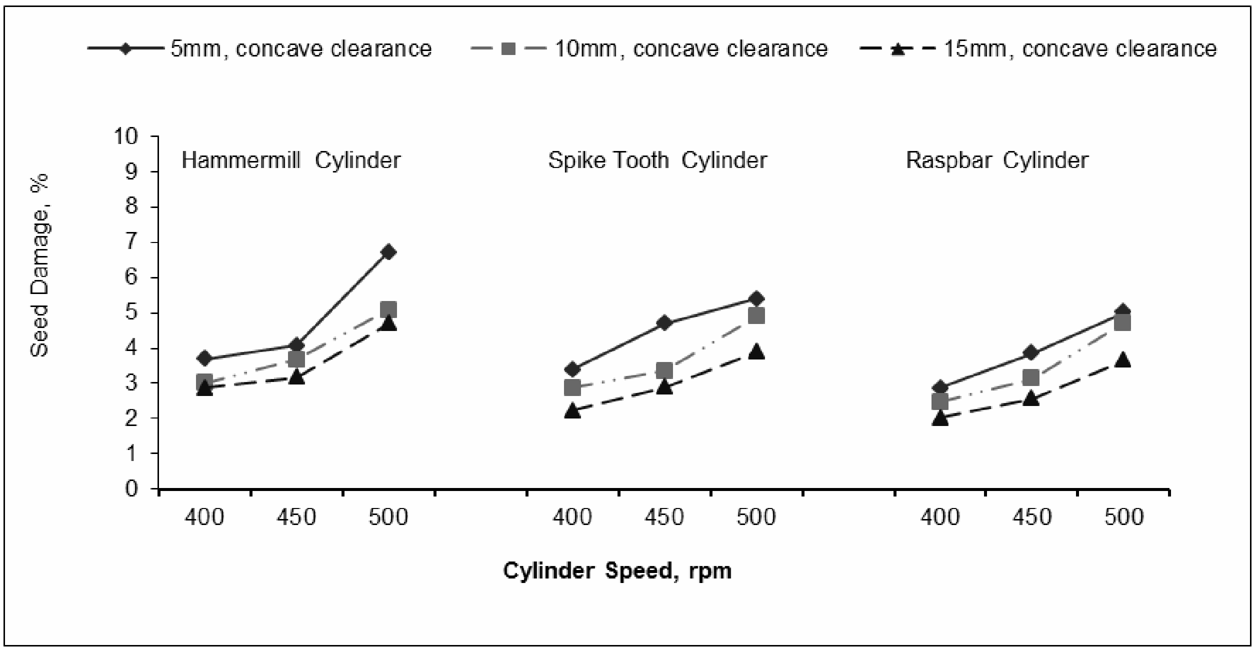

Fig. 1. Effect of cylinder speed and concave clearance on seed damage

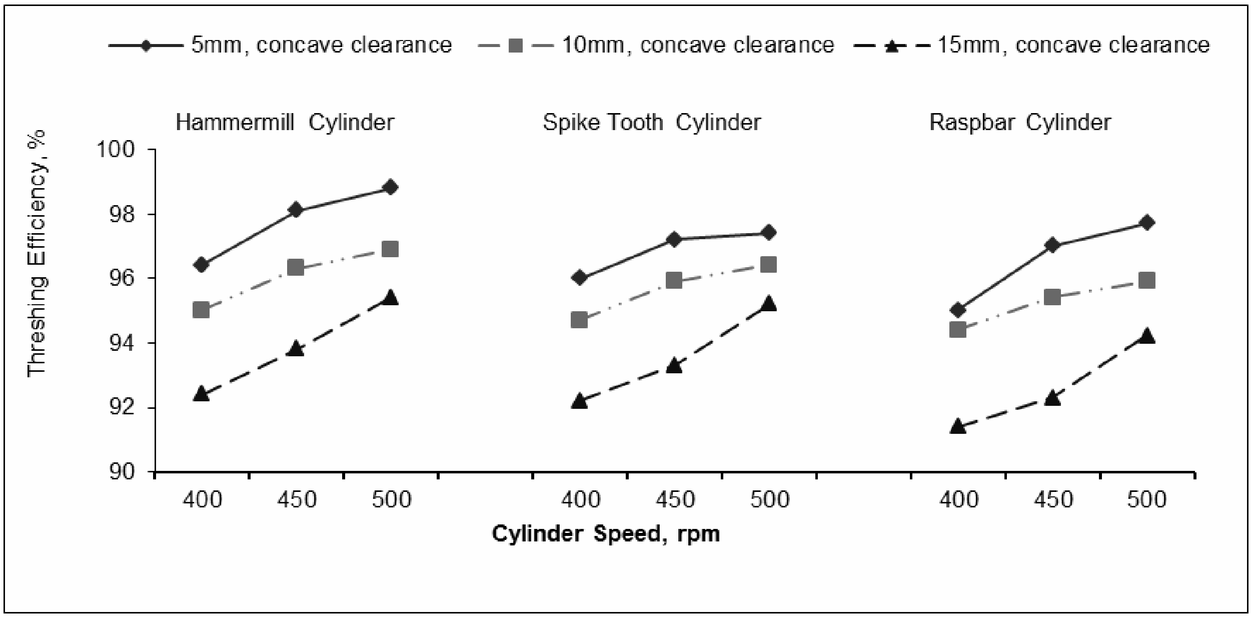

Fig. 2. Effect of cylinder speed and concave clearance on threshing efficiency

of *Neerajand Singh* (1988) for mustard threshing and *Sharma and Devnani* (1980) for cowpea and sunflower crops. *Martin et al (1991)* suggested that severe threshing may be manifested not only as visible damage but also as invisible damage, which may results in decreased viability and vigor of the wheat seed. *Jagadish and Shambulingappa (1984)* reported that the seed damage and threshing efficiency were directly proportional to each other w.r.t. cylinder speed and concave clearance. The rubbing effect between cylinder and concave was also reduced which resulted into minimum seed damage and low threshing efficiency. In sunflower, *Kaushal et al. (2003),* observed the minimum mechanical damage of 3.1 per cent, with the use of threshing speed of 600 rpm resulting in good germination of 81.4 per cent, however, in soybean *Jha et al.* (1996) reported that the significant mechanical damage were caused by the different threshing methods giving mechanical damage percentage of 6.77 to 14.32 per cent.

Physiological parameters of seed quality

For standard germination test the threshing speed and concave clearance interactions were found significant at higher level of significance (p=0.01). The standard germination was observed maximum (94%) in raspbar threshing cylinder at higher concave clearance (15 mm) and lower cylinder speed (400). It decreased to 78 per cent as cylinder speed increased from 400 to 500 rpm with concave clearance of 5 mm with the use of hammermill threshing cylinder (**table** 2). The results revealed that the standard germination was on a decreasing trend with the increase in both cylinder speed (400 to 500 rpm) and concave clearance (5 to 15 mm) in all the three types of threshing cylinders (**Fig. 3**). It was also noticed that the minimum damage and maximum germination were found under low cylinder speed and high concave clearance which could be attributed due to the reduced impact force to thresh the seed from the

Table 2. Pearson correlation coefficients among dependent parameters

	Seed damage	Threshing efficiency	Germination	Electrical conductivity
Seed damage	1.000	0.858 **	-0.861**	0.940**
Threshing efficiency	—	1.000	-0.719**	0.837**
Germination	—	—	1.000	-0.900**
Electrical conductivity	—	—	—	1.000

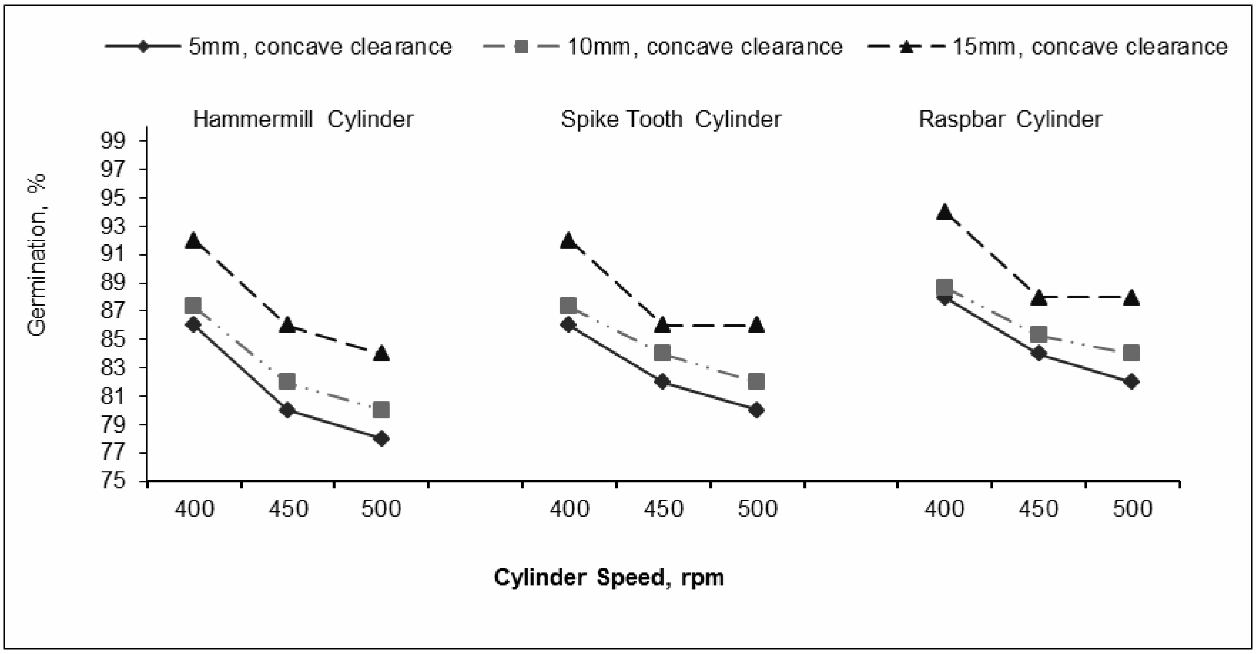

Fig. 3. Effect of cylinder speed and concave clearance on per cent germination

siliquae. The spike tooth cylinder threshing mechanism performed better than to other cylinder threshing mechanisms. The primary factor affecting germinability was cylinder speed, but the concave clearance interaction was also found significant. The threshing efficiency was found to be 97.05 to 98.65 per cent, seed damage of 5.0 per cent and germination 87 to 89 per cent. These results were similar to the findings of *Sinha and Pandita,(2002*).

The electrical conductivity values increased with cylinder speed which reflected the presence of internal seed damage inflicted by the impact during threshing. Reduced viability of apparently undamaged seed threshed at higher cylinder speed was attributed to invisible internal damage. The electrical conductivity of seed leachates increased as the cylinder speed increased and concave clearance decreased. The maximum electrical conductivity (0.364 m mhos $cm^{-1}seed^{-1}$) was observed when threshing was done by spike tooth threshing cylinder with the cylinder speed of 500 rpm and concave clearance of 5 mm. It reduced with increase in concave clearance and decreased cylinder speed. This trend was observed in all the three types of threshing cylinders (Fig. 4). The reduction in amount of seed leachate with increase of concave clearance may be due to the reason that at higher concave clearance, the rubbing effect was reduced, which resulted into less invisible seed damage. The reason could be attributed to the energy supplied to remove the siliquae from the plants and seeds from siliquae. High rubbing / impact/ shear forces resulted in more invisible seed damage and that caused more leaching out of soluble salts from the seed.

The correlation coefficients among dependent parameters namely, seed damage, threshing efficiency, germination and electrical conductivity are given in Table 2. The association among seed damage, threshing efficiency and electrical conductivity were found highly significant and positive. It showed that high magnitudes of seed damage, threshing efficiency and electrical conductivity of seed leachates adversely affected the germination and vigor potential of the seed lot.

From the ongoing discussion it can be concluded that internal damage sustained during threshing may explain some viability differences between threshing mechanisms and operational parameters. At higher cylinder speed the visible seed damage was within 6.73 per cent but the internal seed damage was very high as manifested by reduction in germination percentage. Using a rasp bar type threshing mechanism, the impact forces on seed increased with cylinder speed or with decreasing concave clearance. Maximum damage was observed when threshing was done by hammermill cylinder with the cylinder speed of 500 rpm and concave clearance of 5 mm.

The cylinder speed and concave clearance strongly influenced on seed viability, however leachates conductivity was less affected by cylinder speed. The electrical conductivity of seed leachates

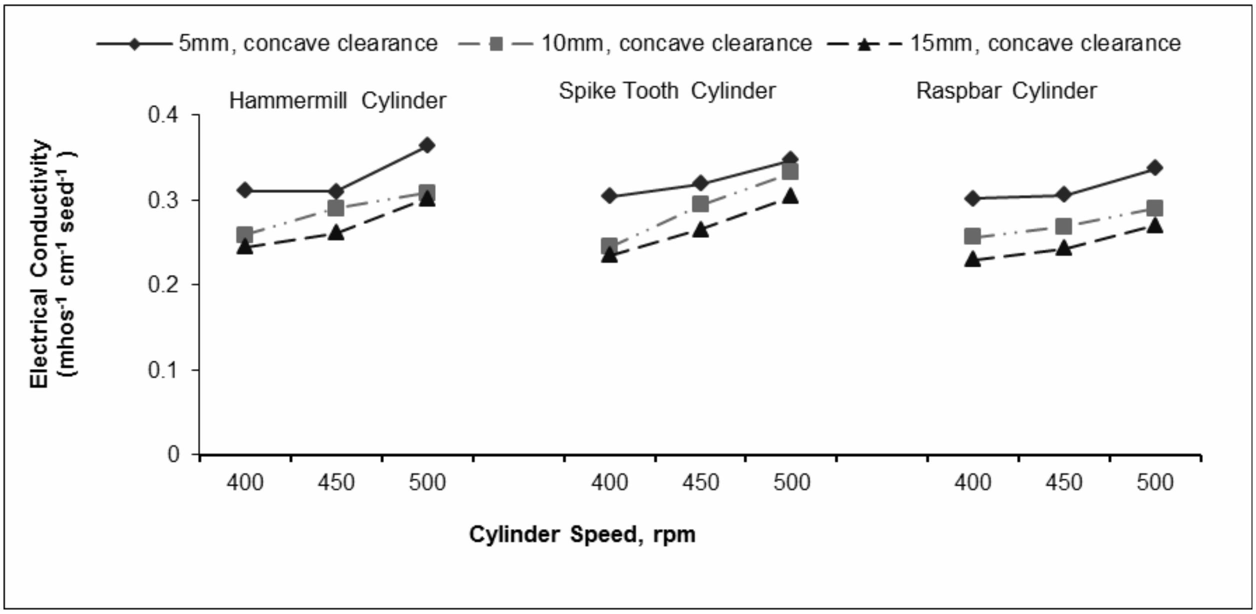

Fig. 4. Effect of cylinder speed and concave clearance on electrical conductivity

increased as the cylinder speed increased and concave clearance decreased. The threshing at high cylinder speed and lower concave clearance may have affected both viability and vigor.

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EFFECT OF NITROGEN AND POTASSIUM ON GROWTH AND YIELD OF FRENCH BEAN AND POTATO GROWN IN INTERCROPPING SYSTEM

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ABSTRACT

A field experiment was conducted during winter season of 2003-04 and 2004-05 at J.V.P.G. College Baraut (Bagpat) in Western Uttar Pradesh to study the optimum dose of Nitrogen for component crop in the sole Rajmash *(Phaseolus vulgaris* Linn) and Potato (S*olanum tubersum*) and in inter cropping system. French bean and Potato yields increased significantly up to the application of 120Kg N and 60 kg K20/ha. French bean equivalent yield were highest of 31.90 q/ha at 120 kg N/ha and 29.63 q/ha which were found 2.28 q/ha (7.9%) and 6.88 q/ha (28.2%) higher than the equivalent yield in sole potato and sole french bean, respectively. Inter cropping system produced 31.2 q/ha equivalent yield. Inter cropping system attained 1.17 L.E.R. which indicates that land may be utilized by 17% more than pure cropping.

Rajmash crop unlike other pulses, is assured crop responding well to irrigation and fertilizers. It gets favour of progressive farmers under input intensive agriculture. It produces 25-30 quintal grain per hectare which corresponds to 100-120 q/ha of wheat. It is grown with intensive inputs suitable for cultivation in relay cropping and inter cropping systems. Potato is an important crop of north India, grown with intensive inputs.

Keywords: Rajmash, Potato, Potassium and Nitrogen application.

Rajmash may be a suitable crop for growing with potato as inter crop because it also responds to higher inputs. Therefore, the present investigation was carried out on intercropping of Rajmash with potato in western Utter Pradesh, where intensive agriculture with higher inputs is mostly adopted.

Nitrogen and Potassium both elements are great importance in crop production. It is essential in the formation and transfer of starches and sugar thus required in large quantities for the crop like Potato. It counteracts the injuries effect of excess nitrogen in plants. (Yawalkar *et al.*1977). Inter cropping of Potato with Rajmash in rabi has been advocated Ali and Lal (1991) and Rajmash + Potato 3 : 2 ratio is ideally remunerative crop Ahalawat (1998).

MATERIALS AND METHODS

A field experiment was conducted during the winter season of 2003-04 and 2004-05 at Janta Vedic Post Graduate College Baraut, (Bagpat). The soil was silty Loam having 0.30 and 0.36% organic carbon, 14.5 and 15.0 Kg/ha available P and; 275 and 263 Kg/ha available K with 7.5 and 7.4 PH values in two years of experimentation. The treatments consisted two sole stands each of French bean and potato in inter crop association of French bean + potato in 3:2 row ratio at 45 cm row spacing in all cases, These three systems were applied with three levels of K (0.30 and 60 Kg K20/ha) and four N levels (0, 60, 120 and 180 Kg N/ha). Combinations of cropping system and K levels were kept in main plots while, N Levels were tried in Sub Plot of a Split Plot design replicated thrice. French bean variety Amber

and Potato variety 'Khufri Chandramukhi' were sown on 26 Oct. and 30 Oct. with 125 kg/ha seed of French been and 25 q/ha Potato seed tuber. An uniform basal dose of 80 Kg. P205/ha through single super phosphate was applied before sowing seeds & N.K. fertilizer were applied on row basis sown in different treatments. Potato crop was digged on 16th & 18th Feb. while French bean was harvested on 10th and 15th March during two years. The important result of investigation on pooled basis over years are presented for evaluation of french bean effect.

Results and Discussion

French bean

Effect of cropping system

Plant stand of French been was significantly high in pure cropping than inter cropping because in inter cropping only 60% area was sown with french bean against 100% in pure cropping. French bean in intercropping showed significantly high values of growth characters n) crop growth rate, relative growth rate, net assimilation rate and dry matter accumulation per plant than in sole cropping. The better growth of French bean in intercropping might be due to availability of more space particularly above

ground which was utilized by crop plants in their development by taking the advantage of solar radiation. However, plant height and number of branches could not be influenced significantly by cropping systems. It might be due to french bean competition with potato as also reported by Ahlawat (1998).

The yield attributes viz. number of pods/plant pods length and 100 grains weight were recorded significantly higher *in intercropping, than pure*

French bean. The translocation of more nutrients from vegetative parts to reproductive organs of crop plants due to better growth might have improved the yield attributes of French bean in intercropping system (Table-1).

Grain and straw yields per unit area were recorded significantly higher in pure french bean than intercropping and these are directly associated with more plant stand of French bean. Though, individual plants did better in intercropping but those could not compensate the losses caused by lower plant stand. Ahlawat (1998) also reported significantly higher yield of French bean in sole cropping than inter cropping system (Table-1).

Effect of Potassium

The increase levels of potassium showed significant increase in growth character viz: plant height, number of branches/plant, dry matter /plant, crop growth rate, relative growth rate and net assimilation rate upto the application of highest dose of 60 kg K20/ha, however in few cases increase beyond K_{30} dose was not significant. Similar results have been reported by Bhaskar *et al. (2001).*

The yield attributes viz: number of pods/plant, pod length, lOO-grains weight and yields per unit area of grain and straw showed significant increase with increasing K-Ievel up to 60 kg K20/ ha. These might be attributed to more utilization of potassium at increased rate of applications which met out the requirement of crop to produce high yield attributes and ultimately the yields of French been. The results confirm the finding of Singh and Tripathi (1994), and Bhaskar *et al. (2001).*

Table 1. Effect of treatments on different plant characters and yield of French Bean (Pooled over 2 years)

Treatment	Plant Population in ha	Plant height in cms.	No. of branches per (g) plant	Dry matter (g) per plant (g)	Crop Growth rate ($g/m^2/day$)			Relative growth rate (mg/g/day)			Net assimilation ($mg/dm^2/day$)			No. of Pods/ plant	Pod length (cm)	100 grain wt.	Grains yield q/ha	Straw yield q/ha
					35-70 DAS	70-105 DAS	105-140 DAS	35-70 DAS	70-105 DAS	105-140 DAS	35-70 DAS	70-105 DAS	105-140 DAS					
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Cropping Systems																		
Pure	31,000	45.65	5.19	18.92	8.042	7.560	7.008	28.162	22,432	8.628	1.203	0.933	1.011	10.56	8.20	43.01	24.41	28.46
Intercropping	182362	45.78	5.17	19.46	8.685	7.948	7.355	29.531	23.960	9.855	1.297	1.076	1.108	11.25	8.51	43.95	15.92	18.88
S.Ed.±	1690	0.20	0.09	0.10	0.073	0.102	0.082	0.231	0.143	0.095	0.025	0.009	0.017	0.19	0.08	0.17	0.19	0.53
C.D.(P=0.05)	3525	N.S.	N.S.	0.22	0.152	2.123	0.170	0.483	0.298	0.199	0.052	0.020	0.035	0.39	0.16	0.36	0.42	1.10
K-Levels (Kg/ha)																		
0	245000	44.55	5.06	18.22	7.483	7.199	6.845	27.340	22.131	8.308	1.135	0.936	0.971	10.00	8.14	42.46	18.70	22.37
30	246259	45,58	5,31	19.09	8.604	7.547	7.234	29.096	23.370	9.395	1.342	0.985	1.036	10.90	8.34	43.48	20.42	23.72
60	247292	47.02	5.16	20.25	9.003	8.515	7.643	30.113	24.088	10.025	1.274	1.092	1.161	11.83	8.58	44.52	21.38	24.93
S.Ed. 0.65	2069	0.24	0.11	0.13	0.089	0.125	0.100	0.283	0.175	0.177	0.030	0.012	0.021	0.23	0.09	0.21	0.24	0.24
C.D. (P=0.05)	N.S.	0.50	N.S.	0.26	0.186	0.260	0.209	0.591	0.365	0.244	0.034	0.024	0.043	0.48	0.19	0.44	0.50	1.35
N-Levels (Kg/ha)																		
0	244000	12.61	4.34	18.83	6.921	6.428	6.326	26.162	21.488	8.636	1.238	0.984	0.871	7.75	6.32	40.97	15.57	20.72
60	245277	44.64	5.22	18.78	8.138	7.446	6.984	28.981	23.074	9.290	1.268	0.983	1.072	9.86	6.32	43.26	18.49	22.71
120	247667	47.80	5.58	20.21	9.138	8.614	7.445	29.654	23.817	9.706	1.291	1.019	1.199	12.56	9.18	44.60	22.86	25.49
180	247778	48.61	5.59	20.92	9.305	8.526	7.969	30.580	24.407	9.335	1.206	1.032	1.095	13.47	9.82	45.10	22.75	25.77
S.Ed.	4333	0.32	0.06	0.17	0.273	0.268	0.300	0.681	0.546	0.527	0.025	0.013	0.023	0.13	0.12	0.25	0.28	0.66
C.D. (P=0.05)	N.S.	0.64	0.12	0.34	0.541	0.531	0.594	1.190	1.081	1.043	0.050	0.026	0.045	0.25	0.24	0.49	0.56	1.31

Effect of nitrogen

All growth characters displayed in (Table-1) were improved significantly by application of increased doses of nitrogen mostly upto 180 kg N/ha. It might be due to more absorption & utilization of nitrogen by crop plants which caused more cell elongation and carbohydrate production the two important characters responsible for growth. It may be supported by the finding of Jha *et at. (2000).*

Yield attributes and yields of French been as indicate in the (Table-1) showed significant increase in N levels upto the application of 120 Kg N/ha in most of the cases. These affects are attributed to better growth parameters of French bean at increased application of N. Besides, the translocation of carbohydrate and proteins from vegetative parts to reproductive parts of crop plant might have caused improvement in different yield attributes which ultimately enhanced grain and straw yields at increased application of nitrogen. Ali and Lal (1991) also reported that French bean is inefficient in symbiotic nitrogen fixation because of poor root nodulation thus responds well to higher dose of nitrogen application.

Potato Crop

Effect of cropping System

Plant stand of Potato was significantly more in pure cropping than intercropping system as only 40% area was sown with inter cropping against 100% in pure crop. Potato in intercropping system attained significantly more plant height than in sole cropping Dry matter accumulation and Tuber number per plant were not affected significantly but tuber size and tuber weight/plant were produced significantly higher in pure crop than inter cropping system. Tuber yield per unit area was significantly higher in sole cropping than intercropping system by margin of 95 q/ha or 38.6%. The lesser tuber yields in intercropping could be attributed to reduced plant density per unit area and also to the competition effect with French bean. Singh *et al.* (2002) also reported the similar results in potato + French bean inter cropping (Table-2).

Effect of Potassium

Growth of Potato was not influenced significantly by K- Levels, while among yield attributes, no. of tuber/plant and tuber weight per plant increased significantly with increasing K-Level upto 60 Kg K20/ha. The application of 60 kg K20/ha produced significantly higher (198.25q/ha). tuber yield which was 7.39 and 20.84 q/ha or 3.87 and 11.25% higher compared with K30 a Ko levels, respectively. These results are in accordance to those of Goswami (2002), Kumar *et al.* (2002) and Madan Pal *et al. (2002).*

Effect of N levels

N levels resulted significantly tallest plants at N 180kg/ha dose. Dry matter/ plant also showed significant increase upto highest tested dose of l80Kg N/ha. Number of tuber per plant, tuber size and tuber weight/plant showed significant increases upto the dose of 120 kg N/ha.

Tuber yield/unit area increased with increasing levels of nitrogen upto 180 kg N/ha but the margin of increase beyond 120 Kg N/ha was not significant. The dose of 120kg N/ha produced 209.25 q/ ha tuber yield which was found 25.85 q/ ha or 14.1 % and 60.05q/ha 40.2% higher over the tuber yields at N60 and No levels respectively. Such higher tuber yields are attributed to better yield

Table 2. Growth and yield of potato under different treatments

Treatments	Plant Stand (ha)	Plant Height (cm)	Dry matter/ plant (g)	No. of tuber/ plant	Tuber size (cc)	Tuber weight/pl ant (g)	Tuber yield (q/ha)
Cropping system							
Sole crop	83405	41.2	73.2	10.7	235	298.9	241.8
Inter crop	57641	44.5	73.3	10.6	238	279.4	136.1
SEd±	129.9	0.17	0.26	0.1	225	2.53	1.62
CD (P=0.05)	270.9	0.36	NS	NS	4.69	5.28	3.39
K levels (kg/ha)							
K 0	70198	42.9	73.2	9.9	229	281.8	177.4
K 30	70581	42.7	72.9	10.9	231	288.2	190.8
K 60	70789	43.0	73.6	11.2	235	297.5	198.2
SEd±	159.1	0.21	0.31	0.12	2.75	3.01	1.99
CD (P=0.05)	NS	NS	NS	0.25	NS	6.47	4.15
N levels (kg/ha)							
N 0	70126	38.3	64.5	8.9	208	234.5	149.2
N 60	70385	42.3	64.2	10.3	227	281.0	183.4
N 120	70624	44.4	76.9	11.5	249	319.7	209.3
N 180	70956	46.4	77.2	11.5	243	321.7	213.5
SEd±	223.5	0.36	0.51	0.2	2.04	3.14	2.92
CD (P=0.05)	NS	0.71	1.01	0.4	4.07	6.32	5.70

attributes. Similar finding have been reported by Dhangal *et al.* (2001) and Singh *et al. (2002).*

Equivalent Yield (q/ha)

Effect of cropping systems

The inter cropping of French bean + Potato has produced significantly maximum French bean equivalent yield. It was followed by potato sole crop while french been sole produced significantly minimum equivalent yield. The intercropping system produced 31.28 q/ ha French bean equivalent yield which was 2.28 q/ha or 7.86 percent and 6.88 q/ha or 28.20% higher than equivalent yields under sale potato and pure French bean, respectively. L.E.R. was also recorded maximum of 1.17 in inter cropping system. (Table-3).

Table 3. Frenchbean yield equivalent and LER under different treatments

Treatments	Yield (kg/ha)	LER
Cropping system		
Sole crop	24.4	1.0
Inter crop	29.0	1.0
SEd±	0.28	-
CD (P=0.05)	0.45	-
K levels (kg/ha)		
K 0	26.5	1.21
K 30	28.6	1.17
K 60	29.6	1.13
SEd±	0.22	0.01
CD (P=0.05)	0.45	0.02
N levels (kg/ha)		
N 0	21.9	1.17
N 60	27.5	1.18
N 120	31.9	1.17
N 180	32.1	1.17
SEd±	0.22	0.01
CD (P=0.05)	0.43	NS

Effect of K Levels

In case of K levels equivalent yield significantly increased upto highest tested dose of 60kg K20/ha which produced 29.63 q/ha equivalent yield which was 1.03 q/ha or 3.6 to and 3.17 q/ha or 11.98% higher than K30 and Ko Levels, respectively. L.E.R. was recorded significantly maximum of 1.21 in control and maximum of 1.31 at 60 kg K20/ha.

Effect of Nitrogen

Nitrogen application increased equivalent yield significantly upto the dose of 120 kg N/ha which produced 31.90 q/ha equivalent yield and it was found 4.38 q/ha or 15.92% and 10.05 q/ ha or 46.0 % higher than the equivalent yield at N60 and No dose, respectively. L.E.R. was not inf1uenced significantly by nitrogen levels. These results are in accordance to findings of Ahlawat (1998), Jha *et al.* (2000) and Dua *et al.* (2002) who reported higher production and L.E.R. in intercropping system (Table 3).

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PERFORMANCE OF WHEAT (*TRITICUM AESTIVUM*) - BASED CROPPING SYSTEMS IN SOUTHERN RAJASTHAN

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Abstract

A field experiment was conducted on sandy clay loam soil at Instructional Farm, Rajasthan College of Agriculture, Udaipur during *kharif* and *rabi* seasons of 2008-09 and 2009-10. The experiment consisted of 3 wheat [*Triticum aestivum* (L.) emend. Fiori and Paol.]-based cropping systems viz., maize (*Zea mays* L.)-wheat, groundnut (*Arachis hypogaea* L.)-wheat and clusterbean (*Cyamopsis tetragonoloba* (L.)Taubert) –wheat] and was laid out in randomised block design with three replications. Results revealed that amongst the *kharif* crops, maize produced mean maximum grain yield (2570 kg/ha) followed by groundnut (1164 kg/ha). Wheat grown after groundnut gave significantly higher grain (5091 kg/ha) and straw yields ((7614 kg/ha). Groundnut –wheat cropping system recorded the highest wheat-grain equivalent yield (7118 kg/ha), net returns (Rs 84245/-/ha), land use efficiency (71.9 %), production efficiency (27.1 kg/ha/day) and monetary efficiency (Rs 320.3/ha/day). The highest benefit:cost ratio (3.66 : 1), energy use efficiency (6.65) and energy productivity (214.8 g/MJ) were obtained under clusterbean-wheat cropping system while total input (34.64 x 10^3 MJ/ha) and output energy (228.5 x 10^3 MJ/ha) and energy output efficiency (921 MJ/ha/day) were maximum under maize-wheat cropping system.

Key words: Wheat, cropping systems, land use efficiency, production efficiency, energetics.

Maize (*Zea mays* L.) -wheat [*Triticum aestivum* (L.) emend. Fiori and Paol.] is the dominant cropping system under Sub-humid Southern Plain and Aravalli Hills Zone of Rajasthan (DOR, 2006). But continuously following a cereal-cereal cropping system on the same piece of land over years has led to soil fertility deterioration and questions are being raised on its sustainability (Prasad, 2005). Efforts are therefore underway to find alternative cropping systems specially those involving legume which have soil recuperative properties (Sharma *et al.*, 2009). Increase in the cost of commercial input energy and decline in fuel reserve promoted the researchers to work out cropping system with better energy use efficiency. The present investigation was therefore, undertaken to study the performance of different wheat-based cropping systems under Sub-humid Southern Plain and Aravalli Hills Zone of Rajasthan.

Materials and Methods

A field experiment was conducted during two consecutive *kharif* and *rabi* seasons of 2008-09 and 2009-10 at Instructional Farm, Rajasthan College of Agriculture, Udaipur situated under Sub-humid Southern Plain and Aravalli Hills Zone of Rajasthan. The soil was sandy clay loam in texture, slightly

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alkaline in reaction (pH 7.9) and calcareous with low in available nitrogen (223.42 kg/ha), sulphur (10.22 kg/ha) and zinc (0.530 ppm), medium in available phosphorus (13.52 kg /ha) and rich in available potassium status (218.54 kg /ha). The experiment consisted of 3 wheat [*Triticum aestivum* (L.) emend. Fiori and Paol.]-based cropping systems [Maize (*Zea mays* L.)-wheat, groundnut (*Arachis hypogaea* L.)-wheat and clusterbean (*Cyamopsis tetragonoloba* (L.)Taubert) –wheat] and was laid out in randomised block design with three replications. The details of varieties used, eed rate, fertilizer doses and spacing are given in Table 1. Nitrogen, phosphorus and potassium were supplied through urea, single super phosphate and muriate of potash, respectively.

Comparison among the cropping systems was done by converting the grain/pod/seed yield into wheat-grain equivalent yield on price basis (Yadav and Newaj 1990). The economic returns (Rs/ha) and cost of cultivation (Rs/ha) for individual crop in sequences were calculated on the basis of prevailing market prices of inputs and selling prices of produce during the years. The intensification of time was measured by calculating values of land use efficiency taking crop duration in individual cropping system dividing by 365, production efficiency by taking wheat-grain equivalent yield of cropping system dividing by total duration of that cropping system and monetary efficiency taking net monetary returns of the cropping system dividing by total duration of that cropping system (Yadav *et al.* 2005). The crops were harvested at physiological stage of maturity and recorded the yields.

Energy input and output was calculated using energy equivalents as suggested by Mittal *et al.* (1985). The energy use efficiency, energy productivity and energy output efficiency were calculated by using the following formulae:

$$\text{Energy use efficiency} = \frac{\text{Energy output}}{\text{Energy input}}$$

$$\text{Energy output efficiency (MJ/ha/day)} = \frac{\text{Output energy (MJ/ha)}}{\text{Total duration of system (days)}}$$

$$\text{Energy productivity (g/MJ/ha)} = \frac{\text{Grain yield (g)}}{\text{Input energy (MJ)}}$$

Results and Discussion

Crop productivity

During *kharif* season, maize recorded the highest grain yield, followed by pod yield of groundnut and seed yield of clusterbean on mean basis. Maize recorded 1406 and 1528 kg/ha higher grain yield over groundnut pod and clusterbean seed yields, respectively. Similarly, maize recorded the highest stover yield over haulm yield of groundnut and straw yield of clusterbean and registered 1853 and 2035 kg/ha higher stover yield over groundnut haulm and clusterbean straw yields, respectively.

The maximum grain yield (5091 kg/ha) was recorded when wheat was grown after groundnut which was significantly higher by 7.6 and 21.6 per cent than that after clusterbean and maize, respectively. It might be due to the fact that nitrogen fixed by preceding legumes was better utilized by the succeeding crop of wheat. Singh *et al.* (2003) also reported the beneficial effect of including legumes in sequence on soil health and yield of

Table 1. Cropping systems and production technology adopted.

Cropping systems	Variety		Seed rate (kg/ha)		Spacing (cm x cm)		Fertilizer (kg/ha) (N: P_2O_5: K_2O)		Duration (days)
	Rainy	Winter	Rainy	Winter	Rainy	Winter	Rainy	Winter	Total
Maize-wheat	Pratap Makka 5	Raj 4037	20	100	60 x 25	22.5	90:35:30	120:40:30	248
Groundnut - wheat	Pratap Mungphali	Raj 4037	100	100	30 x 10	22.5	25 :60:30	120:40:30	263
Clusterbean - wheat	RGC 936	Raj 4037	20	100	30 x 10	22.5	20:40:30	120:40:30	254

succeeding crop compared with that of the cereal – cereal crop sequence.

System productivity

Among the various wheat – based cropping systems, groundnut-wheat cropping system recorded significantly higher system productivity measured in terms of wheat-grain equivalent yield (7118 kg/ha) over other cropping systems. It may be attributed to higher price of groundnut and higher wheat grain yield than the other cropping systems tried. The magnitude of increase in wheat-grain equivalent yield under groundnut-wheat cropping system was 12.3 and 18.2 per cent than that of under clusterbean - wheat and maize - wheat cropping systems, respectively. On the other hand, the lowest wheat-grain equivalent yield (6022 kg/ha) was achieved in maize-wheat cropping system mainly due to lower price of maize grain and could also be attributed to the exhaustive nature of maize crop which leads to poor yield of succeeding wheat crop. The findings are in close conformity with those of Kumar *et al.* (2008).

Economic analysis

Among the different wheat – based cropping systems, groundnut – wheat cropping system gave significantly higher net returns of Rs 84245/- /ha probably due to higher price of groundnut and higher wheat grain and straw yields. On the other hand, clusterbean – wheat cropping system recorded significantly higher benefit : cost ratio and registered 6.7 and 5.2 per cent higher than maize – wheat and groundnut – wheat cropping systems, respectively.

Land use efficiency

Groundnut – wheat cropping system registered the highest land use efficiency (71.9 %) because this system occupied the field for the longest duration (263 days) and was followed by clusterbean-wheat cropping system (69.5 %). Maize-wheat cropping system had the lowest land use efficiency (67.9 %) because this system occupied the field for less duration (248 days). The results are in agreement with those of Jain *et al.* (2011) who also reported the highest land use efficiency in groundnut – wheat cropping system.

Production and monetary efficiency

Groundnut-wheat cropping system recorded the highest production (27.1 kg/ha/day) and monetary efficiencies (Rs 320.3 /ha/day) while the lowest

Table 2. Yield, wheat-grain equivalent yield, economics, land use efficiency (LUE), production efficiency (PE) and monetary efficiency (ME) as affected by various cropping systems (Pooled data of 2 years).

Cropping	Seed/grain/pod yield (kg/ha)		Stover/straw/haulm yield (kg/ha)		Wheat-grain equivalent yield (kg/ha)	Net retunrs (Rs/ha)	Benefit: cost ratio	LUE (%)	PE (kgha/day)*	ME (Rs/ha/day)**
	Rainy	Winter	Rainy	Winter						
Maize-wheat	2570	4187	3884	6450	6022	73185	3.43	67.9	24.3	295.1
Groundnut - wheat	1164	5091	2031	7614	7118	84245	3.48	71.9	27.1	320.3
Clusterbean - wheat	1042	4731	1849	7068	6341	76796	3.66	69.5	25.1	302.3
CD (P = 0.05)		212		276		3381	0.04			

production (24.3 kg/ha/day) and monetary efficiencies (Rs 295.1 /ha/day) were recorded with maize –wheat cropping system due to lower wheat-grain equivalent yield as well as net returns (**Table** 2). The results are in agreement with those of Kumpawat (2001) who also reported the highest land use efficiency under groundnut-wheat cropping system.

Energetics

The total input energy in different cropping systems ranged from 29.53 to 34.67 x 10^3 MJ/ha (**Table** 3). Among the different cropping systems, maize-wheat required the highest input energy (34.67 x 10^3 MJ/ha) while the lowest input energy was recorded in clusterbean-wheat cropping system (29.53 x 10^3 MJ/ha). On the other hand, total output energy (228.5 x 10^3 MJ/ha) and energy output efficiency (921.4 MJ/ha/day) were higher under maize-wheat cropping system followed by groundnut – wheat cropping system (224.5 x 10^3 MJ/ha and 853.6 MJ/ha/day)). Clusterbean - wheat cropping system recorded maximum energy use efficiency (6.65). Energy productivity was also the highest with clusterbean – wheat cropping system (214.8 g/MJ) because of lower input energy while the lowest energy productivity (173.7 g/MJ) was under maize – wheat cropping system due to lower yield and higher input energy. Kumar *et al.* (2008) also reported the lowest energy productivity in cereal – cereal cropping system due to higher input energy.

The present study shows that groundnut – wheat cropping system holds considerable promise as an alternative to the maize-wheat cropping system. The proposed cropping system can also help in reducing the shortage of oilseeds in India.

Table 3. Energy use efficiency of different wheat-based cropping systems (Pooled data of 2 years).

Cropping systems	Total input energy (x 10^3MJ/ha)	Total output energy (x 10^3MJ/ha)	Energy use efficiency	Energy productivity (g/MJ)	Energy output efficiency (MJ/ha/day)
Maize-wheat	34.67	228.5	6.59	173.7	921.4
Groundnut - wheat	34.44	224.5	6.52	206.7	853.6
Clusterbean - wheat	29.53	196.3	6.65	214.8	772.9

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IMPACT OF IMPROVED TECHNOLOGY ON SOYBEAN PRODUCTIVITY IN FRONTLINE DEMONSTRATION

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ABSTRACT

Krishi Vigyan Kendra, Sehore (M.P.) during the period from 2006-07 to 2010-11 conducted a total 64 frontline demonstration of soybean crop. Cultivation practices comprised under FLD *viz.* use of improve variety (JS-93-05, JS - 9560), seed treatment, seed inoculation, spacing 30cm, balance application of fertilizers (20:60:20 kg N:P:K per ha), weed control and plant protection measures show that percentage increase in the yield of soybean ranged from 14.28% to 29.00% over farmer's practice. The highest seed yield 18.9 q ha^{-1} was recorded in the year 2010-11 in FLD, which was 29.00% more over the farmer's practice (14.6 q ha^{-1}). The highest extension gap which ranged from 1.8 q ha^{-1} to 4.3 q ha^{-1} during the period. The additional cost Rs. 700 to Rs.1500 gave additional net return, it was ranged from Rs.3130 to Rs. 8940 per hectare .The increased benifit : Cost ratio was also calculated, it was ranged from 1:1.8 to 1:2.8 in demonstration & 1:1.7 to 1:2.1 in farmers practice.

Keywords: Soybean, frontline demonstration

INTRODUCTION

Soybean (*Glycine max* L. merril) occupies third position among the oilseed crop in India after groundnut and rapeseed-mustard. Soybean is the number one oilseed crop in the world has recently occupied on important place in the edible oil and agricultural economy of the country. Soybean is established as major rainy season in India particularly in central part of the country. Madhya Pradesh has its major share in Area (70%) and production (65%) of soybean in India and hence knows as soybean state. In Madhya Pradesh the average productivity of soybean in very low (10q ha^{-1}) as compare to genetic potential (25q ha^{-1}). The adoption of recommended production technology among farmers is not very encouraging. The reason may be that the most of the technology have not yet reached to the farmer's fields. Hence an efficient technology transfer system is required out of these conducts of demonstration on farmer fields have proved effective for creating awareness and acceptance of improved technologies. Keeping in this view the present study was carried out to find out the impact of improved technologies on soybean productivity in Sehore district of Madhya Pradesh.

METHODOLOGY

The present study was carried out by the Krishi Vigyan Kendra, Sehore (M.P.) during *Kharif* season from 2006-07 to 2010-11 in farmer's field of 5 adopted villages *viz.* Mograram, Dhablamata, Bheelkhedi, Rola & Amlaramjipura. The total number of farmers under this programme was 64. The total area in 5 years was 25 hectare for demonstration of recommended improve practices of soybean. In the demonstration, one control plot was also kept where farmer's practice was carried out. Data were collected with the help of personal

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contact and observations on yield data was also recorded at the time of separate threshing. The yield of each demonstration was recorded in a systematic manner and the yield of farmer's practices was also recorded at the same time.

The results were compared with full package of practices given *viz*. variety (JS – 9305, JS - 9560), seed treatment with fungicide, seed inoculation with Rhizobium & PSB culture, spacing, balanced fertilizers (20:60:20 Kg/ha) as per soil test value, weed control and plant protection measures. The yield data were collected from both the demonstration and farmer's practice and their technology gap; extension gap and the technology index were worked out (Samui *et al*., 2000) as given below.

Technology gap = Potential yield- demonstration yield

Extension gap = Demonstration yield - farmer's yield

$$\text{Technology index} \left\{ \frac{\text{(potential yield- demonstration yield)}}{\text{Potential yield}} \right\} 100$$

Result and Discussion

Total 64 frontline demonstrations were conducted at farmer's field in their farming situation. Table 1 indicated the

Table 1. Adoption gap of recommended soybean technology and percentage of farmers of non-adoption recommended practices.

Sl. No.	Items	Existing practices	Recommended practices	Gap in adoption	% of farmers	Farmers prioriti-zation for critical input
1.	Variety	JS-335, Samrat, Sonia	JS-93-05, JS – 95-60	Full	90	I
2.	Seed rate	100 Kg ha^{-1}	75 Kg ha^{-1}	Partial	80	V
3.	Seed treatment	No use of fungicide	Seed treatment with Thirum 2g+ Carbendazim 1g per kg seed or Calaxin with thiram (Vitavax power) @ 2 g/kg seed	Full	85	III
4.	Seed inoculation	No use of culture	Seed inoculation with Rhizobium 5gm+PSB gm per kg of seed	Full	85	IV
5.	Spacing	9" (22.5cm)	16-18"(30cm)	Full	90	VIII
6.	Fertilizers	50 kg DAP ha^{-1}	20:60:20 Kg N:P:K(100 Kg DAP ha^{-1})	Partial	75	II
7.	Weed control	One hand weeding	One spray of post emergence weedicide+ one hand weeding	Partial	80	VI
8.	Plant Protection	1. Application of insecticide without knowledge 2. Use of incorrect dose	1. Need based insecticide spray 2. Use of correct dose and time of insecticide	Partial Partial	90	VII

factor considered for selection of critical input under FLD. There was partial gap in adoption of recommended practices over farmer's practices with regards to seed rate, fertilizers, weed control and plant protection measures. Whereas complete gap (full) was noted for variety, seed treatment, seed inoculation and spacing.

Table 2 revealed that the highest yield of soybean (18.9 q ha^{-1}) was obtained during the 2010-11 with the additional amount of Rs. 1500 over farmer's practices, which yield 14.6 q ha^{-1}. The average yield under demonstration fluctuated and ranged from 14.16 q/ha to 18.9 qha^{-1} during the 2006-07 to 2010-11. The results clearly indicated that the yield of soybean could be increased by 14.28% to 29.0% over the yield obtained under farmer's practices of soybean cultivation due to adoption of appropriate production technology. Dixit and Singh (2003), Patel *et al.* (2003) and Singh (2002) were also found the similar type of findings.

The results indicated that the frontline demonstration has given a good impact on the farming community of Sehore district as they were motivated by the new agricultural technology applied in the FLD plots.

The extension gap which ranged from 1.8 q ha^{-1} to 4.3 q ha^{-1} during the period of study emphasized the need to educate the farmers through various means for adoption of improved agricultural production technologies to reverse this trends of wide extension gap. More use of latest production technologies with high yielding varieties will subsequently change this alarming trends galloping extension gap.

The technology gap observed ranged from 1.1 q ha^{-1} to 10.8 q ha^{-1}. The technology gap observed may be attributed to the dissimilarity in the soil fertility status and weather condition. Hence variety wise location specific recommendation appears to be necessary to minimize the technology gap for yield level of different situations.

The technology index shows the feasibility of the evolved technology at the farmer's fields. The lower value of technology index more is the feasibility

Table 2. Productivity, extension gap, technology gap and technology index of soybean as grown under FLD and existing package of practices.

Year	Area (ha)	No. of Demo	Yield q/ha		% increase over FP	Extension gap q/ha	Technology gap q/ha	Technolog y index%
			FLD	FP				
2006-07	5	12	14.16	12.39	14.28	1.8	10.8	43.2
2007-08	5	13	15.19	12.87	18.03	2.3	9.8	39.2
2008-09	5	13	14.88	11.57	28.60	3.3	10.1	40.4
2009-10	5	13	18.05	15.00	16.89	3.1	1.9	9.5
2010-11	5	13	18.90	14.60	29.4	4.3	1.1	5.5
Total	25	64	-	-	-	-	-	-
Mean	**-**	**-**	**16.24**	**13.29**	**21.44**	**2.9**	**6.7**	**27.8**

Table 3. Economics analysis of demonstration and farmers practice.

Year	Demonstration			Farmer practices			Additional cost of cultivation Rs ha^{-1}	Additional net return Rs ha^{-1}	Incremental benefit ratio	
	Cost of cultivaton Rs ha^{-1}	Gross returns Rs ha^{-1}	Net return Rs ha^{-1}	Cost of cultivaton Rs ha^{-1}	Gross returns Rs ha^{-1}	Net return Rs ha^{-1}			DP	FP
2006-07	14300	25740	11440	13300	22610	9310	1000	3130	1.8	1.7
2007-08	14500	26100	11600	13500	22275	8775	1000	3825	1.8	1.7
2008-09	13800	35190	21390	12500	26250	13750	1300	8940	2.8	2.1
2009-10	15500	34295	18795	14800	28500	13700	700	5795	2.2	1.9
2010-11	18500	37800	19300	17000	29200	12200	1500	8600	2.0	1.7
Mean	15320	31825	16505	14220	25767	11547	1100	6058	2.12	1.82

of the technology. As such, reduction of technology index from 5.5 % (2010-11) to 43.2 %(2006-07) exhibited the feasibility of technology demonstrated. The variation in yield from location to location can be accounted for varying climatic condition, prevailing microclimatic and variation in agricultural practices followed. More or less similar reasoning was provided by other workers (Sagar and Chandra, 2004).

Table 3 showed that the total cost of demonstrations was Rs. 13800 to Rs. 18500 per hectare while the cost of farmer practice (FP) Rs.12500 to 17000 ha^{-1}. The table 3 also revealed that the net return from demonstration was Rs. 16505 ha^{-1}, while net return from farmers practice was Rs. 11547 ha^{-1}. It means the net return from demonstration was higher than farmer's practices.

The additional cost Rs.700 to Rs.1500 gave additional net return, it was ranged Rs. 3130 to Rs. 8940 per hectare. The increased benefit: cost ratio was also calculated, it was ranged from 1:1.8 to 1:2.8 in demonstration & 1:1.7 to 1:2.1 in farmers practice.

Thus, it was clearly showed that the demonstration of soybean with full package was better to farmer's practices.

Conclusion

The frontline demonstration (FLDs) plays a very important role to disseminate recommended technology because it shows the potential of technologies resulting in an increase in yield at farmer's level. Many farmer approached the FLD farmers to procure the seed of soybean high yielding variety and now the area under these varieties have increased which will spread in the whole including the adjoining area.

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EFFECT OF BIOFERTILIZERS ON BIOMASS PARTITIONING PATTERN AND YIELD OF VEGETABLE PEA

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Abstract

The supplementation of live inoculums of Rhizobium, Azotobacter, Azospirillum, and phosphate solubilizing bacteria (PSB) in the rhizosphere of pea can significantly enhanced the biomass accumulation and yield (27 – 55 %) as compared to uninoculated control. The degree of influence was found to be dependent on variety and preference of genotypes for biofertilizer. A steady increase in root, shoot and leaf biomass accumulation from seedling stage to flowering was evidenced in all the three variety. The shredding of leaf biomass was highest irrespective of varieties followed by shoot biomass at pod formation stage, thereafter up to senescence the leaf and shoot biomass was static. A preference to PSB for Arkel and Rhizobium plus free N fixers for Azad P1 and Azad P3 in terms of accumulation of partitioned biomass were noticed which suggested the use of low cost biofertilizers for higher productivity in pea.

The symbiotic association between Rhizobium sp. and pea (Pisum sativum) is well documented in the literature. In the recent years the application of free N fixers like Azotobacter, Acetobacter and Azospirillum coupled with phosphate solubilizing bacteria (PSB) in the rhizosphere are gaining importance. Scientific literatures indicated the significant positive effect of these microorganisms on peas and beans besides cereals and sugarcane crops (Yakout et al 2001; Wu et al 2005). Dry matter synthesis, accumulation and their distribution pattern are dependent on the genotypic characteristics of plants and environmental factors influence the rhizosphere chemistry and biological equilibrium of soil (Wu et al 2005,Tiwary et al 1999; Srivastava et al 1998). Studies on the biomass production and its partitioning are important aspect of crop management because grain yield largely depended on the partitioning of photosynthates at critical crop growth stages (Clark and Smith 1992, Yan, 1981). The present experiment was carried out with Rhizobium, Azotobacter, Azospirillum and PSB, and observed their impact on the biomass-partitioning pattern of three vegetable pea varieties. This study reports on biomass partitioning in vegetable pea sequentially over three growing phase covering the period from active growth stage to maturity and senescence.

Materials and Methods

An explorative trial on impact of biofertilizers on vegetable pea varieties of eastern Uttar Pradesh was conducted during rabi season (November 2000 to January 2001). The experiment was repeated during rabi season in 2001-2002 and 2002-2003 at the Institute research farm (82.52^0 longitudes and 25.10^0 N latitude), Varanasi. The experiment was conducted with three most promising varieties of pea (Azad P1, Azad P3 and Arkel) and four biofertilizers

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Rhizobium, Azotobacter, Azospirillum and phosphate solubilizing bacteria (PSB) along with control (no applied biofertilizers) in a randomized block design (RBD) with three replications. The soil of the experimental site was recently formed alluvium of Indo-Gangetic plain, sandy loam in texture, neutral in reaction (pH 7.2-7.8), low to medium in available N (275-310 kg/ha) and K (290-340 kg/ha) and medium to high in available P (15-25 kg/ha). The physico–chemical properties of the soil were analyzed, following the standard procedure Jackson (1967). Certified seed of pea variety were treated @ 500 g / 10 kg seeds of individual N fixing biofertilizers following the standard methodology, and sown in each plot at a spacing of 30 x 10 cm with the mechanical seed drill and then covered with PSB @ 25 kg/ha plus N fixer @ 10 kg/ha mixed with finely tilth garden soil. The recommended fertilizer doses N @ 30 kg/ha, P @ 60 kg/ha and K @ 60 kg/ha were applied during the field preparation. The plants were sampled at active growth stage (S1 = 20 days after sowing, DAS), pod-filling stage (45 DAS, S2) and at maturity/ harvesting stage (75 DAS, S3) for the observation of partitioned biomass. On each sampling occasion, the biomass was separated into leaf, stem, and root, weighed and oven dried (60 ^{0}C) for further chemical analysis. The yield and yield attributing parameters were recorded and correlated with the biomass-partitioning pattern.

RESULTS AND DISCUSSION

The application of microbial inoculants as seed treatments and soil application were influenced significantly the accumulated biomass in fresh leaf, shoot and roots of vegetable pea at three critical growth stages. The highest amount of fresh leaf biomass (29.19, 79.43 and 59.32 g) accumulated at S1, S2, and S3 growth stages respectively was observed in Azad P3 when treated with *Rhizobium* (Table 1). The fresh leaf biomass was 60.3 %, 63.42 % and 66.2% higher when treated with *Azotobacter, Rhizobium* and PSB respectively as compared to the control treatment in cv. Arkel. The maximum leaf biomass accumulation stage coincided with the pod filling stage (45 DAS) in all the three varieties. The reduction in the peak of leaf biomass production was observed in all the three variety of pea just after the pod filling stage. The overall performance of Azad P3 was significantly superior as compared to Arkel and Azad P1 in relation to leaf biomass production. The highest average fresh leaf weight (24.27 and 63.19 g) at active and pod filling stage in Azad P1 was recorded when treated with PSM and *Azotobacter* respectively, which was 59 % and 68.85 % higher than the control pea. In Arkel the highest average fresh leaf weight (28.97 and 76.44 g) at active and pod filling stage was observed when treated with *Azotobacter* and *Azospirillum* respectively which was 55.3 % and 45.18 % % higher than the control pea. The maximum shoot biomass production (89.82 g) was achieved at pod filling stage by Azad P 3 cultivar when treated with *Rhizobium* strains that was 61.95 % higher than that of control pea. The root and shoot biomass almost remain constant while leaf biomass decreased significantly from pod filling stage to maturity and senescence. The decreased in the leaf biomass was partitioned towards the formation of pod. Similar trend in shredding leaf biomass for pod formation in other crops has been reported (Hay, 1995; Zhang et al. 2004). The highest amount of average fresh root biomass (2.42 g) in Azad P1 at pod filling stage was observed when treated with

Table 1. Effect of biofertilizers on fresh biomass weight (g) of three vegetable pea varieties

Treatments		**Azad P1**			**Azad P3**			**Arkel**		
Azotobacter		**S1**	**S2**	**S3**	**S1**	**S2**	**S3**	**S1**	**S2**	**S3**
	Leaf	23.1	63.19	43.21	26.12	69.88	48.43	28.97	70.3	63.21
	Shoot	24.93	62.52	55.29	41.92	75.79	51.33	33.92	75.82	65.92
	Root	1.43	2.18	2.15	1.46	1.69	1.70	1.43	1.56	1.51
PSB	Leaf	24.27	62.99	45.92	27.76	78.43	59.32	28.77	69.37	54.38
	Shoot	29.25	68.91	49.30	45.31	83.18	63.28	35.19	73.37	58.53
	Root	1.45	2.42	2.28	1.47	1.69	1.73	1.46	1.70	1.71
Rhizobium	Leaf	23.91	41.05	35.78	29.19	79.43	52.28	28.73	68.52	51.58
	Shoot	34.97	53.29	38.18	59.63	89.82	55.91	37.26	71.53	55.39
	Root	1.41	1.59	1.53	1.41	1.37	2.53	1.4	1.89	1.92
Azospirillum	Leaf	24.07	43.51	29.31	26.88	72.08	45.93	28.63	76.44	65.32
	Shoot	31.32	49.31	31.73	55.36	75.52	49.89	39.45	79.43	53.31
	Root	1.34	1.26	1.29	1.50	2.59	1.39	1.32	1.68	1.69
Control	Leaf	14.32	35.27	27.32	17.61	50.38	39.31	16.03	34.54	22.38
	Shoot	17.92	37.28	29.39	21.49	55.65	42.99	21.90	21.38	29.98
	Root	0.85	1.51	1.53	0.81	1.43	1.21	0.76	1.09	1.01
$LSD_{0.05}$	Leaf	0.69	1.23	2.93	0.69	1.23	2.93	0.69	1.23	2.93
	Shoot	5.69	8.23	3.93	5.69	8.23	3.93	5.69	8.23	3.93
	Root	0.09	0.12	0.35	0.09	0.12	0.35	0.09	0.12	0.35

S1- active growth stage, S2- pod filling stage, S3- harvesting stage

PSB. The PSB mobilises fixed /non-exchangeable P to readily available labile P which helped in root proliferation and nodulation of pea. The PSB resulted in significant increases in nodulation, nitrogenase activity, growth and grain yield of pea (Srivastava et al 1998). Similarly the highest fresh root biomass (1.47 g) was recorded in Azad P3 (inoculated with PSB) at active growth stage that was 55.1 % higher than the control pea. The highest fresh root weight (2.59 g) was observed at pod filling stage when treated with *Azospirillum*, which was 55.2 % higher than the control pea. In Arkel the highest average fresh root weight (1.43 g) was noted at active growth stage when treated with *Azotobacter* followed by *Azospirillum* at pod setting stage which was 53.15 % and 60.8 % higher than the control pea. The highest value of mean leaf dry weight (14.86 g) among all the three pea cultivars was observed in *Rhizobium* treated Azad P 3 which was 41.79 % higher than the control pea. The highest mean shoot and root dry weight (17.82 and 1.34 g) again reported with the Azad P 3 treated with PSM and *Azospirillum* inoculants, which was 89.88 % & 66.41 % higher than, uninoculated pea respectively. The inoculation of *Rhizobium sp.* and free N – fixers induced fixation of more amount of atmospheric nitrogen in the active root nodule of vegetable pea, increased leaf area index, which increases the utilization of solar energy and enhanced the accumulation of photosynthates in the tissue (Lecoeur and Ney 2003, Aira and Paivoke 2003). Increased dry matter production in the senna (*Cassia angustifolia* Vahl) had been reported when the seeds were treated with *Azospirillum* (Arumugam et al 2001).

The number of pods per cluster as well as number of pods per plant was enhanced significantly due to the effect of biofertilizers. The highest number of pods per cluster (2.13) was recorded in Azad P1 when inoculated with the

Table 2, Effect of biofertilizers on pod number/plant (C1), pod length (C2), pod diameter (C3), pod weight (C4), number of grain /pod (C5) and yield of vegetable pea.

		C1 (No.)	C2 (cm)	C3 (cm)	C4 (g)	C5(No.)	Yield (Q/ha)
Azotobacter	Azad P1	8.56	7.43	3.47	3.1	6.72	78.46
	Azad P3	8.24	6.38	3.51	3.2	5.8	85.39
	Arkel	8.90	6.80	3.48	2.9	5.37	71.18
PSB	Azad P1	7.62	6.60	3.22	2.7	6.7	61.50
	Azad P3	8.70	7.20	3.92	3.0	5.43	77.33
	Arkel	9.3	6.68	3.35	2.8	5.23	83.46
Rhizobium	Azad P1	6.86	7.07	3.54	3.5	6.5	67.28
	Azad P3	7.5	6.74	3.43	3.2	5.97	70.37
	Arkel	8.22	6.67	3.40	2.8	7.0	68.11
Azospirillum	Azad P1	8.73	7.02	3.37	3.5	7.37	80.59
	Azad P3	9.8	7.74	3.42	4.0	5.8	92.63
	Arkel	8.35	7.31	3.27	2.9	5.33	78.96
Control	Azad P1	7.66	6.57	3.33	3.0	6.47	52.14
	Azad P3	6.07	6.75	3.47	3.8	5.6	58.22
	Arkel	6.75	6.90	3.45	3.1	5.43	53.27
LSD (0.05)	Azad P1	0.93	0.21	0.26	0.3	0.48	4.09
	Azad P3	0.93	0.21	0.26	0.30	0.48	4.09
	Arkel	0.93	0.21	0.26	0.30	0.48	4.09

Azospirillum, which was 71.83 % higher to control. The highest average number of pods/plant (9.8) was reported in Azad P3 inoculated with *Azospirillum* (45.05 % more than control). The response of Arkel was very impressive towards the application of PSB in relation to number of pod/plant (9.3) and number of pods per cluster. The highest pod length (7.74) was recorded in Azad P3 (inoculated with *Azospirillum*) that was 14.6 % higher to control where as highest pod diameter (3.92) was reported in the same varieties inoculated with the PSB, 12.9 % higher to control (Table 2).

The highest average pod weight (4.0 g) was recorded in Azad P3 inoculated with the *Azospirillum* which was 5.2% higher to uninoculated plant. The highest number of grains per pod (7.37) was recorded in Azad P1 (inoculated with *Azospirillum),* which was 13.9 % higher to the control pea. Green pod yield was significantly higher in Azad P3 (92.63 q/ ha) due to applications of *Azospirillum*, which was 55 % higher to control pea. The symbiotic association of Azad P3 to *Rhizobium/ Azospirillum,* Azad P1 to *Azospirillum /Azotobacter* and Arkel to PSB was more evident. The present finding leads to the understanding that the extraneous application of inoculums of N fixer and PSB in the rhizosphere of pea significantly enhanced the yield and yield attributes. The application of *Azospirillum /Azotobacter* and PSB together with *Rhizobium* may be advocated for higher biomass and yield in pea.

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NURIENT USE EFFICIENCY, GROWTH AND YIELD OF WHEAT (*TRITICUM AESTIVUM* L.) UNDER DIFFERENT NUTRIENT OPTIONS IN RICE WHEAT SYSTEM

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ABSTRACT

A field experiment was conducted during Rabi season of 2007-8 and 2008-09 at crop Research Center of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). The grain, straw and biological yield were significantly higher in the treatment 125% NPK and it was found statistically at par with 75% NPK + VC 3t /ha, 75% NPK + VC 1.5t /ha + 10 t/ha FYM, 100% NPK and 75% NPK +FYM 20 t/ha. Nitrogen, phosphorus and potassium use efficiency recorded were highest with 75% NPK + VC 3t /ha which was found at par with 100% NPK. Lowest Nitrogen and potassium use efficiency was recorded in VC 9t /ha + FYM 20 t/ha however, in case of Phosphorus use efficiency it was lowest in 50% NPK + VC 3t /ha + FYM 20 t/ha treatment

Key Words: INM, Nutrient use efficiency, wheat, yield

Rice *(Oryza sativa)* – wheat *(Triticum aestivum)* system play a significant role in food security contributing 76% to the total food grain production of the country. Enhancement of wheat production from limited land area is great challenge for Indian agriculturist. Apart from developing high yielding wheat varieties, integrated nutrient management will be required to boost wheat production. The role of fertilizers in boosting crop production has already been proved and they have become so essential that the cultivation of present day wheat crop without them is rather a dream. However, non judicious use of chemical fertilizers over a long term in agriculture had shown the adverse effect on soil health and crop yield. Highly productive soils have stated showing signs of declining productivity with increasing cropping intensities, capacity of soil to replenish nutrient level in soil is declining and therefore use of chemical fertilizer increasing day by day. (Balyan and Idnani, 2000). Indiscrimate uses of fertilizer adversely affect the physico-chemical properties of the soil resulting in stagnation in productivity due to limitation of one or more nutrient. The declining response to inputs has been received to be the major issue challenging the sustainability of wheat of wheat based cropping system (Mishra, 2006).

The use of organic manures like FYM, vermicompost with fertilizers is receiving great attention in intensive agriculture. Application of organic along with inorganic sources not only improve soil health but with also improve the produce quality and fertilizer use efficiency and there by reducing the cost of cultivation. Use of organic manure have been found to be promising in arresting the decline in productivity through correction of deficiencies of secondary and micronutrients .Organic sources of nutrient applied to the preceding crop benefit the succeeding crop to great extent (Singh et al 1996).

MATERIALS AND METHODS

Field experiments were conducted for two years at Crop Research Center (CRC) of Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, during Rabi 2007-2008 and 2008 – 2009. The wheat experiment was preceded by paddy during both the years. Ten treatments (Control, 100% NPK, 125% NPK, 75% NPK + VC 3t /ha, 75% NPK +FYM 20 t/ha, 75% NPK + VC 1.5t /ha + 10 t/ha FYM, 50% NPK + VC 6t /ha, 50% NPK + VC 3t /ha + FYM 20 t/ha, 25% NPK + VC 6t /ha + FYM 20 t/ha, VC 9t /ha + FYM 20 t/ha) with different levels of organic manures (FYM and vermicompost) were tested using R.B.D design in four replications. Wheat variety PBW – 343 was sown @ 100 kg ha^{-1} for two years (26.11.07 and 27.11.08) with a row to row distance of 23.0 cm in 20.7 m^2 plot. A total of five irrigations were applied during the crop season.

Recommended doses of NPK were 150:60:40. Require NPK as per treatment were supplied through urea, diammonium phosphate (DAP) and muriate 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. Nitrogen, Phosphorus and Potassium use efficiency was calculated by diving the difference of yield in treated and control plots by amount of nutrient applied. 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

Integration of chemical fertilizer with organic manure has been found to be quite promising in affecting the growth of plants as well as maintaining higher productivity. Vermicompost and farmyard manure are being used as a major source of organic manure in field crops. Vermicompost has been advocated as good organic manure for use in integrated nutrient management practice in field crops as it contain complementary higher nutrients and decompose easily. The Application of 125% NPK produced maximum plant height which was at par with 75% NPK + VC 3t /ha. The control plots resulted significant reduction in plant height compared to 125% NPK and 75% NPK + VC 3t /ha at harvest (Table 1). It seems that higher levels of nutrients improved the fertility level of soil and create congenial condition for better growth and development. The highest numbers of tiller per meter row were recorded in 125% NPK which was at par with 75% NPK + VC 3t /ha. Lowest numbers of tillers were recorded on control plots at harvest. Such a higher number of tillers in these treatments can be linked with optimum supply of essential nutrients at active tillering stage. Dry matter accumulation was recorded to be highest in the treatment 125% NPK followed by 75% NPK + VC 3t /ha and 100% NPK (Table 1). Minimum dry number accumulation was recorded in control plots at harvest. Similar results were also reported by Azad *et al* (2001).

The yield attributes of crop depends on source sink relationship and it is a cumulative function of various growth parameters. Results revealed that significantly higher spike length, number of spikelet per spike, number of grains per spike and test weight were recorded in 125% NPK and it was at par with 75% NPK + VC 3t /ha (Table 2). All these yield attributing characters mentioned

Table 1. Effect of different nutrient options on plant height, number of tillers and dry matter accumulation in Wheat at harvest.

Treatments	Plant height (cm)		Number of tillers m^{-1} row length		Dry matter accumulation (g) m^{-1}	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Control	67.5	63.4	40	32	148.5	140.4
100% NPK	94.6	93.2	69	62	230.1	213.5
125% NPK	99.2	98.2	75	68	245.7	219.9
75% NPK + VC 3t /ha	96.6	95.7	73	66	242.0	218.6
75% NPK +FYM 20 t/ha	93.8	90.5	67	59	225.3	208.5
75% NPK + VC 1.5t /ha + 10 t/ha FYM	96.3	94.2	70	64	233.1	215.3
50% NPK + VC 6t /ha	91.6	90.0	62	58	215.9	200.9
50% NPK + VC 3t /ha + FYM 20 t/ha	89.7	88.9	61	57	208.2	198.2
25% NPK + VC 6t /ha + FYM 20 t/ha	87.7	85.7	59	55	203.9	190.7
VC 9t /ha + FYM 20 t/ha	83.7	81.5	50	47	194.6	182.6
SEm ±	0.70	0.80	2.38	2.75	8.31	10.46
CD at 5%	2.05	2.32	6.95	8.02	24.26	30.52

Table 2. Yield attributes of wheat as influenced by different nutrient options.

Treatments	Length of Spike (cm)		Number of Spikelet/ spike		Number of grains/ spike		1000- grains Weight (g)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Control	7.70	7.10	9.50	9.00	29.83	28.75	33.10	32.90
100% NPK	10.63	10.45	15.75	15.50	41.70	39.50	42.22	41.50
125% NPK	12.13	11.69	17.75	17.00	43.80	41.75	43.71	42.77
75% NPK + VC 3t /ha	11.34	11.03	17.25	16.50	43.40	41.50	43.42	42.22
75% NPK +FYM 20 t/ha	10.50	9.97	15.00	15.00	40.63	39.25	40.64	41.00
75% NPK + VC 1.5t / ha + 10 t/ha FYM	10.83	10.82	16.00	16.00	40.50	40.50	42.77	41.83
50% NPK + VC 6t /ha	9.81	8.95	14.00	13.50	40.00	38.75	39.40	41.13
50% NPK + VC 3t / ha + FYM 20 t/ha	9.73	8.62	14.00	13.50	39.75	38.50	39.25	41.10
25% NPK + VC 6t / ha + FYM 20 t/ha	9.67	8.35	14.00	13.00	39.25	37.50	39.15	38.49
VC 9t /ha + FYM 20 t/ha	9.37	8.15	11.00	10.00	37.50	34.75	37.45	36.55
SEm ±	0.63	0.55	0.71	0.54	0.73	0.60	0.68	0.59
CD at 5%	1.79	1.60	2.06	1.56	2.12	1.73	1.99	1.71

above were observed minimum in control treatment. Such a improved yield attributes can be linked with balanced nutrition particularly nitrogen which plays a vital role in celll division and cell elongation as well as increase in sink size which provide a feedback to source for production of higher amount of photosynthates . Higher level of nutrients improved the fertility level of soil and creates congenial condition for better growth and development thus improved the yield attributes. These results are in conformity with those reported by Dwivedi and Thakur (2000) and Singh and yadav (2006)

The grain, straw and biological yield were observed significantly higher in the treatment 125% NPK and it was found statistically at par with 75% NPK + VC 3t /ha, 75% NPK + VC 1.5t /ha + 10 t/ha FYM, 100% NPK and 75% NPK +FYM 20 t/ha (Table 3). Such results indicates that significantly higher yield attributing characters in above treatments helps in achieving higher Grain, straw and biological yield in these treatments. Grain, straw and biological yield were observed minimum in control plots and this was also associated with poor yield attributing characters in control conditions. The combind use of organic manures and chemical fertilizers enhanced the inherent capacity of soil as

Table 3. Grain, straw, biological yield and harvest index of wheat as influenced by different nutrient options.

Treatments	Grain yield (q ha $^{-1}$)		Straw yield (q ha^{-1})		Biological yield (q ha^{-1})		HarvestIndex (%)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Control	26.25	22.50	42.92	40.04	69.17	62.54	37.95	35.97
100% NPK	44.70	40.10	61.15	57.52	105.85	97.62	42.23	41.08
125% NPK	48.45	42.50	64.46	58.88	112.91	101.38	42.91	41.92
75% NPK + VC 3t /ha	47.50	42.10	63.70	58.62	111.20	100.72	42.72	41.80
75% NPK + FYM 20 t/ha	43.50	38.50	59.85	57.20	103.35	95.70	42.09	40.23
75% NPK + VC 1.5t / ha + 10 t/ha FYM	45.30	41.25	61.97	57.85	107.27	99.10	42.22	41.62
50% NPK + VC 6t /ha	41.25	36.50	57.39	55.58	98.64	92.08	41.82	39.64
50% NPK + VC 3t / ha + FYM 20 t/ha	40.00	35.75	55.72	55.36	95.72	91.11	41.79	39.24
25% NPK + VC 6t / ha + FYM 20 t/ha	39.05	34.00	55.07	53.81	94.12	87.81	41.49	38.72
VC 9t /ha + FYM 20 t/ha	36.25	31.75	53.37	52.24	89.62	83.99	40.45	37.80
SEm ±	3.45	2.70	2.24	2.68	3.85	4.42	0.07	1.95
CD at 5%	9.99	7.86	6.52	7.79	11.23	12.90	0.19	NS

reported by Hati *et al* (2000). The beneficial effect of organic sources of nutrients on growth, grain and straw yield could be attributed to the fact that after proper decomposition and mineralization of the manure available plant nutrient are directy supplied to the plant and also has solubilizing effect of nutrients in the soil. Similar findings were also reported by Hasan and Kamal (1998). Harvest Index was maximum in 125% NPK followed by 75% NPK + VC 3t /ha and was recorded lowest in control plots. Treatments with enhanced nutrition helps in acheieving higher rate of photosynthesis which ultimately reflect in higher harvest index. Similar findings were also reported by Pandey et al (2003).

Results showed that nitrogen, phosphorus and potassium use efficiency was recorded highest with 75% NPK + VC 3t /ha which was found at par with 100% NPK (Table 4). Lowest Nitrogen and potassium use efficiency was recorded in VC 9t /ha + FYM 20 t/ha however, in case of Phosphorus use efficiency it was lowest in 50% NPK + VC 3t /ha + FYM 20 t/ha treatment. Based on two years results to test the effect of different nutrient options on nitrogen, phosphorus and potassium use efficiency it can be stated that enhanced integrated application of nutrients can be linked with maximum N, P and K use efficiency. Similar results were also reported by Singh and Yadav (2006). N, P and K use efficiency is directly correlated with yield.

Table 4. N, P and K use efficiency in wheat as influenced by different nutrient options.

Treatments	NUE (Kg grain yield/ kg applied N)		PUE (Kg grain yield/ kg applied P_2O_5)		KUE (Kg grain yield/ kg applied K_2O)	
	2007-08	2008-09	2007-08	2008-09	2007-08	2008-09
Control	-	-	-	-	-	-
100% NPK	15.38	14.65	30.75	29.33	46.13	44.00
125% NPK	14.80	13.33	29.60	26.67	44.40	40.00
75% NPK + VC 3t /ha	15.74	14.67	31.48	29.34	47.22	44.56
75% NPK +FYM 20 t/ha	9.08	8.42	18.16	16.84	21.56	20.00
75% NPK + VC 1.5t /ha + 10 t/ha FYM	11.72	11.54	23.45	23.08	30.53	30.05
50% NPK + VC 6t /ha	10.00	9.33	20.00	18.67	29.98	27.98
50% NPK + VC 3t /ha + FYM 20 t/ha	6.71	7.21	7.48	7.21	16.16	15.57
25% NPK + VC 6t /ha + FYM 20 t/ha	5.82	5.23	11.64	10.45	14.22	12.78
VC 9t /ha + FYM 20 t/ha	4.26	3.94	8.51	7.87	10.55	9.76
SEm ±	0.548	0.585	0.584	0.589	0.601	0.594
CD at 5%	1.64	1.69	1.46	1.47	1.74	1.69

Increased yield ultimately resulted in higher fertilizer use efficiency. Similar results were also reported by Laxminarayana and Patiram (2006).

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IMPACT OF FRONT LINE DEMONSTRATIONS ON PIGEONPEA PRODUCTIVITY IN RELAY CROPPING SYSTEM IN GUJARAT

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Abstract

Three hundred forty seven front line demonstrations on pigeonpea in groundnut-pigeonpea relay cropping system were conducted on different aspects viz., varietal, fertilizer management, *Rhizobium* inoculation and full package of practices in six districts of Gujarat during 1994-95 to 2010-11. Relay cropping in groundnut with pigeonpea was found highly remunerative over the years without any negligible effect on yield of sole groundnut (main crop). The yield gap between conventional practices and improved package of practices was much higher ranging from 118 kg/ha in *Rhizobium* inoculation, a low cost technology to 382 kg/ha with adoption of new cultivars. There is urgent need to make the extension services fully functional for educating the cultivators to adopt improved technology under existing cropping systems.

Key words: Pigeonpea, groundnut, front line demonstration, relay cropping, yield gap, economics.

Pigeonpea is an important pulse crop grown in the tropics and subtropics lying between 30æ%S and 30æ%N. It occupies 6.5 percent of the world's total pulses area and contributes 5.7 percent to the total pulses production. The crop has its origin in India, and spread to African countries more than 4000 years ago (Rao *et al.,* 2010). Pigeonpea is grown in rainfall-scarce regions often on degraded soils, and is the preferred crop in such marginal environments because of its tap root system that allows optimum utilization of soil moisture and nutrients. Traditional pigeonpea cultivars are of medium to long duration (ranging from 160 to 280 days) and are grown as an intercrop with sorghum and cotton which face greater production risk. In other words, pigeonpea provides resilience to the sustainability of production systems and acts as a cushion against income shocks arising due to failure of short-duration intercrops.

The reported area and production statistics of pigeonpea are often underestimated as it does not include its area and production while grown as homesteads in backyards/hedge crop as well as the area under relay crop of pigeonpea in many states like Gujarat, Karnataka and Maharashtra. It may be noted that homestead production is quite common in many tribal areas of India. The most feasible approach is to raise yield per unit land area, water and capital which can be achieved by providing continuous cropping from beginning of the monsoon season to post monsoon by adopting concept of mixed/ inter/relay cropping. Substantial yield advantage can be achieved through inter/relay cropping as compared to sole cropping.

In *Saurashtra* region of Gujarat state, *kharif* groundnut is the main crop. But a significant shift in pigeonpea areas,

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production and productivity has been occurred during last one and half decade. Initially, farmers were not prepared to grow pigeonpea instead of groundnut. The lack of knowledge on cropping system, non-availability of short duration improved varieties, poor extension of latest package of practices (PoP), low seed replacement rate (SRR) and lack of suitable market price support were the foremost reasons of its poor adoption among the farmers in the state.

The main pigeonpea grown districts of Gujarat state are *Bharuch*, *Vadodara*, *Surat* and *Panchmahal*. In early 90's the area, production and productivity of pigeonpea was almost negligible in *Saurashtra* region.

Front line demonstrations (FLD's) on groundnut-pigeonpea relay cropping system including other improved PoP in *Saurashtra* were conducted to increase production of pigeonpea without affecting the yield of groundnut (main crop). The main objectives of these FLD's in this cropping system are: (i) to grow pigeonpea crop in such a manner without any affecting the sole groundnut crop, (ii) to reduce the risk of groundnut crop failure in aberrant climatic conditions and , (iii) to obtain the additional net return in least cost of cultivation and to increase the farmers income. The Indian Council of Agricultural Research, has implemented a new fully funded programme in mid eighties i.e. FLD's for transfer of technology to the farmers field. Under this unique programme, Pulse Research Station unit from JAU, Junagadh, has randomly conducted the FLD's on pigeonpea in seven districts of Gujarat state in the last one and half decade. The impact analysis of this venture is presented in this chapter.

Material and Methods

Three hundred forty seven FLD's were conducted during *kharif* season 1994-95 to 2010-11 in Junagadh, Rajkot, Amreli, Jamnagar, Bhavnagar, Porbandar and Surendranagar districts of Gujarat state (Table 1) on farmers' field. The objective was to transfer the improved technology to increase the productivity of pigeonpea through various types of demonstrations viz., varietal, fertilizer management, *Rhizobium* inoculation and integrated package of practices (PoP). "Seeing is believing" was the basic philosophy of FLD's. All demonstrations were conducted on medium black to black cotton soils in a block of 0.2/0.4 hectares land in order to show better impact of the demonstrated technologies to the farmers and field level extension functionaries. In relay cropping demo's the improved short to medium duration pigeonpea varieties viz., BDN 2, GT 101, ICPL 87119, BSMR 853 and BSMR 736 were sown in rows 90-120 cm apart in the month of mid August in standing groundnut with a seed rate of 12-15 kg /ha. The groundnut crop was sown after onset of monsoon in the month of June-July. The inputs like improved varieties with recommended dose of fertilizers, biofertilizers and insecticides/pesticides and integrated pest management (IPM) kits were supplied to the farmers. Farmers were advised to use proper seed rate and sowing time with recommended package of practices. The seed was treated before sowing with Thirum @ 2-3 g/kg of seed as per recommendations to control any infection. Plant protection measures were under taken as per need of the crop. Finally yield data of demonstrations and farmers practices were collected on the equal area.

Table 1. Number of successful Frontline Demonstrations on pigeonpea conducted in *Saurashtra* districts of Gujarat during 1994-95 to 2010-11.

Districts	Successful demonstrations conducted																	Total
	1994-95	1995-96	1996-97	1997-98	1998-99	1999-2000	2000-01	2001-02	2002-03	2003-04	2004-05	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11	
Junagadh	03	11	30	15	06	14	07	17	10	20	20	19	10	17	17	06	0	222
Rajkot	08	10	01	02	07	0	01	0	0	0	0	01	0	12	0	0	0	42
Amreli	0	0	02	0	0	0	02	01	02	0	0	0	0	0	0	0	0	07
Jamnagar	01	10	03	0	0	0	0	0	0	0	0	0	0	0	0	17	21	52
Bhavnagar	0	0	0	0	0	0	03	0	08	0	0	0	0	0	0	0	0	11
Porbandar	06	0	0	0	03	0	0	0	0	0	0	0	0	0	0	0	0	09
Surendranagar	0	0	04	0	0	0	0	0	0	0	0	0	0	0	0	0	0	04
Total	**18**	**31**	**40**	**17**	**16**	**14**	**13**	**18**	**20***	**20**	**20**	**20**	**10**	29	**17**	**23**	**21**	**347**

* *Note:* Yield data of 2002-03 was not reported as all 20 FLD's were failed due to heavy and continuous rain.

Results and Discussion

Seed yield

The mean data of 167 FLD's on varietal demo's on pigeonpea and groundnut seed yield in relay cropping are presented in Table 2. Results showed that when pigeonpea was grown as a relay crop with groundnut produced 1464 kg/ha groundnut pod yield which was close to sole groundnut yield (1580 kg/ha) at farmers field under varietal demonstration. Apart from it, the farmers also obtained an average 1299 kg/ha pigeonpea seed yield as a bonus return without any negative impact on sole groundnut production. The reasons for greater yield under intercropping was that component crops were able to use growth resources rationally and make better use of natural resources than grown separately (Willey, 1979). Further introduction of pigeonpea as a relay crop in groundnut produced pigeonpea equivalent seed yield of 2664 kg/ha. Similarly, in other varietal demonstrations (99) in which improved variety was tested over local cultivars, improved varieties produced higher yield (1916 kg/ha) over local cultivars (1534 kg/ha) in groundnut inter relay cropping system. Use of improved varieties contributed 25.0 per cent higher production than the local one. Hence, farmers must be be discouraged to use seed of local cultivars and adopted the system quickly. Ahlawat *et al.*, (1986) reported that in *Saurashtra* region relay cropping in rainfed groundnut, with pigeonpea, sorghum and sesame intercropped 30, 45 and 60 days after sowing (DAS) significantly gave higher equivalent pod yield and net returns than sole groundnut yield. Among relay crops, pigeonpea was found most remunerative irrespective of dates of intercropping.

Fifty eight FLD's were taken on

Table 2. Mean result of groundnut-pigeonpea relay cropping system FLD's conducted on different aspects during 1994-95 to 2010-11.

Improved aspects/ Varieties	No. of FLD's	Yield of groundnet and pigeonpea relay cropping sysem (kg/ha)			PEY (kg/ha)*	Grundnut sole crop yield (kg/ha)	Pigeonpea seed yield in relay cropping system (kg/ha)			Extension gap (kg/ha)	Economics					
											Gross return (Rs/ha)		Net return (Rs/ha)			
		Ground-nut (Sole)	Ground-nut (Relay)	Pigeon-pea (Relay)			Improved variety/ practice/ treated	Local variety/ practice/ untreated	% yield gain over local		Improved variety/ practice/ treated	Local variety/ practice/ untreated	Improved variety/ practice/ treated	Local variety/ practive/ untreated	Net gain over local	Effective gain
Varietal in relay cropping system BDN 2	167	1580	1464	1299	2664	-	-	-	-	-	-	-	-	-	-	-
Varietal in relay cropping system BDN 2, GT 101, BSMR 853, BSMR 736	99	-	-	-	-	1315	1916	1534	25.0	382	42535	34055	26887	19186	7701	6922
Fertilizer management (Sulphur @ 20 kg/ha) BSMR 853, BSMR 736	38	-	-	-	-	1344	1955	1788	9.40	167	43401	39694	28215	25865	2350	993
Rhizobium/PSB inoculation BSMR 853, BSMR 736	32	-	-	-	-	1791	1859	1741	5.80	118	41270	38650	27405	25041	2364	2108
Improved integrated package of practices (20:50:20: 20:15 kg/ha N:P:K:S:Zn+ *Rhizobium)* & IPM GT 101	11	-	-	-	-	1319	1965	1626	20.8	339	43623	36097	29850	24807	5043	2560

* Mean selling price (Rs/kg): Groundnut (20.70); Pigeonpea (22.20), PEY- Pigeonpea equivalent yield.

judicious and adequate sulphur fertilization (sulphur @ 20 kg/ha) as an improved practice over no application of sulphur (farmers' practice). Pigeonpea seed yield in fertilized and farmer practices were 1955 and 1788 kg/ha, respectively. The per cent increase over farmers practice was to the tune of 9.40 without affecting the main crop (groundnut) seed yield. Shankaralingappa *et al.,* (2002) from Bangalore opined that the seed yield and yield components varied significantly with the sulphur rate but not with the application method. They reported that basal application of 20 kg S/ha gave additional monetary benefit of Rs. 3156/ ha over farmer's practice.

Thirty two demonstrations were conducted on *Rhizobium* inoculation i.e. a low cost input technology. The average pigeonpea seed yield under *Rhizobium* inoculation was recorded 1859 kg/ha which was 5.80 per cent higher over without *Rhizobium* inoculation (1741 kg/ ha). Dudhade *et al.* (2009) also reported 9.89 per cent increase in seed yield due to application of *Rhizobium* to chickpea crop.

Front line demonstrations under application of integrated improved package of practices with plant protection measures (20 kg N + 50 kg P_2O_5 20 kg K_2O + 20 kg sulphur + 20 kg $ZnSO_4$ + two spray of endosulphan + installation of bird perches), yielded 1965 kg/ha pigeonpea seed yield which was 20.80 per cent higher over farmers' practice (1626 kg/ha) and sole groundnut pod yield (1319 kg/ha). This indicated that the transfer of improved technology on these aspects is beneficial for up-liftment of farmer's income without affecting the main crop yield in groundnut-pigeonpea inter relay cropping system. The increasing trend due to this technology was also reported by Rai and Saxena, (1995) and Desai *et al.,* (1999).

Economics

Economic analysis revealed that average gross and net returns were influenced considerably by inclusion of pigeonpea as a relay crop in groundnut. Maximum advantage from the relay intercropping of pigeonpea in groundnut was obtained by producing just near to double groundnut equivalent seed yield when compared with 100% sole groundnut yield. In addition the farmers also harvested a good yield of pigeonpea. The mean economic analysis of all demonstrations clearly indicated that highest net return in groundnut – pigeonpea relay cropping was obtained with adoption of improved varieties of pigeonpea (Rs. 27310 /ha) which was 41.0 per cent higher than production potential of local cultivars (Rs. 19355 / ha). The mean net return at farmers' field where full package of practices were demonstrated was 15 per cent higher than local practices. A low cost input technology of *Rhizobium* inoculation may gave 10.6 per cent higher net return as compared to un-inoculated demonstrations. The findings are in close conformity of Khurana and Phutela (1980) who reported that inoculation increased the average seed yield by 9.3 compared with the un-inoculated control.

Yield gains and gaps

Mean yield data of various type of improved demonstration and conventional practices of pigeonpea was compared to estimate the yield gains and gaps over the years (1994-96 to 2010-11). The yield gaps presently ranging between 118 kg to 382 kg/ha (Table 2). Under varietal aspect (availability of improved seed), the yield gap was much higher (382 kg/ha) followed by adoption of full package of practices of pigeonpea (339 kg/ha). The same trend was also observed in yield gains where adoption of improved seed of pigeonpea shows a great impact. Maximum net gain was recorded in varietal demonstrations (Rs. 7701) followed by integrated improved package of practices (Rs. 5043). A similar trend was also recorded in effective gain in varietal demo's at farmer's field. Clearly the results of all demonstrations over the years indicating a slow pace of transfer of technology and that 20-25% increase in productivity can be achieved through adoption of improved technology and spread of varieties. The other package of practices may boost the same. Constant efforts are therefore, needed to bridge this gap through increased seed replacement rate and transfer of technology through various types of demonstrations to educate the cultivators. This will help in enhancing state as well national yield of pigeonpea.

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EFFECT OF ZINC 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 & Iron were studied in individual crop of rice & wheat separately but in the system, a few have conducted the study. Besides the major nutrient micronutrients, like Zinc & Iron also play critical role in rice and wheat, production in Micro nutrients have assumed increasing importance in crop production under modern agricultural technology. 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 zinc micronutrient contents of the soil under rice-wheat cropping sequence.

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 was laid out in R.B. Design with 4 replications. Plots were fertilized with 5 levels of zinc (0, 10, 20, 40 & 60 kg $ZnSO_4$ ha^{-1}) to rice crop only and Fe at 5 levels (0, 14, 28, 56 and 112 kg $FeSO_4$ ha^{-1}) in wheat 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 study content and uptake of phosphorus by rice and content and uptake of (**Table**-4.17) zinc by wheat were computed. 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

Zinc fertilization up to 40 kg ha^{-1}significantly increased the yield in both years. (Table-1). The application of $ZnSO_4$ at 40 kg ha^{-1} enhanced the grain yield significantly as compared to 20 kg $ZnSO_4$. But there was no significant

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

Znso$_4$ level (kg ha^{-1})	Rice			Wheat		
	Year			Year		
	2004	2005	Mean	2004	2005	Mean
0	53.33	47.14	50.23	41.9	41.32	41.61
10	58.67	51.5	55.08	43.1	42.45	42.77
20	59.99	52.8	56.4	44.1	43.5	43.8
40	61.25	53.46	57.35	45.2	44.67	44.93
60	60.67	53	56.83	46.1	45.4	46
SEM ±	0.33	0.61	0.48	0.38	0.35	0.32
CD (P=0.05)	0.72	1.3	0.97	0.81	0.75	0.68

increase in yield at the application of $ZnSO_4$ at 60 kg ha^{-1}. The increase in yield might be attributed to the fact that the initial status of available zinc in the soil was low. The findings are in agreement to the result obtained by Sakal *et al.*, (1989), Dewal and Pareek (2004) and Jain and Dhama (2006).

A perusal of data presented in Table-2 shows that application of zinc sulphate enhanced the nitrogen content in rice grain. The highest increase in nitrogen content was obtained at 60 kg $ZnSO_4$ ha^{-1} followed by 40 kg ha^{-1}. There was significant difference among zinc sulphate levels in respect of N content. The addition of $ZnSO_4$ at 60 kg ha^{-1} increased nitrogen content from 2.03 to 2.13 percent. Further, its application also increased the uptake of nitrogen in rice grain up to 40 kg ha^{-1}. The nitrogen uptake by rice grain increased from 102.2 to 121.9 with 40 kg ZnSO4 ha^{-1}. Higher values of nitrogen uptake with increasing levels of Zinc sulphate addition up to 40 kg ha^{-1} was due to the result of favorable effect on N absorption coupled with greater paddy grain. It was in agreement with the findings of Tiwari and Pathak (Kg 76) and Kothari *et al.* (2005).

Increase in the amount of zinc sulphate up to 20 kg ha^{-1} increased the P content of rice grain significantly from 11.8 to 14.1 kg ha^{-1}but there after it declined with increase on the application of zinc sulphate up to 60 kg ha^{-1}. The

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

Znso$_4$ level	Nutrient content (%)				Nutrient uptake (kgha-1)			
(kg ha^{-1})	N	P	K	Zn (mgkg^{-1})	N	P	K	Zn(mgkg^{-1})
0	2.03	0.23	0.6	28.2	102.2	11.8	30.3	142.3
10	2.05	0.24	0.62	32.4	113.2	13.2	34.1	178.9
20	2.1	0.25	0.63	36	118.7	14.1	35.5	203.3
40	2.12	0.24	0.62	41.1	121.9	13.8	35.8	236.1
60	2.13	0.23	0.61	46.5	121.1	13.4	34.9	264.9
SEM ±	0.009	0.007	0.009	0.82	1.4	0.3	0.42	5.43
CD (P=0.05)	0.018	0.014	0.019	1.67	2.9	0.63	0.88	11.09

reduction in P content at higher 40 and 60 kg $ZnSO_4$ ha^{-1} might be attributed to antagonistic relationship between P and Zinc sulphate. Mehta and Singh (1988) also reported reduction in P content with addition of zinc beyond 20 kg ha^{-1}. The application of $ZnSO_4$ up to 20 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 $ZnSO_4$ at 40 and 60 kg ha^{-1}

The potassium content of paddy grain was in increasing trend up to 20 kg ha^{-1} application of $ZnSO_4$. Thereafter, a reduction is K content in rice grain was noticed at 40 and 60 kg ha^{-1} of $ZnSO_4$. The uptake of potassium by rice grown was in increasing trend up to 40 kg/ha^{-1} application of $ZnSO_4$ The application of 60 kg $ZnSO_4$ ha^{-1} did not improve the uptake of K over 40 kg $ZnSO_4$ ha^{-1}.

The doses of zinc sulphate increased the zinc content of rice grain up to 60 Kg ha^{-1} application. The results revealed that incremental increase in zinc level increased the zinc content of rice as compared to its preceding lower dose. This increase in zinc content may be as ascribed to increased availability of zinc in soil due to its addition. Similar findings were reported by Sharma *et al.*, (1986), Sharma and Singh (1990) and Sahu *et al.*, (1996). Similarly, applications of zinc sulphate increased zinc uptake significantly by rice grain with increase in dose of zinc sulphate from 0 to 60 kg ha^{-1}. The highest value was recorded at 60 kg $ZnSO_4$ ha^{-1}treatment. It increased from 142.3 to 264.9 g ha^{-1}. The finding was in agreement with those of Sakal *et al.*, (1988) and Sahu *et al.*, (1996).

Residual effect of zinc sulphate content

The effect of different levels of $ZnSO_4$ at 10, 20, 40 and 60 kg ha^{-1} were found to be significant on grain yield of wheat (Table-1). Residual effect of zinc sulphate up to 60 kg $ZnSO_4$ ha^{-1}significantly increased the grain yield by 10.0 and 11.1 percent during 2004-05 and 2005-06, respectively over no use of zinc sulphate. It could be attributed to improve fertility status of the experimental fields in terms of available zinc which could act as catalyst in most of the physiological and metabolic processes and metal activator of enzyme, resulting into higher wheat grain yield. It corroborates the findings of Patel *et al.*, (1995), Kulandaivel *et al.*, (2003) and Kothari *et al.*, (2005).

Nutrient content and uptake

The Table-3 shows the residual effect of zinc on N, P and K content (%) and their uptake. The residual effect of zinc enhances the nitrogen content in wheat grain significantly over control. It was maximum under residual effect of 60 kg $ZnSO_4$ ha^{-1}. It increases from 2.04 to 2.18 percent. It may be due to the favorable effect of residual Zn on metabolic process. Kothari *et al.* (2005) also reported increased nitrogen content of grain with zinc application. The phosphorus content in wheat grain remained almost static with the application of different doses of zinc sulphate applied in preceding rice crop. It may be due to hindrances caused by increased concentration of zinc in the absorption and translocation of P from the roots to the above ground parts. The residual $ZnSO_4$ up to 20 kg ha^{-1} had significantly beneficial effect in improving the K content in wheat grain. However, the adverse effect of 60 kg $ZnSO_4$ ha^{-1} was noticed on K absorption by the wheat crop. Sharma *et al.*, (2000) also reported similar results. The doses of zinc sulphate applied in preceding rice crop tended to increase the zinc content in wheat grain as compared to control.

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

$Znso_4$ level	Nutrient content (%)				Nutrient uptake (kgha-1)			
(kg ha^{-1})	N	P	K	Zn (mgkg^{-1})	N	P	K	Zn(mgkg^{-1})
0	2.04	0.21	0.51	22.3	84.7	8.9	21.2	92.6
10	2.09	0.22	0.53	26.5	89.4	9.4	22.9	113.5
20	2.14	0.22	0.55	30.9	93.3	9.8	24.1	135.3
40	2.17	0.23	0.55	35.4	97.1	10.1	24.9	159
60	2.18	0.22	0.54	40.6	100.7	9.8	25	186.7
SEM ±	0.01	0.006	0.013	0.39	1.57	0.32	0.39	2.8
CD (P=0.05)	0.029	0.013	0.026	0.79	3.24	0.66	0.81	5.72

It increased from 22.3 t 40.6 mg ha^{-1}with residual amount of 60 kg $ZnSO_4$. The results obtained are in agreement with those of Sakal *et al.*, (1988) and Sahu *et al.*, (1996).

Wheat fertilized with increasing level of $ZnSO_4$ ha^{-1}significantly increased N uptake. It increased N by 30.7 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 Choudhary *et al.*, (1997) and Jain and Dhama (2006) and Kothari *et al.*, (2005) also reported similar results. The mean uptake of P by wheat grain increased with 40 kg $ZnSO_4$ ha^{-1} applied in the preceding rice crop and minimum in the control group. However, further increase in the $ZnSO_4$ to 60 kg ha^{-1} reduced the P uptake. Samui *et al.* (1980) and Gupta *et al.*, (1986) also reported decreased P uptake by wheat at this level. Further $ZnSO_4$ had significantly beneficial effect on the K uptake by wheat grain up to 60 kg ha^{-1} applied in preceding rice crop. The K uptake by grain increased from 21.2 kg ha^{-1} at control to 25 kg ha ^{1} at 60 kg $ZnSO_4$ ha ^{1} to which is in agreement with the findings of Kothari *et al.* (2005). The Zn uptake by wheat increased significantly with increase in $ZnSO_4$ level uptake 60 kg ha^{-1}. Zinc content in wheat grain increased from 83.7 gm ha^{-1} to 202.2 gm ha^{-1}with residual amount of 60 kg $ZnSO_4$. Added zinc sulphate increased Zn^{++} concentration with soil solution thereby increasing its availability to plants. These findings in agreement with those of Sakal *et al.*, (1988) . Sahu *et al* (1996) and Jain and Dhama (2006) .

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

$Znso_4$ level	Gross returns		Net returns		B:C ratio		
(kg ha^{-1})	Rice	Wheat	Rice	Wheat	Rice	Wheat	Pooled
0	38125	41043	25583	26001	2.62	2.72	2.67
10	42053	42185	27271	26903	2.84	2.76	2.8
20	43408	43247	28386	27725	2.8	2.78	2.83
40	45293	44360	29791	28358	2.92	2.77	2.84
60	45157	45390	29175	28908	2.82	2.75	2.78

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. 58149 ha^{-1} when 40 kg $ZnSO_4$ ha^{-1} was applied in rice crop as followed by net return of Rs. 58083 with the application of 60 kg $ZnSO_4$ ha^{-1}. Similarly B.C. ratio was highest with 40 kg $ZnSO_4$ 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 40 kg ZnSO4 ha^{-1}.Treatment this may be practiced by the farmers of the region as a general practice under rice-wheat cropping system.

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EFFECT ON EXCESS AMOUNT OF ALUMINUM DISCHARGE BY INDUSTRIAL EFFLUENTS WITH INTERACTION OF IRON OXIDE NANOPAARTICLES

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ABSTRACT

Synthesized iron oxide nanoparticles was characterised by scanning Electron Microscopy (SEM), X-ray Photo electron Spectroscopy (XPS) , Fourier Transform Infra-red (FTIR) and other spectroscopy analysis.. The synthesized iron oxide nanoparticles were used to remove the toxicity of aluminum and result are very satisfactory because Iron oxide nanoparticles have very high affinity towards the adsorption of Aluminum due transition metal interaction on their surface., To see the maximum adsorption effect different parameters like agitation time, adsorbent dosage, particle size and pH were varied and best result was observed at 50 nanometer size of iron oxide nanoparticle,125 rpm agitation speed,180 minute agitation time at pH 8.5.at this data the maximum adsorption was 100%.

Key words: Iron oxide nanoparticles, Aluminum, Toxicity, Adsorption, Characterisation.

INTRODUCTION

Many industries such as paint, dyes, glass operations, lead batteries, electroplating, mining and smelters have their contaminated water that has many toxic and heavy metals. There are many metal which are toxic in nature like mercury, cadmium, arsenic, but now –a-days aluminum is one of harmful contaminants in the liquid wastes and discharged by a number of industries (M.K. Aroua *et a*l), it is very harmful because its compounds enter in the human body through the digestive and respiratory systems(Toxicological WHO report). Some food products also contain naturally cumulated (from soil, air, etc.) aluminum; others can be additionally contaminated during the production process and as a result of the use of food dyes, stabilizers and preservatives. Apart from the direct toxic effect of aluminum itself, aluminum and its compounds act jointly with many metals and non-metals which may cause changes in the biological availability of some elements necessary for the proper functioning of living organisms (F. Vegilo *et a*l,Management Environment *et a*l). In the physiological processes aluminum competes with such elements as zinc, calcium, iron, and chromium, which affects to bones, brain and liver of people suffering from kidney disabilities and people on dialysis. It was also found that the long-term intake of drugs containing aluminum compounds (e.g. antacida) also has a negative effect on humans. The excess of aluminum was found in the brain of Alzheimer disease victims [Brzezinski J *et a*l, Ludwicki J.K *et a*l , Klein G.L *et a*l }]. In the lysosoms of the brain, kidneys, and liver, aluminum replaces phosphates, in bones it replaces calcium, and in cell nuclei it replaces magnesium in heterochromatin [KLEIN G.L, Toxicological evaluation}.Therefore the removal of aluminum from wastewaters has received considerable attention in recent years (LEWIS T.E,. *et a*l, Brzezinski J et al). The commonly used procedures for removing metal ions

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from aquatic ecosystems include chemical precipitation, reverse osmosis and solvent extraction (Bayat, et al). However, these techniques have certain disadvantages such as incomplete metal removal, high reagent and energy requirements, generation of toxic sludge or other waste products that require disposal (Chandra *et al.,* 2003). Different types of biosorbents have been used for the removal of metals removal from wastewater (Abdel-Ghani 2007; Abdel-Ghani *et al.,* 2008; Abdel-Ghani 2007; Abdel- Ghani *et al.,* 2008 Horsfall et al; Singh K.K *et al.,*; Zafar *et al.,*), many biosorption processes used to remove aluminum from aqueous phase using *Sargasum fluitans* [H.S. Lee et al] or *Cyanidium caldarium* [A.L.B. Marulanda] are economic and environmentally friendly but they seem to be limited to the extraction of the metals from dilute solutions. The recovery of aluminum from the biomass has not been reported. Lee and Volesky [H.S. Lee,] and and Texier et al. [A.C. Texier] reported that the aluminum interferes with the biosorption process of the desired metals and should be removed first but their life is very short so one new method which have iron oxide nanoparticles and emerging technology i.e. nanotechnology is here being used for the removal of toxic metal aluminum is discussed as below.

MATERIALS AND METHODS

Synthesis of adsorbent

Synthesis of surface-modifying agent

The surface modifying agent was synthesized by a simple reaction. First 0.15 m mol (0.035 g) of oleic acid was dissolved in n-hexane solvent. At 0 C temperature, 0.25 m mol of propylene oxide is dissolved in n hexane. Then mix both the solution and the reaction mixture was kept overnight at room temperature. The final product was separated by column chromatography.

Synthesis of surface-modified iron oxide nanoparticles

In the next step 0.01 m mol (0.002 g) of $FeCl_2 \cdot 4H2O$ and 0.02 m mol (0.0032 g) of anhydrous $FeCl_3$ in 1:2 molar ratio was taken in n-hexane to which 0.23 m mol (0.1 g) of synthesized capping agent was added. The mixture was stirred magnetically and the pH of the solution was adjusted to 8 with drop wise addition of diluted NH_4OH almost 2 h continuous stirring results in a black colored solution. The solution was centrifuged to yield a black precipitate that was washed several times with n-hexane and then dried under vacuum. The black solid residue can be easily redispersed in chloroform, hexane.

CHARACTERIZATIONS

XRD Analysis of Samples

The XRD pattern of the nanocrystal is considerably broadened due to the very small size of the crystallites. The 2è values are 33.16 (104), 35.64 (110), 40.85(113), 54.08(116) and 64.02 (300), which are identified for orthorhombic á-Fe_2O_3 phase (JCPDS ref no. 01-084-

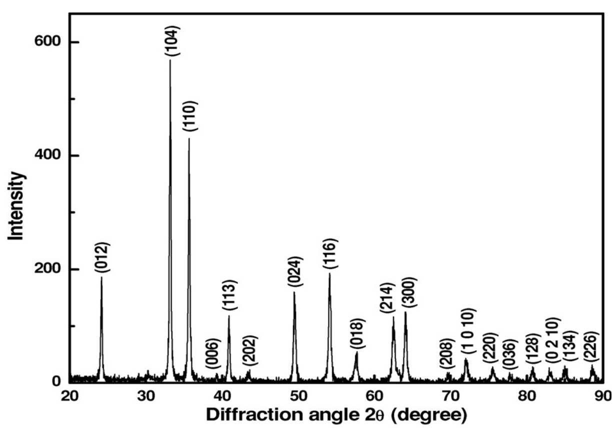

Fig. 1. XRD Analysis of Iron oxide nanoparticles

0306). From the XRD analysis it was evident that the nanocrystal is pure and the diffraction lines are strongly broadened due to small size of the crystals. The powder pattern corresponds to hematite (á-Fe_2O_3) with all reflections of the same peak width. The crystallite size was calculated from Scherer equation and the average crystallite size is 30 nm. The particles have a narrow size distribution and almost exclusively consist of monodispersed á-Fe_2O_3 nanoparticles (Figure. 1).X-ray powder diffraction patterns were taken at room temperature using a Philips diffractometer (Cu-Ka source of 1.5418A radiation). Crystallite sizes (D) of the obtained powders were calculated by the X Ray line broadening technique performed on the direction of lattice using computer software (APD 1800, Philips Research Laboratories) based on the Hall equation and the Scherer formula's =0.94ë/âCos è where ë $_1$ is the X-ray wavelength, è the Bragg's angle and â is the pure full width of the diffraction line at half of the maximum intensity Scherrer formula [P, Oswald et al] applied to the line broadening obtained from the major reflections and was found to be around 20 nm.

SEM and TEM analysis

The size of the particles was also determined from TEM images obtained using a JEOL-TEM-2010 transmission electron microscope with operating voltage of 200 kV. Samples for TEM were prepared by making a clear dispersion of the nanocrystals in acetone and placing a drop of the solution on a carbon coated copper grid. The solution was allowed to evaporate leaving behind the nanocrystals on the carbon grid. SEM analysis was obtained with a JEOL-6500 FEG SEM at 5-kV operating voltage and a working distance of 4 mm.

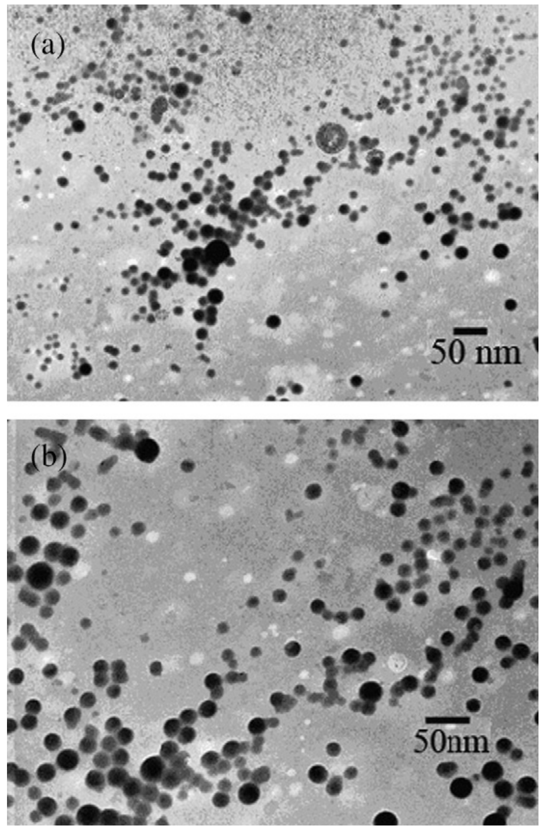

Fig.2. Microscopy Image of Iron oxide nanoparticles (a) SEM Image (b) TEM Image

FTIR Spectra

In this FTIR spectrum, the presence of –CH vibrations at around 2930 cm^{-1} suggests presence of organic impurities and broad stretching vibration of -OH peak around 3000-3600 cm^{-1} implies the presence of the water in the sample. The peak at around 1630 cm^{-1} is the bending mode of the water in the sample. The absorption peaks around 800 cm^{-1} to 1500 cm^{-1} are associated with the solvent n-hexane used, residual propylene oxide or by-products of the ring opening reaction of propylene oxide. The broad absorption peak around 500-700 cm^{-1} can be associated with the Fe-O linkages. The FTIR spectra shown of calcined Fe_2O_3 reveal removal of surfactant and water impurities.

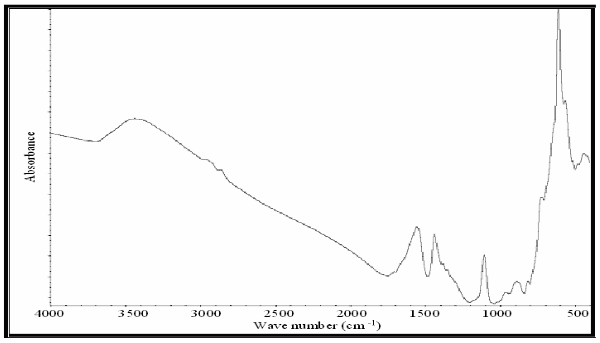

Fig. 3. FTIR spectra of Fe_2O_3

Removal of Aluminum metal by batch experiment Method

Batch Experiment Method

All adsorption studies were carried out by batch process, weighed amount of iron oxide nanoparticles (0.2 gm) was placed in dry conical flask to which 50 ml of sorbate containing 50 ppm concentration of Aluminum of toxic metals was added. The flask was then fitted to rotarary shaker (Kuhner Shaker Switzerland Made) at a speed of 10-250 rpm at 30°c for 10 to 60 minutes,balnnk sample was simultaneously placed in the same shaker.Finaly the samples was filtered by using whatmann filter paper no 42.and samples were set for the finding the concentration of aluminum by AAS (Thermo Electron corporation, M6, FS-95, UK, made), and the maximum removal efficiency of the nanoparticles were determined with the varying of various parameter like pH,particle size, Shaking time,dosase of adsorbent. Shaking period, and concentration of metal.

Effect of particle size

The size of nanoparticles particle is also affecting to the removal efficiency of the metal from aqueous layer .it is clear from the data that as particle size is reducing ,removal of metal is increasing and it is constant at 50 nm,below 50 nm no furthrer increament in removal of metal is observed

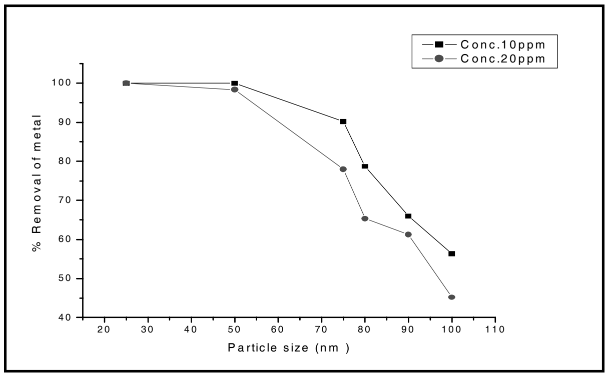

Fig. 4. Effect of nanoparticle Size on % removal of metal

Effect of Agitation Speed

Adsorption of different metal is also depend upon the shaking speed and here we studied in the range of 10 rpm to 250 rpm.it was found that percent sorption increase with increasing shaking speed and attains a maximum sorption at 150 rpm and then declined with increasing shaking speed. Therefore for further studies 150 rpm shaking speed was employed for all metals.

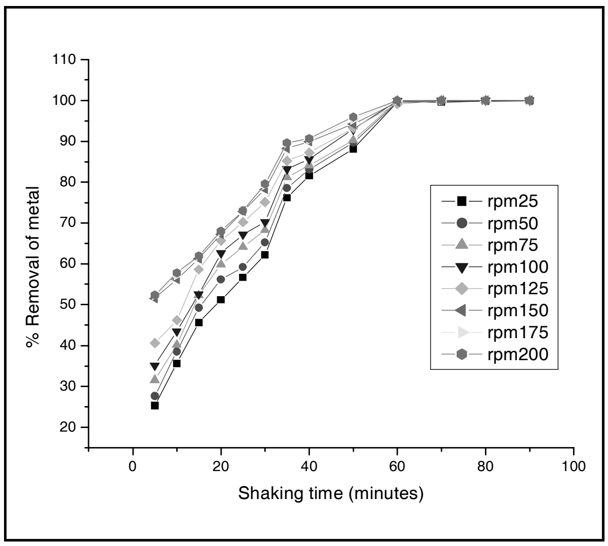

Fig. 5. Effect of Agitation speed on % removal of metal by 50 nm size of iron oxide nanoparticle.

Effect of Agitation Time

The effect of agitation time on the removal of Aluminum is shown in Fig.. The removal increases with time and attains equilibrium within 180 minutes for all concentrations studied (5-50 mg L-1). The amount of metal uptake decreases with increase in metal ion concentration. The curves were single, smooth and continuous leading to saturation indicating monolayer adsorption of Aluminum (III) on the surface of the adsorbent iron oxide nanoparticles.

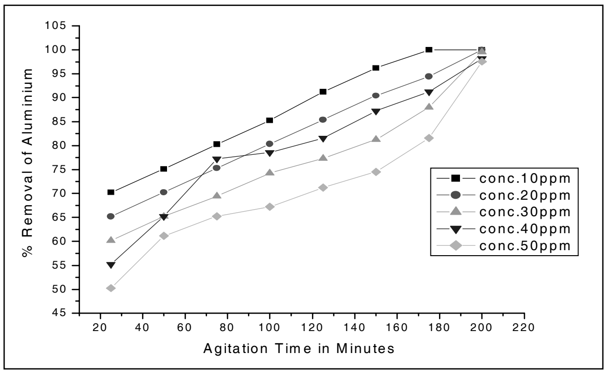

Fig. 6. Effect of Agitation time on % removal of metal, with the agitation speed of 150 rpm corresponds to the 50 nm ironoxide nanoparticle.

Dosages of sorbent

Sorbent dosage is an important parameter because this determines the capacity of a sorbent for a givin initial concentration of sorbate (Y.Bulut).Amount of Sorbent was optimized by a selected pH,and speed, at 3o°c for 50 ml of 20 to 30 ppm of metals. The percent sorption increase rapidly up to 99.96% by increasing the amount of sorbent from 0.05 to 0.4 gm of sorbent and stays almost constant amount of sorbent up to 1.5 gm of dosage. Other research papers (W.Shaobin et al) clearly reveal that thre should be a ratio between sorbent dose and sorbate concentration, which represent maximum percent sorption.

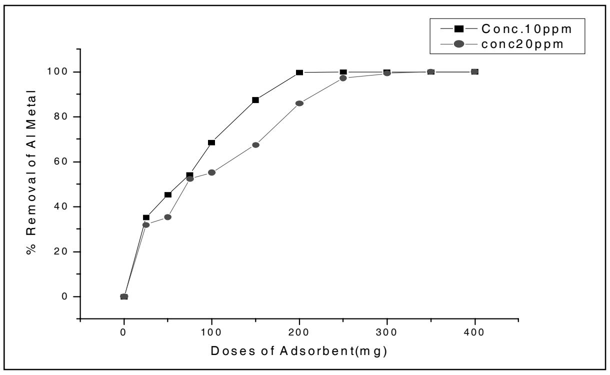

Fig. 7. Effect of doses of adsorbent on % removal of metal, with the agitation speed of 150 rpm for 180 minutes corresponds to the 50 nm iron oxide nanoparticle.

Effect of pH

The change in solution pH may also be changing properties of molecules of metal and as a result their adsorption also. The surface functional group of adsorbate made adsorption complicated by the charge characteristics of the

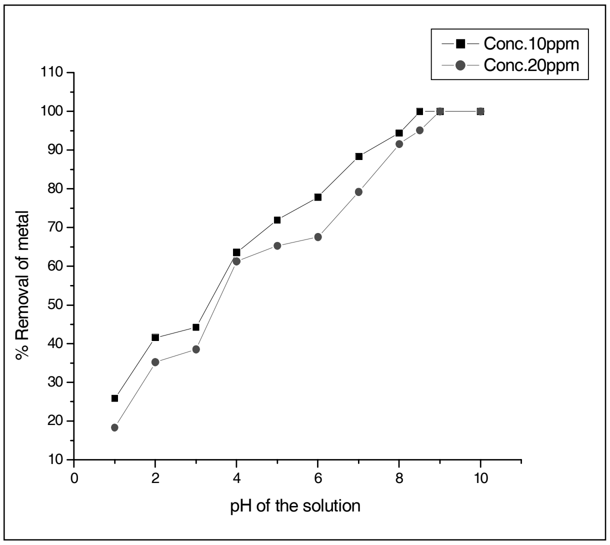

Fig. 8. Effect of pH % removal of metal, with the 200mgof doses content with agitation speed of 150 rpm for 180 minute corresponds to the 50 nm iron oxide nanoparticle.

adsorbent surface .Percent sorption decrease within increase in pH.The value of pH affect surface properties of sorbent.At every low pH values the of sorbent would be surrounded by the hydronium ions, which may enhance the sorbate interaction with binding sites of the sorbent by greater attractive force and hence improve its uptake on polar sorbent. The adsorption tendency of different metal is different at different pH., therefore pH plays an important role in sorption onto surface of sorbent.

Conclusion

It is clear from above discussion that iron oxide nanoparticles can be used effectively for the removal of Aluminum from aqueous layer of any effluent whether it pertains to industry or house hold. Here the experiment was conducted through batch mode adsorption studies, and it has been interpretated that increase of agitation time, adsorbent dosage and decrease of aluminum metal in concentration and particle size increased the percent adsorption of Aluminium ion. so, it is suggested that iron oxide nanoparticle is preferable for aluminum ion removal.

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EFFECT OF PGPR AND MICRONUTRIENTS ON BIOCHEMICAL CHARACTERISTICS OF TWO CULTIVARS IN *CAJANUS CAJAN*

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ABSTRACT

The objective of this study is to determine the biochemical characteristics of Cajanus cajan influenced by PGPR inoculation. Bacterial strain PGPR and Rhizobium were used to inoculate the seeds of two cultivars, i.e. Pusa 992 and UPAS 120 of Cajanus cajan. Inoculated and control seeds were sowed in the field of experiment and the biochemical parameters of the seedling were observed until maturity. In this study the biochemical parameters of protein, carbohydrate and total chlorophyll content were observed. Results showed that the carbohydrate significantly increased throughout the study. In case of protein and chlorophyll content, both the cultivars showed better results with the combination of micronutrients and PGPR alone in comparison to the control.

Key Words: Inoculation, PGPR, Biochemical parameters, *Cajanus cajan*

Beneficial free living soil bacteria are generally referred to as plant growth-promoting rhizobacteria (PGPR) and are found in association with the roots of different kinds of plants (Kloepper *et al.* 1989). Some free living soil bacteria that function as PGPR are as follows: *Azospirillum irakense*, *A lipoferum*, *A brasilense*, *A chroococum*, *Bacillus cerens*, *B coagulans*, *B polymyxa*, *B subtilis*, *Enterobacter cloaceve*, *Erwinia herbicole*, *Klebsilla planticola*, *Pseudomonas aeruginosa*, *P aureogaciens*, *P fluorescence* and *P putida*. PGPR inoculants contribute to plant growth promotion in a number of ways: suppression of plant disease (Bio protectants), phytohormone production (Biostimulus), and improved nutrients acquisition (Bio fertilizers).

Pigeonpea (*Cajanus cajan*) is a nutritionally important crop. Not only does it contain high levels of vitamin B and protein content but more importantly amino acids such as methionine, lysine, and tryptophan. Pigeonpea is a pubescent, many-branched shrub (but cultivated as an annual), 4 to 10 feet or more tall, with yellow or orange papilionaceous flowers that produce brown, hairy, four- to seven-seeded, long-beaked pods, 2 to 3 inches long by 1/2 inch thick.

MATERIAL AND METHODS

The certified seeds of two early varieties i.e., Pusa 992 and UPAS 120 of (*Cajanus cajan* (L) Millsp.) were obtained from genetics division IARI, New Delhi. PGPR strain (Bacillus subtilis) and Rhizobium strain (taken as a nitrogen fixing bacteria) has been collected from Division of Microbiology, IARI, New Delhi. For the biochemical analysis of chlorophyll, carbohydrate and protein, we adopted the following methods:–

- The determination of total sugars in the seed was based on the method known as Nelson (1944) and Somogyi (1952) method.
- Estimation of protein test was done by MICRO-KJELDHAL method. The chlorophyll determination test was done by using the standard method given by Hiscok and Israelstam (1979) at 30^{th}, 40^{th} and 50^{th} day after

sowing in Cv. UPAS 120 and Pusa 992 respectively.

- The experiment was laid out in Random Plot Designing comprising of the two cultivars (Pusa 992 and UPAS 120) of *Cajanus cajan* and different combinations of Mn, Mo, Fe and B in sub plots with three replications. There were 18 treatments combinations and 3 plots. The row to row distance was maintained 90 cms and plant to plant 65 cms.

RESULT AND DISCUSSION

It is evident that carbohydrate content in UPAS 120 (55.47% and 55.19%) was marginally higher in comparison to Pusa 992 (54.53% and 53.35%) respectively. On the other hand, the PGPR alone considerably enhanced carbohydrate contents when compared to control in both the cultivars. The percentage of Pusa 992 and UPAS 120 was substantially higher (52.65% and 55.25 %) in PGPR alone against control (48.50% and 49.60%) respectively. In terms of carbohydrate contents, some of the combinations of PGPR along with certain micronutrients yielded impressive results than PGPR alone as well as control. In this context, the results of the most conspicuous combinations were PGPR along with manganese (57.65%) in Pusa 992; and PGPR along with manganese (59.20%) in UPAS 120.

With respect to protein content, the results of UPAS 120 exceeded that of Pusa 992. UPAS 120 recorded higher protein content, i.e. (24.08%) against Pusa 992 (22.84%). Strikingly, PGPR alone significantly enhanced protein percentage as compared to control in both the cultivars. PGPR alone reported higher protein content, i.e. 22.40% and 23.65%, in both Pusa 992 and UPAS 120 respectively, in comparison to control whose percentage stood relatively lower, viz. 19.25% and 20.55% in both the cultivars respectively.

Table 1. Carbohydrate Content (%) as influenced by PGPR and micronutrients at different stages of growth in two cultivars (Pusa 992 and UPAS 120) of *Cajanus cajan*.

Treatments	V_1	V_2	Mean
Control	48.50	49.60	49.05
PGPR	52.65	55.25	53.95
PGPR + P	56.35	55.30	55.83
PGPR + Fe	55.85	58.40	57.13
PGPR + Mn	57.65	59.20	58.43
PGPR + Mo	56.75	56.10	56.43
PGPR + B	52.20	56.40	54.30
PGPR + Fe + Mo	51.50	54.55	53.03
PGPR + Fe + B	56.00	55.20	55.60
PGPR + Fe + Mn	56.20	55.30	55.75
PGPR + Mo + B	54.70	56.70	55.70
PGPR + Mo + Mn	53.75	54.40	54.08
PGPR + B + Mn	55.70	56.40	56.05
PGPR + Fe + Mo + B	55.90	55.45	55.68
PGPR + Fe + Mo + Mn	55.50	55.80	55.65
PGPR + Fe + B + Mn	55.35	54.70	55.03
PGPR + Mo + B + Mn	54.35	54.80	54.58
PGPR + Fe + Mo + B + Mn	52.55	54.95	53.75
Mean	**54.53**	**55.47**	
CD at 5%			
A (Variety)	0.689		
B (Treatments)	2.069		
AxB	N.S		

PGPR= Plant Growth-Promoting Rhizobacteria, V_1 = Pusa 992, V_2 = UPAS 120

Table 2. Protein Content (%) as influenced by PGPR and micronutrients at different stages of growth in two cultivars (Pusa 992 and UPAS 120) of *Cajanus cajan*.

Treatments	V_1	V_2	Mean
Control	19.25	20.55	19.90
PGPR	22.40	23.65	23.03
PGPR + P	22.55	23.40	22.98
PGPR + Fe	22.65	23.40	23.03
PGPR + Mn	23.75	24.85	24.30
PGPR + Mo	21.80	23.65	22.73
PGPR + B	22.10	22.60	22.35
PGPR + Fe + Mo	21.10	22.60	21.85
PGPR + Fe + B	22.40	26.20	24.30
PGPR + Fe + Mn	23.55	23.05	23.30
PGPR + Mo + B	22.90	25.35	24.13
PGPR + Mo + Mn	22.50	23.30	22.90
PGPR + B + Mn	25.85	26.90	26.38
PGPR + Fe + Mo + B	24.05	25.50	24.78
PGPR + Fe + Mo + Mn	21.50	22.35	21.93
PGPR + Fe + B + Mn	25.45	27.20	26.33
PGPR + Mo + B + Mn	22.70	22.80	22.75
PGPR + Fe + Mo + B + Mn	24.60	26.05	25.33
Mean	**22.84**	**24.08**	
CD at 5%			
A (Variety)	0.295		
B (Treatments)	0.885		
AxB	1.252		

PGPR= Plant Growth-Promoting Rhizobacteria, V_1 = Pusa 992, V_2 = UPAS 120

However, some combinations produced remarkable results when seen in comparison to control as well as PGPR alone. The best results in this regard were observed in PGPR along with iron, boron, and manganese (25.45%) in Pusa 992; and PGPR along with iron, boron, and manganese (27.20%) in UPAS 120.

Data analysis clearly points out that chlorophyll contents 'a' rapidly increased up to 40 DAS whereas the increase was normal up to 30 DAS and 50 DAS respectively in both the cultivars. It is noteworthy that among the two cultivars Cv. Pusa showed reasonably higher chlorophyll content than UPAS 120. The results of Pusa 992 and UPAS 120 in chlorophyll content were 2.62 and 2.5 respectively.

It has been observed that the PGPR along with micronutrients and phosphorus considerably increased chlorophyll content 'a' in both the cultivars in both the years. The combinations that produced best results were PGPR along with iron and boron (3.26) in Pusa 992, and PGPR along with iron and boron (3.11) in UPAS 120.

Chlorophyll content 'b' increased marginally up to 50 DAS in both the years in both Pusa 992 and UPAS 120. Chlorophyll 'b' content showed better result in Pusa 992 (0.93) than UPAS 120.

Significantly, the PGPR contributed to enhancement of chlorophyll 'b' content as compared to control in both the cultivars. Detailed analysis of chlorophyll 'b' content showed that the response of PGPR alone in both Cv. Pusa 992 and UPAS 120 (i.e. 0.785 & 0.766) was relatively better than control (0.745 & 0.711) respectively. It was evident that PGPR along with certain combinations of micronutrients considerably enhanced chlorophyll 'b' in both the cultivars. Cv. Pusa 992 attained higher chlorophyll 'b' contents in the combinations of PGPR along with iron (1.420), and along with iron and boron (1.16), whereas UPAS 120 attained best results in the combination of PGPR along with boron (1.260), and along with iron and boron (1.165).

The biochemical characters of the seeds as carbohydrate and protein content were affected with the PGPR inoculation as compared to control in UPAS 120 and Pusa 992. The nitrogen uptake is directly related to the protein percentage. The PGPR inoculation and different combinations of micronutrients affected the nitrogen uptake in both the cultivars. The PGPR inoculation with combined application of P and micronutrients such as B, Mo and Fe increased the protein and carbohydrate percentage due to more nitrogen uptake and better translocation of sugar in both the cultivars. It has been observed that protein yield of pigeonpea is not affected alone by nitrogen application, but increases linearly with phosphorous application (Matiwade and Sheelavantar 1995) During the experimentation, it was observed that the biochemical characters of the seeds in terms of protein and carbohydrate content was enhanced with the application of PGPR alone and also with Phosphorus and Mo. Singh *et al.* (1994) observed seed and straw contents of nitrogen and

Table 3a: Chlorophyll 'a' as influenced by PGPR and micronutrients at different stages of growth in two cultivars (Pusa 992 and UPAS 120) of *Cajanus cajan*.

Treatments	30 DAS			40 DAS			50 DAS		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
Control	1.950	1.756	1.85	3.110	2.854	2.98	2.740	2.580	2.66
PGPR	2.660	2.415	2.54	2.840	2.641	2.74	2.150	2.110	2.13
PGPR + P	2.620	2.160	2.39	2.980	2.660	2.82	3.000	2.750	2.88
PGPR + Fe	2.110	1.950	2.03	3.240	3.100	3.17	3.000	2.610	2.81
PGPR + Mn	2.140	2.110	2.13	1.980	1.880	1.93	1.650	1.650	1.65
PGPR + Mo	2.440	2.160	2.30	2.660	2.750	2.71	2.740	2.650	2.70
PGPR + B	2.980	2.750	2.87	3.650	3.460	3.56	3.080	3.110	3.10
PGPR + Fe + Mo	2.080	1.670	1.88	3.780	3.110	3.45	3.150	2.945	3.05
PGPR + Fe + B	3.020	2.651	2.84	3.420	3.260	3.34	3.260	3.000	3.13
PGPR + Fe + Mn	2.150	1.750	1.95	2.650	2.440	2.55	2.520	2.420	2.47
PGPR + Mo + B	2.110	1.654	1.88	2.650	2.460	2.56	2.260	2.460	2.36
PGPR + Mo + Mn	2.320	2.250	2.29	3.190	3.210	3.20	2.480	2.550	2.52
PGPR + B + Mn	2.620	2.740	2.68	2.750	2.640	2.70	2.640	2.430	2.54
PGPR + Fe + Mo + B	1.875	1.665	1.77	2.750	2.950	2.85	2.160	2.190	2.18
PGPR + Fe + Mo + Mn	2.020	1.980	2.00	3.420	3.470	3.45	2.840	2.660	2.75
PGPR + Fe + B + Mn	1.825	1.798	1.81	2.650	2.570	2.61	2.120	2.070	2.10
PGPR + Mo + B + Mn	2.420	2.321	2.37	3.110	3.000	3.06	2.640	2.550	2.60
PGPR + Fe + Mo + B + Mn	2.020	1.756	1.89	2.750	2.670	2.71	2.610	2.310	2.46
Mean	**2.30**	**2.09**		**2.98**	**2.84**		**2.61**	**2.50**	
CD at 5%									
A (Variety)	0.011			0.014			0.013		
B (Treatments)	0.035			0.042			0.039		
AxB	0.050			0.061			0.056		

PGPR= Plant Growth-Promoting Rhizobacteria V_1 = Pusa 992 V_2 = UPAS 120

Table 3b: Chlorophyll 'b' as influenced by PGPR and micronutrients at different stages of growth in two cultivars (Pusa 992 and UPAS 120) of Cajanus cajan.

Treatments	30 DAS			40 DAS			50 DAS		
	V_1	V_2	Mean	V_1	V_2	Mean	V_1	V_2	Mean
Control	0.899	0.765	0.83	1.740	1.254	1.50	0.745	0.711	0.73
PGPR	1.108	1.051	1.08	1.074	1.006	1.04	0.785	0.766	0.78
PGPR + P	1.219	1.110	1.16	1.050	0.895	0.97	1.100	0.854	0.98
PGPR + Fe	0.837	0.765	0.80	1.650	1.660	1.66	1.420	1.110	1.27
PGPR + Mn	1.014	0.845	0.93	0.850	0.745	0.80	0.665	0.640	0.65
PGPR + Mo	1.140	0.911	1.03	0.756	0.845	0.80	0.725	0.763	0.74
PGPR + B	1.242	1.174	1.21	1.660	1.740	1.70	1.260	1.260	1.26
PGPR + Fe + Mo	0.937	0.885	0.91	1.310	1.060	1.19	0.995	0.884	0.94
PGPR + Fe + B	1.162	1.065	1.11	1.350	1.240	1.30	1.165	1.165	1.17
PGPR + Fe + Mn	0.811	0.715	0.76	1.050	0.960	1.01	0.841	0.842	0.84
PGPR + Mo + B	1.082	1.110	1.10	1.030	1.001	1.02	0.785	0.766	0.78
PGPR + Mo + Mn	0.872	0.675	0.77	1.650	1.450	1.55	1.065	1.100	1.08
PGPR + B + Mn	0.936	0.845	0.89	0.987	0.998	0.99	0.785	0.685	0.73
PGPR + Fe + Mo + B	0.837	0.745	0.79	0.980	1.450	1.22	0.843	0.806	0.82
PGPR + Fe + Mo + Mn	0.860	0.765	0.81	1.650	1.060	1.36	1.030	0.895	0.96
PGPR + Fe + B + Mn	0.811	0.698	0.75	1.060	1.060	1.06	0.658	0.665	0.66
PGPR + Mo + B + Mn	0.927	1.022	0.97	1.060	0.994	1.03	0.816	0.846	0.83
PGPR + Fe + Mo + B + Mn	0.765	0.875	0.82	0.997	0.785	0.89	1.110	0.690	0.90
Mean	**0.97**	**0.89**		**1.22**	**1.12**		**0.93**	**0.86**	
CD at 5%									
A (Variety)	0.005			0.005			0.004		
B (Treatments)	0.016			0.017			0.014		
AxB	0.023			0.025			0.021		

PGPR= Plant Growth-Promoting Rhizobacteria V_1 = Pusa 992 V_2 = UPAS 120

phosphorus crude protein content of seed and total P uptake increased with phosphorus and Rhizobium application in green gram. In our finding UPAS 120 showed better result in terms of protein and carbohydrate contents than Pusa 992. Rao and Rao (1993) reported the dual inoculation of Rhizobium and VAM fungi increased P and N uptake, total soluble sugar, total phenols and free amino acids in black gram.

Although the duration of both the cultivars was same, the response in terms of protein and carbohydrate percentage in UPAS 120 was better than Pusa 992. Yet the difference between the two cultivars may be due to accumulation of nitrogen in the seed of UPAS 120. Phosphorus along with PGPR and with the combination of different micronutrients gave the significant response in terms of protein and carbohydrate content. The micronutrients such as B, Fe, Mn and Mo produced very positive response along with PGPR. Nutrients such as Mo, and

Mn plays positive role in enhancing nitrogen fixation activity and nodulation in plants. Nitrogen fixation activity increases the uptake of nitrogen as a result of it protein content increases in the seed. Nadeem *et al*. (2004) also reported that the *Rhizobium* inoculation with phosphorus increased protein contents in green gram.

In Pusa 992, the percentage of chlorophyll 'a' and 'b' content was higher in comparison to control. The PGPR inoculation with phosphorous and micronutrients had significant higher chlorophyll 'a' and 'b' for longer duration as compared to other treatments. The application of PGPR along with phosphorous enhanced chlorophyll content in Pusa 992. The higher chlorophyll content was due to application of PGPR, iron, boron and phosphorous might have resulted in better utilization of resources leading to more production of photosynthates. The end result was overall better performance by both cultivars.

The PGPR inoculation along with the different combinations of micronutrients also produced good results in comparison to control in both the cultivars in both years. In chlorophyll 'a' and 'b' content best results were obtained in combination of PGPR iron and boron. This may be due to the better water uptake as reported by Singh *et al.* (1983).

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EFFECT OF RICE RESIDUE, TILLAGE AND NITROGEN MANAGEMENT ON PRODUCTIVITY, N USE EFFICIENCY AND SOIL PROPERTIES IN RICE-WHEAT CROPPING SYSTEM

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SUMMARY

An experiment was carried out during *rabi* 2005-06 and 2006-07 at the Research Farm of the Janta Vedic (P.G.) College, Baraut, District–Baghpat (U.P.) to study the effect of rice residue and zero and conventional tillage practices on productivity wheat (*Triticum aestivum* L.) and soil condition. The rice residue and zero and conventional tillage practices in main plots and four nitrogen levels (0, 50 kg, 100 kg and 150 kg N/ha) in sub plots replicated crops. Residue retained with zero tillage recorded grain and straw yield significantly higher over the other residue and tillage management. Nitrogen use efficiency was positively higher in residue burned with zero tillage than residue incorporated under conventional tillage. Tillage practices had significant effect on bulk density and recorded highest bulk density in zero tillage as compared to conventional tillage. Significantly higher value of organic carbon was recorded from the plot receiving rice residue and sown with zero tillage. Residue incorporation with zero tillage recorded higher amount of available nitrogen and phosphorus, while residue burned with zero tillage recorded higher amount of potash in soil. The increasing rate of nitrogen application showed significantly better grain and straw yield as compared to middle and lower level of nitrogen application. The N use efficiency was higher with 100 kg N/ha. It might be because of operation of low diminishing return. Nitrogen use efficiency did not increase due to excessive nitrogen, which did not show further any response. Net return was found to be maximum (Rs. 40805 and 38848 /ha) under residue retained with zero tillage under 150 kg N/ha and maximum benefit: cost ratio of 2.29 and 2.10 during 2005-06 and 2006-07, was obtained from residue retained with zero tillage under 100 kg N/ha. Significant improvement in available N was due to addition of nitrogenous fertilizer in soil. A high grain yield and reduced cost of cultivation per hectare and greater water saving were noted in zero tilled wheat sowings compared with conventional practices.

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

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

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

MATERIALS AND METHODS

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

Yield Performance

Data recorded on grain and straw yield of wheat crop (Table 1) exhibited significant differences under different tillage and residue management. Different residue and tillage management on grain and straw yield was quite appreciable. Highest yields of grain and straw were recorded under residue retained with zero tillage followed by residue burned with zero tillage over residue incorporated with conventional tillage. The increase in grains and straw yield may be attributed mainly to higher number of effective tillers and the production of grains per spike, which was highly favored under residue retained with zero tillage. These results confirm the findings of Sharma and Mittra (1992), Singh *et al.* (2007), Zamir *et al.* (2010).

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

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

N Use Efficiency

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

Economics

In the present study residue incorporation with conventional tillage under no nitrogen resulted in lower total return as compared to zero tillage. Net return was found to be maximum (Rs. 40805 and 38848 /ha) under residue retained with zero tillage under 150 kg N/ha followed by residue burned with zero tillage under 150 kg N/ha (Table 2). The maximum benefit: cost ratio of 2.29 and 2.10 during 2005-06 and 2006-07,

Table 1 : Yield, N use efficiency and economics of wheat as influenced by rice residue, tillage and nitrogen management

Residue and tillage management	Grain yield (q/ha)		Straw yield (q/ha)		Nitrogen use efficiency (kg grain/kg N)		Net return (Rs/ha)		B:C ratio	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue burned-Con. tillage	39.23	38.81	47.08	47.20	12.91	12.82	24442	23119	1.37	1.23
Residue removed-Con. tillage	40.60	39.85	51.72	50.85	12.40	11.62	25622	23828	1.39	1.22
Residue incorporated-Con. tillage	36.99	36.44	45.08	44.17	12.44	12.08	22000	20459	1.22	1.08
Residue burned-Zero tillage	42.70	42.02	53.67	52.72	12.57	12.15	29938	28419	1.84	1.67
Residue removed-Zero tillage	42.62	41.74	52.29	51.49	12.60	12.40	29121	27369	1.73	1.54
Residue retained-Zero tillage	44.43	43.54	58.00	56.82	13.01	13.33	31865	30126	1.94	1.75
SEm±	0.38	0.44	0.62	0.39	0.15	0.20	274	253	0.023	0.15
CD at 5%	1.20	1.37	1.94	1.24	0.41	0.62	862	797	0.074	0.046
Nitrogen levels (kg/ha)										
0 kg/ha	28.65	28.17	39.21	38.20	-	-	16367	15009	1.12	0.98
50 kg/ha	36.88	36.21	49.14	48.37	16.46	16.07	23693	22132	1.47	1.31
100 kg/ha	47.98	47.02	56.85	56.42	19.33	18.85	33328	31469	1.87	1.68
150 kg/ha	50.87	50.19	60.03	59.18	14.82	14.68	35272	33604	1.86	1.69
SEm±	0.41	0.49	0.58	0.69	0.23	0.15	293	362	0.024	0.017
CD at 5%	1.18	1.41	1.67	2.00	0.66	0.44	841	1039	0.068	0.050

Table 2 : Yield, N use efficiency and economics of wheat as influenced by rice residue, tillage and nitrogen management

Residue and tillage management	Bulk density (g/cc)		Organic carbon (%)		Avialable N (kg/ha)		Avialable P (kg/ha)		Avialable K (kg/ha)	
	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07	2005-06	2006-07
Residue burned-Con. tillage	1.31	1.32	0.41	0.40	164.68	164.70	17.33	17.55	222.40	223.10
Residue removed-Con. tillage	1.34	1.34	0.41	0.41	164.75	165.68	17.40	17.90	217.50	218.50
Residue incorporated-Con. tillage	1.28	1.28	0.42	0.42	168.98	169.93	17.95	18.23	218.25	219.00
Residue burned-Zero tillage	1.39	1.40	0.41	0.41	165.13	165.70	17.35	17.68	223.50	224.00
Residue removed-Zero tillage	1.44	1.45	0.42	0.42	165.80	166.40	17.45	17.70	219.00	220.00
Residue retained-Zero tillage	1.34	1.35	0.42	0.43	170.05	171.45	18.10	18.30	220.25	220.25
SEm±	0.011	0.016	0.004	0.005	0.68	0.93	0.03	0.03	1.03	1.14
CD at 5%	0.33	0.049	0.011	0.016	2.07	2.78	0.09	0.10	3.15	3.47
Nitrogen levels (kg/ha)										
0 kg/ha	1.34	1.35	0.42	0.41	164.10	165.17	17.38	17.57	218.00	219.00
50 kg/ha	1.35	1.35	0.41	0.42	165.67	166.55	17.42	17.68	219.17	220.00
100 kg/ha	1.35	1.36	0.42	0.42	167.40	168.52	17.48	17.75	219.50	220.07
150 kg/ha	1.36	1.36	0.42	0.42	169.08	169.00	17.53	17.83	219.67	220.10
SEm±	0.014	0.018	0.005	0.006	0.84	0.95	0.17	0.19	2.82	2.51
CD at 5%	NS	NS	NS	NS	2.54	2.80	NS	NS	NS	NS

was obtained from residue retained with zero tillage under 100 kg N/ha. Singh *et al.* (2010) showed that the zero tillage method of wheat cultivation is the most economical and attractive option for the farming community of central Uttar Pradesh. A high grain yield and reduced cost of cultivation per hectare and greater water saving were noted in zero tilled wheat sowings compared with conventional practices.

Physical Conditions of Soil

The physical conditions of soil were recorded after harvest of wheat (Table 2). In general, the bulk density was lower in first year as compared to second year. The bulk density estimated after harvest of wheat crop was found statistically significant due to various residue and tillage management. Tillage practices had significant effect on bulk density and recorded highest bulk density in zero tillage as compared to conventional tillage. Field was ploughed repeatedly and soil was pulverized due to planking under conventional tillage. The volume of soil was increased due to pulverization which ultimately resulted in lower value of bulk density under conventional tillage. Mehta *et al.* (1996) and Kumar (2000) also found lower value of bulk density under conventional tillage in comparison to reduced or zero tillage systems. Rice residue incorporation recorded significantly lower bulk density over rice residue removed and rice residue burned. Similar results were reported by Kumar *et al.* (2002), Gangwar *et al.* (2006) and Meena (2010).

In general the addition of residue increased the organic carbon content of the soil after harvesting of wheat crop. It was due to decomposition of residue in soil and production of humic acid during residue decomposition. Significantly higher value of organic carbon was recorded from the plot receiving rice residue and sown with zero tillage. Conventional tillage reduces the extent frequency and magnitudes of mechanical disturbances caused by conventional tillage and reduced the airfield macrospores and slow the rate of carbon oxidation. So any decrease in tillage intensity and maximization of residue return resulted in carbon sequestration. Such results were also reported by Beri *et al.* (1995) and Singh *et al* (2006).

In general, the available NPK in soil increased significantly with tillage and residue management. Residue incorporation with zero tillage recorded higher amount of available nitrogen and phosphorus, while residue burned with zero tillage recorded higher amount of potash in soil. The highest available K_2O in soil was recorded in residue burned due to addition of potash in soil and gaseous loss of N and P by residue burring. Almost similar results were reported by Pannu et al. (2010).

The nitrogen application founded to bring any significant variation in bulk density, organic carbon and available P and K. Significant improvement in available N which may be due to addition of nitrogenous fertilizer in soil. Kumar *et al.* (2004) and *Singh et al.* (2006) also reported similar results.

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INFLUENCE OF REDUCED TILLAGE AND RAISED BED PLANTING ON PRODUCTION AND WATER PRODUCTIVITY OF CHICK PEA

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ABSTRACT

This field experiment was carried out to study the performance of chick pea under different tillage and crop establishment methods for two consecutive years (2006-07). The tillage options viz. conventional tillage (CT) and reduced tillage (RT) had no effect on any character under study except that nodules dry weight per plant was significantly higher under reduced tillage. The FIRB planting of crop produced significantly better result than flat bed planting for all the growth and yield characters under study. The FIRB planting required less water and had higher water productivity than flat bed planting.

Key words :

Chickpea or Bangal gram (cicer arictinum L) is one of the most important winter season grain legume and had been an integral part of rice-wheat cropping system being widely grown in early sixties. The beginning of green revolution era in 1970 replaced or marginalized the traditional cultivation of chickpea with main focus on increased production of rice and wheat. However, the growing of legumes as a break crop has beneficial effect on the productivity of rice and wheat. With the advent of resource conservation technologies in agriculture related to cultural practices in 1990's viz. reducing tillage intensity and raising crops on raised beds, very little research work has been carried out on chickpea (Jat and Sharam, 2005). They observed that yield of chickpea was low under flat bed (1.40 t/ha) compared to furrow irrigation raised bed (1.85 t/ha). With this in mind, the present field experiment was planned with the objective to study the growth and yield of chickpea along with water productivity under reduce tillage and raised bed planting.

MATERIALS AND METHODS

The present field study was conducted during rabi (winter) season of two consecutive years (2006-07) at agricultural farm of J.V. collage, Baraut (Bagpat), U.P. The variety of chickpea was ICCV-10 released by the name Bharti, developed from the cross $P_{'1231'}$ x P_{1265} at ICRISAT, Hyderabad (A.P) which is wilt resistant. The seed rate was kept @ 60 kg/ha. The experiment was laid out in completely randomised block design with 3 treatments each with 4 replications. The treatments were conventional tillage (4 ploughings), reduced tillage (2 ploughings) and furrow irrigated raised beds. Only two irrigation were given. The recommended does of nutrients @ 140 kg/N/ha and 46 kg/P/ha were applied at the time of sowing the crop. The observations were recorded on different growth and yield characters as well as water used. The data collected on

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these characters were analyzed statistically by the technique of analysis of variance. The critical difference at 5%. level was estimated to know the significance of differences among treatment means.

RESULTS AND DISCUSSIONS

Growth and yield

The growth performance of chick pea based on two years data with respect to plant height and number of branches emerged per plant at different stages of growth, number of nodules per plant and the nodules dry weight have been presented in table 1 whereas the average value of the characters showing production performance of the crop viz. number of pods / plant, number of grains / pod, grain yield, stover yield and harvest index have been presented in Table 2. The average plant height of chick pea in the first years was recorded to be 28.0, 28.2 and 29.0 cm under CT, RT and FIRB planting at 30 days after sowing the crop. The corresponding plant height at 60 days of age of the crop had been 48.0, 49.1 and 50.2 cm under different tillage and crop establishment methods. Whereas at 90 days after sowing the crop the plants attained the height of 58.3, 58.2 and 60.0 cm under these treatments in the first year crop. The mature heights of the plants were reached to be 59.7, 59.8 and 60.6 cm under CT, RT and FIRB planting in the first year. The similar trend of growth was observed for the crop in the second year. These figures on plant height of chick pea have clearly indicated that chick pea plants had quicker growth in the first month of the age which was found to be of about 0.95 cm / day and it was reduced to 0.66 cm / day in second month and also the same in third month of age. After 90 days of age, the chick pea plant had very slow growth. This was found true under all the tillage and crop establishment methods as well as in both the years. The perusal of data on plant height had further shown that the plants of the crop sown on raised beds attained more height than on flat beds. The statistical analyses of the data on plant height have indicated that the plants attained significantly more height under FIRB planting than flat bed planting whereas the tillage practices had no effect.

The average values of two years data presented in Table 1 on the number of branches emerged at different stages of growth have shown that the average number of branches under conventional and reduced tillage were almost equal. The FIRB planting produced significantly

Table 1. Effect of different tillage and crop establishment methods on growth characters of Chickpea (Two years data).

T & CE* methods	Plant height (cm) at DAS**				Number of branches/ plant				Number of nodules/plant	Nodule dry wt (mg)
	30	60	90	Harvest	30	60	90	Harvest	Harvest	Harvest
FIRB	28.8	50.0	59.6	60.3	12.0	25.0	29.0	30.5	6.0	189.0
RT	27.9	48.9	58.1	59.2	11.0	24.5	28.1	28.7	5.3	181.8
CT	27.5	48.0	58.1	59.2	11.0	24.0	28.0	28.5	5.0	179.1
CD 5%	0.58	0.36	0.39	0.59	1.17	0.96	0.61	0.80	0.62	2.82

T & C E*=Tillage and crop establishment Methods, DAS**=Days after Sowing more branches than flat bed planting. This was true at different stages of growth and for both the years. It was further observed that maximum branching occurred during first two months of age of the plant and the maximum numbers of branches were found to be in the range of 28.0 to 31.0 at maturity. Perusals of the data presented in Table 1 regarding the number of nodules on the roots per plant have indicated low variability in this character with respect to tillage practices. The number of nodules varied from 5.0 under conventional tillage to 6.0 under FIRB planting system of crop production in the first year and the same variability existed in second year crop. These differences in the number of nodules were not significant either between two years or between tillage options but significantly more number of nodules were found under FIRB planting. The average dry weight of nodules has shown that it was significantly higher under reduced tillage than conventional tillage. The dry weight of nodules under FIRB planting system was found to be significantly higher than on flat bed planting in both the years (Table 1). This indicated that the nodules developed under FIRB planting system were of bigger size with more weight. The average numbers of pods per plant under conventional tillage were observed to be 90 and 88.7 in two years and under reduced tillage as 91.0 in both the years. Thus about one pod in first year and two pods per plant in second year were more under reduced tillage compared to conventional tillage. However, this difference was not found significant. Under FIRB planting system, the plants bear higher number of pods per plant than flat bed planting and this difference approached statistically significant.

The data of number of grains per pod presented in Table 2 have indicated that conventional tillage and reduced tillage could not produce any difference in this character, the numbers being 2.0 in both the years under conventional tillage whereas under reduced tillage the numbers of grains were found to be 2.2 in both the years. The numbers of grains / pod under FIRB planting system were more, being 2.7 and 2.5 in two years, compared to flat bed planting. Statistical analyses of the data on this character have indicated that FIRB system produced significant effect over conventional and reduced tillage. The average grain yield was found nearly equal under conventional tillage (17.5 and 17.2 q/ ha in two years) and reduced tillage (17.8 and 18.1 q/ha in two years). The FIRB planting produced about 2 q / ha higher grain yield than on flats. On subjecting the yield data to

Table 2: Effect of different tillage and crop establishment methods on yield characters and yield of Chickpea pea (Two years data).

T & C E methods	Number of pods/plant	Number of grains/pod	Grain yield (q/ha)	Stover yield (q/ha)	Biological Yield (q/ha)	H.I. %
FIRB	92.8	2.6	19.5	31.7	51.2	38.0
RT	91.0	2.2	17.9	30.0	47.7	37.0
CT	89.3	2.0	17.3	29.9	47.3	36.6
CD5%	1.80	0.44	0.72	0.91	1.32	0.84

T & C E*=Tillage and crop establishment Method statistical analysis it was found that the difference in grain yield on raised beds and flat beds was highly significant. This was attributed to significantly more number of pods per plant and more number of grains / pod under FIRB which together produced significantly higher grains yield compared to that on flat bed system. Jat and Sharma (2005) also reported that yield of chickpea was low under flat bed compared to FIRB technique. On the other hand, Singh (2002) and Sekho et al. (2004) reported similar yield of chick pea on beds and flats in the absence of irrigation compared to flats.

The stover yield combining straw and sticks produced under two tillage practices viz. conventional and reduced tillage was equal in both the years. But, the stover yield obtained under raised beds was about 2q/ha higher than on flat beds and it was true in both the years. The statistical analysis indicated that this difference of 2q/ha was significant. This may be attributed to the combined effect of higher plant height, more number of branches and more number of pods / plant. The average values of biological yield have indicated that tillage practices had no effect on this character. Contrary to this, FIRB planting produced significantly higher biological yield than flat bed planting. The harvest index varied form 37.2 % under conventional tillage to 38.7 % under FIRB planting in the first year with almost similar variability in the second year. The FIRB planting had significant effect over flat bed planting on harvest index.

Water Productivity

The chick pea required 1121 m^3 / ha water under conventional tillage and this was little higher than the water required under reduced tillage (1053 m^3 / ha). The FIRB planting required about 200m^3water less which was about 18 % less than required under conventional tillage. Thus FIRB method is a water saving practice. The water productivity of chick pea crop was found to be 1.56 kg grain / m^3 water under conventional tillage which increased to 1.69 kg grain / m^3 water for reduced tillage. In case of raised bed planting (FIRB), the water productivity was found to be 2.10 kg grain / m^3 water which was higher than flat bed planting. Less water requirement and higher water productivity under FIRB planting have also been reported by Jat and Sharma (2005).

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A DIGITAL EDUCATION INITIATIVE IN AGRICULTURE

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ABSTRACT

With the development in Agricultural Science and technology, the need for improved agricultural education throughout the world has been realized. Quality Education in Agriculture is a service that contributes to national development, integration and regional cohesion. With the development in ICT, eLearning has become the part and parcel of education programmes in all sectors of life. Agriculture sector is also not far behind with the inculcation of digital mode of teaching and learning with the conventional teaching mode. In this direction, an eLearning platform "eLearnAgriculture" has been designed and developed for the post graduate courses in Agriculture Sciences (http://elearnagri.iasri.res.in/home). The system has been developed in way that the teaching, learning, evaluation and administration of the courses and users can be accomplished online. Presently it has been enriched with the fundamental courses under the disciplines of Agricultural Statistics and Computer Applications. The system has the capability to provide teaching and training material in the form of text, graphics, audio and animation. The digital mode provides an opportunity to the agricultural educationists to create and link their course content in a real time format using the multimedia tools which may not be available or accessible with conventional teaching methods. The students also get a chance to study and learn the multimedia enabled digital course content at anytime, anywhere. The standardized format adopted for the digital course content creation on the site has been discussed in this paper along with the technology developed and adopted for the course content creation. The course content has been designed and developed using a standardized format.

Key words :

INTRODUCTION

eLearning is the use of Information and Communication technology to enable people to learn anytime and anywhere. Primarily the traditional methods of learning have been in use in the education. But research has shown that Electronic communication, Information Imaging technologies offer methods for delivery of education, training and learning much more convenient than traditional methods. (Fritz et al. 2002; Murphy & Terry 1998). With the advances in internet technology, web based eLearning systems are gaining popularity. Being online, these systems provide an opportunity to learn any course/subject from any part of the world at anytime. It may be helpful in resource saving in terms of time, money, paper, etc. that will improve the accessibility to the course instructors as well as students. In consideration with the changing trends in ICT and scarcity of time, the role of eLearning has increased. Once the course contents are digitized using some Content Management System (CMS) and the same are made available on the web, they can be effectively used by the researchers, instructors and students. eLearning supports increased communications between teacher and students, and among students. It encourages students to take responsibility for their own learning and creating an environment that promotes an active approach to learning. Students can take quizzes or read the course material during their free time. It is a boon to the working students and professionals who need flexible access to courses, and an eLearning system is a powerful way to give them what they need. The services and format of eLearning allow many additional benefits, like the audio - video presentations makes learning more interesting. An eLearning course has a global student audience. The format allows students to learn easily for the standardized tests by

downloading the study material they want. It also allows the students to improve their scores in the standardized tests, by taking as many tests as they want. The eLearning format allows students to speed up and slow down as they deem necessary. There is more flexibility in terms of time limit or age barrier. eLearning opens up a new world of studying comfortably and with better results. Technology advances and especially web-based training also provide new opportunities for teachers professional development (Grey et. al. 2004).

2. Content Standardization and Creation

Content standardization and creation are two main components of an eLearning system. The course teachers remain involved in this activity during the whole stages of course building and implementation. But before actually starting the course creation, the course content has to be standardized for common modules, common standardized text format and common look and feel of the courses.

The first step towards standardization is designing of a common course framework which includes:

- Design of a uniform structure for the course content.
- Collection and Digitization of Course Material (Syllabus based).
- Detailed digitized course content creation using Moodle: Chapters, Solved examples, Quiz, Assignments, Glossary and presentations.
- Creation of Multimedia enabled Content: Audio recording with lessons, animation Creation in presentations.

2.1 Design of a uniform course structure

A course is subdivided into various lessons based on the main topics underlined in the syllabus. Each lesson had the common structure and format within a course. At the end of each page in the lesson there is a review question; based on the answer of the question the subsequent path in the lesson may be linear or non-linear. With each lesson there is a Goal, the detailed Lesson Content, Quiz, Glossary, Audible Power Point Presentation and the summary. This structure remains the same for all lessons in all courses.

2.2 Course Material Collection and digitization

The course material is collected for each lesson on all common entities depicted under the uniform course structure. The content of each page of a lesson is collected and digitized as per the standardized format Preparing the text material, tables and graphics, Questions, Glossary, Quiz, Assignments and Audio Scripts.

2.3 Creation of the course content

Content development encompasses authoring, maintaining and storing the learning content (Ellis. *et.al.2009*). The

Learning Management System (LMS), MOODLE (Modular Object-Oriented Dynamic Learning Environment), has been used for the creation, management and deployment of the eLearning system. It is a free and open-source eLearning software platform. It has features that allow it to scale to very large deployments and hundreds of thousands of students. The course content has been finally created using the tools available under the MOODLE editor.

2.4 Common Template for eLessons

The system presently contains some basic courses under the disciplines of Agricultural Statistics and Computer Applications. The course material has been designed and developed by the course instructors actually teaching these courses. The courses are offered online, so the students have the flexibility to enroll themselves in the courses of their choice, can study and evaluate themselves at their preferable time. Each course has been divided and arranged into several lessons. Each lesson has the common format for text, figures and presentations etc. Also a common representation scheme/ Template has been followed for all the eLessons under a course. This template includes the following:

- **Goals and Summary**

The goals of each topic have been given in a precise language so that the learners of a particular course can get to know the purpose behind the topic and a general insight into the content they will be going to learn under that topic. The summary of each topic gives a summarized view of the topic. All the content that has been included in the lesson content is depicted briefly in the summary.

- **Interactive Lesson**

The lesson content under a topic is divided into various pages and the Text, Tables, Equations and Images to be included in that page were identified. Some real life solved examples have been added in most of the lesson pages. These solved examples enhance the clarity and practical usability of the content. It was also tried to add a test question after each lesson page so that the user is tested for the content he read in that page. A feedback is provided for each answer that the user selects. If the answer was correct then only he can move on to the next page in sequence, otherwise he has to attempt it again. The equations were added using the Dragmath equation editor integrated with MOODLE.

- **Glossary**

A glossary has been developed for each topic of the course. It contains the definitions of all important keywords used in the lessons. The keywords have been alphabetically arranged in the form of a dictionary. The glossary has the auto-link feature through which the keywords get auto-linked to their definitions wherever they appear in the courses.

- **Audible presentation**

Each topic has been enriched with multimedia enabled presentations. The presentations depict the whole lesson content in a brief and interactive way. With some presentations audio has been recorded in the voice of the teacher and uploaded in the system as SCORM (Sharable Content Object Reference Model). These presentations are very beneficial to the students in understanding the concepts very easily through graphics, animation and voice embedded with these presentations.

- **Quiz**

A quiz containing a series of questions was created for each topic. The type of questions that have been included in the quiz were-

- Multiple choice
- True False
- Matching choice questions
- Short answer questions.

The student can retake the quiz after submission.

- **Grading**

The students are evaluated and graded on the basis of grade system chosen by the teacher. For each correct answer in the Quiz, the teacher can give appropriate grades in the range of -1 to +1 along with a feedback. After submission of the Quiz by the student, an overall percentage grade is provided by the system. Based on the grading and feedback the student can opt to retake the quiz and perform better.

- **News Forum**

In every course of the system, a forum has been created for general announcements and distribution of assignments by the teacher. The students can discuss any topic with other students and teachers through this forum. Every subscribed user of the forum are sent email copies of every post in that forum. The teacher can force the subscription on all the students so that everyone in the class will get email copies.

3. eLearnAgriculture Users

eLearnAgriculture has three user types: The Student, The Teacher and The Administrator. The users have different permissions and different activities to do in the system.

Administrator

Manage discipline information

Create/view teacher

Assign courses to teacher

View course material

Student

Teacher

Create/view student

Add/Edit course material

Manage teacher/student information

3.1 The Student: Students are restricted to make any kind of changes as they only get permission to view and reply in all the courses, Quiz's, assignments and Forums of their category. They can submit their assignments or can write on the forums as an editor window is available to them where they can fire their queries and can reply. On eLearnAgriculture, student role is the default role for the users of this site. For that, they have to register themselveson the site by filling up the Registration Form available under the Register tab on the home page of the site.

3.2 The Teacher: Teachers can view, add and edit all the contents of their subjects. The teachers are the content creators of their courses. They collect the course material as mentioned in the course syllabus and divide the whole course content into various lessons/ topics. Then for each topic they have to prepare the Goals, Glossary, Lesson Content, Quiz, power point presentations and Summary.They can set the marking strategy for the Quiz questions. They are allowed to post in forums and give assignments as per their course. They can generate the reports of students based on their performance. They have the privilege to view and edit the course content. Teacher is the overall creator and manager of his course.

3.3 Administrator: Administrator provides all types of authentications, restrictions and permissions. Administrator has the right to delete any user or restrict any user privileges. An administrator can change relationships as he/she is the person who provides right teacher under right course. He/she manages backup of all the users work, performances and system back up files as he can also maintain login sessions, he can generate reports as a whole and as per specified user according to their performance. So whole system is governed and managed by the administrator. The activities performed by the three types of users of this system.

Discussion

The system eLearnAgriculture has been developed to provide an online eLearning platform to the students and teachers of agriculture education. The students can access the course material at their preferable time and can complete their assignments whenever and where ever they are. They are also free to discuss their view point and problems within the user groups and the teachers as well. They can also collaborate for the betterment of the course content. The eLearning system will support increased communications between staff and students, and amongst students. It will provide frequent and timely individual feedback through computer assisted assessment. It will support economic reuse of high quality expensive resources and encourage students to take responsibility for their own learning by creating an environment that promotes an active approach to learning. The teachers can make the classes more effective and efficient by including multimedia content like graphics, charts, audio and video. It will also help in avoiding face-to-face interaction time. There is a wide scope of adding agriculture courses of other disciplines in eLearnAgriculture. Once the material of all courses will be created and implemented, it will be helpful to the people involved in teaching and learning agricultural education online and will act as a significant online resource.

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STRENGTHS OF SHG – BRINGING WOMEN TOGETHER

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Self Help Groups (SHGs) of women in India have been recognized as an effective strategy for the empowerment of women in rural as well as urban areas : bringing women together from all spheres of life to fight for their rights or a cause.

A study was conducted in Udaipur district of Rajasthan to identify the strengths of SHG as perceived by women beneficiaries. For this purpose, DWDA (District Women Development Agency) a government organization having 190 SHGs and IFFDC (Indian Farm Forestry Development Cooperative Ltd.] a NGO having 250 SHGs were taken up for the study purposively with the rationale that any organization that has more number of groups formed under them could be assumed to have more credibility, more experience and wider range of activities for its beneficiaries.

A list of women's SHG working under DWDA and IFFDC was obtained from the respective organizations. Out of the total groups formed under these organizations, 10 SHGs were selected from each organization on the basis of maximum number of years of standing.

The number of members in each of the SHGs ranged between 15-20. For the selection of respondents, 9 members from each group were drawn on random basis out of which one was leader. Thus the sample size constituted of 90 members from each GO and NGO. Interview schedule was used for data collection.

Pin-pointing to the major strengths of SHG will help to sustain the groups in long run. To see the association between rank assigned by the respondents of government and non-government organization to the strengths of SHG, rank order correlation (r_s) was calculated.

The Table 31 inferred that the major strengths of SHG as perceived by the members of government and non-government organization were similar. In both the organizations the three strengths namely, "SHG has developed a habit of saving among women", "helped in meeting emergency needs" and "freedom from moneylenders" were ranked as 1st, 2nd and 3rd respectively.

The other two strengths that were ranked as 4th and 5th by members of government organization were "motivated for saving and entrepreneurship" and "women have become capable to express their likes and dislikes" while in NGO these were "SHG has developed awareness for clearing debts" and helped to "control the husband from unnecessary expenditure".

Further a close examination of the data further reveal that there exist association between ranks assigned by the respondents of GO and NGO as the 'r_s' value (r_s = 0.69) was found to be significant at 1 per cent level. It means that there exist similarity in ranks assigned by respondents of both the organizations.

Joseph and Jeyagowri (2006) revealed the benefits of SHG as perceived by

Table. Strengths of SHG

S.No.	Strengths	Beneficiaries			
		GO		NGO	
		MWS	Rank	MWS	Rank
1.	Developed a habit of saving among women	3	1	3	1.5
2.	Freedom from moneylenders	2.87	3	2.96	3
3.	Helped in meeting emergency needs	2.97	2	3	1.5
4.	Provided a platform for discussing common problems	1.94	14.5	2.67	7
5.	Developed leadership capabilities among rural women	1.74	18	2.31	17
6.	Developed confidence for putting the view point in front of male	2.42	7	2.34	14
7.	Motivated women to participate in various extension activities	2.33	11	2.56	9
8.	Provided an opportunity for exposure to outside environment	1.94	14.5	2.5	13
9.	Started going to market for purchase of household items	2.33	11	2.52	12
10.	Became capable to express their likes and dislikes	2.64	5	2.64	8
11.	Became capable to take decisions regarding children's :				
	a. Education	2.33	11	2.53	10.5
	b. Marriage	2.36	8	2.53	10.5
12.	Controls the husband from unnecessary expenditure	1.44	20	2.8	5
13.	Developed awareness for clearing debts	2.62	6	2.83	4
14.	Motivated for saving and entrepreneurship	2.75	4	2.77	6
15.	Increased enrollment of girls in school and reduced dropout	1.8	17	2.33	15
16.	Reduced drudgery at household level through trainings	1.15	21	2.05	20
17.	Developed awareness regarding health and sanitation	1.64	19	2.15	19
18.	Reduction in *Parda* system	1.83	16	2.02	21
19.	Increased awareness regarding government programme for women	2.32	13	2.32	16
20.	Increase in income and agriculture production	2.34	9	2.28	18

r_s = 0.69 significant at 1.00 per cent level

members of SHG in the study area. It was reported that economic security, entrepreneurial skills, savings and access to credit facilities along with educational benefits like technological knowledge, vocational training, life skill education, informal education and awareness of current affairs were the major benefits accrued.

It is crystal clear that the SHG is a very strong mechanism and can go a long way in empowerment of women. There is a lot of research work that highlight on the strengths of SHG. Several impact studies of SHG carried out by Kumaran (1997), NABARD (1995), AARO (1998), Hussain (1999), Kumaran (1999), Choudhary *et al.* (2000), Jha (2000), Kesar *et al.* (2001), Kulshestha (2000), Raman (2000) and Ojha (2001) concluded that SHGs have helped in improving socio-economic conditions of their members.

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CONSTRAINTS EXPERIENCED BY WOMEN BENEFICIARIES IN EFFECTIVE FUNCTIONING OF SHGS

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A constant feedback with respect to implementation of the programme is necessary to strengthen the programme and to provide more benefits to the people. Besides, it also helps in ensuring that work is being executed properly and that the means employed for its execution are adequate and appropriate. This would help to pin-point to the major impediments that come in the way of smooth functioning of SHG. Thus a strategy to overcome these problems could be framed.

Keeping this in view, a study was conducted in Udaipur district of Rajasthan with women beneficiaries of GO and NGO SHGs. 90 women members from District Women Development Agency (DWDA) of GO and similar number of beneficiaries of IFFDC [Indian Farm Forestry Development Cooperative Ltd.] an NGO were chosen as sample for study. Interview schedule was used for data collection.

To see the association between rank assigned by the respondents of government and non-government organization to the weaknesses of SHG, rank order correlation (r_s) was calculated.

The ranking pattern of the respondents of both the organizations as depicted in table clearly highlights that the major weaknesses of SHG as perceived by them were more or less similar.

Among the GO respondents, the first three weaknesses were – "lack of training regarding functioning of SHG", "lack of adequate technical support for taking up enterprise" and "illiteracy among group members that created problem in maintaining financial record" respectively. (table 1)

Whereas among the NGO respondents the first three weaknesses were mainly centred around illiteracy. They ranked "the problem in keeping records and diaries", "maintaining financial record" and "bank transactions" as 1^{st}, 2^{nd} and 3^{rd} respectively.

Overall in the ranking of other weaknesses not much variation was observed in the responses from the respondents of the two organizations. Table 32 further inferred that 'r_s' value was found to be 0.79 which was significant at 1.00 per cent level. Thus there exist a significant association between ranks assigned by the respondents of GO and NGO.

The respondents from GO organizations mainly felt the lack of systematic and proper training on the functioning of SHG. These groups were those from 'women in agriculture' scheme and 'women development programme'. The respondents were not trained in SHG and the ongoing groups were told to start collecting money and were provided with registers and diaries for the purpose. Also much emphasis was given on taking up entrepreneurial

Table 1. Weaknesses of SHG

S.No.	Weaknesses	Beneficiaries			
		GO		NGO	
		MWS	Rank	MWS	Rank
1.	Due to illiteracy; problem in				
	(a) Maintaining financial record	2.42	3	2.61	2
	(b) Keeping records and diaries	2.37	4	2.65	1
	(c) Bank transactions	2.13	6	2.32	3
	(d) Communicating freely with extension personnel and with bank officials.	0.92	11	1.44	7
2.	Ignorance regarding various programs and schemes of social and economic development	2.2	5	1.77	6
3.	Feeling of mistrust among members	1.44	10	0.91	8
4.	Lack of adequate technical support for taking up enterprise	2.68	2	1.98	4
5.	Irregularity of members in monthly meetings	1.94	7	0.66	10
6.	Irregularity in depositing money by members	1.83	8	0.73	9
7.	Problem of defaulters	1.53	9	0.63	11
8.	Lack of training regarding functioning of self help group	2.74	1	1.96	5
9.	Disagreement among members with regard to group leader	0.67	13	0.07	12
10.	Caste differences among members	0.68	12	0.06	13

r_s = 0.79 significant at 1.00 per cent level

activities but no such technical support mechanism was provided to them. The ladies liked the concept of SHG and the idea of becoming entrepreneurs but at the same time they were disheartened as no machinery was there that would support them in this venture. Now that the women reported that they had capital but did not know where to invest it and if at all they start a petty trade, they did not know where they would find a market their products. Before the majority of women members became self-reliant the government withdrew its schemes and the zeal and enthusiasm was shattered. Also it was much talked about that rotation of leadership must be done. In reality the women members were afraid in taking the responsibility as they found it difficult in maintaining financial record and keeping records and diaries.

The results of the present investigation are in conformity with the researches conducted by Upadhyay (2000), Dwarakanath (2002), Rani (2003), Singh *et al.* (2003) and Dangi and Khajuria (2003), Joseph and Jeyagowri (2006) who also pointed out to similar constraints in the implementation and functioning of effective SHG programme.

On the basis of findings, it is suggested that literacy must be promoted among members. There is a need to train both the leaders and group members for proper organizational and management of group. There is a need for rotation of leadership among members and due emphasis should be given to development of leadership. There is a need for meticulous thinking while planning for exposure cum learning visits of members as well as functionaries. The women need to be given inputs in information empowerment, technological interventions, and income generating activities. There is a need for activating the groups in social mobilization also. Further evaluation, feedback and follow-up of groups is a must. Also proper organizational linkages need to be developed for effective functioning of SHG.

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