RESIDUAL, DIRECT AND CUMULATIVE EFFECT OF ORGANIC MANURES AND BIOFERTILIZERS ON YIELD, NUTRIENT UPTAKE, GRAIN QUALITY AND ECONOMICS OF WHEAT UNDER ORGANIC FARMING OF RICE-WHEAT CROPPING SYSTEM

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Abstract: The field experiments carried out at the Indian Agricultural Research Institute, New Delhi during *Rabi* season of 2002-2003 and 2003-2004 to study the effect of different combination of organic manures and biofertilizers on growth, yield,nutrient uptake and economics of wheat under organic farming. The results indicated that the cumulative effects of farmyard manure (FYM) and green manuring (GM) were more effective than its direct and residual effects and GM was significantly effective to FYM for increasing the productivity, nutrient uptake and economics of wheat. The inoculation of biofertilizers (B) with GM was better than GM alone in its cumulative effect. The combination of GM+FYM was still better than GM or FYM alone in its direct and cumulative effects for increasing productivity and gross return but net return was significantly reduced due to the higher cost of GM+FYM compared to FYM and GM alone. However, the residual effect of GM+FYM was similar to the cumulative effect of GM or FYM alone. The maximum improves the productivity and nutrient uptake was recorded with the use of GM+FYM+Biofertilizers. However, net return was significantly reduced due to higher cost of sources in combination of GM+FYM+B. It was concluded that the cumulative effect of GM+FYM+B for higher productivity and the cumulative effect of GM+B for higher net return were suitable for wheat in organic farming of rice-wheat cropping system.

Keywords: Organic farming, Wheat, Green manuring, Yield, NPK uptake, Economics

INTRODUCTION

What is the second most staple food crop after rice in India and occupies about 26.7 million ha of area and contributes about 33.9% of the total grain production of the country. The rice-wheat cropping system covers 10 million ha representing 75% of the total rice area and 63% of the total wheat area in India (Mishra, 2009). This signifies the important contribution of wheat meeting the food requirements of the country. The soils under rice-wheat cropping system are now showing the sign of fatigue and there is a decline in yield (Yadav, 1998) and Researcher (Duxbury *et al*, 2000, Ladha *et al*, 2000, Yadav, *et al*, 2000 and Prasad, 2005) reported that the production of rice and wheat in a rotation is, however, facing a sustainability problem due to some practices of the modern production system with its indiscriminate use of chemical fertilizers and pesticides. The adverse effects of agro-chemicals are clearly visible on soil fertility, microflora, quality of water, food and fodder. The quality of the produce is deteriorated due to the entry of chemical residues in the plant body and then food chain. The factor productivity declined to report by Biswas & Sharma, 2008, Patil, 2008 and Yadav, 2008, depletion of soil organic carbon and mineral nutrient reported by Prakash *et al*, 2008 and water logging and salinization, increasing nitrate concentration in well water reported by Singh *et al*, 1995. These consequents are emerging in modern rice-wheat production system due to unbalance and injudicious use of chemical fertilizers and pesticides. The emerging scenario necessitates the need for the adoption of practices which maintain soil health, makes the production system more sustainable and provides quality food for meeting the nutritional requirements. Keeping all these things in view, the organic farming is one of the options to make the production system more sustainable without adverse effects on the natural resources and the environment (Stockdate *et al*, 2001) and over the past decade India has exhibited a rapid uptake of organic farming (Paull, 2011). The application of ample amount of organic manure is the key for success of organic farming. Therefore, different combination of organic manures and biofertilizers were tested for filling the nutrient requirement of wheat under organic farming. This paper implements different treatments with different composition of organic manures and biofertilizers and comparing their direct, residual and cumulative effects to find out the effect of its on yields, NPK uptake, grain quality and gross and net returns of wheat under organic farming.

MATERIAL AND METHOD

Field experiments were conducted at the Research Farm of the Indian Agricultural Research Institute, New Delhi (28°35'N latitude, 77°12'E longitude and at an altitude of 228.61 m above mean sea level) during *Rabi* season (December to April) of 2002-

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2003 and 2003-2004. The soil of experimental field was sandy clay loam (Ustochrept) with alkaline in reaction (pH 8.12), low in organic carbon (0.54%), low in available nitrogen (162.2 kg N/ha), medium in available phosphorus (19.22kg P/ha) and high in available potassium (245.32kg K/ha) in 0-15cm soil depth at the start of the experiment. The experiment was laid out in a factorial Randomized plot design with three replications. Treatment consisted of sixteen combinations of different organic manures and biofertilizers. There were three sets of five treatments *viz.* Farm yard manure (FYM), Green manure (GM), GM+Biofertilizers (B), GM+FYM and GM+FYM+B and a control. The experiment was carried out in a rice-wheat cropping system and the rice was taken before the wheat crop. Hence, one set of the treatments was applied to rice, which was regarded as a direct effect to rice and the residual effect to the succeeding wheat. The second set of the treatments was applied to wheat, which was regarded as a direct effect of wheat and a residual effect to the succeeding rice and the third set of treatments was applied to both rice and wheat which regarded as a cumulative effect of both rice and wheat. For green manures, *Sesbania aculeata* (SGM) was used for rice and Leucaena green leaf manuring (LGLM) was used for wheat. For biofertilizers, blue green algae (BGA) used in rice and Azotobacter used in wheat. Variety HD-2687 was used for sowing of wheat in the experiment.

The nutrient content in organic manures is presented in Table 1. Well decomposed FYM @10t/ha on dry weight basis used during field preparation for wheat and before sowing *sesbania* for rice. *Sesbania aculeata* was seeded for green manuring in SGM treated plots at a uniform row spacing of 30 cm in the last week of April and it incorporated in-situ about 60 DAS with the help of tractor mold board plow followed by heavy disc. The lop of *Leucaena leococephala* (Subabul) were manually collected from pruning of shrubs and applied @ 5t/ha on dry weight basis in the plots having the LGML treatment. It was incorporated into the soil with a tractor drawn heavy disc at 20 days before of sowing of wheat. Multani mitti (Fuller's earth) based, Blue Green Algae (BGA) containing four micro-organisms species *Aulosira fertilissima, Nostoc muscorum, Tolypothrix tenuis* and *Anabaena variabilies* was inoculated twice in the plots having BGA treatment**.** The first inoculation was done in 10 days after transplanting (DAT) and then second at 20 DAT @ 4 kg ha^{-1}. Strains of *Azotobacter chroococcum* specific to wheat crop was used to inoculate the seeds as per the treatments. Sowing of what was done by a Pora method with the help of the hand Plough in the rows spaced at a spacing of 15cm using with seed rate @120kg/ha. *Pora* method was used because some plots were sown with *Azotobacter* culture treated seed, whereas other plots were sown with untreated seed.

RESULT AND DISCUSSION

Growth and yield attributes

Growth and yield attributes influenced by the different combinations of organic manures and their modes of applications are presented in Table 2. The residual effect of FYM, SGM, SGM+BGA, SGM+FYM and SGM+FYM+BGA on plant height and earheads/m^2 was found significantly superior over control. The grains/earhead significantly increased with residual effect of organic manures and biofertilizers over control in both the years. The test weight of wheat was not significantly influenced through the residual effect of organic manures and biofertilizers in first year, however it significantly higher in the second year. The residual effect of SGM+FYM+BGA was significantly increased the growth and yield attributes over control and FYM alone. As regards the direct effect of different combinations of organic manures and biofertilizers significantly increased plant height and yield attributes over control in both the years. Direct effect of FYM significantly increased plant height, earhead and grains over residual effect of FYM. In the second year, direct effect of green manuring on growth and yield attributes was found significantly superior over residual effect of green manuring except test weight. Direct effect of LGLM + FYM + Azotobacter significantly increased growth and yield attributes over residual effect of SGM+FYM+BGA. The cumulative effect of GM+FYM and GM + FYM + biofertilizer was found significantly superior over the direct effect of GLML+FYM and GLML + FY +Azotobacter, respectively.

Grain and straw yield

The data on grain and straw yield of wheat as influenced by the different combinations of organic manures and biofertilizer and its methods of application are presented in Table 3. The residual effect of FYM on grain and straw yields was found significantly higher than the control in second year. The residual effect of SGM on grain and straw yield was significantly superior over FYM in second year. The residual effects of SGM+BGA, SGM+FYM and SGM+FYM+ BGA on grain and straw yield were recorded significantly superior over FYM alone in both the year. The combination of SGM+FYM+BGA significantly increased grain and straw yield over SGM alone in both the year. The direct effect of different combinations of organic manures and biofertilizers on yield was found significantly superior over control in both the years. The direct effect of organic manures and biofertilizers were found significantly superior over their residual effect, respectively. The cumulative effects of organic manures and biofertilizers were found significantly superior over residual effect of FYM, SGM, SGM+BGA and SGM+FYM+BGA, respectively. The cumulative effect of FYM was significantly

increased 6.73-9.67 and 19.67-35.37 % grain yield and 8.70-9.53 and 19.40-22.55% straw yield superior over direct and residual effects of FYM, respectively. There was no significant between cumulative and direct effect of FYM in harvest index. Thakur and Patel (1998) and Singh and Agarwal (2004) have previously reported a beneficial effect of FYM on wheat. Whereas, the cumulative effect of GM was found at par with the cumulative effect of FYM and significantly higher than direct effect of GLML on grain yield in second year and straw yield in both the year by 15.6% grain yield and 7.91-16.2% straw yield, respectively. The addition of nutrients through GM resulted in significantly higher growth and yield attributes and consequently straw and grain yield was further more with application of GM over FYM. Shah *et al* (2000) reported a significant increase in growth and yield attributes and yield of wheat due to the application of GM. Inoculation of GM with biofertilizers resulted in a significantly higher grain yield and straw yield than FYM alone. The cumulative effect of GM+FYM was significantly superior over their direct effect. The grain and straw yield increased 6.29-11.14 and 4.21-10.78% higher by cumulative use of GM+FYM than direct use of GLML+FYM. The cumulative effect of GM+FYM was found significantly higher over cumulative effect of FYM in both the years. The cumulative effect of GM+FYM was also found significantly superior over GM alone and increased 7.34-22.51% grain yield and 3.26-19.74% straw yield over GM alone. The maximum grain yield (4.59-5.52t/ha) and straw yield (6.79-8.40t/ha) were recorded with cumulative use of GM+FYM+Biofertilizer which was significantly superior over GM+FYM in first year and statistically at par with GM+FYM in second year. The cumulative effect of GM+FYM+biofertilizer significantly increased 7-60-17. 71% grain yield and 8.96-15.67% straw yield higher than GM+biofertilizer and gave 9.32-32.16% grain yield and 9.52-27.63% straw yield significantly higher than GM alone. However, harvest index 3.54% higher than GM alone in second year. The cumulative effect of GM+FYM+biofertilizer was significantly increased 24.32-37.39% grain yield, 26.7-31.3% straw yield and 2.83-4.59% harvest index higher than FYM alone. The application of biofertilizer in wheat resulted in the addition of 17-20kg N/ha and some amount of N can be expected from the residual effect of biofertilizer applied to the proceeding rice crop. Thus the cumulative effect of GM+Bifertilizer proved more effective than GM alone. The application of Biofertilizer significantly increased all the growth and yield attributes and consequently yields were also increased. Apte and Shende (1981), Rabie *et al*. (1995), Khalid *et al* (1997), Khosravi *et al* (1998) and Kaushik *et al* (2001) have previously reported a significant a significant improvement in growth and yield attributes and yields of wheat by Azotobacter inoculation. Rathore *et al* (1995) have reported a residual effect of BGA inoculated in rice on yield of succeeding wheat crop. The combination of GM+FYM was significantly better than GM and FYM alone in increasing grain and straw yield in both the year. The combination of GM+FYM generated significantly higher amounts of nutrients than GM and FYM alone and resulted in significantly higher yields than GM and FYM alone. Across the methods of application, the cumulative effect of nutrient combinations recorded significantly higher yields than direct. The direct effect was significantly more than the residual effect of nutrient combination in both the year. The nutrient combinations applied to wheat, as well as to the preceding rice crop, resulted in improved soil fertility status and nutrient combinations applied to wheat (direct) and applied to rice (residual). Previously Sharma *et al* (1995) and Dwivedi and Thakur (2000) also reported that the cumulative effects of organic manures were higher as compared to their direct effect.

Nutrient uptake

The data on N, P and K uptake by wheat influenced by the different combinations of organic manures and biofertilizers and their methods of applications are presented in Table 4. The residual effect of FYM on N, P and K uptake was found at par with control in the first year but significantly higher than control in second year. The residual effect of SGM on nutrient uptake was significantly superior over FYM and control. Whereas, residual effect of SGM+BGA on nutrient uptake at par with SGM. The residual effect of SGM+FYM was significantly superior over SGM and FYM alone. The residual effect of SGM+FYM+BGA was significantly higher than SGM+BGA and at par with SGM+FYM. The direct effect was significantly superior over their residual effects. The significant differences were recorded in nutrient uptake as the direct effect ofFYM>control, LGLM>FYM, LGLM+Azotobater>LGLM, LGLM+FYM>LGML+ Azotobacter and LGLM+FYM+Azotobacter>LGLM+FYM. The cumulative effects of organic manures and biofertilizers were significantly superior over their direct effects. The cumulative effect of FYM was significantly superior over the direct effect of FYM. The cumulative effect of GM was significantly superior over FYM in second year. However, the cumulative effect of GM+Biofertilizers was significantly superior over GM in first year. The cumulative effect of GM+FYM significantly increased N and P uptake in first year and K uptake in both the years over GM+Biofertilizers. The maximum nutrient uptake was recorded in cumulative use of GM+FYM+Biofertilizers which was significantly superior over rest combinations of organic manures and biofertilizers. Previously, Bhardwaj and Tyagi (1994), Ghosh and Shah (1997)

and Singh and Agarwal (2004) have reported increased NPK uptake by wheat with FYM application. Inoculation of biofertilizer with GM showed significantly higher N uptake than GM alone. The combination of GM+FYM supplied significantly more nutrients and improved soil fertility. Consequently, growth and yield were increased significantly and resulted in significantly higher N, P and K uptake than GM and FYM alone. N, P and K uptake were significantly influenced by the method of application, the cumulative effect of organic manures and biofertilizer combinations resulted in significantly higher N, P and K uptake than the direct effect which in turn was significantly superior over residual effects of the nutrient combinations. These results are explained as due to the higher fertility status of treatments received by organic manures and biofertilizers in both the crop (cumulative effect) than those received in wheat (direct effect) and received in rice (residual effect).

Economics of wheat cultivation

The data on gross return, cost of cultivation, net return and B:C ratio influenced by the different combinations of organic manures and biofertilizers and their methods of application are presented in table 5. The significant effect of FYM over control was observed in term of gross return and net return in second year, however, gross return and net return were found no significant difference between FYM and control in first year. The residual effect of SGM on gross and net return was found at par with control in first year and significantly superior over control in second year. The residual effects of SGM+BGA, SGM+FYM and SGM+FYM+BGA on gross and net return were found significantly superior over control in both the years. The residual effect of SGM on gross and net return significantly higher than FYM in second year, whereas, the effect of SGM+BGA significantly superior over FYM in both the years. No significant variation between SGM+FYM and SGM but significant variation observed between SGM+FYM and FYM in both the years. The residual effect of SGM+FYM+BGA was significantly increased gross and net return over SGM in first year and over FYM in both the years. The maximum B: C (0.88) in first year and 1.45 in second years observed with residual effect of SGM+FYM+BGA. The direct effect of FYM on gross and net return was significantly higher than residual effect of FYM in second year. Whereas, direct effect of LGML significantly increased grass return over SGM in second year and decreased negatively net return compared to residual effect of SGM. The direct effect of LGLM+Azotobacter, LGLM+FYM and LGLM+FYM+Azotobacter significantly increased gross return over residual effect of SGM+BGA, SGM+FYM and SGM+FYM+BGA, respectively. The direct effect of organic manures and biofertilizers combinations was found negative in net return compared to their residual effects. The cumulative effect of FYM was found no significant over direct effect of FYM. Whereas, the cumulative effect of GM was found significantly superior over direct effect of LGLM in second year. The cumulative effect of GM+biofertilizer was found no significant over LGLM+Azotobacter. Whereas, cumulative effect of GM+FYM significantly superior over LGLM+FYM in first year. The cumulative effect of GM+FYM+Biofertilizers was found significantly superior over direct effect of LGLM+FYM+Azotobacter in both the years. The cumulative effect of GM on gross return was significantly higher than cumulative effect of FYM in second year. Whereas, the cumulative effect of GM+biofertilizer on gross and net return significantly higher than GM alone in first year. The cumulative effect of GM+FYM+biofertilizers was at par with GM+FYM and GM+biofertilizer but significantly superior over GM and FYM alone. The cost of wheat cultivation varied from Rs, 13559/ha for control treatment to Rs 21147/ha for GLML+FYM+Azotobacter/GM+FYM+biofertilizers in both the years. The addition of FYM, GM, GM+Biofertilizers, GM+FYM and GM+FYM+biofertilizers increased the cost of cultivation over the control. Across the methods of application, the cumulative effect resulted in significantly higher gross and net return followed by direct and residual effects. The B:C ratio was significantly higher in the residual effect compared to the cumulative and direct effects of organic manures and biofertilizers combinations in both the years.

CONCLUSION

The application of a combination of green manuring+farm yard manure+biofertilizers in a cumulative manner was found to achieve the highest yields of wheat. However, with lower cost of inputs, an appropriate yield of wheat with enhanced net returns can be obtained by the application of green manuring and biofertilizers in a cumulative manner in organic farming of rice-wheat cropping system. This latter result applies under the costs established for the present study and assumes a buy-in by the farm of the inputs. However, where a farm is self producing of farm yard manure or the costs of farm yard manure are lower than reported in this study, then in that case the application of farm yard manure can be expected to both enhance grain yields and net returns. Higher organic nutrient inputs result in higher yields. The challenge for the farmer is always to make the trade-off between the changing cost of inputs versus the changing market price for the produce and changing premium for organic produce.

Table 1. Addition of C, N, P and K (kg/ha) through organic manures and biofertilizers

Treatments	Total C (kg/ha) of two years	Total N (kg/ha) of two years	Total P (kg/ha) of two years	Total K (kg/ha) of two years	C:N ratio
Control	0	0	0	0	0
Organic manures and biofertilizers applied to rice					
FYM	2802	98	51	103	28.59
SGM	3525	239	35	205	14.75
SGM+BGA	3525	280	35	205	12.59
SGM+FYM	6327	338	86	308	18.72
SGM+FYM+BGA	6327	378	86	308	16.74
Organic manures and biofertilizers applied to wheat					
FYM	2850	99	48	100	28.79
LGLM	4680	299	31	227	15.65
LGML+Azotobacter	4680	339	31	227	13.81
LGLM+FYM	7530	398	79	327	18.92
LGLM+FYM+Azotobacter	7530	438	79	327	17.19
Organic manures and biofertilizers applied to rice and wheat					
FYM	5652	197	99	203	28.69
GM*	8205	539	66	432	15.26
GM+Biofertilizer**	8205	619	66	432	13.83
GM+FYM	13857	736	165	635	18.83
GM+FYM+Biofertilizer	13857	816	165	635	16.98

*GM: SGM in rice and LGLM in wheat; **Biofertilizers: BGA in rice and Azotobacter in wheat
Including 20kg N/ha contribution from each BGA and Azotobacter as reported by Subba Rao (2002)

Table 2. Residual, direct and cumulative effect of organic manures and bioertilizers on growth and yield attributes of wheat

Treatments	Plant height (cm)		Earheads/m^2		Earheads length (cm)		Grains/ earhead		Test weight (g)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Control	88.7	86.7	240	211	9.5	8.7	31.1	31.1	35.0	35.0
Organic manures and biofertilizers applied to rice										
FYM	89.5	90.6	247	281	9.7	10.2	31.7	33.1	35.1	35.2
SGM	91.0	91.5	250	288	9.9	10.4	33.8	35.1	35.1	35.5
SGM+BGA	91.6	93.1	253	294	10.1	11.0	35.3	35.5	35.1	35.5
SGM+FYM	91.7	95.3	260	300	10.4	11.4	35.5	36.0	35.1	35.6
SGM+FYM+BGA	92.0	96.2	267	315	10.6	11.6	36.1	36.2	35.2	35.7
Organic manures and biofertilizers applied to wheat										
FYM	91.0	92.2	252	292	9.9	10.6	33.8	36.5	35.1	35.4
LGLM	91.7	94.8	264	304	10.0	10.8	36.6	37.2	35.1	35.6
LGML+Azotobacter	92.5	96.2	268	316	10.5	11.2	40.0	41.7	35.2	35.6
LGLM+FYM	94.0	97.6	272	324	10.8	11.6	40.2	42.5	35.1	35.8
LGLM+FYM+Azotobacter	95.8	98.8	280	336	11.0	12.2	40.4	43.1	35.2	35.8
Organic manures and biofertilizers applied to rice and wheat										
FYM	91.6	95.8	260	307	10.0	11.0	36.2	37.1	35.1	36.2
GM*	92.3	96.9	267	317	10.2	11.2	36.5	40.3	35.1	36.8
GM+Biofertilizer**	93.0	97.3	273	328	10.5	11.6	40.0	41.8	35.2	36.8
GM+FYM	95.2	98.5	285	345	10.9	11.9	41.4	42.9	35.3	36.8
GM+FYM+Biofertilizer	97.0	101.0	293	357	11.1	12.2	43.7	43.5	35.3	36.8
LSD (P=0.05)	1.03	2.25	6.12	8.16	0.28	0.31	1.53	1.57	0.15	0.16

*GM: SGM in rice and LGLM in wheat; **Biofertilizers: BGA in rice and Azotobacter in wheat

Table 3. Residual, direct and cumulative effect of organic manures and biofertilizers on growth and yield attributes of wheat

Treatments	Grain yield (t/ha)		Straw yield (t/ha)		Harvest index (%)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Control	2.62	2.61	4.13	4.12	38.8	37.7
Organic manures and biofertilizers applied to rice						
FYM	2.75	3.28	4.33	5.41	38.8	38.8
SGM	2.93	4.02	4.60	6.04	38.9	38.8
SGM+BGA	3.14	4.11	4.86	6.21	39.2	38.8
SGM+FYM	3.16	4.21	4.90	6.63	39.3	38.8
SGM+FYM+BGA	3.30	4.23	5.00	6.69	39.7	38.9
Organic manures and biofertilizers applied to wheat						
FYM	3.00	4.16	4.72	6.10	38.9	38.9
LGLM	3.16	4.36	4.93	6.60	39.0	39.3
LGML+Azotobacter	3.66	4.70	5.63	7.44	39.4	39.4
LGLM+FYM	3.77	5.09	5.75	7.60	39.6	40.1
LGLM+FYM+Azotobacter	3.98	5.18	6.01	7.62	39.8	40.5
Organic manures and biofertilizers applied to rice and wheat						
FYM	3.29	4.44	5.17	6.63	38.9	39.2
GM*	3.42	5.04	5.32	7.67	39.2	39.6
GM+Biofertilizer**	3.84	5.13	5.87	7.69	39.5	40.0
GM+FYM	4.19	5.41	6.37	7.92	39.7	40.5
GM+FYM+Biofertilizer	4.52	5.52	6.79	8.40	40.0	41.0
LSD (P=0.05)	0.29	0.27	0.27	0.48	0.82	0.90

*GM: SGM in rice and LGLM in wheat; **Biofertilizers: BGA in rice and Azotobacter in wheat

Table 4. Residual, direct and cumulative effect of organic manures and biofertilizers on nutrient uptake by wheat

Treatments	N uptake (kg/ha)		P uptake (kg/ha)		K uptake (kg/ha)	
	2002-03	2003-04	2002-03	2003-04	2002-03	2003-04
Control	54.4	54.3	8.9	8.5	72.3	69.3
Organic manures and biofertilizers applied to rice						
FYM	59.0	71.4	9.7	11.7	76.6	93.5
SGM	64.7	86.4	10.6	14.6	81.8	107.4
SGM+BGA	68.7	90.4	11.4	15.2	87.0	110.6
SGM+FYM	71.2	96.0	11.7	15.9	88.3	117.6
SGM+FYM+BGA	74.3	97.3	12.3	16.2	90.7	121.1
Organic manures and biofertilizers applied to wheat						
FYM	64.8	89.8	10.7	14.8	84.3	110.2
LGLM	70.5	97.6	11.7	16.1	89.3	119.7
LGML+Azotobacter	81.9	107.3	13.6	18.1	102.6	134.8
LGLM+FYM	87.1	117.9	14.5	19.8	106.8	140.8
LGLM+FYM+Azotobacter	92.2	120.4	15.7	20.8	113.6	145.8
Organic manures and biofertilizers applied to rice and wheat						
FYM	72.5	96.3	12.1	16.2	92.6	120.3
GM*	76.8	115.7	13.0	19.1	97.4	139.4
GM+Biofertilizer**	86.9	117.2	14.6	19.8	108.3	141.6
GM+FYM	96.8	121.6	16.8	20.5	120.5	149.4
GM+FYM+Biofertilizer	105.8	131.7	18.3	22.6	130.6	160.1

LSD (P=0.05)	4.67	4.59	0.61	0.94	6.03	5.73

*GM: SGM in rice and LGLM in wheat; **Biofertilizers: BGA in rice and Azotobacter in wheat

Table 5. Residual, direct and cumulative effect of organic manures and biofertilizers on economics of wheat

Treatments	Gross return (Rs/ha)		Cost of cultivation (Rs/ha)	Net return (Rs/ha)		B:C ratio	
	2002-03	2003-04	2002-03 & 2003-04	2002-03	2003-04	2002-03	2003-04
Control	20364	20563	13559	6804	7004	0.50	0.52
Organic manures and biofertilizers applied to rice							
FYM	21380	26074	13559	7821	12515	0.58	0.92
SGM	22764	31376	13559	9205	17817	0.68	1.31
SGM+BGA	24301	32103	13559	10742	18544	0.79	1.37
SGM+FYM	24502	33153	13559	10953	19594	0.81	1.45
SGM+FYM+BGA	25452	33339	13559	11893	19780	0.88	1.46
Organic manures and biofertilizers applied to wheat							
FYM	23320	32308	16059	7261	16249	0.45	1.01
LGLM	24526	34068	18559	5966	15509	0.32	0.84
LGML+Azotobacter	28296	37302	18647	9649	18655	0.52	1.00
LGLM+FYM	29138	39667	21059	8078	18608	0.38	0.88
LGLM+FYM+Azotobacter	30652	40254	21147	9504	19107	0.45	0.90
Organic manures and biofertilizers applied to rice and wheat							
FYM	25568	34602	16059	9509	18543	0.59	1.15
GM*	26554	39422	18559	7995	20863	0.43	1.12
GM+Biofertilizer**	29683	40009	18647	11036	21362	0.59	1.15
GM+FYM	32327	42003	21059	11268	20945	0.54	0.99
GM+FYM+Biofertilizer	34821	43146	21147	13674	22029	0.65	1.04
LSD (P=0.05)	2654.5	2761.8	-	2654.5	2761.8		

*GM: SGM in rice and LGLM in wheat; **Biofertilizers: BGA in rice and Azotobacter in wheat

REFERENCES

Apte, R. and Shende,S.T. (1981). Studies on Azotobacter chrococcum on germination of agricultural crops. Zentralblatt fur Bakteriologie Parasitenkunde,Infektionskrankheiten und Hygiene. *AYG*.**136**(7):556-559.

Bhardwaj,V. And Tyagi,V.V. (1994). Impact of continues manuring on crop yields and uptake of nitrogen,phosphorus and potassium. *Journal of Potassium Research*, **10**(3):290-293.

Biswas,P.P. and Sharma,P.D. (2008). A new approach for estimating fertilizer response ratio-the indian scenario. *Indian Journal of Fertilizers*, **4**(7):59-62.

Duxbury,J.M.,Abrol,I.P.,Gupta,R.K.and Bronson,K. (2000). Analysis of long-term soil fertility experiments with rice-wheat rotation in South Asia. *Rice-wheat consortium for the indo-gangetic plains.Series* (6): vii-xxii.

Dwivedi,D.K.and Thakur,S.S. (2000). Effect of organics and inorganic fertility levels on productivity of rice (Oryza sativa). *Indian journal of Agronomy*,**45**(3):568-574.

Ghosh,T.K.and Saha,K.C. (1997). Effect of inoculation of BGA with Mg fixing agrobacteria on the nitrogenage activity in soils. *Plant Biology*, (1):244-252.

Kaushik,R.Saxena,A.K.and Tilak, K.V.B.R. (2001). Selection and evaluation of *Azospirillum brasilence* strains at a sub-optimum temperature in rhizocoenosis with wheat. *Folia Microbiologica*, **46**(4):327-332.

Khalid,K.W.,El-Sesawy,M.M.,El.-Ghany,B.F.A. and Awadalla,S.Y.T. (1997). Interaction between organic manures mixtures, applied N-level and biofertilizers on calcareous soil properties and wheat production in Wadi Sudr,South Sinari. *Egyptian Journal of Soil Science*, **37**(3):367-397.

Kharub,A.S.and Chander,Subhash (2008). Effect of organic farming on yield,quality and soil fertility status under Bansmati rice (*Oryza sativa*)-wheat (*Triticum aestivum*) cropping system. *Indian journal of agronomy*,**53**(3):172-177.

Khosravi, H., Rastin,N.S. and Mohammadi, M. (1998). Effect of Azotobacter inoculation as a biological fertilizer on growth and yield of wheat. *Soil and water Journal*,**12**(6):1-8.

Ladha,J.K.,Fisher,N.S., Hossain,M., Hobbs,P.R.and Hardy,B. (2000). Improving the productivity and sustainability of rice-wheat systems of the Indo-Gangetic Plains, A synthesis of NARS-IRRI partnership research. Discussion paper no.40.IRRI,Los Banos, Philippines,pp 1-33.

Mishra, B. (2009). Advances in rice and wheat research for food and nutritional security. Paper presented at 9th Agricultural Science Congress on ”Technological and industrial innovations for enhancing agricultural income” held at Srinagar,India during June 22-24,2009.

Patil,V.C. (2008). Declining factor productivity and improving nutrient use efficiency. Paper presentated in National Symposium on ”New Paradigms in Agronomic Research” held at Navsari, Gujarat during Nov.,19-21,2008.

Paull,J. (2008). The uptake of organic agriculture:A decade of worldwide development.*Journal of Social and Development Sciences*,**2**(3):111-120.

Prakash, Anand, Singh, V.P.,Kumar, Rajeev and Singh,I.P. (2008). Effect of organics and micronutrient fertilization in rice (*Oryza stiva*)-wheat (*Triticum aestimum*) cropping system. Paper presentation in National symposium on “New Paradigms in Agronomic Research” held at Navsari,Gujarat during Nov.,19-21,2008.

Prasad,R. (2005). Organic farming vis-a-vis modern agriculture. *Current Science*, **89** (2):255-339.

Rabie,K.A.E.,Nasr,S.A.and Amara,M.A. (1995). The effect of symbiotic nitrogen fixers on the growth and endogenous growth substances of wheat plant. *Annals of Agricultural Science* (*Cairo*),**40**(1):11-32.

Rathore, A.L, Chipde, S.J. and Pal, A.R. (1995). Direct and residual effects of bio-organic and inorganic fertilizers in rice (*Oryza sativa*)-wheat (*Triticum aestivum*) Cropping system. *Indian Journal of Agronomy*, **40** (1):14-19.

Shah,R.R., Rai, R.K. and Mukherjee, P.K. (2000). Effect of green manuring of dhaincha and phosphorus on growth,yield and phosphorus uptake by wheat. *Indian Journal of Agronomy*, 45(4):707-710.

Sharma, S.N., Prasad, R., and Singh, S. (1995). The role of mungbean residue incorporation on productivity and nitrogen uptake of rice-wheat cropping system. *Bioresources Technology*, **67**:171-175.

Singh, Ravindra and Agarwal, S.K. (2004). Effect of organic manuring and nitrogen fertilization on productivity, nitrogen use efficiency and economics of wheat (*Triticum aetimum*).*Indian Journal of Agronomy*, **49**(1):49-52.

Singh, S. Prasad, R. and Sharma, S.N. (1995). Effect of blue green algae, nitrogen level and modified urea materials on yield attributes and yield of wet land rice (*Oryza sativa*). *Indian Journal Of Agronomy*,**40** (4):594-597.

Thakur,D.S. and Patel, S.R, (1998). Growth and sink potential of rice as influenced by the split application of potassium with FYM in inceptisols of eastern-central India. *Journal of potassium Research*, **14**(1-4):73-77.

Stockdale, E.A, Lampkin, N.H., Hovi, M., Keatinge R, Lennartssen EKM, Mac Donald D.W., Padel, S., Tattersall, F.H., Woffe, M.S.and Watson, C.A. (2001). Agronomic and environmental implications of organic farming systems. *Advance Agronomy*, **70**:261-327.

Yadav, R.L. (1998). Factor productivity trends in rice-wheat cropping system under long term use of chemical fertilizers. *Experimental Agriculture*, **34**:1-8.

Yadav,R.L.,Dwivedi,B.S.and Pandey,P.S. (2000). Rice-wheat cropping system.Assessment of sustainability under green manuring and chemical fertilizer inputs. *Field Crop Research*,**65**:15-30.