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Growth, yield and economics of rice-wheat system as influenced by integration of organic sources and inorganic fertilizer

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Abstract
A field experiment was conducted with objective to find out long term effect of combination of organic sources and inorganic fertilizer on growth, yield and economics under rice-wheat cropping system in Indo-Gangetic Plains. The highest plant height, number of tillers per square meter, length of panicle/earhead, weight of panicle/earhead and test weight of rice and wheat was recorded in treatment getting 50% N through FYM and 50% RDF through inorganic fertilizers and was significantly higher than rest of the treatments except T_7, T_8, T_{10} and T_{11}, which were at par with each other. Data showed that substitution of either 50% or 25% N through organic sources had established superiority over the application of 100% recommended dose of fertilizers only in inorganic form. Treatment getting 50% N through FYM and 50% RDF through inorganic fertilizers produced significantly higher grain yield (5562, 4377 and 12185 kg/ha) of rice and wheat as well as rice equivalent yield, respectively. Treatment getting 50% N through FYM and 50% RDF through inorganic fertilizers recorded higher net returns and B: C ratio (Rs.36735, Rs. 49951, Rs. 86686, 1.02, 1.62 and 1.30 in rice, wheat and rice-wheat system, respectively). It may be summarized as organo-inorganic combination as integrated nutrient supply system is superior to use of inorganic fertilizers alone. Organic sources even in their moderate doses substituting only 25% of recommended N in the base crop of the cropping system, are capable of improving physical, chemical as well as biological properties of soil up to a considerable extent. Substitution of 50% N either through FYM or wheat straw or green manuring+50% RDF through inorganic fertilizers in rice followed by 100% RDF through inorganic fertilizers in wheat is the best mechanism for raising crop productivity.

Keywords: Economics; growth parameters; yield; rice-wheat system

Introduction
Rice (*Oryza sativa* L.)-wheat (*Triticum aestivum* L.) Cropping system plays a significant role in food security, contributing 76% of total food grain production of India. About 33% of India's rice and 42% of wheat is grown in this rotation. This system is the principal cropping system occupying 24 m ha of cultivated land in the Asian subtropics. In south Asian countries, this system is prevalent in 13.5 m ha in the Indo-Gangetic plain of which 10 m ha lies in India (Mahajan and Sharma, 2005). However, application of imbalanced chemical fertilizers has led to decline of nutrient use efficiency making fertilizer consumption uneconomical and producing adverse effects on environment. Prolonged use of chemical fertilizer hampers the sustainability of crop production and soil fertility. Imbalance use of chemical fertilizer alone tends to decline yield over a period of years with given input. All these factors led to search for alternative sources of plant nutrients. In this circumstance, nutrient recycling in the soil-plant ecosystem through judicious and efficient use of fertilizers and organic manures may play a vital role towards sustainable productive agricultural enterprise. Use of chemical fertilizers and organic manures has been found promising in arresting the declining trend in soil-health and crop productivity through the correction of marginal deficiencies of some secondary and micro-nutrients, micro-flora and fauna and their beneficial influence on physical and biological properties of soil. Integrated nutrient management system can bring about equilibrium between degenerative and restorative activities in the soil eco-system (Upadhyay *et al.,* 2011). Thus, keeping in view the above consideration the study was formulated on long term effect of combination of organic sources and inorganic fertilizer on growth parameters, yield and economics under rice-wheat cropping system in Indo-Gangetic Plains.

Methods and materials
A field experiment during *kharif* and *rabi* seasons of two consecutive years, 2014-15 and 2015-16 in on-going long term permanent manorial trial since 1984.

The Bihar Agricultural College Farm, Sabour is located south of the river Ganges, beyond the natural levees. It is situated at latitude of 25°15' 4"N and longitude 78°2' 45"E with an altitude of 37.19 meters above the mean sea level in Bhagalpur district of Bihar state under Gangetic plains of India. The experimental plot was provided with assured irrigation facility having uniform topography and proper drainage. The experiment was laid under RBD in four replications. Net plot size was 7.5 m x 4.35 m for rice and 7.5 m x 4.15 m for wheat. The spacing was 15 cm x 15 cm for rice and 20 cm (Row to Row) for wheat. 40 kg/ha in rice and 100 kg/ha in wheat seed was used. Recommended dose of fertilizer (N, P and K) was 80:40:20 (kg/ha) in rice and120:60:40 (kg/ha) in wheat. Rice variety 'Sita' and wheat variety 'PBW 343' were used in the investigation. Well decomposed FYM (0.5% N) and wheat straw after threshing by a thresher containing (0.65% N) was used in the experiment. For green manuring 50 days old succulent crop of *Sesbania aculeata* (Dhaincha) was used from which required quantity of twigs were chopped and incorporated during puddling as green manure. FYM and wheat straw were incorporated in soil 15 days ahead of transplanting time. Wherever or whenever required additional irrigations were given for speedy decomposition and mineralization of added organic manures. Full dose of phosphorus as DAP (18%N + 46% P_2O_5) and potash as muriate of potash (60% K_2O) was applied at the time of last ploughing in rice and in rows before sowing of wheat crop. Nitrogen was applied through urea (46% N) in 3 splits as per the recommended practice for both the crops, in which half was applied at transplanting of rice and sowing of wheat. Remaining half of N was top dressed in two splits as one fourth at active tillering and one fourth at panicle initiation stages in rice. In case of wheat, the remaining N was top dressed equally after first and second irrigation. 25 days old seedlings were used in rice transplanting. Two seedlings per hill were transplanted keeping both inter and intra row spacing at 15 cm and 15 cm, respectively on 9th July during 1st and 2nd year of study. Gap filling was done one week after transplanting. Wheat was sown in lines behind the plough at row spacing of 20 cm on 22.11.14 in the first year and 21.11.15 in the second year. Wheat was sown in lines by opening the furrows with the help of Dutch hoe. Weed free conditions both in rice and wheat were maintained by timely weeding and inter-culturing operations during 2014-15 and 2015-16. The rice harvesting was done on 1.11.2014 and 1.11.2015. The wheat harvesting was done on 7.4.2015 and 4.12.2016.

Treatments

The experiment was conducted in randomized block design with four replications. Treatments comprised T_1: Control *i.e.* no application of any manure/fertilizer to both crops; T_2: 50% RDF to both crops; T_3: 50 % RDF to rice followed by 100% RDF to wheat; T_4: 75% RDF to both crops; T_5 : 100% RDF to both crops; T_6: 50%N through FYM+50% RDF to rice followed by 100% RDF to wheat; T_7: 25%N through FYM+75% RDF to rice followed by 75% RDF to wheat; T_8: 50% N through wheat straw+50% RDF to rice followed by 100% RDF to wheat; T_9: 25% N through wheat straw+75% RDF to rice followed by 75% RDF; T_{10}: 50%N through green manure (*Sesbania aculeata*) + 50% RDF to rice followed by 100% RDF to wheat; T_{11}: 25% N through green manure (*Sesbania aculeata*)+75% RDF to rice followed by 75% RDF to wheat and T_{12}: Farmers' practice ($N_{70}P_{30}K_{10}$) to rice followed by ($N_{80}P_{30}K_{15}$) to wheat. The recommended dose of fertilizer for rice was 80 kg N+40 kg P_2O_5+20 kg K_20 ha^{-1} while it was 120 kg N+40 kg P_2O_5+40 kg K_20 ha^{-1} for wheat. Rice variety 'Sita' was transplanted at spacing of 15 cm × 15 cm using seed rate of 40 kg/ha whereas, wheat variety 'PBW343' was sown 20 cm apart using a seed rate of 100 kg/ha. The soil of the experimental plot at the inception of the experiment during 1984 was well drained, sandy loam in texture, neutral in reaction, low in organic carbon and nitrogen and medium in phosphorus and potassium.

Climate and Weather

Sabour, Bhagalpur has sub-tropical climate characterized with hot and dry summer, cold winter and moderate annual rainfall. The average annual rainfall of this locality is 1167.0 mm, about 75 to 80% of which precipitates during middle of June to middle of October (about 120 days) and there is very scanty rainfall during the remaining period (245 days). Late arrival and early cessation of monsoon are common features of this place. Westerly rain originating through Mediterranean Sea brings winter rain which is heavier in west and gradually weakens by the time it reaches Indo Gangetic plains of the eastern India. Pre-monsoon showers are usually received in the month of May. May is the hottest month when average monthly temperature touches heights around 36.0°C while the winter monthly average drops down below to 10.0°C in the month of January.

Results

Plant height (cm)

It is evident from the data (Table 1) that plant height differed significantly due to levels of inorganic fertilizer and integration of inorganic fertilizer with organic sources at different stages of plant growth. As age of plant progressed, plant height of rice and wheat increased steadily up to harvest. Data clearly showed that treatment T_6 (50% N through FYM and 50%N through inorganic fertilizers) produced tallest plants of rice and wheat at each growth stages. But, it was statistically at par with T_5, T_7, T_8, T_9, T_{10} and T_{11} at all the growth stages. In general, plant height was observed higher in integrated series where applications of organic along with chemical fertilizers were practiced.

In rice, there was 6.31% increase in plant height in treatment T_6 (50% N through FYM and 50%N through inorganic fertilizers) over treatment T_5 (100% RDF through fertilizer) at 30 DAT. Whereas in wheat increase in plant height was 6.77% in treatment T_6 (50% N through FYM and 50%N through inorganic fertilizers in *kharif* followed by 100% RDF in *rabi*) over treatment T_5 (100% RDF through fertilizer in both season) at 30 DAS.

At 60 DAT/S increase in plant height was 5.27% and 16.60% in treatment T_6 (50% N through FYM and 50%N through inorganic fertilizers in *kharif* followed by 100% RDF in *rabi*) over treatment T_5 (100% RDF through fertilizer) in rice and wheat, respectively.

At 90 DAT/S increase in plant height was 4.02% and 4.64% in treatment T_6 (50% N through FYM and 50%N through inorganic fertilizers in *kharif* followed by 100% RDF in *rabi*) over treatment T_5 (100% RDF through fertilizer) in rice and wheat, respectively.

At harvest, increase in plant height was 4.13% and 4.02% in treatment T_6 (50% N through FYM and 50%N through inorganic fertilizers in *kharif* followed by 100% RDF in *rabi*) over treatment T_5 (100% RDF through fertilizer) in rice and wheat, respectively. The shortest plants grew at all the stages in control ($N_0P_0K_0$).

Number of tillers per m^2

Irrespective of treatments, production of tillers per m^2 in rice and wheat was found maximum at 60 DAT/S and thereafter the number of tillers per m^2 decreased with advancement in age of the crop but considerable reduction in tiller number took place in between 60 to 90 DAT/S. Data showed a progressive increase from 30 DAT to 60 DAT and thereafter it declined gradually up to maturity in both the years. It is evident from the Table 2 that number of tillers per m^2 differed significantly due to combined application of inorganic fertilizers and organic sources. The number of tillers per m^2 varied from 102.50 to 166.50, 194.50 to 326.00, 180.00 to 296.50 and 169.50 to 275.50 at 30DAT, 60 DAT, 9 DAT and at harvest, respectively in rice. At each growth stages (*i.e.*30 DAT, 60 DAT, 90 DAT and at harvest), the highest number of tillers per m^2 in rice was recorded in treatment T_6 (166.50, 326.00, 296.50 and 275.50, respectively) which was statistically at par with T_8 and T_{10} and significantly superior to T_1, T_2, T_3, T_4, T_5, T_7, T_9, T_{11} and T_{12}.

In wheat, it varied from 105.50 to 175.00, 147.10 to 354.25, 137.55 to 328.20 and 126.65 to 304.30 at 30DAS, 60 DAS, 90 DAS and at harvest, respectively. At each growth stages (*i.e.*30 DAS, 60 DAS, 90 DAS and at harvest), the highest number of tillers per m^2 was recorded in treatment T_6 (175.00, 354.25, 328.20 and 304.30, respectively) which was statistically at par with T_5, T_7, T_8, T_9, T_{10} and T_{11}.

Length of panicle/ earhead (cm)

It is evident from the Table 3 that length of panicle differed significantly due to combined application of inorganic fertilizers and organic sources in rice followed by 100% RDF in wheat. The length of panicle varied from 14.25 to 22.80 cm in rice. Maximum length of panicle (22.80 cm) was recorded in treatment T_6 which was statistically at par with T_8 and T_{10} and significantly superior to rest of the treatments. The length of earhead varied from 9.24 to 12.52 cm. Maximum length of earhead (12.52 cm) was recorded in treatment T_6 which was statistically at par with T_8 and T_{10} and significantly superior to rest of the treatments. In rice next to T_8, treatment T_7 was significantly superior to T_9 and T_{10}. T_4 and T_5 were at par to each other. There was 19.73%, 17.56% and 17.93% increase over T_5 in T_6, T_8 and T_{10}, respectively. In wheat next to T_8, T_7 was at par with treatment T_3, T_4, T_5, T_9 and T_{11} and significantly superior to all other treatments. Treatment T_4 and T_5 were also at par to each other. There was 7.34%, 0.51% and 2.52% increase over T_5 in T_6, T_8 and T_{10}, respectively.

Weight of panicle/earhead (g)

Perusal of data (Table 3) indicated that weight of panicle in rice was influenced by different INM practices. Weight of panicle in rice varied from 1.23 to 2.12 g. The highest weight of panicle (2.12 g) was recorded in treatment T_6 which was statistically at par with T_8 and T_{10} and significantly superior to rest of the treatments. Treatment T_7 and T_{11} were at par to each other. There was 7.54%, 5.76% and 6.22% increase over T_5 in T_6, T_8 and T_{10}, respectively.

Perusal of data indicated that weight of earhead in wheat was influenced by different INM practices. Weight of earhead in wheat varied from 0.73 to 1.79 gm. The highest weight of earhead (1.79 g) was recorded in treatment T_6 which was statistically at par with T_8 and T_{10} and significantly superior to rest of the treatments. In wheat next to T_8, T_7 was at par with treatment T_{11} and significantly superior to all other treatments. There was 7.26%, 2.92% and 5.14% increase over T_5 in T_6, T_8 and T_{10}, respectively.

1000- grain weight (g)

It is evident from the Table 3 that 1000-grain weight differed significantly due to combined application of inorganic fertilizers and organic sources in both crops. Mean 1000-grain weight of rice varied from 22.10 to 23.90 g. The highest 1000-grain weight (23.90 g) was recorded in treatment T_6 and lowest (22.10 g) was recorded in T_1. Next to T_8, T_7 was at par with T_4, T_5, T_9, T_{11} and T_{12}. Among inorganic treatments, T_5 was at par withT_4 and T_{12}. There was 5.02%, 2.15% and 3.81% increase over T_5 in T_6, T_8 and T_{10}, respectively.

In wheat, 1000-grain weight varied from 36.90 to 39.05 g. The highest 1000- grain weight (39.05 g) was recorded in treatment T_6 and lowest (36.90 g) was recorded in T_1. Next to T_8, T_7 was at par with T_3, T_4, T_5, T_9, T_{11} and T_{12}. T_5 was at par with T_3 and T_4. There was 4.73%, 2.61% and 3.62% increase over T_5 in T_6, T_8 and T_{10}, respectively.

Grain yield (kg ha^{-1})

Table 4 showed that, in rice, the highest grain yield (5562 kg ha^{-1}) was obtained in T_6 (50% N through FYM + 50% RDF) which was significantly superior to all the treatments except T_8 and T_{10}. The increase in grain yield was 41.38% over farmers' practice. The lowest grain yield (920 kg ha^{-1}) was recorded in control T_1 ($N_0P_0K_0$).The treatment T_{12} (farmers' practice) recorded grain yield of 3260 kg ha^{-1}. Use of 100% RDF (inorganic) recorded 4893 kg ha^{-1} grain yield, which was 33.37% more than farmers' practice. Data revealed that integrated use of FYM coupled with chemical fertilizers as in T_6 produced 12% higher grain yield in comparison to T_5 (100% RDF). Treatment T_5 and T_7 were at par with each other. Other organic sources for INM, T_7 and T_{10} were at par to each other. Therefore, among these three organic sources, substitution up to 50% N through FYM was found to be effective in INM practices. In wheat, it is evident from the table 4 that grain yield differed significantly due to levels of inorganic fertilizers. Data also revealed that level of application of inorganic fertilizers and organic sources applied in *kharif* crop, significantly influenced grain yield in *rabi* crop of wheat. The highest grain yield (4377 kg ha^{-1}) was recorded in T_6 getting 100% RDF (in plot of 50% N through FYM and 50% RDF through inorganic fertilizers during *kharif*) and was statistically at par with T_8 and T_{10} and significantly superior to T_1, T_2, T_3, T_4, T_5, T_9, T_{11} and T_{12}.The lowest grain yield (761 kg ha^{-1}) was recorded in control T_1 ($N_0P_0K_0$). The grain yield recorded in T_6 was 11.37% more in comparison to the treatment receiving 100% RDF in both seasons (T_5) and 40.91% more in comparison to farmers' practice. In farmers' practice (T_{12}) grain yield of 2586 kg ha^{-1} was recorded which was more than the plot receiving 50% RDF only. Further, T_5 as an inorganic application of 100% RDF (in plot of 100% RDF through inorganic fertilizers during *kharif* and *rabi*) yielded 3879 kg ha^{-1} (33.33% higher) in comparison to farmers' practice (T_{12}). Furthermore, T_6 as an inorganic application of 100% RDF (in plot of 50% N through FYM and 50% RDF through inorganic fertilizer during *kharif*) yielded 4377 kg ha^{-1} (40.91% higher) in comparison to farmers' practice (T_{12}). T_8 as an inorganic application of 100% RDF (in plot of 50% N through WS and 50% RDF through inorganic fertilizer during *kharif*) yielded 4088 kg ha^{-1} (36.74% higher) in comparison to farmers' practice (T_{12}). T_{10} as an inorganic application of 100% RDF (in plot of 50% N through GM and 50% RDF through inorganic fertilizer during *kharif*) yielded 4297 kg ha^{-1} (39.81% higher) in comparison to farmers' practice (T_{12}). In other words, critical examination of the data revealed that residual effect of FYM (integrated with

chemical fertilizer in 1:1 proportion used in *kharif*)produced 11.37 % higher wheat (grain) yield as compared to 100% RDF (inorganic only).

Grain yields of rice (*Kharif*) crop and wheat (*rabi*) crop were combined into equivalent yield of rice (based on selling price and yield of both the crops) to present yield of the rice-wheat system. Pooled data for rice equivalent yield (kg/ha) in rice-wheat system have been presented in Table 4. Significantly highest REY (12185 kg/ha) was recorded in treatment T_6 (getting 50% N through FYM +50% RDF in *kharif* rice and 100% RDF in *rabi* wheat). In particular, it was significantly 13.20% higher than REY 10764 kg/ha obtained in treatment T_5 (getting 100% RDF in each crop *i.e.* cultivation on inorganic fertilizer). INM practice T_8 (11546 kg/ha) and T_{10} (11994 kg/ha) were at par with T_6. T_6 was significantly 41.12% higher than REY (7174 kg/ha) obtained in farmers' practice *i.e.* N: P: K @ 70:30:15 kg /ha in rice and 80:30:15 in wheat. Therefore, INM treatment T_6 having substitution up to ½ N through FYM along with ½ RDF (inorganic) was found to be effective as one component in INM practice. After this, T_{10}- 50% through GM+50% RDF (inorganic) stood second and T_8-50% N through GM+50% RDF (inorganic) stood third.

Economics

Net returns (`Rs. ha^{-1})

Perusal of data revealed that the cost of cultivation was marginally higher when the nutrient was applied through organic sources because of higher cost involved in purchase of FYM, wheat straw and production of green manure crop. Effect of continuous fertilizer and manure application (*i.e.* INM practices) in continuous cropping system of rice-wheat was significant on gross return. Significantly highest net returns of Rs. 86686/ha was accrued when 50% N was substituted by FYM + 50% RDF through inorganic in rice followed by 100% RDF through inorganic in wheat (T_6). However, this treatment showed statistical parity with the treatments substituting 50% N through green manuring with *Sesbania aculeata* in rice followed by 100% RDF through inorganic in wheat *i.e.* T_{10} (Rs. 84379/ha). Next to T_{10}, T_8 was at par with T_7 and T_{11}. Control ($N_0P_0K_0$) gave the lowest and loss in net return i.e. Rs.28905/ha. Application of inorganic fertilizers T_5 (100% RDF in both crops) gave net return of Rs. 72049/-. T_6 recorded 16.88% and 64.58% higher net return than that of T_5 (100% RDF in both crops) and T_{12} (Farmers' practice), respectively.

Therefore, substitution up to 50% N through FYM was found to be effective as one component along with 50% RDF (inorganic) in INM practices. After this, T_{10} 50% N through GM+50% RDF (inorganic) stood second.

Benefit: cost ratio

Perusal of data revealed that effect of continuous fertilizer and manure application (*i.e.* INM practices) in continuous cropping system of rice-wheat was significant on benefit: cost ratio of the system. Significantly highest B: C ratio of 1.30 was recorded in treatment T_6 (getting 50% of N through FYM + 50% recommended dose of nutrients through chemical fertilizers in rice and 100% RDF in succeeding wheat crop) over rest of the treatments and it was 12.30% and 60.76% higher than that of T_5 (100% RDF in both crops) and T_{12} (Farmers' practice), respectively. T_6 and T_{10} were at par with each other. T_{11} (getting 25% of N through GM+ 75% recommended dose of nutrients through chemical fertilizers in rice and 100% RDF in succeeding wheat crop) stood third which was at par with T_7 and T_8. T_2 (50% RDF through inorganic in both crops) produced lowest B: C ratio *i.e.* 0.22 while control ($N_0P_0K_0$) gave further loss *i.e.* -0.52. Thus, both rice and wheat cultivation without any fertilizer application was found uneconomical.

Discussion

Growth of rice reflected in terms of plant height, number of tillers got their best expression in the treatments involving application of organic manures in rice in any quantum i.e., either 50% or 25% substitution of the N of the recommended dose of fertilizers (RDF). However, the performance of 50% substitution (T_6, T_8 and T_{10}) established an edge over 25% substitution (T_7, T_9 and T_{11}). The effectiveness of the organic sources *viz*. wheat straw or green manuring with *Sesbania aculeata* both in their lower or higher substitution were not as effective as FYM in accelerating growth of rice. However, these had slightly an edge over the treatments receiving 100% recommended NPK dose in inorganic fertilizers form. It was evident that increase in nutritional dose through FYM was much more effective than the increase in dose through inorganic fertilizers.

Growth of wheat was also markedly influenced by organic matter substitution in the preceding crop of rice. The plots which received 50% of the recommended dose of N in rice through FYM and got 100% NPK in wheat had the best expression as observed in terms of plant height, number of tillers. This treatment however, did not differ significantly with the treatment substituting N in rice by wheat straw and green manuring in the same proportion and quantity, but was superior to those developed under the application of 100% RDF in both rice and wheat in inorganic forms (T_5). It was interesting to note that substitution of only 25% N through FYM +75% RDF through fertilizers in rice and supplying only 75% of the RDF in wheat also proved to be equally effective as that of the treatments having the maximum growth. This indicated a high degree of residual and cumulative effect of even a very moderate dose of FYM supplied to rice. It was also pertinent to note that even the other organic sources viz. wheat straw and green manuring substituting for only 25% of the RDN in rice and getting only 75% of the RDF in wheat were equally effective as that of application of 100% RDF in inorganic forms to both the crops. This is a clear reflection of the fact that organic recycling in any form under investigation was effective in accelerating growth of wheat.

The highest values for different yield attributing characters were observed in treatment (T_6) receiving 50% N substitution by FYM+50% RDF in rice, which were statistically at par with T_8 (50% substitution of N through wheat straw+50% RDF in rice) and T_{10} (50% substitution of N through green manure+50% RDF in rice). The findings in respect to yield attributes are well supported by the work Gangola *et al.* (2013).

Yield

Higher availability of nutrients due to effect of organic sources leads to improve physiological and metabolic functions in the plant body. This might have been responsible for better expression of growth parameters. Better growth of plant, in turn, might have been responsible for bearing yield attributes in rice and wheat, the sum total of which was reflected in increased yield in both the crops. Organic sources especially in their moderate doses play the key role in enhancing efficient utilization of the native as well as added

nutrients and in maintaining a balance between growth and yield attributes. Amongst different organic sources, FYM has advantage over wheat straw in being fully decomposed before application. Similarly in comparison with green manuring with *Sesbania aculeata*, FYM has higher quantum of organic matter capable of improving the physical and biological properties of soil. These advantages of FYM over wheat straw and green manuring with *Sesbania aculeate* might have been the prime factors responsible for higher yield under FYM substitution. FYM, as compared to wheat straw and green manuring with *Sesbania aculeata* has dominance of highly humified state (fulvic acid) of organic matter as well as relatively higher availability of macro and micro nutrients for improving the physical and chemical properties of soil. Wider C:N ratio of wheat straw than that of FYM or *Sesbania aculeata* also resulted in initial immobilization of soluble soil N and delayed decomposition, creating a shortage of plant available N and thus, resulting inferior yield. Similar result have been reported by Ram *et al*. (2016).

Pooled mean data for rice equivalent yield (kg/ha) in rice-wheat cropping system also influenced by INM practices. Substitution of 50% N through FYM+50% RDF in *kharif* and 100% RDF in *rabi i.e.* T_6 increased REY to the extent of 11.66% higher as compared to balanced application of 100% RDF as chemical fertilizers alone. This is in agreement with the results of long term fertilizers experiments carried out in different agroclimatic situations of the country (Singh and Wanjari, 2013).

Net returns and benefit: cost ratio are, mainly the function of yield level and market price of input and output. The treatment having higher yield ultimately resulted in higher profitability also. Higher yield under the organic manure treatments might have been responsible in fetching higher net return.

The results as regards economics of the treatments are in close conformity with those reported earlier by Sharma *et al*. (2007).

Table 1: Effect of Integrated Nutrient Management practices on plant height (cm) (pooled mean) at different growth stages

Treatments			30DAT/Das		60DAT/Das		90DAT/Das		At harvest	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1	$N_0P_0K_0$	$N_0P_0K_0$	36.10	19.10	55.00	39.20	63.20	55.40	64.40	57.60
T_2	50% RDF	50% RDF	41.00	23.15	62.00	51.30	77.50	65.00	78.60	67.43
T_3	50% RDF	100% RDF	42.30	27.50	63.90	57.40	79.00	73.00	81.20	75.87
T_4	75% RDF	75% RDF	44.20	26.92	65.05	55.00	81.20	71.00	83.40	73.60
T_5	100% RDF	100% RDF	46.00	30.00	71.90	66.00	85.90	80.00	88.00	82.35
T_6	50% N through FYM+50% RDF	100% RDF	49.10	32.18	75.90	69.20	89.50	83.90	91.80	85.80
T_7	25% N through FYM+75% RDF	75% RDF	47.05	30.90	72.70	67.02	87.20	81.00	89.40	83.55
T_8	50% N through WS+50% RDF	100% RDF	48.10	31.00	72.50	68.00	88.00	81.90	90.10	84.41
T_9	25% N through WS+75% RDF	75% RDF	46.20	30.50	72.10	66.40	86.80	80.65	88.90	82.70
T_{10}	50% N through GM+50% RDF	100% RDF	48.90	31.98	72.30	68.80	88.90	82.90	91.10	85.00
T_{11}	25% N through GM+75% RDF	75% RDF	46.90	30.80	69.90	67.00	87.00	80.00	89.00	82.50
T_{12}	FP ($N_{70}P_{30}K_{10}$)	FP ($N_{80}P_{30}K_{15}$)	42.50	24.65	57.20	54.00	67.60	70.51	69.50	72.60
SEm(±)			1.35	0.87	2.21	1.18	2.73	2.77	2.86	2.78
CD at 5%			3.82	2.45	6.25	4.01	7.73	7.86	8.09	7.88

DAT/S: Days after transplanting/sowing, RDF: Recommended dose of fertilizer, WS: Wheat straw GM: Green manure, FP: Farmers' practice

Table 2: Effect of Integrated Nutrient Management practices on number of tillers/m^2 (Pooled mean) at different growth stages

Treatments			30DAT/Das		60DAT/Das		90DAT/Das		At harvest	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1	$N_0P_0K_0$	$N_0P_0K_0$	102.50	105.50	194.50	147.10	180.00	137.55	169.50	126.65
T_2	50% RDF	50% RDF	120.50	121.10	234.00	239.55	211.50	219.45	179.00	209.50
T_3	50% RDF	100% RDF	124.00	152.00	245.00	330.75	216.00	300.05	185.00	280.00
T_4	75% RDF	75% RDF	130.00	145.10	271.00	304.60	227.00	284.20	208.00	270.55
T_5	100% RDF	100% RDF	136.00	156.30	288.50	338.00	258.50	312.00	249.00	287.40
T_6	50% N through FYM+50% RDF	100% RDF	166.50	175.00	326.00	354.25	296.50	328.20	275.50	304.30
T_7	25% N through FYM+75% RDF	75% RDF	151.00	164.00	296.00	344.60	270.10	319.05	254.20	294.50
T_8	50% N through WS+50% RDF	100% RDF	155.50	166.00	311.50	347.35	289.00	320.35	266.00	295.70
T_9	25% N through WS+75% RDF	75% RDF	141.00	156.00	290.00	335.85	265.00	309.35	249.10	287.80
T_{10}	50% N through GM+50% RDF	100% RDF	162.00	168.00	318.00	349.55	289.00	324.35	269.50	299.70
T_{11}	25% N through GM+75% RDF	75% RDF	143.00	160.00	294.10	343.00	268.00	317.40	252.00	292.60
T_{12}	FP ($N_{70}P_{30}K_{10}$)	FP ($N_{80}P_{30}K_{15}$)	127.00	130.10	257.00	268.55	218.50	252.10	194.50	240.55
SEm(±)			4.44	6.89	9.92	7.14	8.97	6.39	7.02	6.00
CD at 5%			12.58	19.49	27.97	29.08	20.21	18.11	19.89	16.98

DAT/S: Days after transplanting/sowing, RDF: Recommended dose of fertilizer, WS: Wheat straw GM: Green manure, FP: Farmers' practice

Table 3: Effect of Integrated Nutrient Management practices on yield attributes (Pooled mean)

Treatments			Length of panicle/earhead (cm)		Weight of panicle/earhead (g)		Test weight (g)	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1	$N_0P_0K_0$	$N_0P_0K_0$	14.25	9.24	1.23	0.73	19.85	30.30
T_2	50% RDF	50% RDF	15.80	10.01	1.57	1.15	21.00	34.85
T_3	50% RDF	100% RDF	16.60	10.62	1.73	1.58	21.30	37.12
T_4	75% RDF	75% RDF	17.75	10.84	1.92	1.45	22.65	36.10
T_5	100% RDF	100% RDF	18.30	11.60	1.96	1.66	22.70	37.20
T_6	50% N through FYM+50% RDF	100% RDF	22.80	12.52	2.12	1.79	23.90	39.05
T_7	25% N through FYM+75% RDF	75% RDF	20.25	11.23	1.99	1.67	22.80	37.35

T_8	50% N through WS+50% RDF	100% RDF	22.20	11.66	2.08	1.75	23.20	38.20
T_9	25% N through WS+75% RDF	75% RDF	19.30	11.00	1.90	1.61	22.75	37.25
T_{10}	50% N through GM+50% RDF	100% RDF	22.30	11.90	2.09	1.76	23.60	38.60
T_{11}	25% N through GM+75% RDF	75% RDF	19.45	11.11	1.95	1.65	22.90	37.15
T_{12}	FP ($N_{70}P_{30}K_{10}$)	FP ($N_{80}P_{30}K_{15}$)	17.30	10.19	1.85	1.15	22.70	37.00
SEm(±)			0.22	0.32	0.02	0.01	0.34	0.59
CD at 5%			0.62	0.91	0.05	0.04	0.96	1.66

RDF: Recommended dose of fertilizer, WS: Wheat straw GM: Green manure, FP: Farmers' practice

Table 4: Effect of Integrated Nutrient Management practices on yield of the system (Pooled mean)

Treatments			Grain yield (kg/ha)		
	Rice	**Wheat**	**Rice**	**Wheat**	**REY (kg/ha)**
T_1	$N_0P_0K_0$	$N_0P_0K_0$	920	761	2072
T_2	50% RDF	50% RDF	2730	1964	5701
T_3	50% RDF	100% RDF	2762	3638	8269
T_4	75% RDF	75% RDF	3571	2980	8086
T_5	100% RDF	100% RDF	4893	3879	10764
T_6	50% RDF+50% N through FYM	100% RDF	5562	4377	12185
T_7	75% RDF+25% N through FYM	75% RDF	5128	3988	11162
T_8	50% RDF+50% N through(WS)	100% RDF	5361	4088	11546
T_9	75% RDF+25% N through (WS)	75% RDF	4946	3912	10864
T_{10}	50% RDF+50% N through (GM)	100% RDF	5492	4297	11994
T_{11}	75% RDF+25% N through (GM)	75% RDF	5106	3972	11116
T_{12}	FP($N_{70}P_{30}K_{10}$)	FP($N_{80}P_{30}K_{15}$)	3260	2586	7174
SEm(±)			131.75	118.53	321.53
CD at 5%			373.32	335.87	885.59

RDF: Recommended dose of fertilizer, WS: Wheat straw GM: Green manure,
FP: Farmers' practice, REY: Rice equivalent yield

Table 5: Effect of Integrated Nutrient Management practices on economics (Pooled mean)

Treatments			Net return (Rs./ha)			B:C ratio		
	Rice	**Wheat**	**Rice**	**Wheat**	**System**	**Rice**	**Wheat**	**System**
T_1	$N_0P_0K_0$	$N_0P_0K_0$	-16102	-12803	-28905	-0.55	-0.48	-0.52
T_2	50% RDF	50% RDF	5297	8019	13316	0.17	0.28	0.22
T_3	50% RDF	100% RDF	5774	36435	42210	0.18	1.18	0.68
T_4	75% RDF	75% RDF	15281	25416	40698	0.48	0.85	0.66
T_5	100% RDF	100% RDF	31330	41402	72049	0.96	1.34	1.14
T_6	50% N through FYM+50% RDF	100% RDF	36735	49951	86686	1.02	1.62	1.30
T_7	25% N through FYM+75% RDF	75% RDF	32732	44166	76627	0.96	1.49	1.20
T_8	50% N through WS+50% RDF	100% RDF	34045	44546	78591	0.95	1.44	1.18
T_9	25% N through WS+75% RDF	75% RDF	30446	41670	72800	0.89	1.40	1.14
T_{10}	50% N through GM+50% RDF	100% RDF	36108	48270	84379	1.01	1.57	1.27
T_{11}	25% N through GM+75% RDF	75% RDF	33385	43543	76928	1.00	1.47	1.22
T_{12}	FP ($N_{70}P_{30}K_{10}$)	FP ($N_{80}P_{30}K_{15}$)	11266	19433	30700	0.35	0.67	0.51
SEm(±)			1153.1	1195	1906	0.03	0.04	0.02
CD at 5%			3263.4	3388	5401	0.08	0.10	0.07

RDF: Recommended dose of fertilizer, WS: Wheat straw GM: Green manure, FP: Farmers' practice

Conclusion

It may be summarized as organo-inorganic combination as integrated nutrient supply system is superior to use of inorganic fertilizers alone. Organic sources *viz.*, FYM, wheat straw and green manuring of *Sesbania aculeata* can be used as a viable alternative through partial substitution of inorganic fertilizers. Organic sources even in their moderate doses substituting only 25% of recommended N in the base crop of the cropping system, are capable of improving physical, chemical as well as biological properties of soil up to a considerable extent. Substitution of 50% N either through FYM or wheat straw or green manuring+50% RDF through inorganic fertilizers in rice followed by 100% RDF through inorganic fertilizers in wheat is the best mechanism for raising crop productivity. If FYM is not available, green manuring with *Sesbania aculeata* or wheat straw can be viable alternatives for substitution of inorganic fertilizers.

References

1. Gangola P, Singh R, Bhardwaj AK, Gautam P. Effect of integrated nutrient management on wheat under long term rice-wheat cropping system in Mollisol. Madras Agriculture Journal. 2013; 100(4-6):365-371.
2. Mahajan A, Sharma R. Integrated nutrient management (INM) system- Concept, need and future strategy. Agrobios Newsletter, 2005; 4(3):29-32.
3. Ram S, Singh V, Sirari P. Effects of 41 Years of Application of Inorganic Fertilizers and Farm Yard Manure on Crop Yields, Soil Quality, and Sustainable Yield Index under a rice-wheat cropping system on Mollisols of North India. Communications in Soil Science and Plant Analysis, 2016; 47(2):179-193.
4. Sharma AK, Thakur NP, Kour M, Sharma P. Effect of integrated nutrient management on productivity, energy use efficiency and economics of rice-wheat system. Journal of Farming System Research and Development 2007; 13(2):209-213.

5. Singh M, Wanjari RH. Measures to sustain and restore declined productivity in Alfisol under long-term Fertilizer Experiments. Indian Journal of Fertilizer. 2013; 9(2):24-32.
6. Upadhyay MK, Tripathi HP, Yadav AS. Effect of Integrated Nutrient Management on yield and yield attributes of rice-wheat cropping system. Indian Journal of Ecology. 2011; 38(1):21-25.