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Original Research Article

Effect of Combination of Organic Sources and Inorganic Fertilizer on Nutrient Uptake and Crop Productivity under Rice-Wheat System

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A B S T R A C T

A field experiment was conducted with objective to find out long term effect of combination of organic sources and inorganic fertilizer on nutrient uptake and crop productivity under rice-wheat cropping system in Indo-Gangetic Plains. The highest N, P and K uptake by rice and wheat as well as rice-wheat system was recorded in treatment T_6 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 (T_5). Treatment T_6 produced significantly higher grain yield (5562, 4377 and 12185 kg/ha) of rice and wheat as well as rice equivalent yield, respectively than treatments. 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

Crop productivity; nutrient uptake; 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 indices and crop productivity under rice-wheat cropping system in Indo-Gangetic Plains.

Materials and Methods

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 and Discussion

Nutrient uptake

Nitrogen

Pooled data for total uptake (kg/ha) by rice and wheat as well as system have been presented in Table 1 and 2, respectively. The highest total N uptake by rice (102.86 kg/ha) was recorded in treatment T_6 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. Treatment T_{10} (50% N through green manure and 50% RDF through inorganic fertilizers) stood 2nd in total N uptake 100.95 kg /ha. The lowest N uptake by crop (16.44 kg/ha) was found in control T_1 ($N_0P_0K_0$). T_6 registered 13.62% and 42.11% increase over T_5 and T_{12}, respectively in rice crop.

It is evident from the Table 1 that N uptake by wheat that the highest total N uptake (99.99 kg/ha) was recorded in treatment T_6 getting 50% N through FYM and 50% RDF through inorganic fertilizers in *kharif* and 100% RDF through inorganic in *rabi* and was significantly higher than rest of the treatments except T_8 and $T_{10,}$ which were at par with each other.

Treatment T_{10} (50% N through green manure and 50% RDF through inorganic fertilizers in *kharif* and 100% RDF through inorganic in rabi) stood 2nd in total N uptake 97.18 kg /ha. The lowest N uptake by crop (17.16 kg/ha) was found in control T_1 ($N_0P_0K_0$). Next to T_8, T_7 was at par with T_5, T_9 and T_{11}. T_5 and T_3 were at par to each other. T_6 registered 13.16% and 43.30% increase over T_5 and T_{12}, respectively in wheat crop. The highest N uptake by the system (199.66 kg/ha) was recorded in T_6.

Phosphorus

It is evident from the table that total P uptake by rice crop differed significantly due to levels of inorganic fertilizers. The highest total P uptake by rice (31.28 kg/ha) was recorded in treatment T_6 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. Treatment T_{10} (50% N through green manure and 50% RDF through inorganic fertilizers) stood 2nd in total P uptake 30.79 kg /ha. The lowest P uptake by crop (4.93 kg/ha) was found in control T_1 ($N_0P_0K_0$). T_6 registered 13.77% and 42.67% increase over T_5 and T_{12}, respectively in rice crop.

It is evident from the table that total P uptake by wheat crop differed significantly due to levels of inorganic fertilizers. The highest total N uptake (26.55 kg/ha) was recorded in treatment T_6 getting 50% N through FYM and 50% RDF through inorganic fertilizers in *kharif* and 100% RDF through inorganic in *rabi* and was significantly higher than rest of the treatments except T_8 and $T_{10,}$ which were at par with each other. Treatment T_{10} (50% N through green manure and 50% RDF through inorganic fertilizers in *kharif* and 100% RDF through inorganic in *rabi*) stood 2nd in total P uptake 25.58 kg /ha.

The lowest P uptake by crop (4.39 kg/ha) was found in control T_1 ($N_0P_0K_0$). Next to T_8, T_7 was at par with T_5, T_9 and T_{11}. T_5 and T_3 were at par to each other. T_6 registered 14.12% and 44.34% increase over T_5 and T_{12}, respectively in wheat crop. The highest P uptake by the system (56.68 kg/ha) was recorded in T_6.

Potassium

It is evident from the table that total K uptake by rice crop differed significantly due to levels of inorganic fertilizers.

The highest total K uptake (119.36 kg/ha) was recorded in treatment T_6 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_9, T_{10} and $T_{11,}$ which were at par with each other.

Treatment T_{10} (50% N through green manure and 50% RDF through inorganic fertilizers) stood 2nd in total K uptake 117.67 kg /ha. The lowest K uptake by crop (19.78 kg/ha) was found in control T_1 ($N_0P_0K_0$). T_6 registered 13.41% and 40.25% increase over T_5 and T_{12}, respectively in rice crop.

It is evident from the table that total K uptake by wheat crop differed significantly due to levels of inorganic fertilizers.

Table.1 Effect of Integrated Nutrient Management practices on nutrient uptake (kg/ha) (Pooled mean)

	Treatments		N uptake		P uptake		K uptake	
	Rice	Wheat	Rice	Wheat	Rice	Wheat	Rice	Wheat
T_1	$N_0P_0K_0$	$N_0P_0K_0$	16.44	17.16	4.93	4.39	19.78	18.93
T_2	50% RDF	50% RDF	49.14	44.59	14.76	11.48	58.54	49.36
T_3	50% RDF	100% RDF	50.06	79.97	15.27	20.50	60.18	85.33
T_4	75% RDF	75% RDF	64.35	65.73	19.48	16.86	76.52	70.97
T_5	100% RDF	100% RDF	88.85	86.83	26.97	22.80	103.35	92.07
T_6	50% N through FYM+50% RDF	100% RDF	102.86	99.99	31.28	26.55	119.36	106.22
T_7	25% N through FYM+75% RDF	75% RDF	95.42	89.89	28.94	23.55	111.71	95.40
T_8	50% N through WS+50% RDF	100% RDF	99.40	92.55	30.12	24.36	115.55	98.97
T_9	25% N through WS+75% RDF	75% RDF	90.20	88.18	27.36	22.99	107.71	94.00
T_{10}	50% N through GM+50% RDF	100% RDF	100.95	97.18	30.79	25.58	117.67	103.08
T_{11}	25% N through GM+75% RDF	75% RDF	95.24	89.70	29.01	23.41	112.18	95.45
T_{12}	FP($N_{70}P_{30}K_{10}$)	FP($N_{80}P_{30}K_{15}$)	59.54	56.69	17.93	14.51	71.31	60.84
	SEm(±)		3.27	3.49	0.81	0.93	4.24	3.75
	CD at 5%		9.22	9.86	2.39	2.72	11.96	10.58

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

Table.2 Effect of Integrated Nutrient Management practices on nutrient uptake by the system (Pooled mean)

Treatments			N uptake	P uptake	K uptake
	Rice	Wheat	(Kg./ha)	(Kg./ha)	(Kg./ha)
T_1	$N_0P_0K_0$	$N_0P_0K_0$	33.95	9.40	38.85
T_2	50% RDF	50% RDF	93.68	26.11	106.38
T_3	50% RDF	100% RDF	131.36	36.00	145.38
T_4	75% RDF	75% RDF	130.70	36.34	146.01
T_5	100% RDF	100% RDF	175.15	49.47	192.40
T_6	50% N through FYM+50% RDF	100% RDF	199.66	56.68	219.07
T_7	25% N through FYM+75% RDF	75% RDF	181.87	51.26	199.92
T_8	50% N through WS+50% RDF	100% RDF	188.89	53.41	208.34
T_9	25% N through WS+75% RDF	75% RDF	176.78	49.70	195.15
T_{10}	50% N through GM+50% RDF	100% RDF	195.92	55.48	214.75
T_{11}	25% N through GM+75% RDF	75% RDF	181.47	51.12	199.93
T_{12}	FP ($N_{70}P_{30}K_{10}$)	FP ($N_{80}P_{30}K_{15}$)	116.97	32.51	131.28
SEm(±)			4.57	1.31	5.40
CD at 5%			12.94	3.71	15.29

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

Table.3 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

The highest total K uptake (106.22 kg/ha) was recorded in treatment T_6 getting 50% N through FYM and 50% RDF through inorganic fertilizers in *kharif* and 100% RDF through inorganic in *rabi* and was significantly higher than rest of the treatments except T_8 and T_{10}, which were at par with each other. Treatment T_{10} (50% N through green manure and 50% RDF through inorganic fertilizers in *kharif* and 100% RDF through inorganic in *rabi*) stood 2nd in total K uptake 103.08 kg /ha. The lowest K uptake by crop (18.93 kg/ha) was found in control T_1 ($N_0P_0K_0$). Next to T_8, T_7 was at par with T_5, T_9 and T_{11}. T_5 and T_3 were at par to each other. T_6 registered 13.32% and 42.72% increase over T_5 and T_{12}, respectively in wheat crop. The highest P uptake by the system (219.07 kg/ha) was recorded in T_6.

Grain yield (kg ha^{-1})

Pooled data on grain yield (kg ha^{-1}) has been presented in Table 3. It revealed that INM practices (inorganic fertilizer and in combination with organic sources) significantly influenced the grain yield of rice and wheat.

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.

Nutrient uptake

The treatment T_6 having 50% N substitution through FYM in rice and getting 100% RDF in wheat, being at par with the treatment involving 50% N through wheat straw or *Sesbania aculeata* in rice and 100% RDF supplicated to wheat, exhibited the maximum NPK uptake. The higher nutrient uptake with organic manure might be attributed to solubilization of native nutrients, creation of complex intermediate

organic molecules, their mobilization and accumulation of different nutrients in different plant parts. Increase in nutrient uptake might also be due to higher availability of nutrient from soil reservoir and additional quantity of nutrient supplied by adding fertilizers which in turn resulted in higher grain yield and nutrient uptake. Favourable characteristics of FYM in regard to aforesaid parameters might have given impetus to accelerate uptake of nutrients in plot treated with it. The findings in respect of nutrient uptake by rice and wheat with integrated nutrient management practices are in close agreement with those reported by Math *et al.*, (2016).

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).

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.

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