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Studies on the effect of integrated nutrient management practices (INM) on yield and economics of aromatic rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted at Instructional farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya during kharif season 2018 to evaluate the effect of effect of integrated nutrient management (INM) on yield, and economics of aromatic rice (*Oryza sativa* L.) *var.* Basmati. The treatments consisted of different sources of organic manures and inorganic fertilizer *viz*., T_1 (100:40:30 kg ha^{-1} N_2, P_2O_5, K_2O) kg ha^{-1}, T_2 (75% NPK + 25% N through vermicompost),T_3 (75% NPK + 25% N through FYM), T_4 (50%NPK+25%N through vermicompost FYM), T_5 (50% NPK + 50% N through FYM), T_6 (50% NPK + 50% N through vermicompost), T_7 (125% NPK (RDF) T_8 (100% NPK + 25% N through FYM) T_9 (100% NPK + 25% vermicompost).among all the treatments, application of 100% NPK+25% vermicompost (T_9) registered taller plant, no. tillers^{-2}, Number of Panicle m^{-2}, grain per panicle and Length of panicle (cm), protein content, kernel length, kernel breadth, hulling %, milling %, Grain yield and straw yield followed by treatment having T_8 (100%NPK +25% N through FYM). Maximum net return (Rs.) and benefit cost ratio recorded in the treatment having 100% NPK+25% vermicompost (T_9).

Keywords: Integrated nutrient management practices (INM), economics and aromatic rice

Introduction
Rice (*Oryza sativa* L.) is the most important staple food crop in the World. It is the rich source of energy and contains reasonable amount of protein (6-10%), carbohydrate (70-80%), minerals (1.2-2.0%) and vitamins (Riboflavin, Thiamine, Niacin and Vitamin E). The area and production of rice in U.P. is about 5.95 million hectares and 13.27 million tonnes, respectively with productivity of 2230 kg per hectare (Agricultural Statistics at a Glance, 2018) [1]. To increase the productivity, the farmers are shifting towards growing hybrid rice. Very less work has been reported on nutrient supply system for hybrid rice. It has also been experienced that the soil health is continuously deteriorating due to continuous use of inorganic fertilizers only and the available carbon content has become quite low in the soil. Rice crop demands a heavy fertilization for better growth and yield. Nitrogen is pivotal in realization of higher rice grain yield. Basal application of nitrogen has low nitrogen use efficiency and higher losses due to volatilization, leaching and de-nitrification. Hence, application of appropriate quantity of nitrogen as split doses will meet the crop demand and enhance the nutrient uptake at critical stages (10 days before panicle initiation) without causing much loss. Farm yard manure (FYM) is the most commonly used organic manure in most countries of the world. FYM not only supplies a variety of macro and micronutrients to the soil, but also improves the physico-chemical and biological properties of soil. Vermicompost is a rich source of enzymes, antibiotics, immobilized micro flora and growth hormones like gibberellins which regulate the growth of plants and microbes. Efficiency of nutrient use may be raised by the combined use of organic and inorganic fertilizers. Organic fertilizers not only act as the source of nutrients but also provide micronutrient and modify soil physico-chemical behavior as well as increase the efficiency of applied nutrients. Keeping in view the above facts into consideration, the present study was done to evaluate the effect of integrated nutrient management (INM) on yield, quality and economics of aromatic rice (*Oryza sativa* L.) var. Basmati was undertaken.

Materials and Methods

The present investigation entitled "Effect of integrated nutrient management (INM) on yield, and economics of aromatic rice (*Oryza sativa* L.) var. Basmati" was carried out at Instructional farm, Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya during kharif season 2018. The chemical properties of the soil were determined in laboratory of the department of Soil Science. The experimental site falls under sub-tropical region in Indo-Gangetic plains and situated at 24.40-26.470 N latitude and 82.120-83.980 E longitude with an altitude of 113 meters from mean sea level. The mean annual rainfall is 1085.6 mm recording about 90%in monsoon season only. The experiment was conducted in randomized block design in three replications with 9 treatments. The treatments consisted of different sources of organic manures and inorganic fertilizer *viz*., T_1 (100:40:30 kg ha^{-1} N_2, P_2O_5, K_2O) kg ha^{-1}, T_2 (75% NPK + 25% N through vermicompost),T_3 (75% NPK + 25% N through FYM), T_4 (50%NPK+25%N through vermicompost FYM), T_5 (50% NPK + 50% N through FYM), T_6 (50% NPK + 50% N through vermicompost), T_7 (125% NPK (RDF) T_8 (100% NPK + 25% N through FYM) T_9 (100% NPK + 25% vermicompost). The experimental soil was silty loam in texture having pH 8.20, EC 0.31, OC 0.24, and available N: 137.18, P_2O_5: 14.80, and K_2O:255.20 kg ha^{-1}.The crop was transplanted in second week of July and harvesting in second week of Nov. 2018. Plants from 1 m row length were uprooted from sample rows of each plot at 30, 60 days after transplanting (DAT) and at harvest. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70 °C and recorded the dry matter yield. Total grains were counted from the same threshed panicles used for counting spikelets per panicle. 1000-grains were counted from the grain samples drawn from each net plot grain yield. The weight of these counted grains was recorded as test weight. Threshed grains were separated out manually and grains were sun dried to moisture of 14% before recording their weight. Straw yield was recorded by subtracting the weight of grains from the weight of each net plot. Harvest index of each plot was calculated with the help of following formula:

$$\text{Harvest index (\%)} = \frac{\text{grain yield(q/ ha)}}{\text{total biological yield}(\frac{\text{q}}{\text{ha}})} \times 100$$

Growth attributes

Plant height

The data pertaining to plant height as influenced by different treatments have been presented in table 1. The significant differences were observed in plant height due to different doses of chemical fertilizers, FYM and vermicompost treatments. The application of FYM and vermicompost as well as RDF enhanced the plant height appreciably at different growth stages. The highest plant height was recorded in the T_9 (100% NPK+25% N through vermicompost). Increase in plant height may be attributed to the fact that the better nourishment causes beneficial effects such as accelerated rate of photosynthesis, assimilation, cell division and vegetative growth. These results are in agreement with the findings of Dutta and Chauhan (2010) [2].

Number of Tillers m^{-2}

It is evident from the data given in the Table-1, that the maximum number of tillers m^{-2} were recorded with the treatment T_9 (100% NPK+25% N through vermicompost) a different growth stages. This might be due to the fact that balanced nutrition enhances number of tillers. Similar results were also reported by Dutta and Chauhan (2010) [2], Singh *et al.* (2011) [10]. Favorable responses of FYM and vermicompost have also been reported by Sharma and Sharma (2002) [7].

Yield and yield attributes

Yield contributory characters are the resultant of vegetative development of the crop which determine yield. All the yield attributes *viz.*, number of effective tillers m^{-2}, length of panicle, number of grains $panicle^{-1}$ and test weight as well as yield were influenced by the application of various doses of fertilizer and manures.

Number of Panicle m^{-2}

Data presented in the Table-2 revealed that maximum number of panicles m^{-2} were also recorded in T_9 (100% NPK+25% N through vermicompost). Balanced nutrients supply through organic and inorganic fertilizers (RDF) with FYM and vermicompost might have increased the uptake of nutrients which had possibly contributed to more vegetative growth. The favorable synthesis of growth promoting constituents in plant system owing to better supply of nutrients might be resulted in higher number of panicle m^2. These results are in agreement with the findings of Maurya and Yadav (1987).

Number of grain per panicle

Maximum number of grains per panicle were also recorded in T_9 (100% NPK+25% N through vermicompost) as given in the Table-2. Balanced nutrients supply through organic and inorganic fertilizers (RDF) with FYM and vermicompost increased the uptake of nutrients which had possibly contributed to more vegetative growth. The favorable synthesis of growth promoting constituents in plant system owing to better supply of nutrients might have resulted in higher number of grains per panicle. These results are in agreement with the findings of Shankar and Laware (2011) [6].

Length of panicle (cm)

The highest values of panicle length as given in the Table-2 were recorded from 100% NPK with 25% vermicompost (integration of organic and inorganic source) which ultimately might have resulted in the higher yield attributing characters. Similar results were reported by Maurya and Yadav (1987).

Grain and straw yield

Grain and straw yield presented in Table-2 revealed that maximum yield was recorded in T_9 (100% NPK+25% N through vermicompost). The more or less similar trend was observed in grain as well as straw yield. This might be due to adequate nutrient availability by the application of organic manure in combination with 100%RDF which contributed to better soil physical, chemical and biological properties. The improvement in soil properties might have enhanced growth parameters and yield attributes. Productivity of crop is collectively determined by vigor of the vegetative growth and yield attributes which resulted in higher grain and straw yield. The increase in yield might be attributed to better translocation of photosynthates from source to sink due to higher uptake of NPK which are responsible for quick and easy translocation. Similar results have also been reported by Kumar *et al.* (2000) [4] and Singh *et al.* (2000) [8].

Hulling and Milling percentage

The hulling and milling per cent have not been influenced considerably by fertilizer and organic manure. The maximum hulling and milling percent were observed with T_9 (100%NPK+25% N through vermicompost), while minimum was recorded with T_5 (50%NPK+50% N through FYM (Table-3) The result is in close conformity with the findings of subhash *et al.* (2005).

Protein content: The maximum protein content was recorded with application of T_9 (100%NPK+25%N through vermicompost) and minimum in T_5 (50%NPK+50% N through FYM) (Table 4).This might be due to the high content and uptake of nitrogen by crop. Similar finding was observed by Singh and Thakur (2007).

Kernel length and breadth

Kernel length and kernel breadth were not influenced considerably by fertilizer, vermicompost and FYM. The maximum kernel length and kernel breadth were observed with T_9 (100%NPK+25%N through vermicompost) while minimum with T_5 (50%NPK+50% N through FYM) (Table-4). The result is in close conformity with the finding of Singh *et al.* (2006).

Economics of various treatments

The variation in the cost of cultivation in different treatments (Table-5) was found due to vermicompost, FYM and RDF in the major inputs. Grain yield was major output factor which caused difference in net income and B-C ratio. Highest net return was computed under the treatment T_9 (100% NPK RDF+ 25% N through vermicompost) followed by T_8 (100% NPK + 25% through FYM).The variation in treatments might be due difference among treatments. This trend in economic return might be mainly due to the treatment effect on the grain yield and straw yield of rice. The highest BC ratio (1.24) was calculated under the treatment T_8 (100% NPK+25% FYM) closely followed by (1.23) T_9 (100% NPK+ 25% vermicompost).These results also corroborated with the findings of Rathore (1996) [5]; Jaybala *et al.* (1999) [3].

Table 1: Effect of INM Practices on growth attributes

Treatments		Plant height (cm)				Number of tillers m^{-2}			
		30 DAT	60 DAT	90 DAT	At harvest	30 DAT	60 DAT	90 DAT	At harvest
T_1	100%NPK(100:40:30kgha^{-1}N:P_2O_5: K_2O)	43.80	76.70	90.20	92.00	216.00	330.00	337.00	327.00
T_2	75% NPK + 25% N through vermicompost	43.00	75.10	88.30	90.10	214.00	324.00	331.00	321.20
T_3	75% NPK + 25% N through FYM	42.60	74.10	87.20	89.00	212.00	320.00	327.00	317.00
T_4	50%NPK+25%Nthroughvermicompost+FYM	42.00	71.70	84.30	86.00	209.00	310.00	316.00	307.00
T_5	50%NPK+50% N through FYM	41.80	70.00	82.30	84.00	207.00	304.00	310.00	301.00
T_6	50%NPK+50% N through vermicompost	41.90	70.80	83.30	85.00	215.00	307.00	313.00	304.00
T_7	125%NPK(RDF)	46.20	85.00	100.0	102.00	222.00	368.20	375.00	365.00
T_8	100%NPK+25% N through FYM	46.50	86.90	101.0	103.00	223.00	371.30	379.00	367.60
T_9	100%NPK+25%N through vermicompost	47.00	89.90	105.8	108.00	225.00	387.60	395.00	384.00
	S.Em±	2.01	2.62	3.65	4.34	8.62	12.53	12.78	12.41
	C.D. (P=0.05)	NS	7.85	10.96	13.00	NS	37.55	38.30	37.20

Table 2: Effect of INM practices on yield and yield attributes

Treatments		No. of panicle m-2	Length of panicle (cm)	Grain Panicle^{-1}	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest Index %
T_1	100%NPK (100:40:30 kg ha^{-1} N, P_2O_5, K_2O)	324.00	20.50	166.00	22.00	34.20	51.70	39.80
T_2	75% NPK + 25% N through vermicompost	318.00	20.10	163.00	21.70	33.50	51.53	39.40
T_3	75% NPK + 25% N through FYM	314.00	19.85	162.00	21.60	33.10	51.34	39.20
T_4	50%NPK+25%Nthrough vermicompost + FYM	304.00	19.20	156.00	21.50	32.00	50.90	38.60
T_5	50%NPK+50% N through FYM	298.00	18.90	153.00	21.40	31.30	50.21	38.40
T_6	50%NPK+50% N through vermicompost	301.00	19.00	154.00	21.45	31.65	50.45	38.55
T_7	125%NPK(RDF)	361.00	22.70	185.00	22.10	38.00	57.00	40.00
T_8	100%NPK+25% N through FYM	364.00	23.00	186.00	22.15	38.35	57.29	40.10
T_9	100%NPK+25% N through vermicompost	380.00	23.60	192.00	22.25	38.68	59.26	40.30
	S.Em±	10.65	0.91	7.92	0.61	1.29	2.00	1.48
	C.D. (P=0.05)	31.93	2.73	23.75	NS	3.87	6.00	NS

Table 3: Effect of INM practices on hulling and milling percentage of rice crop

Treatments		Hulling (%)	Milling (%)
T_1	100%NPK (100:40:30 kg ha^{-1} N, P_2O_5, K_2O)	74.20	66.80
T_2	75% NPK + 25% N through vermicompost	74.10	66.70
T_3	75% NPK + 25% N through FYM	73.60	66.30
T_4	50%NPK+25%Nthrough vermicompost+FYM	73.40	66.10
T_5	50%NPK+50% N through FYM	73.00	65.70
T_6	50%NPK+50% N through vermicompost	73.50	66.20
T_7	125%NPK(RDF)	74.30	66.90
T_8	100%NPK+25% N through FYM	74.50	67.00
T_9	100%NPK+25% N through vermicompost	74.80	67.30
	S.Em±	2.80	2.51
	CD at 5%	NS	NS

Table 4: Effect of INM practices on kernel length, kernel breadth, protein content of the rice

Treatments		Kernel length (mm)	Kernel breadth (mm)	Protein content (%)
T_1	100%NPK (100:40:30 kg ha^{-1} N, P_2O_5, K_2O)	7.00	1.54	8.12
T_2	75% NPK + 25% N through vermicompost	6.90	1.53	8.06
T_3	75% NPK + 25% N through FYM	6.70	1.52	7.94
T_4	50%NPK+25%Nthrough vermicompost+FYM	6.60	1.51	7.88
T_5	50%NPK+50% N through FYM	6.50	1.51	7.69
T_6	50%NPK+50% N through vermicompost	6.55	1.52	7.81
T_7	125%NPK(RDF)	7.60	1.55	8.31
T_8	100%NPK+25% N through FYM	7.70	1.55	8.37
T_9	100%NPK+25% N through vermicompost	8.00	1.55	8.50
	S.Em±	1.13	0.05	0.12
	CD at 5%	NS	NS	0.33

Table 5: Economic analysis of various treatments

Treatments		Cost of cultivation ($Rsha^{-1}$)	Gross Income ($Rsha^{-1}$)	Net return ($Rsha^{-1}$)	B-C ratio
T_1	100% NPK (100:40:30 kg ha^{-1} N, P_2O_5, K_2O)	43553	93455	49902	1.14
T_2	75% NPK + 25% N through vermicompost	46863	92119	45256	0.96
T_3	75% NPK + 25% N through FYM	45698	93246	47548	1.08
T_4	50% NPK + 25% N through vermicompost + FYM	49009	89085	40076	0.81
T_5	50% NPK + 50% N through FYM	47844	87411	39567	0.82
T_6	50% NPK + 50% N through vermicompost	50228	88180	37952	0.75
T_7	125% NPK (RDF)	54441	103550	49109	0.90
T_8	100% NPK + 25% N through FYM	46553	104351	57798	1.24
T_9	100% NPK + 25% N through vermicompost	47718	106209	58491	1.23

Conclusion

On the basis of results obtained in this experiment, it can safely be concluded that by using 75% RDF + 25% N through bio-compost was found most effective in increasing the growth, yield, yield attributes and also helped in maintaining soil health for sustainable rice production. This treatment was also remunerative.

Thus, the recommendation of 75% RDF through chemical fertilizers and 25% N through bio-compost should be made to the farmers of eastern Uttar Pradesh for successful cultivation of hybrid Rice.

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