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Effect of Integrated Nutrient Management (INM) on Soil Properties and Performance of Rice Crop (*Oryza sativa L.*)

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A field experiment was conducted during 2014-15 to investigate the Effect of integrated nutrient management (INM) on soil properties and performance of rice crop (*Oryza sativa L.*). The treatments were Control (T_1) , 50%NPK through inorganic fertilizer+50% N through FYM (T_2), 50% NPK through inorganic fertilizer(T_3), 75% NPK through inorganic fertilizer + 25 % N through FYM (T_4), 75% NPK through inorganic fertilizer(T_5) and 100% NPK through inorganic fertilizer(T_6). Application of 50%NPK through inorganic fertilizer+50% N through FYM recorded significantly higher organic carbon content, available N, P, K, S and soil physical properties as well as higher growth rate in terms of plant height, number of tillers and also yield as compared to other treatments. Effect of 50%NPK through inorganic fertilizer+50% N through FYM on availability of nutrients and growth and yield of rice was significantly superior. Integration of organic and inorganic fertilizers increased soil available nutrients (N, P, K and S) status in comparision to chemical fertilizer alone. Application of 2 50%NPK through inorganic fertilizer+50% N through FYM recorded significantly higher nutrients (N,P,K,S) uptake by crop as compared to other treatments.

Keywords: Integrated nutrient system, nutrients uptake, rice, FYM, soil properties, Growth, yield.

Rice (*Oryza sativa* L.) is the staple food of more than 65 % of the world population. India is the largest producer and consumer of rice in the world. Nitrogen is the most important essential plant nutrient, makeup green and dark plant body. Nitrogen increase plant vegetative growth. To improve the production efficiency of rice, it is necessary to apply required dose of N, P, K and organic matter. There is a scope to reduce the recommended dose of fertilizer by use of organic sources like, FYM, carpet waste, Biofertilizers and green manure in rice field (Bajpai *et al.* 2006). For a sustainable agriculture system, it is imperative to utilize renewable which can maximize the ecological benefits and minimize the environmental hazards (Vance 1997). Extensive use of chemical fertilizers caused to occur in environmental pollution and ecological damage and increased production cost (Ghost and Bhat 1998; Gerber *et al.* 2005; Mitsh and Day 2006).Under these circumstances, integration of chemical and organic sources and their management have shown promising result not only in sustaining the productivity but have also proved to be effective in maintaining soil health and enhancing nutrient use efficiency . Kumar *et al.* 2012). FYM are one of the best modern tools for agriculture. It is a gift of our modern agricultural science. FYM are applied in the agricultural field as a replacement to our

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conventional fertilizers. But obviously the chemical fertilizers are not environment friendly. They are responsible for water, air and soil pollution and can spread cancer causing agents. FYM contains microorganisms which promote the adequate supply of nutrients to the host plants and ensure their proper development of growth and regulation in their physiology. Only those microorganisms are used which have specific functions to enhance plant growth and reproduction.FYM are the objective of increasing number of such micro-organisms and accelerate those microbial processes which augment the availability of nutrients that can be easily assimilated by plants. FYM play a very significant role in improving soil fertility by fixing atmospheric nitrogen, both, in association with plant roots and without it, solubilise insoluble soil phosphates and produces plant growth substances in the soil. The yield and nutrient uptake by rice were significantly lower with the sub optimal dose of NPK. Addition of Zn did not improve rice yield significantly. Thus, integrated application of inorganic and organic sources maximized the yield of rice crop and improved the soil fertility (Chesti *et al.* 2015). The major objective of this experiment was to evaluate the effects of this organic manure and inorganic fertilizers on the promotion of plant growth (rice) and improvement in soil properties by means of field experiment.

MATERIALS AND METHODS

A field experiment was conducted in *kharif* season (2015-2016) at agricultural form of U.P. Autonomous College, Varanasi developed on alluvium deposited. The soil of experimental site was sandy clay loam in texture, slightly saline and non-alkaline in reaction. The initial physico-chemical properties of experimental soil were bulk density 1.35 g cm^{-3}, particle density 2.65 g cm^{-3}, pH (1:2.5) 7.44, EC 0.48 dS m^{-1}, organic carbon 0.43 %, water holding capacity 41.5 %, available nitrogen 190 kg ha^{-1}, available phosphorus 14.55 kg ha^{-1}, available potassium 130 kg ha^{-1} and available sulphur 10 kg ha^{-1}. The various treatments applied to rice crop were control (T_1), 50%NPK through inorganic fertilizer +50% N through FYM (T_2), 50% NPK through inorganic fertilizer (T_3), 75% NPK through inorganic fertilizer + 25 % N through FYM (T_4), 75% NPK through inorganic fertilizer (T_5) 100% NPK through inorganic fertilizer (T_6).The treatments were triplicated in randomized block design (RBD). The recommended dose for rice was 120-60-40 kg N-P_2O_5-K_2O ha------$^{-1}$. NPK and FYM were applied as per schedule of treatments. Nitrogen from urea was given as 50% basal, 25% after 45 days of transplanting and 25% after 60 days. The full dose of P and K through single super phosphate and mureate of potash were applied at time of sowing as basal dressing. The composition of FYM was 0.5% N, 0.2 % P_2O_5, 0.5% K--$_{2--}$O. The required quantities of FYM were applied 15 days before sowing as per treatment. Soil samples from 0-15 cm depth were collected in plastic bag from individual plots at 30 DAT and after harvest of the crop. One soil sample of each plot was air- dried, processed to pass through 2 mm round hole sieve and analysed for oxidizable organic carbon (1*N* $K_2Cr_2O_7$), available N (0.32% alkaline$KMnO_4$ oxidizable), P(0.5 M $NaHCO_3$ extractable), K (1 *N* neutral ammonium acetate extractable) and S (0.15% $CaCl_2$) following the methods described by Walkley and Black method (1934), Subbiah and Asija, (1956), Olsen's et al. (1954), Hanway and Heidel,(1952)and Williams and Steinbergs (1959), respectively. Soil pH was determined in 2:1 soil: water suspension with the help of glass electrode in digital pH meter and electrical conductivity of soil was measured in the supernatant liquid of soil water suspension (1:2) by conductivity bridge (Jackson, 1973). Bulk density in undisturbed samples collected with metal cores of 4.2 cm diameter and 5.8 cm height was measured (Black, 1965). Field was prepared by cross harrowing followed by planking and puddling. Around each plot bonds were made to control water in the plots. Healthy seedlings of 21 days old rice plant (var.Moti) was transplanted with a spacing of 20X10 cm. Five plants are marked randomly in each replicated plot and height was measured from base of plant to the tip of the upper most fully matured and stretched leaf before emergence of ear and from the base of plant to tip of ear after it emergence for calculating mean plant height at 30 and 120 days after transplanting (DAT). Number of tillers per meter in row length at different growth stages (30 DAT and at maturity) of crop were recorded. Dry matter of plants is taken at 60 DAT by cutting the plants in one meter row length in each plots then kept in shade for dry and weighed. After harvesting and threshing the weight of grain was recorded. Straw yield was calculated by subtracting grain yield from biological yield. Plant samples (grain and leaf) drawn at harvesting were dried in shade and then kept in oven at 70^{0}C for 12 hours to make free from moisture. After there, samples were ground in grinder and the total P, K and S content in plant samples were determined by digesting the samples with di–acid (HNO_3:$HClO_4$ in 10:4) mixture **(Jackson, 1973)** while N was determined by chromic acid **(Trivedi et al.1999).** Plant uptake of NPK and S were computed by multiplying the yield with the respective nutrient content. The data collected from field and laboratory were analyzed statistically using standard procedure of randomized block design (Cochran and Cox, 1957). Critical difference (C.D.) and standard error of mean (SEM) were calculated to determine the significance among treatment means.

RESULTS AND DISCUSSION

Organic carbon

It is evident from the table- that integration effect of chemical fertilizer and organic manure as applied in T_2 and T_4 had significant positive impact on organic carbon over other treatment (table-1). Reason attributed is the direct incorporation of organic matter, better root growth and more plant residues addition during the crops. These findingsare in agreement with the observations of Moharana *et al*. (2012). Bajpai *et al*. 2006 also found that when 50 % N was substituted with *sesbania aculeata*, the organic carbon content in soil was increased as compared to 100 % NPK (inorganic fertilizer). Higher organic carbon content with incorporation of organic manures has been reported by Kumar *et al. (2012)* and Babar *et al.* (2013). Significantly higher organic carbon in soil was found under T_2 (50% NPK through inorganic fertilizers and 50% N through FYM) and lower as compared to rest of treatment. Results also indicated that organic carbon content of soil increased with rise in dose of NPK may be due to higher left over plant residues in the form of tissue and plant roots exudates owing to higher biomass production under higher level of NPK were also made by Das *et al*. (2011) in mustard crop. The effect of different treatments on organic carbon

Table 1. Effect of integrated nutrient management (INM) on organic carbon, available N.P.K. and S of soil under rice crop (*Oryza sativa* L.)

Treatments	Organic carbon (%)		Available nutrients (kg ha^{-1})							
			N		P		K		S	
	30 DAT	At harvesting	30 DAT	At harvesting	30 DAT	At harvesting	30 DAT	At harvesting	30 DAT	At harvesting
T_1	0.45	0.40	195.00	178.00	15.30	11.03	135.50	121.65	11.0	7.50
T_2	0.61	0.55	236.66	214.45	26.50	19.30	168.40	151.80	21.60	18.00
T_3	0.50	0.45	204.50	181.80	18.70	13.60	140.85	128.00	13.0	9.80
T_4	0.58	0.54	227.83	210.50	24.10	17.50	160.00	145.00	19.30	15.30
T_5	0.53	0.48	211.00	185.90	19.20	15.30	144.30	133.50	14.70	11.00
T_6	0.55	0.51	217.50	200.00	22.10	16.60	150.50	140.45	16.50	12.50
SEm(±)	0.062	0.037	7.475	5.609	1.137	0.613	2.721	0.911	1.818	1.008
CD (P=0.05)	0.138	0.084	16.655	12.497	2.533	1.366	6.064	2.031	4.051	2.246

DAT=Days of transplanting

content of soil was found in the order $T_2>T_4>T_6>T_5>T_3>T_1$ and the values were 0.55, 0.54, 0.51, 0.48, 0.45 and 0.40 at harvesting the completion of experiment

Available nitrogen

The effect of different treatments of organic manures, and inorganic fertilizers on available nitrogen content of soil was found in the order $T_2> T_4> T_6> T_5> T_3> T_1$ and values of available nitrogen content of soil varied from 214.45 to 236.66, 210.50 to 227.83, 200.00 to 217.50, 185.90 to 211.00, 181.80 to 204.50 and 178.00 to 195.00 kg ha^{-1} under respective treatments (table-1). The available nitrogen content differed significantly due to addition of various levels of chemical fertilizers alone with FYM. The increase in available N might be attributed to the enhanced multiplication of microbes by the incorporation of manure for the conversion of organically bound N to inorganic form. The favorable soil conditions under organic manure application might have helped the mineralization of soil N leading to build – up of higher available N. The most suitable soil condition under organic sources might have helped the mineralization of soil N leading to build – up of higher available N (Kumar *et al*. 2012).

Available phosphorus

The content of available P in soil showed significant increase under all treatments combinations throughout the crops as compared to control (table-1). In general application of FYM showed highest improvement in available P status of soil which was followed by 50 – 50 INM treatment (T_2) and then 100 % RDF treatment (T_6). The positive effect of manure, inorganic fertilizers and there integration in improving available P status of

Table 2. Effect of integrated nutrient management (INM) on physico-chemical properties of soil under rice crop (*Oryza sativa* L)

Treatments	Soil pH		EC (dS m^{-1})		Bulk density (Mg m^{-3})		Soil porosity (%)	
	30 DAT	At harvesting	30 DAT	At harvesting	30 DAT	At harvesting	30 DAT	At harvesting
T_1	7.72	7.77	0.63	0.66	1.47	1.50	44.52	43.39
T_2	7.46	7.49	0.50	0.55	1.38	1.41	47.92	46.79
T_3	7.68	7.73	0.60	0.64	1.45	1.48	45.28	44.15
T_4	7.50	7.55	0.53	0.57	1.40	1.44	47.16	44.66
T_5	7.63	7.70	0.58	0.62	1.44	1.47	45.66	44.52
T_6	7.58	7.65	0.57	0.60	1.43	1.45	46.03	45.28
SEm(±)	0.081	0.142	0.025	0.0297	0.038	0.038	1.839	1.502
CD (P=0.05)	0.182	0.318	0.056	0.066	0.086	0.086	4.097	3.346

DAT=Days of transplanting

Table 3. Effect of integrated nutrient management (INM) on soil properties and performance of under rice crop (*Oryza sativa* L)

Treatments	Plant height (cm)		Number of tillers (meter^{-1}row length)		Dry matter at 60 (DAT)	Grain yield	Straw yield
	30 DAT	At harvesting	30 DAT	At harvesting	(g m^{-1} row)	(Q ha^{-1})	(Q ha^{-1})
T_1	49.20	69.50	21	36	38.00	30.50	42.50
T_2	68.50	92.00	39	65	82.20	68.00	73.80
T_3	55.50	77.90	27	41	43.50	35.50	46.65
T_4	64.00	86.80	36	58	66.00	43.50	61.15
T_5	59.30	82.50	29	50	45.00	38.00	51.50
T_6	62.50	87.50	34	56	62.00	40.50	55.50
SEm(±)	2.166	1.803	1.316	3.546	5.262	3.692	3.026
CD (P=0.05)	4.826	4.017	2.933	7.901	11.724	8.226	6.742

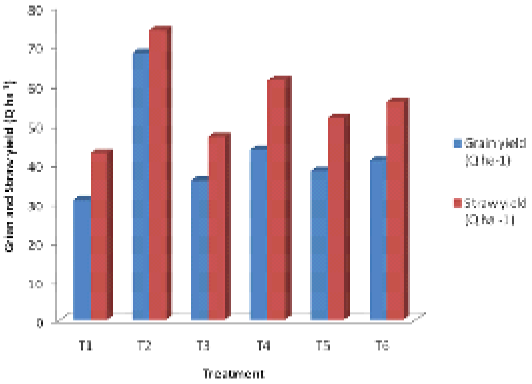

Fig. 1. Effect of integrated use of FYM and NPK on grain and straw yield (Q ha^{-1}) of rice crop

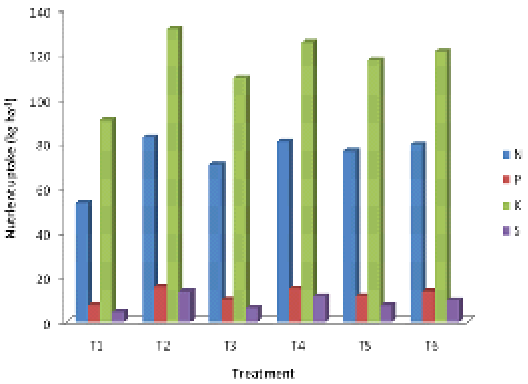

Fig. 2. Effect of N P K S and FYM on total uptake by rice crop

soil is in accordance with Kumar *et al.* (2007). The values of available phosphorus content of rice plots at harvesting were 19.30, 17.50, 16.60, 15.30, 13.60 and 11.03 kg ha^{-1} under T_2, T_4, T_6, T_5, T_3 and T_1 treatments, respectively.

Available potassium

Effect of various treatments on potassium content of soil could be arranged in the order of $T_2 > T_4 > T_6 > T_5 > T_3$ and T_1 the values varied from 151.80 to 168.40, 145.00 to 160.00, 140.45 to 150.50, 133.50 to 144.30, 128.00 to 140.85 and 121.65 to 135.50 under the respective treatments(table-1). The content of available K in soil increased significantly due to different treatments during the growth period of rice as compared to control with the only exception of T_4 treatment . Application of 50 % NPK with FYM significantly increased the available K as compared to 100 % recommended dose of NPK through inorganic source only at harvesting. Babar *et al.* (2013) reported increased in K availability with use of manure and fertilizers compared to control treatment

Available sulphur

Addition of NPK (through inorganic fertilizer) and FYM significantly increased available sulphur content of experimental soil (table-1). The superiority of T_2 (NPK 50% through inorganic fertilizer + 50%N through FYM) over T_6 (100 % NPK through inorganic fertilizer) has been seen at all growth stages of rice during experiment. Treatment T_2 recorded maximum available S followed by T_4, T_6, T_5, T_3 and T_1 and value varied between 7.50 to 21.60 Kg ha^{-1}. It was also found that addition of organic manure (FYM) significantly increased available sulphur content of soil over chemical fertilizer alone at all level of NPK. The increased availability of available S with FYM could be described to their solubilization effect on native S and direct addition of labile pool. Organic carbon is main source of organic sulphur and significantly positive correlation of available S with organic carbon suggests that sulphur supplying power of soils in largely dependent upon organic carbon. These results are accordance with those of Basumatary *et al.* (2010). Among the various levels of N, P and K through inorganic source, available sulphur content increased significantly with increasing levels of N, P and K might be due to addition of higher amount of organic residue at higher levels of NPK and FYM.

Soil pH

Application of FYM with fertilizers significantly decreased the soil pH over that control and inorganic fertilizer alone (table-2). Effect of different treatments on soil pH could be arranged in order of $T_1 > T_3 > T_5 > T_6 > T_4 > T_2$ and values varied from 7.77 to 7.72, 7.73 to 7.68, 7.70 to 7.63, 7.65 to 7.58, 7.55 to 7.68 and 7.46 to 7.49 under respective treatments. The pH of soil water suspension increased with day after transplanting and highest values were recorded at harvesting of crop might be attributed to decrease in organic matter content with time. Organic matter (FYM) treated plots recorded low pH as compared to chemical fertilizer alone may be due to release of organic acids during decomposition of added organic manures. Lower soil pH with incorporation of organic manures (FYM) has also been reported by Kumar *et al.*(2012).

Electrical conductivity

The effect of different treatments of NPK + FYM on soil EC could be arranged in order T_1> T_3> T_5> T_6> T_4> T_2 the values varied from 0.63 to 0.66, 0.60 to 0.64, 0.62 to 58, 0.57 to 0.62, 0.53 to 0.57 and 0.50 to 0.55 d Sm^{-1} under respective treatments (table-2). Significantly lower EC of soil was recorded in 50% NPK through inorganic fertilizer + 50% N through FYM applied plots over control. The increased electrical conductivity under chemical fertilizer alone was probably due to accumulation of soluble salts which might become from the application of fertilizers and exchange of several cations. These result are in line with finding of Kumar *et al*. (2012). Application of FYM significantly decreased soil EC might be due to formation of complex between organic acid (which released during decomposition) and salts which soluble and leached out during irrigation.

Bulk density

The bulk density of rice plots increased slightly from 30 DAT and at harvesting and values varied from 1.38 to 1.50 Mg m^{-3}. The bulk density increased gradually with time on account of natural compaction (table-2). Significantly lower bulk density was recorded under 50% NPK + 50%N through FYM over control. The effect to different treatment in bulk density was found in the order T_1> T_3> T_5> T_6> T_4> T_2> the values varied from 1.47 to 1.50, 1.45 to 1.48, 1.44 to 1.47, 1.43 to 1.45, 1.44 to 1.47 and 1.38 to 1.41 Mg m^{-3} under respective treatments. Decreased the bulk density in 50% NPK + 50% N through FYM applied plots may be due to higher organic carbon content of soil more places and better soil aggregation. Singh *et al*. 2000; also reported that more crop residue, higher organic matter content and better root growth, might be possible reasons for decease in bulk density.

Total Porosity

The total porosity of soil increased from 30 DAT to the harvest of crop. Application of 50 % NPK + 50 % N through FYM (T_2) significantly as compared to other treatments while it was remained at par with T_4 (table-2).The effect of various treatment on total porosity could be arrange in order of $T_2 > T_6 > T_4 > T_5 > T_3 > T_1$ and values at harvesting were 46.79, 45.28, 45.66, 44.52, 44.52, 44.15 ,respectively. It was also found that application of FYM increased the porosity over chemical fertilizer alone.

Effect of NPK and FYM on growth and yield of rice crop

Plant height

Application of organic manure along with inorganic fertilizers significantly increased plant height as compared to chemical fertilizer alone the plant height of rice crop increased continuously with advancement in growth stages up to the harvesting under all treatments and was found in the order T_2> T_4> T_6> T_5> T_3> T_1 (table-3). Significantly higher plant height was recorded with the application of 50% NPK through inorganic fertilizer + 50%N through FYM (T_2) over rest of treatments but was at par with the application of 75% NPK through inorganic fertilizer + 25%N through FYM (T_4). Similar results were also reported by Kumar *et al.*(2012). Higher plant height in NPK + FYM treated plots may be due to NPK and FYM play crucial role in meristematic growth through its effect on the synthesis of phyto-harmones. Among various plant harmones cytokinin plays important role in growth of tillers and buds (Beringer, 1983).

Number of tillers

Significantly higher number of tiller was recorded with application of FYM along with graded dose of NPK over chemical fertilizers alone (table-3). The highest number of tillers were recorded under 50 % NPK + 50 % FYM – N (T_2), which was at par with 75 % NPK + 25 % FYM – N. These results are in agreement with findings of kumar *et al.* (2012). The number of tillers per meter row length of rice under different treatments increased with time and reached maximum at 60 DAT. The effect of various treatments on number of tillers could be arranged in the order of $T_2 > T_4 > T_6 > T_5 > T_3 > T_1$ and values varied between 21 to 69 per meter row length.

Dry matter, Straw and Grain yield

Application of 50 % NPK + 50 % FYM – N recorded significantly higher dry matter followed by 75 % NPK + 25 % FYM – N (table-3 and fig.-1).. The effect of various treatments on dry matter production could be arranged in order of T_2> T_4> T_6> T_5> T_3> T_1 and the values were 82.20, 66.00, 62.00, 45.00, 43.50 and 38 g m^{-1} row respectively. Higher yield response in comparison to NPK alone was recorded with combined application of NPK + FYM. Application of 50 % NPK + 50 % FYM – N significantly increased the grain yield over rest of treatments, emphasizing on the essentiality of organic manure with inorganic fertilizers to obtain higher productivity. According to yield different treatments may be arranged as: $T_2 > T_4 > T_6 > T_5 > T_3$ and T_1. And value of grain yield were 68.00, 43.50, 40.50, 38.00, 35.50 and 30.50 under respective treatments. Benefits accruing from integrated use of FYM with 50 % NPK might be attributed to better supply of nutrients through incorporation of organic manure along with conducive physical environment leading to better root activity and higher nutrient adsorption. Which resulted in better plant growth and superior yield attributes responsible for high yield (Thakur *et al.* 2011; Chesti, MH 2013 and Kumar *et al.* 2012). Like gain yield, straw yield also recorded significantly higher in T_2 (50% NPK through inorganic fertilizer + 50%N through FYM) as compared to other treatments. The effect of various treatments on straw yield could be arranged in order of $T_2 > T_4 > T_6 > T_5 > T_3 > T_1$ and values were 73.80, 61.15, 55.20, 51.50, 46.65 and 42.50 q ha^{-1}, respectively.

Total nutrients uptake by rice plant as influenced by integrated use of organic manure and inorganic fertilizers.

Nutrients uptake

Application of N P K either alone or in combination with FYM recorded significantly higher total (grain + straw) uptake of N P K and S over that of control (fig.-2). Application of 50 % NPK + 50 % FYM – N recorded significantly higher N P K S (82.53, 15.20, 131.20 and 13.25 kg ha^{-1}, respectively.) uptake in comparison to NPK alone use of FYM significantly enhanced the total uptake of NPK and S over that of chemical fertilizers alone at all level of NPK . The increase in uptake of nutrient in the organic manures treated plots may be due to extra amount of nutrients supplied by FYM and organics providing conductive physical environment facilitating better root growth and adsorption of nutrients from the native as well as applied sources which ultimately favoured the highest nutrient uptake (Chesti *et al.* 2013). The effect of various treatments on N, P, K and S uptake could be arranged in order of $T_2 > T_4 > T_6 > T_5 > T_3 > T_1$ and among the treatments, the uptake on N varied from 53.16to 82.53 kg ha^{-1}, P from 7.25 to 15.20 kg ha^{-1}, K from 90.25 to 131.20 kg ha^{-1} and S from 4.23 to 13.25 kg ha^{-1}. The substantial improvement in nutrient uptake indicate the requirement of integration of nutrient supply sources for rice crop and also for over all improvement in soil's physico-chemical properties and biological environment. These results are on conformity with those reported by Sharma *et al*. (2009)

It is concluded from the present study that application of 50 % N.P.K through inorganic fertilizer along with 50% N through F.Y.M not only produced higher yield of rice, but also soil fertility as compared application of chemical fertilizer alone. Thus optimum mineral nutrients in conjunction with organic manure can play vital role in exploiting high yield potential of rice through its favorable effect on nutrient supply and soil properties in the study zone.

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