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EFFECT OF INTEGRATED NUTRIENT MANAGEMENT ON YIELD, NUTRIENT UPTAKE AND SOIL FERTILITY IN AUTUMN RICE IN AN INCEPTISOL OF ASSAM

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ABSTRACT

A field experiment was conducted at the Instructional-cum-Research Farm, Assam Agricultural University, Jorhat during autumn season of 2010-11 to study the effect of integrated use of inorganic fertilizers and organic manure on yield, nutrient uptake and soil fertility in autumn rice. Integrated nutrient management approach brought about a positive influence on organic carbon, soil available nutrient status, crop yield and uptake of nutrients by autumn rice. Combined application of 120 kg N + 39.3 kg P + 100 kg K ha^{-1} along with 10 t FYM ha^{-1} resulted in the build up of organic carbon, available N and P in soil. The highest amount of available K was found in the treatment receiving 120 kg N, 26.2 kg P and 100 kg K ha^{-1} along with 10 t FYM ha^{-1}. The highest grain (30.85 q ha^{-1}) and straw yield (35.25 q ha^{-1}) and uptake of nitrogen (83.5 kg ha^{-1}) and phosphorus (35.7 kg ha^{-1}) by rice were obtained with combined application of 120 kg N + 39.3 kg P + 100 kg K along with 10 t FYM ha^{-1}.

Keywords: Autumn rice, integrated nutrient management, soil fertility, yield

INTRODUCTION

In Assam, rice is the most important and staple food crop for more than two thirds of the population. The gross and net cropped area for rice in Assam is 38.39 and 27.53 lakh hectare, respectively of the three rice types, winter (*Sali*) rice is the most important culture with a productivity of 1993 kg ha^{-1} and that of autumn (*Ahu*) rice with a productivity of 1155 kg ha^{-1}. The total area under rice is 27.3 lakh hectare with a productivity of 1969 kg ha^{-1} as against the national average of 2240 kg ha^{-1}. One of the reasons for lower productivity in Assam is imbalanced fertilization of N, P and K nutrients. High cost of fertilizers is constraint for the farmers of Assam to apply adequate amount of fertilizers to crop. Therefore, greater economy in fertilizer use can be made if integrated nutrient management is followed, to improve soil fertility for sustaining the desired level of crop production and productivity through optimization of the benefits from all possible sources of plant nutrients in an integrated manner. This practice ensures balanced fertilization, higher yield and more profitability. Though integrated nutrient management is an age old practice, farmers are still not adopting this practice for autumn rice in Assam. With these facts in views, experiments were conducted to study the effect of INM on productivity of autumn rice, nutrient uptake and fertility status in an Inceptisol of Assam.

MATERIALS AND METHODS

A field experiment was conducted during autumn season of 2011 at Instructional cum Research Farm of Assam Agricultural University, Jorhat (26°48′N latitude) and (95°50′E longitudes). Soil of the experimental field was sandy clay loam with pH 5.1 and organic C 0.6g kg^{-1}. The amount of available N, P and K was 213, 15 and 90 kg ha^{-1}, respectively. Following the Inductive methodology of Ramamoorthy *et al.* (1967), four fertility gradients were created by dividing the experimental field into four equal strips which were fertilized with $N_0P_0K_0$, $N_{1/2}P_{1/2}K_{1/2}$, $N_1P_1K_1$ and $N_2P_2K_2$ levels. The recommended fertilizers ($N_1P_1K_1$) were 60, 8.7 and 33.3 kg ha^{-1} of N, P and K, respectively. Thereafter, rice (cv. Ranjit) as exhaust crop was transplanted on 7th July'10 in each fertility strip and harvested on 23 November 2010. After the harvest of the exhaust crop each of the fertility strip was subdivided into 24 sub-plots (4×3 m each) resulting in 96 (24 × 4) plots. The field experiment was designed as per the ICAR guidelines framed under All India Co-ordinated Research Project on the Soil Test Crop Response Correlation. Four strips comprising of 6 treatments were made within a strip randomized with farmyard manure levels. There were 24 treatments comprising of various selected combination levels of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}), phosphorus (0, 13.1, 26.2 and 39.3 kg ha^{-1} P), potassium (0,50 and 100 kg ha^{-1} K) and farmyard manure (0, 2.5, 5 and 10 t ha^{-1}) (Table 1). The graded doses of N, P and K were applied in the form of urea, single superphosphate and muriate of potash, respectively in each strip. Farmyard manure was incorporated in the soil 15 days prior to transplanting of rice. The moisture and N, P and K content of FYM were 20 %, 0.6 %, 0.3 % and 0.5 %, respectively. Entire quantity of single superphosphate and muriate of potash was applied by

Table 1: Treatment details for test crop experiment

Strip I	Strip II	Strip III	Strip IV
$N_0 P_0 K_0 OM_0$	$N_0 P_0 K_0 OM_0$	$N_0 P_0 K_0 OM_0$	$N_0 P_0 K_0 OM_0$
$N_0 P_0 K_0 OM_1$	$N_0 P_0 K_0 OM_1$	$N_0 P_0 K_0 OM_1$	$N_0 P_0 K_0 OM_1$
$N_0 P_0 K_0 OM_2$	$N_0 P_0 K_0 OM_2$	$N_0 P_0 K_0 OM_2$	$N_0 P_0 K_0 OM_2$
$N_0 P_0 K_0 OM_3$	$N_0 P_0 K_0 OM_3$	$N_0 P_0 K_0 OM_3$	$N_0 P_0 K_0 OM_3$
$N_0 P_0 K_2 OM_1$	$N_0 P_0 K_2 OM_2$	$N_0 P_0 K_2 OM_3$	$N_0 P_0 K_2 OM_0$
$N_0 P_3 K_0 OM_3$	$N_0 P_3 K_0 OM_0$	$N_0 P_3 K_0 OM_1$	$N_0 P_3 K_0 OM_2$
$N_1 P_1 K_0 OM_3$	$N_1 P_1 K_0 OM_0$	$N_1 P_1 K_0 OM_1$	$N_1 P_1 K_0 OM_2$
$N_1 P_1 K_1 OM_3$	$N_1 P_1 K_1 OM_0$	$N_1 P_1 K_1 OM_1$	$N_1 P_1 K_1 OM_2$
$N_2 P_0 K_1 OM_3$	$N_2 P_0 K_1 OM_0$	$N_2 P_0 K_1 OM_1$	$N_2 P_0 K_1 OM_2$
$N_2 P_1 K_0 OM_2$	$N_2 P_1 K_0 OM_3$	$N_2 P_1 K_0 OM_0$	$N_2 P_1 K_0 OM_1$
$N_2 P_1 K_1 OM_2$	$N_2 P_1 K_1 OM_3$	$N_2 P_1 K_1 OM_0$	$N_2 P_1 K_1 OM_1$
$N_2 P_2 K_0 OM_2$	$N_2 P_2 K_0 OM_3$	$N_2 P_2 K_0 OM_0$	$N_2 P_2 K_0 OM_1$
$N_2 P_2 K_1 OM_2$	$N_2 P_2 K_1 OM_3$	$N_2 P_2 K_1 OM_0$	$N_2 P_2 K_1 OM_1$
$N_2 P_2 K_2 OM_2$	$N_2 P_2 K_2 OM_3$	$N_2 P_2 K_2 OM_0$	$N_2 P_2 K_2 OM_1$
$N_3 P_1 K_1 OM_1$	$N_3 P_1 K_1 OM_2$	$N_3 P_1 K_1 OM_3$	$N_3 P_1 K_1 OM_0$
$N_3 P_2 K_2 OM_1$	$N_3 P_2 K_2 OM_2$	$N_3 P_2 K_2 OM_3$	$N_3 P_2 K_2 OM_0$
$N_3 P_3 K_0 OM_1$	$N_3 P_3 K_0 OM_2$	$N_3 P_3 K_0 OM_3$	$N_3 P_3 K_0 OM_0$
$N_3 P_3 K_1 OM_1$	$N_3 P_3 K_1 OM_5$	$N_3 P_3 K_1 OM_3$	$N_3 P_3 K_1 OM_0$
$N_3 P_3 K_2 OM_0$	$N_3 P_3 K_2 OM_1$	$N_3 P_3 K_2 OM_2$	$N_3 P_3 K_2 OM_3$
$N_4 P_2 K_1 OM_0$	$N_4 P_2 K_1 OM_1$	$N_4 P_2 K_1 OM_2$	$N_4 P_2 K_1 OM_3$
$N_4 P_2 K_2 OM_0$	$N_4 P_2 K_2 OM_1$	$N_4 P_2 K_2 OM_2$	$N_4 P_2 K_2 OM_3$
$N_4 P_3 K_1 OM_0$	$N_4 P_3 K_1 OM_1$	$N_4 P_3 K_1 OM_2$	$N_4 P_3 K_1 OM_3$
$N_4 P_3 K_2 OM_0$	$N_4 P_3 K_2 OM_1$	$N_4 P_3 K_2 OM_2$	$N_4 P_3 K_2 OM_3$
$N_4 P_0 K_0 OM_3$	$N_4 P_0 K_0 OM_0$	$N_4 P_0 K_0 OM_1$	$N_4 P_0 K_0 OM_2$

N_0 = 0 kg ha^{-1} P_0 = 0 kg ha^{-1} K_0 = 0 kg ha^{-1} FYM (OM_0) = 0.0 t ha^{-1}
N_1 = 30 kg ha^{-1} P_1 = 13.1 kg ha^{-1} K_1 = 50 kg ha^{-1} FYM (OM_1) = 2.5 t ha^{-1}
N_2 =60 kg ha^{-1} P_2 =26.2 kg ha^{-1} K_2 =100 kg ha^{-1} FYM (OM_2) =5.0 t ha^{-1}
N_3 = 90 kg ha^{-1} P_3 = 39.3 kg ha^{-1} FYM (OM_3) = 10.0 t ha^{-1} N_4 = 120 kg ha^{-1}

broadcasting at the time of transplanting. Urea was applied in three splits. Half of the recommended dose was applied as basal application, and the remaining half was applied at maximum tillering and panicle initiation stage. Pre-sowing soil samples were collected from each plot before the superimposition of the treatments and analysed for organic C, available N, available P and available K (Jackson, 1973). Rice (cv. Luit) as test crop was transplanted on 22nd March 2011 and harvested on 24 June 2011. The plant samples from each plot were analysed for N (modified Kjeldahl's method), P (di-acid digestion and vanadomolybdate method) and K content (Flamephotometer). The respective percent content of different nutrients was multiplied by the corresponding dry matter yield to estimate the nutrient uptake. The climate of the region as a whole is sub-tropical humid having hot summer and cold winter. Normally, the monsoon season starts from the month of June and extends upto the month of September. Maximum and minimum temperature during the study period ranged from 27.5 to 32.2^{o}C and 17.0 to 25.4^{o}C, respectively. Mean relative humidity in the morning was 87.5% and at evening was 60.0%. Total rainfall was highest (104.6 mm) in May and bright sunshine hours of the crop season ranged from 2.6 to 2.9.

Table 2: Initial soil test values before transplanting of crop

Strip	Organic C (g kg^{-1})		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Strip I	5.0-6.5	5.9	169.3-219.5	198.6	13.9-17.9	14.9	81.3-90.2	84.1
Strip II	5.5-6.5	6.0	188.1-250.8	211.6	17.9-21.7	19.9	85-94.1	89.3
Strip III	5.5-6.8	6.3	188.1-250.8	223.4	22.6-26.5	24.1	88.5-99.3	94.6
Strip IV	6.0-6.8	6.5	219.5-288.5	232.8	26.4-30.3	28.3	94.1-104.1	100.1

RESULTS AND DISCUSSION

Crop yield

The results showed an increase in grain and straw yields of rice in integrated treatments over inorganic treatments and control. Integrated nutrient management reflected an average increase of 6.6, 12 and 9.9 % in grain yield and 6.6, 10.5 and 10.1 % in straw yield (Fig. 1) over chemical fertilizer alone. Data (Table 3) revealed that the average crop yield increased in the order strip I< strip II< strip III< strip IV. It was found that the treatments receiving 120 kg ha^{-1} of N, 39.3 kg ha^{-1} of P and 100 kg ha^{-1} of K along with 10 t ha^{-1} of FYM showed higher grain and straw yields over other treatments.

Table 3: Effect of INM on grain yield and nutrient uptake (kg ha^{-1}) by crop

Strip	Grain yield (q ha^{-1})		Nitrogen uptake		Phosphorus uptake		Potassium uptake	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Strip I	16.15-22.75	19.34	22.0-59.4	40.2	5.1-21.4	14.9	20.8-53.3	37.5
Strip II	16.50-25.80	21.62	22.2-68.9	50.0	5.1-27.1	18.4	23.0-79.5	48.5
Strip III	16.58-30.25	23.12	25.1-82.2	59.4	7.7-32.2	20.6	24.8-92.8	55.4
Strip IV	18.11-30.85	23.65	25.9-83.5	64.9	8.2-35.7	22.3	25.7-106.9	62.8

The beneficial effect of combined use of organic manure and fertilizers resulted from increased nutrient availability through enhanced microbial activity, conversions from unavailable to available forms and improved physical, chemical and bio-chemical conditions (Babhulkar *et al.* 2000). This could be attributed to decomposition of FYM, which favoured better nutrient availability coupled with higher assimilation of nutrients. The significant correlation between available nutrients of soil and yield of rice also supported the finding (Table 5). The increases in crop yield with integrated treatments are in line with the findings of Singh *et al*. (2006) and Kumar *et al.* (2008).

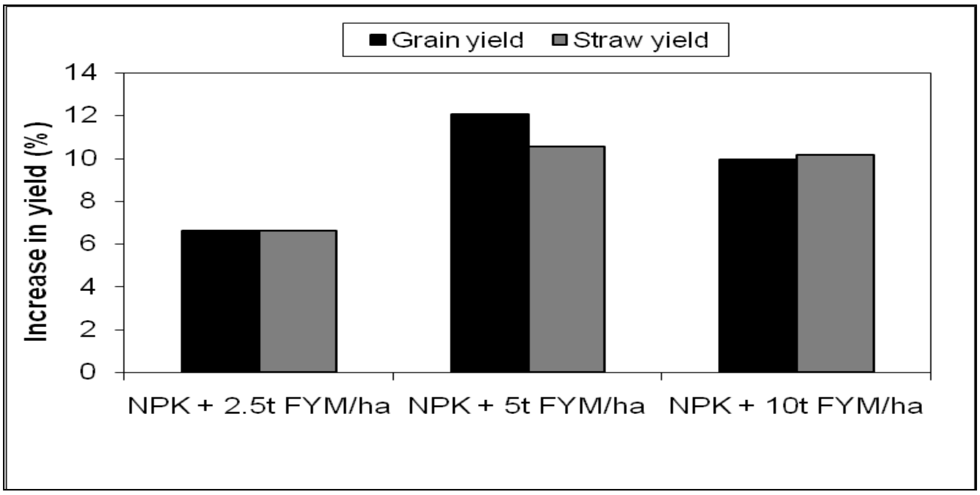

Fig 1: Per cent increase in grain and straw yield under INM over NPK fertilizer alone

Nutrient Uptake

The treatments of integrated nutrient management had a favourable effect on the uptake of nutrients (N, P and K) than that of inorganic treatments and control (Fig. 2). This might be ascribed to higher dry matter production as well as nutrient concentration with combined uses of organic and inorganic fertilizers were applied. Better performance under these treatments might also be due to favourable soil environment, which encouraged better root proliferation and ensured higher nutrient uptake. Such results corroborates with the findings of Mishra and Sharma (1997). The favourable effect of incorporation of FYM in soil for higher NPK uptake by rice was also reported by Sharma *et al*. (2001). Similar increase in nutrient uptake by rice due to combined application of inorganic fertilizers and FYM was reported by Singh *et al*. (2009) and Gogoi *et al.* (2010) in an Inceptisol of Assam. Thus, it appears that integrated nutrient management directly or indirectly influences uptake of nutrients.

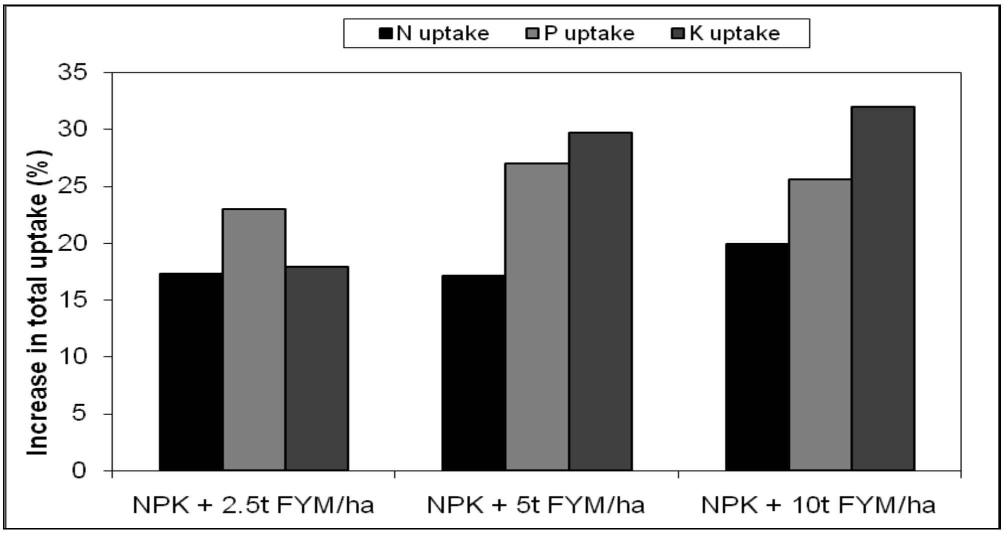

Fig 2: Per cent increase in nutrient uptake under INM over NPK fertilizer alone

Soil fertility

Integrated treatments receiving chemical fertilizers along with farmyard manure exhibited a considerable increase in organic C content over chemical fertilizer treatments. This increase might be due to addition of organic manure which stimulated the better root growth (Banswasi and Bajpai 2006). The effect was further enhanced by the addition of NPK fertilizers resulting in the improvement in root and shoot growth and thus higher production of biomass which, in turn, increased the organic C content in soil (Babhulkar *et al.* 2000). In general, available N content was found to be higher in the integrated treatments receiving both organic and inorganic at the end of rice crop (Table 4). The mean available N was found to be the highest in strip IV, followed by strip III, strip II and strip I. Integrated nutrient management reflected an average increase of 4.5, 7.1 and 10.7 % in available N with 2.5, 5 and 10 t ha^{-1} FYM along with NPK, respectively over chemical fertilizer alone. Addition of nitrogenous fertilizer along with FYM helps in narrowing down of C:N ratio and, thus, increased mineralization resulted in rapid conversion of organically bound N to inorganic forms (Kumar and Wagenet 1984). Singh *et al*. (2006), Jagtap *et al*. (2007) and Sharma *et al*. (2009) reported that increase in available N with farmyard manure application might be attributed to the direct addition of N through farmyard manure to the available pool of soil.

Table 4: Effect of INM on soil fertility after harvest of crop

Strip	Organic C ((g kg^{-1})		Available N (kg ha^{-1})		Available P (kg ha^{-1})		Available K (kg ha^{-1})	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Strip I	5.6-9.6	7.4	169.1-250.8	216.0	9.0-18.4	14.16	71.2-96.8	83.9
Strip II	6.0-9.6	7.5	182.5-270.6	225.5	10.5-25.8	18.7	75.0-103.7	90.1
Strip III	6.1-9.6	7.7	185.1-270.6	235.5	13.3-28.0	23.1	75.1-113.1	95.0
Strip IV	6.2-9.6	7.8	195.4-290.6	238.0	18.2-35.2	28.5	79.6-120.9	102.9

Available phosphorus contents in soil was found higher in the treatments having conjoint use of NPK fertilizer with FYM @ 2.5, 5 or 10 t ha^{-1} over single application of NPK. Increase in available P with FYM application could be justified due to solubilization of the native P in the soil through release of various organic acids (Tolanur and Badanur, 2003). The organic anions and hydroxyl acids, such as tartaric, citric, malonic and malic acids liberated during the decomposition of organic matter might complex or chelate Fe, Al and Ca and prevent them from reacting with phosphate in inceptisol of Assam (Jagtap *et al.* 2007). Such favourable effect of combined application of inorganic and organic source of nutrients in enhancing the availability of P was also noted by Prasad *et al.* (2010). Integrated nutrient management showed higher value of available K content as compared to control and NPK alone. Beneficial effect of conjoint use of FYM along with inorganic fertilizer might be the reason of this increase. Application of organic matter improved the CEC of the soil and thus increased the retension of K in exchangeable form by a mass action effect. It might be ascribed to the reduction of K fixation and release of K in exchangeable site due to the interaction of organic matter with clay besides the direct addition of K to available pool of the soil. This is in agreement with the findings of Sharma *et al*. (2009), Bharadwaj *et al*. (2010) and Gogoi *et al*. (2010).

Table 5: Correlation coefficient (r) between soil parameters with N, P, K uptake and grain yield

	N uptake	P uptake	K uptake	Grain yield
Organic C	0.63**	0.72**	0.69**	0.69**
Available N	0.80**	0.82**	0.78**	0.82**
Available P	0.87**	0.79**	0.80**	0.82**
Available K	0.88**	0.86**	0.87**	0.89**

*** Significant at 1% level of probability*

Simple Correlation

Simple correlation coefficient was computed to assess the relative contribution of the various soil parameters in yield and nutrient uptake of rice (Table 5). Results revealed that the grain yield of rice had significant positive correlation with organic C (r = 0.69**), available N (r = 0.82**), available P (r = 0.82**) and available K (r = 0.89**). Similarly, the grain yield of rice was also found to be significantly and positively correlated with uptake of N, P and K.

Multiple regression equation

Relationship between grain yield as dependent variable and the soil test values, fertilizer doses, farmyard manure doses, interactions between soil test values, fertilizer doses and among fertilizer nutrients as independent variables was established through a multiple regression equation of quadratic model and are presented below:

Y = 2.707 + 0.011* SN – 0.038* SP + 0.058* SK + 6.023 SOC + 0.057* UN + 0.146* UP + 0.059* UK + 0.003* FN -0.006* FP – 6.397* FK – 0.029* OM (R^2 = 0.965**)

Where, Y, FN, FP, FK, UN, UP and UK represent in kg ha^{-1} are the grain yield, applied fertilizer and total uptake of N, P and K, respectively. SN, SP and SK expressed in kg ha^{-1} are the soil available nutrients. SOC is the soil organic carbon and OM is the organic manure (FYM) represent in percentage and t ha^{-1}, respectively. The equation showed the combined effect of all the independent variables (FN, FP, FK, OM, UN, UP, UK and SN, SP, SK and SOC) on grain yield of rice. These relationships suggest that variations in grain yield of rice could be ascribed to changes in soil available nutrients, applied organic manure and fertilizer nutrients with high order of predictability (R^2). From R^2 value, it can be observed that variation up to 96.5 % in rice grain yield can be explained by the variation in soil test values and fertilizer doses. Significant linear relationships between grain yield and nutrient removal by the crop testified that target yield equations in terms of nutrient uptake, soil test values and applied organic manure and fertilizer could be developed.

Table 6: Correlation coefficient (r) between N, P, K uptake and grain yield

	Grain yield
N uptake	0.94**
P uptake	0.94**
K uptake	0.94**

*** Significant at 1% level of probability.*

The results obtained from the present investigation indicated that integrated treatments involving combined application of inorganic fertilizers and farmyard manure had pronounced influence in improving the crop yield and soil fertility status as compared to control and inorganic alone. Among the integrated treatments, application of 120 kg ha^{-1} N, 39.3 kg ha^{-1} P and 100 kg ha^{-1} K along with 10 t ha^{-1} FYM exhibited the highest value as compared to other treatments.

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