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Response of rice to different nitrogen and phosphorous levels under irrigated conditions

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Abstract
A field experiment was conducted at Agricultural Research Station, kampasagar, Nalgonda, Telangana during kharif 2011 & kharif 2012 to study the response of transplanted rice to four levels of Nitrogen (0, 120,160 and 200 kg N ha^{-1}) and four levels of Phosphorous (0,30,60 and 90 kg ha^{-1}). The experiment was designed in Randomized Block Design and replicated thrice. Significantly more number of tillers and panicles were observed at 200 kg N ha^{-1} than other levels. Panicle length and number of filled grains $panicle^{-1}$ were significantly higher at 120 kg N ha^{-1} than 0 kg N ha^{-1} and it was comparable with 160 and 200 kg N ha^{-1}. Significantly lower sterility percentage was observed at 120 and above levels than 0 kg N ha^{-1}. The grain yield was significantly higher in 120 kg N ha^{-1} (5069 kg ha^{-1}) than the 0 kg N ha^{-1} (3730 kg ha^{-1}). The grain yield at upper doses was comparable with that of 120 kg N ha^{-1}. Straw yield was significantly higher at 120 kg N ha^{-1} than 0 kg N ha^{-1}. Straw yield at higher doses were statistically similar with 120 kg N ha^{-1}. Harvest Index was significantly higher in 200 kg N ha^{-1} than 120 and 0 kg N ha^{-1}. HI at 160 kg N ha^{-1} was comparable with both 120 and 200 kg N ha^{-1}. Both in grain and straw 120 kg N ha^{-1} significantly increased NPK uptake than 0 kg N ha^{-1}. Grain and straw NPK uptake at above levels were comparable with 120 kg N ha^{-1}. P_2O_5 levels did not show any significant influence on yield attributes, yield and nutrient uptake. High NNG was attained at 120 kg N ha^{-1} and above doses than control. Reverse trend of NUEPG was obtained with increase in N doses.

Keywords: N levels, P levels, rice, nutrient uptake, grain yield, irrigated conditions, N use efficiency indicators

Introduction

Rice (*Oryza sativa* L) is one of the major crop grown in an area of 1.4 m. ha in Telangana state under irrigated eco system. In India, grain yields have been improved for the past three decades in cereal based irrigated intensified agriculture with cultivation of high yielding varieties and enhanced usage of chemical fertilizer. After attaining independence and subsequent efforts made through green revolution, the country has got ability to produce 5 times more food grains, where as fertilizer consumption increased by 322 times since green revolution implies low fertilizer use efficiency (Prasad, 2009) [13]. The soil available reserves of carbon and major nutrients are shoveled heavily in cereal based cropping systems. Continuous mining of secondary and micro nutrients are seldom replenished. A deficit of about 10 M t of NPK is estimated in the recent past for the estimated NPK requirement of 30 M t every year. Now a day's more N and P are applied to cereals due to subsidized rate and instant response of N fertilizers on foliage and habituated application of DAP and ignoring of K causes highly nutrient imbalance. Decreasing of factor productivity or response ratio to 6 kg is another alarming situation.

However, rice farmers usually do not apply balanced doses of N, P, K and other fertilizers. Nitrogen is the major nutrient that most frequently limits the rice production and is the key input in nutrient management. Proper fertilization is an important management practice which can increase the yield of rice. In low land rice ecosystems in wet season, usually nitrogen use efficiency is approximately 30-40% (Ramakrishna *et al*. 2007) [14] and rest of 60-70% being lost by different ways, which in turn contributes substantially to environmental pollution. Inadequate N application adversely affects the grain production. Judicious and proper use of fertilizers can markedly increase the yield and improve the quality of rice (yoshida 1981) [21]. Removal of P has markedly increased with the higher yields of new systems involving improved germ plasm and intensive fertilization; particularly under high N application. In the early years of green revolution, crop responses to fertilizer P and K were marginal (De Datta and Mikkelsen, 1985) [1]. With continuous intensive cropping, P became first deficient nutrient as revealed in long-term experiments (Shiga, 1982) [2]. Relationships between nutrient supply, nutrient uptake, tissue concentration and its use efficiency in rice have been well documented by Dobermann *et al* (1998) [3] mostly on the basis of long term experiments conducted at IRRI.

Nutritional imbalances may also prevent new cultivars from expressing their full yield potential. Interaction among nutrients is also considered as a key factor in deciding the agronomic efficiency of added nutrients in irrigated rice. In a long-term experiment at IRRI, large-scale interactions between N and P were reported by De Datta *et al.* (1988) [2]. Both N response ratio and agronomic efficiency of N decreased drastically due to imbalanced nutrition of P as manifested by decreased uptake of P.

A very few sporadic research studies were done under irrigated conditions on effect of N and P on the yield, yield components and nutrient uptake of rice. Considering the above facts, the present experiment was undertaken to investigate the effect of N and P on the yield attributes, yield, and nutrient uptake of rice.

Materials & Methods

A field experiment entitled “Response of transplanted rice to different N and P levels under irrigated situations” was conducted at Agricultural Research Station, Kampasagar, Nalgonda district during *kharif* 2011& *Kharif* 2012. The nursery of BPT 5204 a long duration variety was sown at 2nd and 3rd week of July and transplanted on II fortnight of August during 1st and 2nd year respectively. The experimental soil was of sandy clay loam type with P^H of 6.9 and E C of 0.208 ds m^{-1}. Fertility status indicated that the soil was low in available N and high in available P and K. The experiment was conducted in factorial RBD with 16 treatments combined with four N levels of 0, 120, 160 and 200 kg N ha^{-1} and four P levels 0, 30, 60 and 90 kg ha^{-1} and replicated thrice.

The gross and net plot sizes of the treatments were 118.8 m^2 (12X9.9 m) and 104.16 m^2 A spacing of 20X15 cm was adopted with 2-3 seedlings per hill. N & P fertilizers were applied as per the treatments. Nitrogen was applied in three equal splits at basal, active tillering and panicle initiation stages. While, entire P_2O_5 was applied as basal and K_2O @ 40 kg ha^{-1} was applied in 2 equal splits as basal and at panicle initiation. The crop was managed well keeping free from weeds, pest and disease. Oxadiargyl was applied @ 90 g/ha 4th day after transplanting and further weed growth was checked by hand weeding at 20 and 35 days after transplanting. Irrigation and need based pest and disease management were done as per the recommendations of PJTSAU (Professor Jayashnkar Telangana State Agricultural University).

Crop samples collected at harvest were utilized for chemical analysis. These samples were used for estimation for NPK content. Nitrogen was estimated by kelplus nitrogen analyzer (Piper, 1966). Phosphorus was estimated by di acid digestion method (HNO_3 and $HCLO_4$ in the ratio of 9:1) and by using UV Visible spectro photo meter (Jackson, 1967). Potassium was estimated by di acid digestion method using Flame photometer (Jackson, 1967). The N, P and K contents were expressed as per cent. The N, P and K uptake was computed by multiplying the per cent content with grain and straw yield and expressed as kg $ha^{-1.}$

N Use Efficiency Indicators

1) N Needed by 100 kg Grain, NNG:

$$NNG= \frac{TN}{GY} x100$$

2) N Physiological Efficiency, NPE:

$$NPE= \frac{BIO}{GY}$$

3) N Use Efficiency of Producing Grain, NUEPG:

$$NUEPG= \frac{GY}{TN}$$

BIO is total aboveground dry weight on a dry weight basis (at 80°C),
TN is total plant N uptake at harvest time,
GY is grain yield
All of the above quantities expressed in kg ha^{-1}.
At harvest the yield and yield attributes were recorded and the data was analyzed statistically by the procedure outlined by Gomez and Gomez (1984).

Results and Discussion

Yield attributes

Pooled data of yield attributes and yield presented in table 1, tiller number was significantly higher in 200 kg N ha^{-1} than the other N levels. Tiller number was comparable between 120 and 160 kg N ha^{-1} and significantly higher than 0 kg N ha^{-1}. Hoque et al., 2010 [7] reported that 110 kg N ha^{-1} produced the highest number of tillers $hill^{-1}$ and 0 kg N ha^{-1} recorded the lowest total tillers $hill^{-1}$. Tiller number did not differ significantly among different P levels.

Significantly more number of panicles were observed at 200 kg N ha^{-1} than other levels. The panicle number was on par between 120 and 160 kg N ha^{-1} and significantly higher than 0 kg N ha^{-1}. Enhanced tillering by increased nitrogen application might be attributed to more nitrogen supply to plant at active tillering stage and resulted in significantly higher number of panicles. Results are in conformity with the findings of Ombir singh *et al.*, (2007) [11] who stated that increasing N application was effective in increasing the number of panicles. Islam *et al.*, (2008) [8] reported maximum number of panicle m^{-2} in 100 kg N ha^{-1} than 0, 50 and 150 kg ha^{-1}. Heluf Gebrekidan and Mulugeta Seyoum (2006) stated in his report that application of N up to 120 kg ha^{-1} increased the number of panicles m^{-2} significantly apparently by increasing the number of productive tillers. Different P_2O_5 levels did not show any significant influence on panicle number.

P_2O_5 did not show any significant influence on panicle length. Panicle length was significantly higher at 120 kg N ha^{-1} than 0 kg N ha^{-1} and it was comparable with 160 and 200 kg N ha^{-1}. Salahuddin *et al*., (2009) [15] reported that panicle length increased with the increase of nitrogen rate up to 150 kg N ha^{-1} and thereafter declined. The longest panicle was observed when 150 kg N/ha was applied. The longest panicle (25.43 cm) was obtained from 110 kg N ha^{-1} and the shortest (21.55 cm) from control (Hoque etal., 2010) [7]. Heluf Gebrekidan and Mulugeta Seyoum 2006 reported application of 90 kg N ha^{-1} increased panicle length significantly up to 90 kg N ha^{-1}.

200 kg N ha^{-1} recorded significantly number of filled grains $panicle^{-1}$ than 0 kg N ha^{-1} and comparable with 120 and 160 kg N ha^{-1}. It is mainly due to an increase in panicle length and panicle number. Application of more than 120 kg ha^{-1} of N caused comparable number of grains per panicle which may be due to an increase in competition for metabolic supply among tillers thereby decreasing or stagnating the production of grains (Wu *et al*., 1998) [20] or possibly due to vigorous vegetative growth causing heavy drain on soluble carbohydrate resulting in reduced availability for grain formation (Hasegawa *et al*., 1994) [5]. Filled grains were not differed significantly among different P levels.

200 kg N ha^{-1} recorded lower number unfilled grains and it is significantly lower than 0 and 120 kg N. 120 kg N ha^{-1}

recorded significantly lower no of unfilled grains/panicle than 0 kg N ha^{-1}. Unfilled grains did not differ significantly among different P_2O_5 levels. Sterility percentage significantly lower at 200 kg N ha^{-1} than 0 kg N ha^{-1} and it was on par with 120 and 160 kg N ha^{-1}. Significantly lower sterility percentage was observed at 120 and above levels than 0 kg N ha^{-1}. Hoque *et al.*, (2010) [7] reported that the highest number of unfilled grains panicle^{-1} (19.11) was obtained from 0 kg N ha^{-1} and the lowest (16.81) from 110 kg N ha^{-1}. P levels did not show any significant effect on sterility percentage.

1000 grain weight was not differ significantly among different N & P_2O_5 levels the findings reported by Thakur (1993) [19]. Salahuddin *et al.*, (2009) [15] stated that Thousand grain weight remained unaltered due to N fertilizer application from 0 to 200 kg N ha^{-1}.

The grain yield was significantly higher in 120 kg N ha^{-1} (5069 kg ha^{-1}) than the 0 kg N ha^{-1} (3730 kg ha^{-1}). The grain yield at upper doses was comparable with that of 120 kg N ha^{-1}. N application upto 120 kg N ha^{-1} significantly increased the yield attributes like panicle number m^{-2}, panicle length, filled grains panicle^{-1} and Nutrient uptake has resulted into significantly increased grain yield than control. Increased level of nitrogen up to 120 kg N ha^{-1} causes for higher availability of nitrogen during all stages leading to increased cell multiplication, rapid cell elongation, improved metabolic activity, which resulted in more tiller growth and marked improvement of yield attributes like panicles m^{-2}, panicle length, filled grains panicle^{-1} and 1000 grain weight. Finally all which lead to increased grain yield at 120 kg N ha^{-1}. Beyond 120 kg N ha^{-1} the yield improvement was not that much significant due to more or less similar yield attributes of number of panicles m^{-2} and filled grains panicle and 1000 grain weight at higher doses.

Results are supported by srivastava *et al.,* (2006) [17]. Significant increase in grain yield of rice might be due to increased photosynthesis and photosynthates translocation from leaf to grain leading to increased production as confirmed by Sudakar *et al.,* (2006). Significantly higher grain yield was observed in 100 kg N ha^{-1} than 0, 50 and 150 kg N ha^{-1} (Islam *et al.*, 2008) [8]. Salahuddin *et al.*, (2009) [15] observed that grain yield of transplanted aman rice increased gradually with the increasing levels of nitrogen up to 150 kg N ha^{-1}, but at higher rates (200 kg ha^{-1}), grain yield tended to decrease. The highest grain yield (4.91 t ha^{-1}) was obtained at 150 kg N ha^{-1} and the lowest (3.31 t ha^{-1}) from 0 kg N ha^{-1}. Hoque *et al.,* (2010) [7] reported that 110 kg N ha^{-1}produced the highest grain yield (3090 kg ha^{-1}) and the lowest (2020 kg ha^{-1}) from the control. Different P_2O_5 levels did not show any significant difference on grain yield.

Straw yield was significantly higher at 120 kg N ha^{-1} than 0 kg N ha^{-1}. Straw yield at higher doses were statistically similar with 120 kg N ha^{-1}. Straw yield did not differ significantly among different P_2O_5 levels.

Harvest Index was significantly higher in 200 kg N ha^{-1} than 120 and 0 kg N ha^{-1}. HI at 160 kg N ha^{-1} was comparable with both 120 and 200 kg N ha^{-1}. HI at 120 kg N ha^{-1} was significantly higher than 0 kg N ha^{-1}. Interaction effect on yield and yield attributes were found non-significant

Table 1: pooled data of Yield attributes under different levels of N and P

Treatment	Tiller number/ m^{-2}	Panicle numberm^{-2}	Panicle length (cm)	Filled grains panicle^{-1}	Unfilled grains panicle^{-1}	Spikelet sterility (%)	1000 grain weight (g)	Grain Yield (kg ha^{-1})	Straw Yield (kg ha^{-1})	HI
Nitrogen levels										
0 kg ha^{-1}	285	276	18.4	137	26	15.7	13.3	3730	4875	0.43
120 kg ha^{-1}	369	350	18.9	148	18	10.5	13.5	5069	5883	0.46
160 kg ha^{-1}	373	354	19.0	149	15	8.8	13.3	5226	5985	0.47
200 kg ha^{-1}	399	370	18.9	150	13	8.0	13.7	5303	5816	0.48
SE m±	5.2	4.8	0.17	3.5	1.7	1.3	0.2	86	105	0.006
CD(P=0.05)	15	14	0.50	10	5	3.8	NS	250	303	0.02
Phosphorous levels										
0 kg ha^{-1}	370	341	19.0	154	17	10.2	13.5	4935	5716	0.45
30 kg ha^{-1}	359	337	18.6	141	18	11.3	13.5	4862	5730	0.45
60 kg ha^{-1}	360	334	18.6	142	19	11.5	13.3	4723	5911	0.44
90 kg ha^{-1}	357	330	18.9	148	17	10.1	13.7	4809	5991	0.44
SE m±	5.2	7	0.2	3.5	1.7	1.3	0.2	122	105	0.006
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction										
SE m±	11	9.9	0.28	7.0	3.5	2.6	0.3	173	210	0.007
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

NPK uptake

Both in grain and straw 120 kg N ha^{-1} significantly increased N uptake than 0 kg N ha^{-1} (Table 2). Grain and straw N uptake at above levels were comparable with 120 kg N ha^{-1}. P_2O_5 uptake in straw and grain significant response was observed upto 120 kg N ha^{-1}. Beyond it was comparable. K_2O uptake in straw was significantly higher at 120 kg N ha^{-1} than 0 kg N ha^{-1} and all other levels are comparable with 120 kg N ha^{-1}. However, K_2O uptake in grain was increased significantly with increment in N level from 0 to 200 kg N ha^{-1}. NPK uptake in both grain and straw did not differ significantly at different P_2O_5 levels.

Increases in yield components are associated with better nutrition, plant growth and increased nutrient uptake (Kumar and Rao, 1992; Thakur, 1993) [10, 19].

N Use Efficiency Indicators

High NNG was attained at 120 kg N ha^{-1} and above doses than control. Reverse trend of NUEPG was obtained with increase in N doses (Table 2). NUEPG was higher at control than 120 kg N ha^{-1} and above levels. Therefore, the in- crease of NNG could be at the expense of N application. These results indicated that excessive N application in China might be inconsistent with the physio- logical requirement of the rice, thereby leading to low N use efficiency indexes (NUEPG) and high NNG. Similar finding reported by G.Y. Song *et al.,* (2013) regarding NNG, NPE and NUEPG indices among different genotypes under varying N levels. NNG increased with increase in P_2O_5 doses and reverse trend noticed with respect to NUEPG

Table 2: NPK uptake (kg/ha) under different levels of N and P (Pooled)

Treatment	N (kg ha^{-1})		P_2O_5 (kg ha^{-1})		K_2O (kg ha^{-1})		NNG	NPE	NUEPG
Nitrogen levels	**Straw**	**Grain**	**Straw**	**Grain**	**Straw**	**Grain**			
0 kg ha^{-1}	14.0	40.4	8.6	12.6	33.3	17.2	1.25	2.21	79.6
120 kg ha^{-1}	18.3	50.0	11.6	16	40.6	21.5	1.33	2.15	74.6
160 kg ha^{-1}	18.9	49.1	11.6	15.6	41.8	23.5	1.39	2.20	73.8
200 kg ha^{-1}	18.7	49.1	11.3	15.6	43.8	25.0	1.39	2.16	72.5
SE m±	0.6	1.1	0.4	0.3	1.2	0.4	0.01	0.02	0.92
CD (P=0.05)	1.7	3.2	0.9	0.9	3.5	1.2	0.04	NS	2.7
Phosphorous levels									
0 kg ha^{-1}	19.1	46.5	9.3	14.2	42.2	21.6	1.25	2.20	80.5
30 kg ha^{-1}	19.3	46.6	11.2	14.9	42.5	21.6	1.33	2.17	75.3
60 kg ha^{-1}	19.6	49.5	11.3	14.9	42.6	21.8	1.39	2.19	72.5
90 kg ha^{-1}	20.7	49.4	12.2	15.0	45.6	22.7	1.39	2.18	72.2
SE m±	0.6	1.1	0.4	0.3	1.2	0.4	0.01	0.02	0.92
CD (P=0.05)	NS	NS	NS	NS	NS	NS	0.04	NS	2.7
Interaction									
SE m±	1.1	2.2	0.6	0.6	2.4	0.8	0.03	0.04	1.91
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Conclusion

It is concluded that application of 120 kg N ha^{-1} with 30-60 kg P_2O_5 is recommended to obtain the higher grain yield under irrigated condition where P reserves are high.

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