International Journal of Farm Sciences **4(1)** :6-15, 2014

Effect of different doses of nitrogen on performance of promising varieties of rice in high altitude areas of Andhra Pradesh

K TEJESWARA RAO, A UPENDRA RAO, D SEKHAR, P SEETHA RAMU and N VENUGOPALA RAO

Agricultural Research Station, Seethampeta, Srikakulam 532443 AP
Email for correspondence: ***arsseethampeta@gmail.com***

ABSTRACT

Field experiment was conducted during three consecutive Kharif seasons of 2009-10, 2010-11 and 2011-12 at Agricultural Research Station, Seethampeta, Andhra Pradesh on sandy clay loam soil with three varieties (RGL 2537, RGL 2332 and MTU 7029) and four nitrogen levels (60, 80,100 and 120 kg/ha) with an objective to find out suitable variety with optimum nitrogen level for high altitude areas of Andhra Pradesh. Among the varieties RGL 2537 recorded higher number of tillers and panicles m^{-2} with lengthy panicles, higher grain yield, harvest index, partial factor productivity, gross returns, net returns and rupee per rupee invested compared to RGL 2332 and MTU 7029. MTU 7029 recorded noticeably higher number of dead hearts, white ears/m^2, per cent leaf folder, per cent silver shoots and BPH/hill compared to RGL 2332 and RGL 2537. Tiller production, days to 50 per cent flowering, dry matter production at harvest, yield attributes, yields and harvest index, gross returns, net returns and rupee per rupee invested, protein content of grain, soil organic carbon and available nitrogen were progressively augmented by incremental levels of N. Nutrient response in terms of partial factor productivity was progressively decreased with incremental levels of N from 60 kg to the highest dose tried. Post soil fertility status revealed that the status was progressively increased with incremental levels of N up to the highest dose tried that increased significantly by elevated levels of N.

Keywords: Rice; varieties; N levels; yield; partial factor productivity; economics

INTRODUCTION

Rice is an important crop of Andhra Pradesh as well as India. It requires higher amounts of nutrients to express its yield potential to the maximum. Rice required 20.7 kg N, 5.17 kg P and 35.5 kg K during kharif season for every metric tonne of grain produced (Yoshida 1981). Among the essential plant nutrients nitrogen is the most important element for growth and development of rice. Fertilizer nitrogen being an ever-shrinking non-renewable fossil fuel based energy source its availability is progressively declining and the cost is becoming increasingly prohibitive. Nitrogen fertilization becoming an increasingly important in gauging the economic and environmental viability of agro ecosystems and exploiting genotypic differences in N demand and efficiency have been proposed as possible alternatives for reducing the cost and reliance upon fertilizer N (Gardner et al 1994). Genetic character of a variety limits the expression of yield. Rice cultivars differ in their potential to respond to high fertility conditions. Selection of suitable varieties and their nutrient requirements have great relevance in boosting up productivity of low land rice. High altitude and tribal area zone of Andhra Pradesh is endowed with the special soil and climate where varietal response to inputs vary compared to coastal plains. Selection of proper variety suitable to the specific ecological situation may prove to be a boon to the farmer. Hence a study was proposed to identify suitable variety, N level and varietal response under different levels of N in high altitude and tribal zone of Andhra Pradesh.

MATERIAL AND METHODS

Field experiment was conducted during three consecutive Kharif seasons of 2009-10, 2010-11 and 2011-12 at Agricultural Research Station, Seethampeta, Andhra Pradesh. The soil was sandy clay loam having pH 6.8, organic carbon 0.62 per cent, available nitrogen 257 kg ha^{-1}, available P_2O_5 26.1 kg ha^{-1} and K_2O 302 kg ha^{-1}. The treatments consisted of three varieties (RGL 2537, RGL 2332 and MTU 7029) and four nitrogen levels (60, 80,100 and 120 kg/ha). The experiment was laid out in a factorial RBD design with three replications planting 30 days old seedlings at a spacing of 20 x 15 cm with 2-3 seedlings per hill. Water was maintained at a depth of 2 cm up to panicle initiation and 5 cm thereafter up to one week before harvest. Weeds were controlled by two hand weedings at 20 and 40 days after transplanting. The field was drained before application of fertilizers and one week before harvest. Nitrogen was applied in different doses and 60 kg P_2O_5 and 50 kg K_2O per ha as basal. The experiment received uniform plant protection and cultural management practices throughout the period of crop growth.

Data on tillers m^{-2} were collected from ten randomly marked hills at active tillering stage. Dry matter production at harvest was recorded from ten randomly marked hills, samples were air-dried and then oven dried at 60^{o}C to a constant weight and expressed as kg ha^{-1}. The number of ear bearing tillers were counted from tagged plants, averaged to compute productive tillers hill^{-1} and expressed as panicles m^{-2}. Panicle weight and panicle length were recorded following standard procedures from 10 randomly marked hills. Root volume at flowering was calculated using water displacement method. Root biomass and weed biomass were estimated at flowering duly following standard procedure. Pests and diseases were collected following standard procedures from 10 randomly marked hills. Grain from the net plot was thoroughly sun dried to 14 per cent moisture content, weighed and expressed in kg $ha^{-1.}$ Nitrogen was estimated by modified micro-kjeldahl method and crude protein was estimated by multiplying total N with factor 5.95; phosphorus was estimated by calorimetric method using a Technicon auto-analyzer and potassium by flame photometry (Jackson 1973). The uptake of N, P and K in kg ha^{-1} at harvest was calculated by multiplying the nutritional content with the respective dry matter production. The nutrient content of grain and straw was analyzed separately and then multiplied with respective weights of grain and straw which were summed up to present nutrient uptake at harvest. The soil available P was estimated by the method of Olsen et al (1954), the available K by flame photometer (Jackson 1973) and organic carbon in the soil by the chromic acid digestion method of Walkley and Black (1954).

Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference (p= 0.05) by pooling three years data. Partial factor productivity from applied nutrients is a useful measure of nutrient use efficiency because it provides integrative index that quantifies total economic output related to the utilization of all nutrients (Cassmen et al 1996). It is the ratio of yield in kg/ha to applied nutrients.

RESULTS AND DISCUSSION

The effects of various levels of N and varieties on various parameters have been presented in Tables 1 to 3.

Varieties

There were significant differences among the varieties in tiller production, days to 50 per cent flowering, dry matter production at harvest, yield attributes, yields and harvest index. Among the three varieties RGL 2332 recorded significantly taller plants than MTU 7029 and was found at par with RGL 2537. Number of tillers and panicles/m^2 were measurably higher with lengthy panicles in RGL 2537 compared to MTU 7029. However there were no measurable differences among varieties in total and filled grains per panicle. Thousand grain was conspicuously higher in MTU 7029 compared to RGL 2537. Grain yield was significantly higher in RGL 2537 compared to RGL 2332 and MTU 7029 and the latter two were found at par. Straw yield was significantly lesser in MTU 7029 compared to RGL 2537 and RGL 2332 and the difference between latter two was not statistically measurable. Productivity of crop is collectively determined by vegetative growth coupled with higher yield attributes resulting in higher grain and straw yields. Yield differs among varieties because of their lodging, pests, diseases and physiological problems (Pal et al 2008).

Higher harvest index was recorded with RGL 2537 and MTU 7029 compared to RGL 2332. Differences in harvest index were also reported among the varieties by Bufogle et al (1997).

Nutrient response in terms of partial factor productivity was higher in RGL 2537 over RGL 2332 and MTU 7029. Similar results were also reported by Pal et al (2008). Analysis of economic parameters shows that the gross returns, net returns and rupee per rupee invested were conspicuously higher with RGL 2537 followed by RGL 2332 and MTU 7029. This might be due to higher grain yield coupled with lesser cost of cultivation in RGL 2537. Post soil fertility status revealed that the soil organic carbon and available phosphorus status were unaffected by varieties whereas available nitrogen and potassium status was markedly higher with MTU 7029 followed by RGL 2537 and it declined with cultivation of RGL 2332. Protein content of grain and uptake of phosphorus at harvest were at par among the varieties whereas N and K uptake at harvest was higher by RGL 2332 followed by RGL 2537 and was markedly higher over MTU 7029.

Measurable variation was also observed in root parameters among varieties. MTU 7029 recorded higher root volume as well as root biomass followed by RGL 2537 and RGL 2332. Enhanced growth and development associated with higher grain yield of cultures include more vigorus and extensive root system (Yang and Sun 1988). Pest and disease incidence also showed conspicuous variation among varieties. Among the varieties MTU 7029 recorded noticeably higher number of dead hearts, white ears m^{-2}, per cent leaf folder, per cent silver shoots and BPH/hill compared to RGL 2332 and RGL 2537. Similarly MTU 7029 also recorded noticeably higher per cent sheath blight and blast incidence compared to RGL 2332 and RGL 2537. Similar findings of differential response of varieties due to pest and disease tolerance have been reported previously by Rao et al (2013).

N levels

There were significant differences with increased levels of N in tiller production, days to 50 per cent flowering, dry matter production at harvest, yield attributes, yields and harvest index and all the parameters were progressively augmented by incremental levels of N. Plant height number of tillers and panicles/m^2 increased significantly and progressively with incremental levels of N up to the highest dose tried. This could be attributed to the fact that higher dose of nitrogen being constituent of enzymes and protein enhanced cell expansion and various metabolic processes. Days to 50 per cent flower also progressively increased with incremental levels of N up to the highest dose tried. Total and filled grains per panicle increased progressively with incremental levels of N up to 100 kg N ha^{-1}. Panicle length increased conspicuously by increasing N Level from 60 and 80 kg/ha to120 kg/ ha whereas 1000 grain weight increased markedly with increasing N level from 60 to 100 kg/ha and above. Dry matter production at harvest increased significantly with incremental levels of N up to 100 kg N/ha. This could be attributed to the higher nitrogen application which might have increased the chlorophyll formation and improved photosynthesis and thereby increased the plant height, number of leaves and number of tillers per unit area leading to the production of high dry matter. Grain yield and straw yield increased progressively with incremental levels of N up to 100 kg N ha^{-1}. However harvest index decreased progressively with incremental levels of N from 60 kg to the highest dose tried. Increase in nitrogen might have assisted in greater photosynthesis and nitrogen being a basic constituent of protoplasm and chloroplast might have stimulated meristematic growth and thus increased the various growth parameters of semi-dry rice. As yield is a manifestation of the individual yield components in this case also the nitrogen dose which resulted in highest grain yield (120 kg N ha^{-1}) was due to the highest number of panicles m^{-2}, number of filled grains $panicle^{-1}$ and thousand grain weight coupled with higher nitrogen uptake and efficient translocation to sink. Similar results with graded levels of nitrogen were noticed by Singh and Tripathi (2007).

Nutrient response in terms of partial factor productivity decreased progressively with incremental levels of N from 60 kg to the highest dose tried. Singh et al (1999) reported decreased nutrient response with enhanced N levels. The probable reason for lower N efficiency at higher N levels may be due to higher N losses with increased levels of N (Daftardar and Savant 1995). Analysis of economic parameters shows that the gross returns, net returns and rupee per rupee invested increased progressively with incremental levels of N up to the highest dose tried. This might be due to higher grain yield coupled with lesser cost of cultivation. Post soil fertility status revealed that the soil organic carbon and available nitrogen status increased progressively with incremental levels of N up to the highest dose tried. However available phosphorus and potassium status was markedly progressively decreased with incremental levels of N from 60 kg to the highest dose tried. Protein content of grain was significantly increased by elevated levels of N. This might be due to increased nitrogen assimilation (protein synthesis) in plants because nitrogen is a major component of amino acids and proteins. Similar results were reported by Singh and Bajpai (1990). Uptake of nitrogen, phosphorus and potassium at harvest increased progressively with incremental

Table 1. Effect of varieties and N levels on growth, yield attributes and root parameters of rice

Treatment	Plant height (cm)	Tillers m^{-2}	Days to 50% flowers	Panicles m^{-2}	Total grains/ panicle	Filled grains/ /panicle	Panicle length (cm)	1000 grain wt (g)	DMPH ($kgha^{-1}$)	Root volume ml/plant	Root biomass g/hill
Variety											
RGL 2537	115.7	528	131	373	132	112	23.8	19.70	12670	25.95	12.70
RGL 2332	119.1	479	130	351	141	125	24.4	22.56	12356	23.53	12.08
MTU 7029	103.5	471	126	344	140	123	21.7	24.03	11551	27.36	13.20
SEm±	1.52	11.7	0.76	9.31	5.27	4.61	0.81	0.73	320	1.15	0.83
$CD_{0.05}$	4.44	34.16	2.22	27.19	NS	NS	2.37	2.13	934	3.36	2.42
N level (kg/ha)											
60	107.2	462	127	316	104	91	22.6	22.85	10792	21.18	9.85
80	112.6	498	131	351	120	106	23.8	23.33	11953	23.72	11.91
100	118.4	535	133	382	136	129	24.5	23.84	13181	26.22	13.36
120	123.3	567	135	414	148	134	25.2	23.97	13828	27.49	15.02
SEm±	1.62	10.87	0.83	10.15	4.81	4.22	0.73	0.31	341	1.22	1.15
$CD_{0.05}$	4.75	31.85	2.43	29.74	14.09	12.29	2.14	0.91	999	3.57	3.37

Table 2. Effect of varieties and N levels on yield, economics and nutrient uptake of rice

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	HI (%)	PFP	Gross returns (₹ ha^{-1})	Net returns (₹ ha^{-1})	RRI (₹/₹) (%)	Protein content	Uptake at harvest (kg ha^{-1})		
								N	P	K	
Variety											
RGL 2537	5665	6918	44.71	—	—	—	—	7.65	128.1	23.23	140.6
RGL 2332	5265	6721	42.61	29.82	67503	24003	0.55	7.58	113.7	23.85	156.4
MTU 7029	5150	6105	44.58	27.71	62955	19955	0.46	7.61	96.8	23.57	129.8
SEm±	94	118	—	27.11	61228	16478	0.37	0.11	1.85	0.35	2.47
$CD_{0.05}$	274	345	—	—	1205	685	0.21	0.32	5.40	1.02	7.21
N level (kg/ha)											
60	4795	5653	44.43	--	3519	2000	0.61	7.55	95.6	20.71	119.7
80	5175	6283	43.29	28.21	56984	13455	0.31	7.59	103.7	22.26	127.8
100	5605	6865	42.52	27.24	61637	17887	0.41	7.64	116.3	23.83	138.5
120	5860	7169	42.38	26.69	66803	22834	0.52	7.72	131.5	24.27	151.2
SEm±	108	129	--	25.48	69836	25647	0.58	0.09	2.15	0.42	3.15
$CD_{0.05}$	316	378	--	--	1411	705	0.12	0.26	6.30	1.23	9.23

HI- Harvest index, PFP- Partial factor productivity, RRI- Rupee retuned per rupee invested

Table 3. Effect of varieties and N levels on pest, disease incidence and post available soil nutrient status (kg ha^{-1}) of rice

Treatment	Dead hearts/ m^2	White ears/m^2	BPH hill	Per cent leaf folder	Per cent silver shoots	Per cent sheath blight incidence	Per cent blast incidence	Weed biomass (g)	Organic carbon (%)	Available post soil status (kg ha-1) N	P_2O_5	K_2O
Variety												
RGL 2537	15.74	17.41	19.93	8.25	4.80	17.04	13.03	20.80	0.60	250	25.89	291
RGL 2332	18.15	16.14	23.30	7.14	5.50	16.75	12.61	17.53	0.59	247	25.86	285
MTU 7029	20.16	24.33	28.37	10.82	8.45	24.66	18.73	23.95	0.65	260	26.18	299
SEm±	1.21	1.25	1.75	0.51	0.62	2.12	0.81	1.13	0.18	2.11	0.16	1.56
$CD_{0.05}$	3.53	3.65	5.11	1.49	1.81	6.19	2.37	3.30	0.52	6.2	NS	4.5
N level (kg/ha)												
60	13.17	17.52	13.95	6.56	3.65	12.15	11.31	15.28	0.53	6.16	0.53	4.56
80	15.63	18.09	21.17	9.38	5.80	14.77	14.36	17.33	0.58	245	27.05	298
100	17.44	20.61	32.35	14.67	7.46	18.41	16.58	20.07	0.60	251	26.23	294
120	21.18	22.05	46.79	18.19	8.52	27.38	19.27	24.42	0.63	262	25.79	287
SEm±	1.30	1.19	1.55	0.63	0.69	2.21	1.07	1.21	0.65	269	25.17	277
$CD_{0.05}$	3.81	3.49	4.54	1.85	2.02	6.48	3.14	3.55	0.17	3.09	0.13	1.74

BPH- Brown plant hopper, RRI- Rupee returned per rupee invested levels of N up to the highest dose tried. Better and early nutrient availability with higher levels of N might have helped in improved root volume which in turn increased the uptake of N, P and K. Safeena et al (1999) reported higher nutrient uptake at increased N rates due to more solubility of urea and greater root development.

Pest and disease incidence also increased progressively with incremental levels of N up to the highest dose tried. Number of dead hearts, white ears m^{-2}, per cent leaf folder, per cent silver shoots and BPH/hill, per cent sheath blight and blast incidence were highest with application of N @ 120 kg ha^{-1} and these parameters were at their minimum with application of N @ 60 kg ha^{-1}. Higher levels of N lead to relatively higher crop growth creating favourable conditions for pests and diseases (Ohm et al 1996). This supports the findings of Kajimura et al (1995) who noted low densities of BPH and WBPH in cultivated fields those with low N content. Higher incidence of stem borer with higher doses of nitrogen has been also reported by earlier workers (Saroja and Raju 1981). Higher incidence of pests and pathogens with higher doses of nitrogen was probably due to increased succulence of the stem ensuring easy penetration of pests and pathogens (Dhandapani et al 1990).

CONCLUSION

It can be concluded that among the varieties RGL 2537 proved most impressive by recording higher number of tillers and panicles/m^2 with lengthy panicles, higher grain yield, harvest index, partial factor productivity, gross returns, net returns and rupee per rupee invested. MTU 7029 recorded noticeably higher pest and disease incidence compared to RGL 2332 and RGL 2537. Tiller production, days to 50 per cent flowering, dry matter production at harvest, yield attributes, yields and harvest index, gross returns, net returns, rupee per rupee invested, protein content of grain, soil organic carbon and available nitrogen were progressively augmented by incremental levels of N.

REFERENCES

Bufogle JA, Brollich PK, Kovar JL, Micchiavelli RE and Lindau CW 1997. Rice variety differences in dry matter and nitrogen accumulation as related to plant stature and maturity group. Journal of Plant Nutrition **20**: 1203-1224.

Cassmen KU, Gines GC, Dizon MA, Samson MI and Alcantace M 1996. Nitrogen use efficiency in tropical lowland rice system contribution from indigenous and applied nitrogen. Field Crops Research **47(1)**: 1-12.

Daftardar SY and Savant NK 1995. Evaluation of environmentally friendly fertilizer management for rainfed lowland rice on tribal farmers fields in India. In: Fragile lives in fragile ecosystems, IRRI, LosBanos, Philippines, pp173-186.

Dandapani N, Balasubramanayan P and Gopalan M 1990. Influence of nitrogen levels and plant populations on the incidence of stem borer. Madras Agricultural Journal **77(7-8)**: 290-294.

Gardner JC, Marnville JW and Paparozzi ET 1994. Nitrogen use efficiency and diverge sorghum cultivars. Crop Science **34**: 728-733.

Jackson ML 1973 . Soil chemical analysis. Prentice Hall of India Private Limited, New Delhi.

Kajimura T, Fujisaki K, Nagsuji F 1995. Effect of organic farming on leaf hoppers, plant hoppers and amino acid contents in rice phloem sap and survival rate of plant hoppers. Applied Entomology **30**: 17-22.

Ohm H, Katyal SK and Dhiman SD 1996. Response of rice hybrids to seedling vigour and nitrogen levels in Haryana, India. IRR Notes **22(2)**: 38-39.

Olsen SR, Cole CL, Watanabe FS and Dean DA 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. DSDA Ciro, No 939.

Pal MS, Guoping Z and Jinxin C 2008. Nitrogen uptake and N use efficiency in hybrid and common rice as influenced by nitrogen fertilization . Oryza **45(2)**: 156-159.

Rao AU, Murthy KMD, Sridhar TV and Srinivas D 2013. Studies on performance of organic farming and chemical farming in rice–rice system. Journal of Eco-Friendly Agriculture **8(1)**: 15-19.

Safeena AN, Wahid PA, Balachandran PV and Sachdev MS 1999. Absorption of molecular urea by rice under flooded and non flooded soil conditions. Plant and Soil **208**: 61-166.

Saroja R and Raju N 1981. Varietal reaction to rice stem borer under different N levels. IRR Notes **6(1)**: 7.

Singh K and Tripathi HP 2007. Effect of nitrogen and weed control practices on performance of irrigated direct-seeded rice (*Oryza sativa*). Indian Journal of Agronomy **52(3)**: 231-234.

Singh U, Patil SK, Das RO, Padilla JL, Singh VP and Pal AR 1999. Nitrogen dynamics and crop growth on an alfisol and a vertisol under rainfed lowland rice based cropping system. Field Crops Research **61**: 337-352.

Singh VK and Bajpai RP 1990. Response of rice to nitrogen and phosphorus. Indian Journal of Agronomy **35**: 321-322.

Walkley A and Black CA 1954. An examination of Degtijar off method for determining soil organic matter and proposed modification of the chromic acid titration method. Soil Science **37**: 29-34.

Yang X and Sun X 1988. Physiological characteristics of hybrid rice roots. In: Hybrid rice, IRRI, Los Banos, Philippines, pp159-164.

Yoshida S 1981. Fundamentals of rice crop science. IRRI, Los Banos, Philippines pp129.

Received: 8.11.2013 ***Accepted: 21.12.2013***