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PERFORMANCE OF RICE UNDER SRI AS INFLUENCED BY EFFECT OF GRADED NUTRIENT LEVELS AND TIME OF NITROGEN APPLICATION

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ABSTRACT

Field experiments were conducted for two consecutive *kharif* seasons of 2005 and 2006 at Agricultural College farm, Naira, Srikakulam district, A. P. on sandy clay loam soil with an objective of optimization of agro-techniques for higher productivity of rice under SRI in North Coastal Zone of Andhra Pradesh. The treatments comprised of four graded nutrient levels assigned to main plots and four time of nitrogen application practices assigned to sub plots tried in split plot design. The highest stature of growth ,yield attributes , lesser spikelet sterility , higher grain yield and more returns were obtained with the application of 100-50-50 kg ha^{-1} N, $P_2$05, $K_2$0 and these parameters were at their minimum with the supply of 60- 30 - 30 kg ha^{-1} of N, P205, $K_2$0. The increase in yield with supply of 100- 50 - 50 kg ha^{-1} N, $P_2 0_5$, $K_2$0 (N_3), compared to supply of 60- 30 - 30 kg ha^{-1} N, $P_2 0_5$, $K_2$0 (N_1) was15.1 and 15.4 percent respectively during 2006 and 2007 respectively. Similarly, The highest stature of growth, yield attributes, lesser spikelet sterility, higher grain yield and more returns were produced with the supply of nitrogen fertilization in three splits as 1/3 basal + 1/3 at active tillering +1/3 at panicle initiation (T_1),. While these parameters were the lowest with split application of nitrogen dose as ½ at active tillering + ½ at panicle imitation without basal application (T_4) and increase in yield with (T_1) compared to (T_4) was10.6 and 14.4 percent respectively during 2006and 2007 respectively under SRI.

KEYWORDS: Rice, SRI, Graded levels of nutrients, Time of N application, Yield attributes, Grain yield, Returns.

INTRODUCTION

Rice is the most important crop in India, covering an area of about 44 million hectares with an annual production of 90 million tonnes and productivity of 2.2 tonnes per ha is far below than neighboring countries and world as well. Further, plateau in rice yields coupled with restrictions on area expansion, availability of water, labour and the need to achieve projected targets of about 140 million tonnes by 2020 are the major challenges facing Indian rice researchers. The increase in rice productivity therefore needs to be achieved through adoption of suitable and newer technologies. The System of Rice Intensification (SRI) is an important tool in this direction and offers opportunities to researchers and farmers to expand the yield potentials already existing in the rice genome (Stoop *et al.*, 2002). It is also a new sustainable methodology for increasing the productivity of irrigated rice through a change in plant, soil, water and nutrient management resulting in both improvement of soil health and increased yields supported by greater root growth and the soil microbial abundance and diversity. The system of rice intensification (SRI) has been recently introduced to India and is slowly gaining momentum. It has been field tested in the state of Andhra Pradesh by the state department of Agriculture and District Agricultural Advisory and Transfer of Technology centres of Acharya N.G. Ranga Agricultural University. Scientists and farmers dealing with SRI are of the opinion that the high productivity under SRI calls for adoption of greater nutrient supply as the Indian soils are low in organic matter and nutrient status.

Nutrient management plays very key role in sustaining the productivity of lowlanarice. Nitrogen supply is known to affect both dry matter production and its effective partitioning and tillering in rice. Higher nitrogen supply favours the dry matter accumulation in foliage rather than in economic sink. Sub optimal level of nutrient supply subdues the dry matter accrual in source system. Thus optimum nitrogen supply is very much essential for effective partitioning of accumulated dry matter to saleable parts/economical parts. Therefore, nitrogen application should be moderate and timely, in order to prevent excessive development of vegetative growth at the cost of panicle and grain development. Moreover, nitrogen is a costly input in crop production. It is, therefore necessary that it should be applied in such a way that the various losses are minimized and the maximum efficiency can be realized. In this context, the present study was undertaken with the objectives to determine the level of fertilizer application and time of nitrogen application for higher productivity under SRI cultivation.

MATERIALS & METHODS

Field experiments were conducted for two consecutive *kharif* seasons of 2005, 2006 at Agricultural College farm, Naira, Srikakulam district, Andhra Pradesh (18.24^{o}N latitude and 83.84^o E longitude). The soils were sandy clay loam in texture, low in organic carbon and available nitrogen, medium in available phosphorous and available potassium. In both the years the test variety of rice tried was Swarna (MTU 7029). Experiment was conducted in a split plot design with three replications. The treatments comprised of four graded nutrient levels assigned to main plots [N_1 : 60 – 30 - 30 kg N, P_20_5 and K_20 ha^{-1} ; N_2: 80 – 40 - 40 kg N, P_20_5 and K_20 ha^{-1} ;N_3 : 100 – 50 - 50 kg N, P_20_5 and K_20 ha^{-1} and N_4 : 120 – 60 - 60 kg N, P_20_5 and K_20 ha^{-1}] and four time of nitrogen application practices to sub plots [T_1: 1/3 as basal + 1/3 at active tillering + 1/3 at panicle initiation (3 splits); T_2 : ¼ as basal+ ¼ at active tillering + ¼ at panicle initiation + ¼ at flowering (4splits); T_3 : No basal application, 1/3 at active tillering + 1/3at panicle initiation + 1/3rd at flowering (3 splits) and T_4: No basal application, ½ at active tillering + ½ at panicle initiation (2 splits)]. The nursery was prepared with raised beds of 1.5 m width and of convenient length. Bold and healthy seeds were soaked for 12 hours and incubated in moist gunny cloth for 24 hours. A fine thin layer of well decomposed farm yard manure (FYM) was spread over the seed bed and then the sprouted paddy seed was broadcasted uniformly. After broadcasting the seeds, a thin layer of sieved FYM was again spread over the bed surface to cover the seed and water was sprinkled everyday for keeping the soil moist and also for better seedling stand. Coconut palm leaves were also used for covering the beds for retention of soil moisture. The recommended nutrient dose of N, P_2O_5 and K_2O (80-60-50 kg ha^{-1}) was applied as per the treatments. The experiments were provided uniform plant protection and cultural management practices throughout the period of crop growth. 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-analyser and potassium by flame photometry (Jackson, 1973). 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 available P was estimated by the method of Olsen *et al.*(1954), respectively. The available K was estimated by flame photometer (Jackson, 1973). The organic carbon in the soil was estimated by the chromic acid digestion method of Walkley and Black (1934).. Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference (p= 0.05).

RESULTS & DISCUSSION

Effect of graded levels of nutrients on performance of rice under SRI

During both the years of study, grain yield of rice was significantly influenced by supply of graded nutrient levels and it was increased significantly with increase in nutrient levels from N_1 to N_3. Grain yield of rice was the highest with the supply of 100- 50 - 50 kg ha^{-1} N, P_20_5, K_20 (N_3), which was comparable with the supply of 120 - 60 - 60 kg ha^{-1} N, P_20_5, K_20 (N_4) and significantly higher than with the other two nutrient levels tried. The lowest grain yield was obtained with the supply of 60- 30 - 30 kg ha^{-1} N, P_20_5, K_20 (N_1), which was however, on par with 80- 40 - 40 kg ha^{-1} N, P_20_5, K_20 (N_2).The increase in yield with supply of 100- 50 - 50 kg ha^{-1} N, P_20_5, K_20 (N_3), compared to supply of 60- 30 - 30 kg ha^{-1} N, P_20_5, K_20 (N_1) was15.1 and 15.4 percent respectively during 2006 and 2007 respectively. The improvement in yield with (N_3) was due to better availability and uptake of nutrients, which in turn lead to efficient metabolism. High level of biomass accrual and efficient translocation of photosynthates from source to sink might be responsible for the production of elevated level of yield structure. Rice plants when grown under saturated condition develop more hairy, branched secondary adventitious roots near the root-soil interface in order to absorb dissolved oxygen in the oxidized layer and take up more nutrients resulting in higher yields. These results are in accordance with those of Mulugeta seyoum and Heluf gebrekidan (2005) and Dwivedi *et al*. (2006).

Nitrogen, phosphorous and potassium uptake of rice estimated at harvest was significantly influenced by graded nutrient levels. The highest Nitrogen and phosphorous uptake by rice was recorded with the supply of highest dose of NPK *i.e.* 120- 60-60 kg ha^{-1} N, P_20_5, K_20 (N_4) which was on par with the supply of100- 50 - 50 kg ha^{-1} N, P_20_5, K_20 (N_3) and were significantly higher than with the other two nutrient levels tried. The lowest uptake of nitrogen and phosphorus was registered with the supply of 60- 30 - 30 kg ha^{-1} N, P_20_5, K_20 (N_1), which was however, comparable with 80- 40 - 40 kg ha^{-1} N, P_20_5, K_20 (N_2). The highest potassium uptake was registered with application of 120-60-60 kg ha^{-1} N, P_20_5, K_20 (N_4), followed by supply of 100-50-50 kg ha^{-1} N, P_20_5, K_20 (N_3) , 80-40-40 kg ha^{-1} N, P_20_5, K_20 (N_2) and 60-30-30 kg ha^{-1} N, P_20_5, K_20 (N_1),with significant disparity between any two of them and the lowest potassium uptake was noticed with (N_1).Nutrient uptake is a combined effect of dry matter at harvest and respective nutrient concentration. Application of additional doses of fertilizers enrich the available nutrient status consequently results in higher nutrient uptake. The concentration of nutrients in plants is an indication of their relative supply to the crop from the growing medium, resulting into increased concentration with increased levels of nitrogen (Mujumdar *et al.*, 2005). Increased nutrient absorption by rice with increased fertilizer doses has also been reported by Singh and Namdeo (2004).

Post harvest soil fertility status estimated in terms of organic carbon, available nitrogen, available P_2O_5 immediately after the harvest of rice crop was significantly influenced by graded nutrient levels, whereas available K_2O was unaffected during both the years of study (Table 1). The highest percent organic carbon in the soil was recorded with the supply of highest dose of NPK i.e., 120- 60-60 kg ha^{-1} N, P_20_5, K_20 (N_4) which was however found on par with the supply of100- 50 - 50 kg ha^{-1} N, P_20_5, K_20 (N_3) and was significantly higher than with the other two nutrient levels tried. The soil available nitrogen and available P_2O_5 also found conspicuously higher with the supply of highest dose of NPK *i.e.*, 120- 60-60 kg ha^{-1} N, P_20_5, K_20 (N_4). Application of 60- 30 - 30 kg ha^{-1} N, P_20_5, K_20 (N_1), recorded lowest values of post harvest soil organic carbon, available nitrogen, available P_2O_5 which was however, comparable with 80- 40 - 40 kg ha^{-1} N, P_20_5, K_20 (N_2). These results are in agreement with that of Lakpale *et al.* (1999).

TABLE1. Grain yield grain and NPK uptake at harvest of rice under SRI as influenced by graded nutrient levels and varied time of nitrogen application.

Treatments	Grain yield (kg ha^{-1})		Nitrogen uptake (kg ha^{-1})		Phosphorous uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007
Nutrient levels								
N_1	6888	6554	57.1	50	16.72	15.52	112.2	119.5
N_2	7136	6665	60	55	17.72	16.63	123.7	124.2
N_3	7927	7564	79.5	75	26.76	25.09	131.9	129.5
N_4	7684	7372	83.4	77.7	28.03	26.87	138.6	136.2
S.Em $\pm$	154	194	2.44	1.78	0.56	0.63	1.31	1.23
CD (P=0.05)	534	675	8.44	6.16	1.94	2.18	4.53	4.26
Time of Nitrogen application								
T_1	7795	7522	90.7	84.3	29.77	28.44	143.9	148.2
T_2	7646	7341	84.0	80.0	27.94	26.57	140.9	142.7
T_3	7144	6716	55.6	49.4	16.90	15.97	120.7	133.9
T_4	7049	6577	49.8	44.1	14.62	13.14	115.8	129.4
S.Em $\pm$	105.7	134.7	1.33	0.97	0.39	0.43	0.62	1.13
CD (P=0.05)	308	393	3.87	2.82	1.13	1.25	1.80	3.29

Effect of time of nitrogen application on performance of rice under SRI

Grain yield of rice was significantly influenced by varied time of nitrogen application during both the years of study. The highest grain yield was recorded with the supply of nitrogen in three splits of 1/3rd each at basal, active tillering and panicle initiation (T_1), which was comparable with the application of nitrogen ¼basal, ¼ at active tillering , ¼th at panicle initiation and ¼ at flowering (T_2) and significantly higher than with other two times of nitrogen application tried. The lowest grain yield was produced with the supply of nitrogen ½ each at active tillering and panicle imitation (T_4), which was however, on par with the nitrogen supply in three splits of 1/3rd each at active tillering, panicle initiation and flowering (T_3). The increase in yield with (T_1) compared to (T_4) was10.6 and 14.4 percent respectively during 2006 and 2007 respectively.. This might be due to the fact that split application of nitrogen to rice under SRI will maintain the constant nutrient content at different growth stages thereby there is improvement in the stature of growth as well as yield attributes, resulting in higher grain yields. Application of nitrogen up to the flowering stage could have attributed to the increased grain filling percentage by increasing leaf nitrogen concentration, Ribulose bisphosphate carboxylase (RUBISCO) content, photosynthetic rate of flag leaves and by delayed leaf senescence due to continuous availability of nitrogen in sufficient quantities from sowing to ripening which might have reduced the losses of nitrogen due to increase in number of splits of applied nitrogen. Application of nitrogen in two splits i.e. ½ at active tillering + ½ at panicle initiation, without basal application recorded the lowest grain and straw yields of rice under SRI, which indicates the importance of nitrogen nutrition to rice crop right from basal to panicle initiation. These results are in accordance with those of Dinesh Chandra (1997) and Singh (2006).

TABLE 2. Post harvest soil nutrient status of rice under SRI as influenced by graded nutrient levels and varied time of nitrogen application

Treatments	Organic carbon (%)		Available Nitrogen (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	2006	2007	2006	2007	2006	2007	2006	2007
Nutrient levels								
N_1	0.42	0.40	145	136	47.9	46.8	223	228
N_2	0.44	0.42	151	144	50.9	50.4	230	229
N_3	0.46	0.45	164	162	53.0	52.5	240	236
N_4	0.49	0.50	180	175	55.2	54.0	254	240
S.Em $\pm$	0.01	0.02	3.57	2.79	2.21	1.86	15.67	13.52
CD (P=0.05)	0.03	0.06	12.35	9.65	7.64	6.44	NS	NS
Time of Nitrogen application								
T_1	0.50	0.44	142	139	50.8	49.8	235	232
T_2	0.45	0.44	138	140	48.8	49.0	227	220
T_3	0.42	0.42	161	160	52.8	51.7	240	243
T_4	0.44	0.46	154	157	51.5	52.1	233	229
S.Em $\pm$	0.03	0.02	8.78	9.04	1.57	1.18	13.79	11.63
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Nitrogen ,phosphorus and potassium uptake by rice at harvest was the highest with the supply of nitrogen in three splits of 1/3rd each at basal, active tillering and panicle initiation (T_1), followed by supply of nitrogen in four splits of 1/4 th each at basal, active tillering, panicle initiation and flowering (T_2), three splits of 1/3rd each at active tillering, panicle initiation and flowering (T_3) and ½ each at active tillering and panicle imitation (T_4), with significant disparity between any two of them and the lowest uptake of nitrogen was associated with T_4. Split application of nitrogen at respective stages of crop growth which clearly showed that as the quantity of nitrogen supplied through splits was higher, dry matter production was also higher leading to increased nutrient uptake. Application of nitrogen in splits according to crop requirement caused not only reduction in loss of nitrogen but also increased the nitrogen absorption, consequently better utilization of applied nitrogen leads to higher dry matter production and finally resulted in higher nutrient uptake (Devi *et al.*,2012). These findings are conforming the earlier findings of Zaidi *et al.*, (2007).Post harvest soil fertility status estimated in terms of organic carbon, available nitrogen, available P_2O_5 and available K_2O, immediately after the harvest of rice crop was not significantly influenced by varied time of nitrogen application tried, during both the years of study (Table 2). These results are in accordance with those of Jhansi (2012).

CONCLUSION

It can be inferred that, the highest stature of growth ,yield attributes , lesser spikelet sterility , higher grain yield and more returns were obtained with the application of 100-50-50 kg ha^{-1} N, P_205, K_20 among four graded nutrient levels and with the supply of nitrogen fertilization in three splits as 1/3 basal + 1/3 at active tillering +1/3 at panicle initiation among four time of nitrogen application practices under SRI.

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