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RESEARCH ARTICLE

Age of Seedlings and Planting Pattern on Grain yield, Protein Content, NPK Uptake and Post-harvest Nutrient Status of Rice under SRI

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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, on sandy clay loam soil with an objective to optimize agro-techniques for higher productivity of rice under System of Rice Intensification (SRI) in north coastal zone of Andhra Pradesh. The treatments comprised of combination of 4 different ages of seedlings (8, 12, 16 and 20 d old) and four planting patterns (20 x 20 cm, 25 x 25 cm, 30 x 30 cm and 35 x 35 cm). Transplanting of 12 d old seedlings resulted in the highest grain yield, grain protein and NPK uptake. Planting pattern of 25 x 25 cm recorded higher grain yield, grain protein and NPK uptake while these parameters were lowest with planting pattern of 35 x 35 cm.

Keywords: *Kharif,* agro-techniques, system of rice intensification, planting patterns, grain yield.

Introduction

Rice is also the principal food crop cultivated throughout the state of Andhra Pradesh occupying 9-10% of the total cropped area in the country and contributing to about 16-18% of the total rice production and is aptly termed 'Rice bowl of south India'. Plateauing of rice yields coupled with restrictions on area expansion, availability of water and labour are the major aspects threatening the rice farmers, researchers and policy makers. 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; Uphoff *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 improvement of soil health and increased yields supported by greater root growth and the soil microbial abundance and diversity. The application of SRI to over 24 million ha of rice grown under irrigation in the country is projected to increase the irrigated area under rice by at least 50%, leading to about 50% increase in the production with the same amount of water now being used for irrigating the lowland rice crop (Thakkar, 2005). The SRI has been recently introduced to India and is slowly gaining momentum. It has been field tested in the state of AP by the state Department of Agriculture and District Agricultural Advisory and Transfer of Technology centres of Acharya N.G. Ranga Agricultural University. The results indicated higher rice productivity with SRI. However, most of the farmers have expressed difficulties with certain practices envisaged under SRI, one of them being high labour requirement for transplanting of young seedlings, compared to the 25-30 d old seedlings under the traditional method of planting, owing to their tiny size. In addition, 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. Systematic field research on some of the vital agro-techniques for rice culture under SRI in AP is however limited. In this context, the present study was undertaken with the objective to determine the optimum age of seedlings and planting pattern for higher productivity under SRI cultivation.

Materials and methods

Study area: Field experiments were conducted for two consecutive *kharif* seasons of 2005, 2006 at Agricultural College farm, Naira, Srikakulam district, AP (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).

Experimental design: Experiments were conducted in a randomized block design with factorial concept and replicated thrice. The treatments comprised of combination of four different ages of seedlings [A_1(8 d old), A_2 (12 d old), A_3 (16 d old) and A_4 (20 d old)] and four planting patterns [P_1 (20 x 20 cm), P_2 (25 x 25 cm), P_3 (30 x 30 cm) and P_4 (35 x35 cm)].

Table 1. Effect of age of seedlings and planting patterns on grain yield, protein content and NPK uptake under SRI.

Treatments	Grain yield (kg ha^{-1})		Protein content of grain (%)		Nitrogen uptake (kg ha^{-1})		Phosphorous uptake (kg ha^{-1})		Potassium uptake (kg ha^{-1})	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Age of seedlings										
A_1 -8 d old seedlings	6848	7161	6.39	6.51	77.3	92.8	24.5	29.5	158.9	166.8
A_2- 12 d old seedlings	7039	7368	6.47	6.68	79.5	99.7	27.0	31.6	161.2	168.7
A_3- 16 d old seedlings	5163	5770	5.60	5.75	72.6	90.2	22.0	26.1	147.3	152.2
A_4- 20 d old seedlings	4993	5487	5.39	5.59	68.3	86.8	20.5	24.3	144.9	149.2
S.Em ±	201	209	0.03	0.05	3.18	4.03	2.08	0.07	5.64	5.97
CD (P=0.05)	574	595	0.09	0.14	9.06	11.48	6.24	5.93	16.07	17.01
Planting pattern										
P_1 - 20 x 20 cm	6644	7333	6.20	6.39	73.9	93.6	33.2	28.44	166.2	171.0
P_2 -25 x 25 cm	6848	7702	6.38	6.47	77.9	98.0	35.8	29.57	171.9	176.9
P_3- 30 x 30 cm	5543	6020	5.68	5.86	67.9	89.9	22.5	15.97	138.7	145.2
P_4- 35 x 35 cm	4993	5430	5.59	5.76	64.8	84.0	20.9	13.14	135.5	143.7
S.Em ±	224	211	0.04	0.06	4.46	4.69	2.11	1.99	4.72	3.91
CD (P=0.05)	638	601	0.11	0.17	12.71	13.37	6.01	5.67	13.45	11.14

The nursery was prepared with raised beds of 1.5 m width and of convenient length. Bold and healthy seeds were soaked for 12 h and incubated in moist gunny cloth for 24 h. 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. Nitrogen was applied in three equal splits, one each at basal, active tillering and panicle initiation, while P and K were applied basally. Grain from the net plot was thoroughly sun dried to 14% 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 available soil P was estimated by the method of Olsen *et al.* (1954). 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 (1956).

Statistical analysis: Data were analyzed using ANOVA and the significance was tested by Fisher's least significance difference (p= 0.05) by pooling four years data.

Results and discussion

Age of seedlings: Planting of 12 d old seedlings (A_2) resulted in the highest grain yield, which was on par with 8 d old seedlings (A_1) (Table 1). The lowest grain yield was recorded with older seedlings (A_4) which was however, comparable with 16 d old seedlings (A_3) with all the planting patterns tried, indicated the beneficial effects of early seedlings. This was due to enhanced stature of yield attributes, forming larger sink size coupled with efficient translocation of photosynthates to the sink, when grown following the optimal agro-techniques. Upholf (2005) indicated that enhanced yield under SRI with optimum seedling age was due to the fact that larger rhizosphere with large canopies lead to accrual of more photosynthates, resulting in higher grain yield of rice under SRI. Performance of age of seedlings with variation in the yield has been universally accepted and voluminous research findings to confirm this feature are available across the literature (Rafaralahy, 2002; Randriamibarisoa and Upholf, 2002; Upholf, 2005).

Table 2. Effect of age of seedlings and planting patterns on post-harvest soil nutrient status under SRI.

Treatments	Organic carbon (%)		Available N (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	2005	2006	2005	2006	2005	2006	2005	2006
Age of seedlings								
A_1 -8 d old seedlings	0.45	0.45	173	178	53.8	53.1	233	232
A_2- 12 d old seedlings	0.47	0.49	176	175	53.2	52.4	230	231
A_3- 16 d old seedlings	0.45	0.44	169	171	53.0	50.7	226	229
A_4- 20 d old seedlings	0.45	0.46	167	169	51.0	49.9	223	226
S.Em ±	0.01	0.02	3.36	4.15	0.17	1.29	1.37	2.34
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Planting pattern								
P_1 - 20 x 20 cm	0.42	0.46	165	167	51.3	50.0	227	226
P_2 -25 x 25 cm	0.46	0.44	169	170	52.8	51.6	234	227
P_3- 30 x 30 cm	0.47	0.48	175	176	54.2	52.8	236	235
P_4- 35 x 35 cm	0.47	0.48	180	181	55.6	53.2	241	244
S.Em ±	0.03	0.04	4.13	4.05	1.21	1.02	4.56	3.96
CD (P=0.05)	NS	NS	11.89	11.66	3.45	2.93	13.09	11.36

During both the years, planting of 12 d old seedlings (A_2) resulted in the highest protein content of grain which was followed by planting of 8 (A_1), 16 (A_3) and 20 d (A_4) old seedlings, with significant disparity between any two of them and the lowest number of panicles (m^{-2}) was produced when 20 d old seedlings were planted.

Uptake of nitrogen phosphorus and potassium by rice at harvest was significantly higher with planting of 12 d old seedlings (A_2) compared to planting of older seedlings (A_4), however which was on par with 8 d old seedlings (A_1) and 16 d old seedlings (A_3) during both the years of study. Perhaps profuse and robust root system due to early seedling vigour might have facilitated greater ability to mobilize more nutrients, concomitant higher absorption and translocation of nutrients. A well developed and healthy root system plays an important role in uptake and translocation of nutrients from soil in SRI particularly with planting younger seedlings (Uphoff, 2005). 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 different age of seedlings tried, during both the years of study.

Planting pattern: The highest grain yield was produced with planting pattern of 25 x 25 cm (P_2), which was however, comparable with planting pattern of 20 x 20 cm (P_1) and both of them were significantly superior to other two planting patterns tried (Table 1). The lowest grain yield was recorded with the planting pattern of 35 x 35 cm (P_4), which was in parity with the planting pattern of 30 x 30 cm (P_3). This was due to enhanced stature of yield attributes, forming larger sink size coupled with efficient translocation of photosynthates to the sink, when the crop was raised under optimum planting pattern. Performance of rice under SRI, in terms of grain yield, in the present case was corresponding with the stature of different yield attributes under different planting patterns tried. These results corroborate with those reported by Cessay (2002), Fernandes and Upholf (2002) and Krupakara Reddy (2004). The protein content of grain was highest with planting pattern of 25 x 25 cm (P_2), which was however, comparable with planting pattern of 20 x 20 cm (P_1) and both of them were significantly superior to other two planting patterns tried. The lowest grain protein was recorded with the planting pattern of 35 x 35 cm (P_4), which was in parity with the planting pattern of 30 x 30 cm (P_3). Planting pattern of 25 x 25 cm (P_2), might have created better growth environment with proper root development due to prevailing of optimum moisture and better availability of nutrients resulted to higher protein content. The uptake of nitrogen was highest with planting pattern of 25 x 25 cm (P_2), which was however, comparable with planting pattern of 20 x 20 cm (P_1) and planting pattern of 30 x 30 cm (P_3). However, it was significantly superior to the planting pattern of 35 x 35 cm (P_4). Among the different spacings tested under SRI i.e. 20 cm x 20 cm, 25 cm x 25 cm, 30 cm x 30 cm, spacing were at par in their influence on N uptake (Krupakara Reddy, 2004). The uptake of phosphorus and potassium was highest with planting pattern of 25 x 25 cm (P_2), which was however, comparable with planting pattern of 20 x 20 cm (P_1) and both of them were significantly superior to other two planting patterns tried.

The lowest uptake of phosphorus and potassium was recorded with the planting pattern of 35 x 35 cm (P_4), which was in parity with the planting pattern of 30 x 30 cm (P_3) during both the years of study. Post-harvest soil fertility status estimated in terms of organic carbon was not significantly influenced by different planting patterns tried, during both the years of study, however available nitrogen, available P_2O_5 and available K_2O, immediately after the harvest of rice crop was markedly higher with the planting pattern of 35 x 35 cm (P_4) and remaining planting patterns were found at par to each other (Table 2). Perusal of two years data of effect of age of seedlings and planting patterns on rice under SRI revealed that transplanting of 12 d old seedlings and planting pattern of 25 x 25 cm resulted in the highest grain yield, grain protein and NPK uptake.

Conclusion

Optimization of agro-techniques for higher productivity of rice under System of Rice Intensification (SRI) in north coastal zone of Andhra Pradesh was carried out. The treatments comprised of combination of 4 different ages of seedlings (8, 12, 16 and 20 d old) and four planting patterns (20 x 20 cm, 25 x 25 cm, 30 x 30 cm and 35 x 35 cm). Transplanting of 12 d old seedlings resulted in the highest grain yield, grain protein and NPK uptake. Planting pattern of 25 x 25 cm recorded higher grain yield, grain protein and NPK uptake while these parameters were lowest with planting pattern of 35 x 35 cm.

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