The Pharma Innovation Journal 2022; 11(9): 2617-2621

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 2617-2621

www.thepharmajournal.com
Received: 01-06-2022
Accepted: 08-08-2022

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Comparative effect of nutrient levels and weed management practices on production potential and nutrient uptake in direct seeded rice

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Abstract
Field experiments were conducted during *kharif*, 2020 and 2021 at wetland farm of S. V. Agricultural College, Tirupati in split plot design and replicated thrice in order to evaluate the effect of nutrient levels and weed management practices. The treatments in main plot comprised of three nutrient levels *viz*., 100% RDF (N_1), 125% RDF (N_2) and 150% RDF (N_3) under main plots and five weed management practices assigned to sub plots *viz*., Pre emergence (PE) application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* penoxsulam + cyhalofop-p-butyl 125 g ha^{-1} at 20 DAS (W_1), Pre emergence (PE) application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (W_2), Pre emergence (PE) application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* bispyribac-sodium 20 g ha^{-1} at 20 DAS (W_3), hand weeding twice at 20 and 40 DAS (W_4) and unweeded check (W_5). The results revealed that, among different nutrient levels, 150% RDF (N_3) recorded higher grain and Straw yield and higher uptake of nitrogen, phosphorous and potassium which were significantly superior to 125% RDF (N_2) and 100% RDF (N_1) during both the years of study and in the pooled mean. With respect to different weed management practices, higher grain & Straw yield and higher uptake of nitrogen, phosphorous and potassium were observed with hand weeding twice at 20 and 40 DAS (W_4) which was comparable with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (W_2) but it was superior to PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* penoxsulam + cyhalofop-p-butyl 125 g ha^{-1} at 20 DAS (W_1) and PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* bispyribac-sodium 20 g ha^{-1} at 20 DAS (W_3) with a significant disparity during both the years of investigation and in the pooled mean. Among different combinations, grain and straw yield were higher with 150% RDF coupled with hand weeding twice at 20 and 40 DAS (N_3W_4) which was comparable with 125% RDF coupled with hand weeding twice at 20 and 40 DAS (N_2W_4) and 150% RDF in combination with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} (N_3W_2).

Keywords: Direct seeded rice, nutrient levels, weed management practices, nutrient uptake, grain and straw yields

1. Introduction
Direct seeded rice is becoming prominent because it became an alternative to transplanting and avoids puddling and continuous submergence of the field. It has several advantages by reducing labour charges over transplanting and water requirement. Besides this, it emits less amount of methane gases and machinery usage too.

The production potential is lower in direct seeded rice is mainly due to the problems associated with weeds. Whenever optimum conditions of nutrient availability and moisture, weeds emerge earlier than crop and hence there is a reduced yields. The extent of yield reduction is up to 46% (Choudhary and dixit 2018) [4]. Manual and mechanical control measures were effective against weeds but shortage of labour during peak period and increasing of labour charges causes delayed weed control practices in the field. In the case of direct seeded rice (DSR), nutrient management is critical for crop production optimization. The most essential nutrients are N, P, and K, although their efficacy is dependent on crop-weed dynamics in the growing environment. Deficiency of even a single essential nutrient may disturb plant physiological functions and thereby substantial reduction in crop yields.

In direct seeded rice, manual and mechanical weed control procedures were effective, but labour shortages during peak period and rising labour wages are causing weed control practices to be delayed and costly.

Weeds usually grow faster than crop plants and thus absorb nutrient earlier resulting in lack of nutrients for growth of plant. The use of herbicides is gaining popularity in rice culture due to their rapid effects and lower costs compared to traditional methods. However, sole applications of either pre or post emergence herbicides could not control diverse weeds effectively in direct seeded rice (Awan *et al*., 2015) [1]. Again, over-dependence on similar herbicide(s) may lead to weed shift and/or herbicide-resistant weeds. Fewer research results have shown that sequential application of pre and post emergence herbicides for broad spectrum of weed control, which is essential to boost rice productivity and profitability, is the most effective method (Awan *et al*., 2015; Chauhan *et al*., 2015) [1, 3].

2. Materials and methods

Field experiments were conducted during *kharif*, 2020 and 2021 at wetland farm of S. V. Agricultural College, Tirupati, geographically situated at 13.5°N latitude and 79.5°E longitude and at an altitude of 182.9 m above the mean sea level in the Southern Agro-Climatic Zone of Andhra Pradesh. The experimental soil was sandy clay loam in texture, slightly alkaline in reaction, low in organic carbon and available nitrogen and medium in available phosphorus and available potassium during both the years of study in direct seeded rice. The treatments in main plot comprised of three nutrient levels *viz*., 100% RDF (N_1), 125% RDF (N_2) and 150% RDF (N_3) under main plots and five weed management practices assigned to sub plots *viz*., Pre emergence (PE) application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* penoxsulam + cyhalofop-p-butyl 125 g ha^{-1} at 20 DAS (W_1), Pre emergence (PE) application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS(W_2), Pre emergence (PE) application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* bispyribac-sodium 20g ha^{-1} at 20 DAS (W_3), hand weeding twice at 20 and 40 DAS (W_4) and unweeded check (W_5). Application of nutrients was done as per the treatments in the form of urea, single super phosphate and muriate of potash, respectively. Nitrogen was applied in three splits at 15 DAS, tillering and at panicle initiation stages. Entire quantity of phosphorus was applied at the time of sowing and potassium was applied in two splits, ½ at the time of sowing and the remaining ½ at panicle initiation stage. Five plants were selected at random from net plot area and labeled with tags for recording parameters during crop growing period. The data recorded on various parameters of crop during the course of study was statistically analyzed byfollowing the analysis of variance procedure as suggested by Panse and Sukhatme (1985) [7]. Statistical significance was tested with F test at 5 per cent level of probability and compared the treatment means with critical difference.

Based on the nutrient content in grain and straw of rice crop, the uptake of N, P and K was worked out and expressed in kg ha^{-1} using the following formula

$$\text{Nutrient uptake (kg ha}^{-1}) = \frac{\text{Dry matter production (kg ha}^{-1}) \text{ x Nutrient content (\%)}}{100}$$

3. Results and discussion

3.1 Grain yield

The higher grain yield was observed with 150% RDF (N_3) which was significantly superior to 125% RDF (N_2) and 100% RDF (N_1) during both years of study and in the pooled mean. Adequate supply of nutrients allowed the rice crop to synthesize more chlorophyll content and which lead to better accumulation of photosynthates and resulted in higher translocation which increased the higher number of grains, number of panicles and test weight, and ultimately higher grain yield of rice. The results are in confirmity with the findings of Sridhar *et al*. (2018) [9].

With respect to different weed management practices, hand weeding twice at 20 and 40 DAS (W_4) which was statistically on par with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (W_2) in obtaining higher grain yield which was followed by PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* penoxsulam + cyhalofop-p-butyl 125 g ha^{-1} at 20 DAS (W_1) and PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* bispyribac-sodium 20 g ha^{-1} at 20 DAS (W_3) during both the years of study as well as pooled mean. The lower grain yield was observed with unweeded check (W_5). This might be due to increased number of yield attributes in a lesser weed competition environment resulted in higher grain yield. The results are similar with those of Hemalatha *et al*. (2020) [5].

Irrespective of the weed management practices, 100% RDF (N_1) recorded least grain yield among all other nutrient levels. Regardless of any nutrient level, hand weeding twice at 20 and 40 DAS (W_4) recorded higher grain yield which was statistically at par with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (W_2) but significantly superior to other weed management practices during both the years of study and in the pooled mean.

Among different combinations of nutrient levels and weed management practices, higher grain yield was recorded with the combination of 150% RDF along with hand weeding twice at 20 and 40 DAS (N_3W_4) which was comparable with 125% RDF along with hand weeding twice at 20 and 40 DAS (N_2W_4) and 150% RDF along with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (N_3W_2) during both the years of study and in the pooled mean. Minimum grain yield was observed with 100% RDF in combination with unweeded check (N_1W_5) during the both years of study and in the pooled mean.

Table 1: Grain yield (kg ha^{-1}) of direct seeded rice as influenced by nutrient levels and weed management practices

Treatments	2020-21				2021-22				Pooled			
	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)
W_1	1894	2466	2552	2304	1706	2235	2398	2113	1800	2351	2475	2208
W_2	2673	3124	3221	3006	2633	3025	3106	2921	2653	3074	3163	2964
W_3	1642	1949	2256	1949	1531	1807	2092	1810	1587	1878	2174	1880
W_4	2714	3236	3322	3091	2694	3143	3226	3021	2704	3190	3274	3056
W_5	747	951	1090	929	612	857	957	809	680	904	1023	869
Mean (N)	1934	2345	2488		1835	2213	2356		1885	2274	2422	
	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)
N	39.4			155	39.7			156	34.9			137
W	38.4			112	34.2			100	36.1			108
N at W	92.1			297	85.5			281	78.0			254
W at N	66.5			194	59.3			173	55.1			161

3.2 Straw Yield

Nutrient levels, weed management practices and their interaction influenced the straw yield significantly during both instances of study as well as pooled mean.

During both years of study as well as pooled mean in direct seeded rice, higher straw yield was observed with 150% RDF (N_3) which was significantly superior to 125% RDF (N_2) and 100% RDF (N_1). Straw yield was higher due to better vegetative growth associated with increase of dry matter production. Similar results were revealed earlier by Singh *et al*. (2006) [8].

With respect to different weed management practices, hand weeding twice at 20 and 40 DAS (W_4) recorded higher straw yield which was at par with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (W_2) followed by PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* penoxsulam + cyhalofop-p-butyl 125 g ha^{-1} at 20 DAS (W_1) and PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* bispyribac-sodium 20 g ha^{-1} at 20 DAS (W_3) during both the years of study and in the pooled mean. The lower straw yield was observed with unweeded check (W_5). Lower straw yield could be due to heavy weed infestation in unweeded check which might be due to non-availability of nutrients to the crop. The results are in conformity with the findings of Yadav *et al*. (2018) [10].

Regardless of weed management practices, 100% RDF (N_1) recorded lower straw yield among all other nutrient levels. Irrespective of any nutrient level, hand weeding twice at 20 and 40 DAS (W_4) was recorded higher straw yield which was statistically on par with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (W_2) but significantly superior to PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* penoxsulam + cyhalofop-p-butyl 125 g ha^{-1} at 20 DAS (W_1), PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* bispyribac-sodium 20 g ha^{-1} at 20 DAS (W_3) and unweeded check (W_5) during both the years of study and in the pooled mean.

Among different combinations of nutrient levels and weed management practices, higher straw yield was recorded with the combination of 150% RDF along with hand weeding twice at 20 and 40 DAS (N_3W_4) which was comparable with 125% RDF along with hand weeding twice at 20 and 40 DAS (N_2W_4) and 150% RDF along with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (N_3W_2) during both the years of study. Whereas, minimum straw yield was observed with 100% RDF in combination with unweeded check (N_1W_5) during both the years of study and in the pooled mean.

Table 2: Straw yield (kg ha^{-1}) of direct seeded rice as influenced by nutrient levels and weed management practices

Treatments	2020-21				2021-22				Pooled			
	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)
W_1	2849	3487	3676	3337	2462	2985	3289	2912	2655	3236	3483	3125
W_2	3917	4391	4459	4255	3461	3992	4093	3848	3689	4191	4276	4052
W_3	2581	2999	3389	2990	2316	2589	2914	2606	2449	2794	3152	2798
W_4	4029	4491	4602	4374	3519	4156	4222	3966	3774	4324	4412	4170
W_5	1214	1555	1758	1509	1006	1352	1587	1315	1110	1454	1673	1412
Mean (N)	2918	3385	3577		2553	3015	3221		2735	3200	3399	
	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)
N	36.7			144	48.9			192	26.4			104
W	40.7			119	41.6			122	40.4			118
N at W	94.2			299	104.5			343	87.7			269
W at N	70.4			206	72.1			210	70.0			204

3.3 Nutrient uptake

Nutrient uptake by direct seeded rice *viz*., nitrogen, phosphorus and potassium was significantly influenced by nutrient levels and weed management practices and their interaction was found non-significant at harvest during both the years of study and in the pooled mean.

Among different nutrient levels, 150% RDF (N_3) recorded higher uptake of nitrogen, phosphorus and potassium which was significantly superior to 125% RDF (N_2) and 100% RDF (N_1) during both the years of study and in the pooled mean. The results obtained in this study are in line with the findings of Chaudhary *et al*. (2014) [2].

With respect to different weed management practices, higher uptake of nitrogen, phosphorus and potassium was observed with hand weeding twice at 20 and 40 DAS (W_4) which was comparable with PE application of pyrazosulfuron-ethyl 25 g

ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (W_2) but it was superior to PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* penoxsulam + cyhalofop-p-butyl 125 g ha^{-1} at 20 DAS (W_1) and PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* bispyribac-sodium 20 g ha^{-1} at 20 DAS (W_3) with a significant disparity during both the years of investigation and in the pooled mean. However, lower uptake of three nutrients was recorded with unweeded check (W_5). The results are in accordance with Manisankar *et al*. (2021) [6].

Table 3: Nitrogen uptake (kg ha^{-1}) by direct seeded rice as influenced by nutrient levels and weed management practices at harvest

Treatments	2020-21				2021-22				Pooled			
	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)
W_1	67.1	83.3	90.1	80.2	55.1	69.9	76.6	67.2	61.1	76.6	83.4	73.7
W_2	100.6	111.7	114.8	109.0	85.2	95.6	98.9	93.3	92.9	103.7	106.9	101.2
W_3	63.0	73.7	80.0	72.3	51.4	61.3	67.5	60.1	57.2	67.5	73.8	66.2
W_4	104.0	115.8	119.4	113.1	88.4	99.6	103.4	97.1	96.2	107.7	111.4	105.1
W_5	41.1	46.7	50.8	46.2	35.3	38.9	43.0	39.1	38.2	42.8	46.9	42.6
Mean (N)	75.2	86.3	91.0		63.1	73.1	77.9		69.1	79.7	84.5	
	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)
N	0.62			2.5	0.75			3.0	0.69			2.7
W	1.42			4.1	1.37			4.0	1.36			4.0
N at W	2.96			NS	2.91			NS	2.85			NS
W at N	2.46			NS	2.37			NS	2.35			NS

Table 4: Phosphorus uptake (kg ha^{-1}) by direct seeded rice as influenced by nutrient levels and weed management practices at harvest

Treatments	2020-21				2021-22				Pooled			
	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)
W_1	15.0	17.4	18.1	16.8	13.7	16.0	16.1	15.3	14.4	16.7	17.1	16.0
W_2	19.3	20.3	20.8	20.1	16.9	18.0	18.3	17.7	18.1	19.1	19.5	18.9
W_3	14.2	15.9	17.0	15.7	13.4	14.4	15.4	14.4	13.8	15.1	16.2	15.0
W_4	19.6	20.9	21.6	20.7	17.1	18.5	18.9	18.2	18.3	19.7	20.2	19.4
W_5	10.6	11.3	12.2	11.3	10.7	11.3	12.1	11.4	10.7	11.3	12.1	11.4
Mean (N)	15.7	17.1	17.9		14.4	15.6	16.1		15.0	16.4	17.0	
	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)
N	0.11			0.4	0.11			0.3	0.14			0.5
W	0.20			0.6	0.17			0.5	0.21			0.6
N at W	0.43			NS	0.38			NS	0.45			NS
W at N	0.35			NS	0.30			NS	0.36			NS

Table 5: Potassium uptake (kg ha^{-1}) by direct seeded rice as influenced by nutrient levels and weed management practices at harvest

Treatments	2020-21				2021-22				Pooled			
	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)	N_1	N_2	N_3	Mean (W)
W_1	74.4	97.9	115.2	95.8	61.8	83.8	88.1	77.9	68.1	90.9	101.7	86.9
W_2	116.6	126.7	131.1	124.8	92.5	103.2	106.1	100.6	104.6	115.0	118.6	112.7
W_3	66.3	83.0	93.9	81.1	58.6	68.3	78.3	68.4	62.5	75.7	86.1	74.7
W_4	119.8	132.4	138.8	130.4	94.8	108.4	111.9	105.0	107.3	120.4	125.4	117.7
W_5	41.2	47.5	56.5	48.4	39.2	45.2	54.5	46.3	40.2	46.4	55.5	47.4
Mean (N)	83.7	97.5	107.1		69.4	81.8	87.8		76.5	89.6	97.4	
	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)	S.Em±			CD (P=0.05)
N	1.24			4.8	1.26			5.0	0.86			3.4
W	2.15			6.3	1.89			5.5	2.02			5.9
N at W	4.59			NS	4.12			NS	4.20			NS
W at N	3.73			NS	3.28			NS	3.50			NS

4 Conclusion

Higher grain and straw yields was recorded with the combination of 150% RDF along with hand weeding twice at 20 and 40 DAS which was comparable with 125% RDF along with hand weeding twice at 20 and 40 DAS and 150% RDF along with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS during both the years of study and in the pooled mean. Among different levels, higher nutrient uptake by crop was recorded with 150% RDF and with respect to weed management practices, hand weeding twice at 20 and 40 DAS which was comparable with PE application of pyrazosulfuron-ethyl 25 g ha^{-1} *fb* florpyrauxifen benzyl + cyhalofop-p-butyl 150 g ha^{-1} at 20 DAS (W_2) resulted in higher uptake during both the years of study and in the pooled mean.

5. Acknowledgement

The author says that, it gives immense pleasure to gratefully acknowledge and express my profound sense of gratitude and heartfelt devotion to Dr. Karuna Sagar, Dr. V. Chandrika, Dr. K.V. Naga Madhuri and Dr. V. Umamahesh for their learned guidance, painstaking help, indefatigable efforts, interests, close supervision and concrete suggestions during the course of investigation and preparation of this manuscript. I consider myself fortunate for getting the golden opportunity to learn under their valuable guidance.

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