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Effectiveness of Integrated Weed Management Practices on Dry Matter Production and Crop Nutrient Uptake in Machine Transplanted Rice

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Authors' contributions

This work was carried out in collaboration among all authors. Author BR designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors KPV and MY managed the analyses of the study. Author TR managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment entitled "Weed management in machine transplanted rice" was conducted during *kharif* season, 2019 at Agricultural Research Institute Farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad to evaluate the influence of different weed management practices on growth and nutrient uptake machine transplanted rice crop. The results revealed that among different weed management treatments hand weeding at 20, 40 DAT (T_8) recorded significantly higher dry matter production at harvest (14.7 t ha^{-1}) which was at par with T_4 i.e. penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (14.3 t ha^{-1}). Hand weeding at 20, 40 DAT had significantly increased the crop nutrient uptake at harvest (147.0: 16.9: 153.6 NPK kg ha^{-1}), statistically at par with penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (142.6: 16.0: 145.4 NPK kg ha^{-1}) while lowest was recorded with weedy check (91.9: 9.9: 89.2 NPK kg ha^{-1}).

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Keywords: Weed management; machine transplanting; rice and nutrient uptake.

1. INTRODUCTION

Rice (*Oryza sativa* L.) is considered as the "global grain" and is the staple food for Asia and for more than half of the global population. In India, it contributes to about 40 per cent of the total food grain production [1]. The growing demand of rice necessitating enhancement of productivity with limited resources. Several factors are responsible for reducing the yield of transplanted rice. However, weed infestation is the major threat to productivity of transplanted rice and causes 45-51% loss in rice yield [2]. Transplanted rice encounters diverse type of weed flora consisting of grasses, broad-leaf weeds and sedges. Weeds by the virtue of their high adaptability and faster growth dominate the crop habitat and reduce the crop yield [3]. Under machine transplanting inter row spacing of 30 cm allows severe weed infestation in the field and finally resulting in significant yield loss. Thus, weed management is an essential practice in machine transplanted rice and farmers are looking for better weed management option in machine transplanting.

2. MATERIALS AND METHODS

The present investigation entitled "Weed management in machine transplanted rice'' was conducted during *kharif*, 2019 at ARI Farm, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad. The soil of the experimental site was sandy loam in texture, slightly alkaline, medium in organic carbon and available nitrogen and potassium, high in available phosphorus.

The experiment was laid out in Randomized Block Design (RBD) consisting of eight treatments *viz*., pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + cono weeder at 15, 30 & 45 DAT (T_1), pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + power weeder at 15, 30 & 45 DAT (T_2), flucetosulfuron 10 % WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (T_3), penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (T_4), penoxsulam 0.97% W/W + butachlor 38.8% W/W @ 820 g ha^{-1} at 7 DAT + power weeder at 30-40 DAT (T_5), bentazone @ 960 g *a.i* ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 – 40 DAT (T_6), weedy check (T_7) and hand weeding at 20, 40 DAT (T_8). The recommended dose of fertilizers 120-60-40 kg NPK ha^{-1} in the form of diammonium phosphate, urea and muriate of potash was applied to all treatments.

Paddy mat nursery was sown on july 11th 2019 (variety RNR-15048) and 22 days old seedlings were used for transplanting in main field with self propelled 6 row paddy transplanter at a spacing of 30 x 12 cm in a plot size of 7.5 X 4.0 m. The pre emergence herbicide pretilachlor was applied at 3 DAT as sand mix broadcast using 150 sand/ha, penoxsulam + butachlor (pre mix herbicide combination) was applied at 7 DAT and the post emergence herbicides were applied at 2-3 leaf stage of weeds (15 DAT) as spray using knapsack sprayer with flood jet nozzle in a spray volume of 300 litres ha^{-1}. Destructive sampling of the above ground portion of five hills in each plot was done to record dry matter production. Plant protection measures for the control of insect pests were taken and the crop was harvested on november 14th 2019.The plant samples collected at different intervals were oven dried and grounded into fine powder using Wiley mill. Nitrogen, phosphorus and potassium content of the samples were estimated by microkjeldhal method, vanadomolybdate method and flame photometer method, respectively. The nutrient uptake was calculated through the following equation.

Nutrient uptake (kg ha^{-1}) = Nutrient content % X Dry matter production (kg ha^{-1}) /100

3. RESULTS AND DISCUSSION

Dry matter is an index of overall growth of plant. Weed management practices recorded significantly higher crop dry matter compared to unweeded control (Table 1). More dry matter production at 30 DAT was recorded with T_8 i.e. hand weeding at 20, 40 DAT (4.17 t ha^{-1}) which was at par with T_4 {penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT} (4.04 t ha^{-1}) followed by T_3 i.e. flucetosulfuron 10% WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (3.91 t ha^{-1}) and lower dry matter of 2.41 t ha^{-1} recorded with weedy check (control). Similar trend of results was obtained with 60 DAT and 90 DAT. Resource availability by minimizing weeds can influence dry matter production [4].

Table 1. Dry matter production influenced by weed management practices in machine transplanted rice

Treatment	Dry matter production (t ha^{-1})			
	30 DAT	60 DAT	90 DAT	Harvest
T_1 - Pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + cono weeder at 15, 30 & 45 DAT	3.52	8.57	11.85	12.86
T_2 - Pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + power weeder at 15, 30 & 45 DAT	3.65	8.69	12.15	13.08
T_3 - Flucetosulfuron 10 % WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	3.91	9.19	12.80	13.95
T_4 - Penoxsulam 1.02 % W/W + cyhalofop- p- butyl 5.1 % W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	4.04	9.42	13.10	14.31
T_5 - Penoxsulam 0.97 % W/W + butachlor 38.8 % W/W @ 820 g ha^{-1} at 7 DAT + power weeder at 30 - 40 DAT.	3.83	8.99	12.42	13.46
T_6 - Bentazone @ 960 g *a.i* ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	3.07	8.18	10.84	11.64
T_7 - Weedy check (control).	2.41	6.80	7.82	8.79
T_8 - Hand weeding at 20, 40 DAT.	4.17	9.71	13.48	14.71
SEm±	0.06	0.15	0.18	0.19
CD	0.18	0.47	0.56	0.59

The treatment with hand weeding at 20, 40 DAT (9.71 t ha^{-1}) produced significantly highest dry matter over rest of the treatments at 60 DAT, statistically at par with T_4 {penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT} (9.42 t ha^{-1}).

Higher dry matter production at harvest was recorded with T_8 i.e. hand weeding at 20, 40 DAT (14.71 t ha^{-1}) which was at par with T_4 {penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT} (14.31 t ha^{-1}) followed by T_3 i.e. flucetosulfuron 10% WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (13.95 t ha^{-1}) and minimum crop dry matter was observed with weedy check plot (8.79 t ha^{-1}). The increase in dry matter accumulation in weed control treatments might be due to less weed competition and good aeration of soil, thereby facilitating luxurious crop growth resulting into more dry matter accumulation as compared to unweeded control treatment. These results are in consonance with findings of [5] and Kumar et al. [6].

Crop nutrient uptake is the function of nutrient concentration and dry matter production. The nutrient uptake of rice crop increased linearly with the ontogeny of the crop. The critical examination of data (Table 2) revealed that weed management practices in machine transplanted rice had significant influence on nitrogen uptake of the crop. Maximum crop nitrogen uptake of 41.64 kg ha^{-1} at 30 DAT was noticed with T_8 i.e. hand weeding at 20, 40 DAT, statistically at par with T_4 {penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT} (39.22 kg ha^{-1}) followed by T_3 i.e. flucetosulfuron 10% WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (37.30 kg ha^{-1}), while minimum nutrient uptake by rice was observed with T_7 {weedy check} (24.31 kg ha^{-1}). Similar trend of results were obtained at 60 DAT and 90 DAT.

At harvest, both grain and straw samples were analyzed for nitrogen separately and results revealed that grain and straw nitrogen uptake was significantly influenced by weed management practices. Maximum nitrogen uptake both by grain and straw of rice crop (98.53 & 48.53 kg ha^{-1} respectively) was observed by T_8 i.e. hand weeding at 20, 40 DAT which was at par with uptake of nitrogen by grain and straw of 96.98 & 45.65 kg ha^{-1} with treatment applied with penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (T_4) followed by T_3 i.e. flucetosulfuron 10% WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (90.37 & 44.51 kg ha^{-1}) and penoxsulam 0.97% W/W + butachlor

38.8% W/W @ 820 g ha^{-1} at 7 DAT + power weeder at 30-40 DAT (T_5) (86.84 & 42.77 kg ha^{-1}). Lowest nitrogen uptake by grain and straw was observed with weedy check treatment (61.58 & 30.33 kg ha^{-1} respectively). Kolo and Umaru [7] also reported that N uptake by grain and straw was inversely to the nutrient depletion by the weeds.

Higher P uptake of 4.95 kg ha^{-1} at 30 DAT was obtained with T_8 i.e. hand weeding at 20, 40 DAT, statistically at par with T_4 {penoxsulam1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT} (4.55 kg ha^{-1}) followed by T_3 i.e. flucetosulfuron 10% WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (3.93 kg ha^{-1}). Weedy check plot recorded lowest phosphorus uptake of 1.59 kg ha^{-1}. Similar trend of results was seen with 60, 90 DAT (Table 3). Higher phosphorus uptake of 11.34 & 5.58 kg ha^{-1} by rice gain and straw at harvest stage was noticed with T_8 i.e. hand weeding at 20, 40 DAT which was at par with T_4 (10.71 & 5.28 kg ha^{-1}) while lowest phosphorus uptake was observed with T_7 treatment (6.65 & 3.27 kg ha^{-1} respectively).

Scrutiny of data (Table 4). revealed that potassium uptake was significantly influenced by weed management practices of machine transplanted rice. In machine transplanted rice at 30 DAT, higher potassium uptake was noticed with T_8 i.e. hand weeding at 20, 40 DAT (45.08 kg ha^{-1}) which was at par with T_4 {penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT} (42.01 kg ha^{-1}) followed by T_3 i.e. flucetosulfuron 10% WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (39.63 kg ha^{-1}). Potassium uptake was lowest with T_7 {weedy check} (25.53 kg ha^{-1}).

Potassium uptake was higher in straw than grain of rice crop. Maximum K uptake by grain and straw of rice crop was recorded with T_8 i.e. hand weeding at 20, 40 DAT (39.94 & 113.69 kg ha^{-1} respectively) which was at par with T_4 {penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT} (37.84 & 107.70 kg ha^{-1}) followed by T_3 i.e. flucetosulfuron 10% WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT (34.82 & 101.03 kg ha^{-1}). Potassium uptake was observed least with weedy check plot (21.39 & 67.79 kg ha^{-1}).

Table 2. Nitrogen uptake (kg ha^{-1}) of machine transplanted rice crop influenced by weed management practices

Treatments	30 DAT	60 DAT	90 DAT	Harvest		
				Grain	Straw	Total
T_1 - Pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + cono weeder at 15, 30 & 45 DAT	30.70	86.04	113.97	79.62	37.72	117.34
T_2 - Pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + power weeder at 15, 30 & 45 DAT	32.11	89.66	115.45	80.95	39.87	120.82
T_3 - Flucetosulfuron 10 % WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	37.30	99.84	126.16	90.37	44.51	134.87
T_4 - Penoxsulam 1.02 % W/W + cyhalofop- p-butyl 5.1 % W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	39.22	106.72	133.81	96.98	45.65	142.63
T_5 - Penoxsulam 0.97 % W/W + butachlor 38.8 % W/W @ 820 g ha^{-1} at 7 DAT + power weeder at 30 - 40 DAT.	36.05	94.86	123.67	86.84	42.77	129.62
T_6 - Bentazone @ 960 g *a.i* ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	27.18	78.61	109.29	72.99	35.95	108.94
T_7 - Weedy check (control).	20.43	64.12	82.59	61.58	30.33	91.91
T_8 - Hand weeding at 20, 40 DAT.	41.64	109.66	135.77	98.53	48.53	147.06
SEm±	1.02	2.63	2.90	3.01	1.28	4.48
CD	3.36	8.06	9.45	9.23	5.04	13.72

Table 3. Phosphorous uptake (kg ha^{-1}) of machine transplanted rice crop influenced by weed management practices

Treatments	30 DAT	60 DAT	90 DAT	Harvest Grain	Harvest Straw	Harvest Total
T_1 - Pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + cono weeder at 15, 30 & 45 DAT	2.95	9.74	13.26	8.94	4.41	13.35
T_2 - Pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + power weeder at 15, 30 & 45 DAT	3.18	9.95	13.64	9.19	4.53	13.72
T_3 - Flucetosulfuron 10% WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	3.93	11.41	15.13	10.18	5.02	15.20
T_4 - Penoxsulam 1.02 % W/W + cyhalofop- p- butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	4.55	12.27	15.94	10.71	5.28	15.99
T_5 - Penoxsulam 0.97 % W/W + butachlor 38.8 % W/W @ 820 g ha^{-1} at 7 DAT + power weeder at 30 - 40 DAT.	3.50	10.78	14.63	9.75	4.48	14.25
T_6 - Bentazone @ 960 g *a.i* ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	2.32	9.19	12.08	8.21	4.04	12.25
T_7 - Weedy check (control).	1.59	7.96	9.79	6.65	3.27	9.92
T_8 - Hand weeding at 20, 40 DAT.	4.95	12.63	16.65	11.34	5.58	16.92
SEm±	0.14	0.35	0.44	0.26	0.17	0.39
CD	0.42	1.07	1.13	0.81	0.52	1.21

Table 4. Potassium uptake (kg ha^{-1}) of machine transplanted rice crop influenced by weed management practices

Treatments	30 DAT	60 DAT	90 DAT	Harvest Grain	Harvest Straw	Harvest Total
T_1 - Pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + cono weeder at 15, 30 & 45 DAT	34.08	90.11	111.54	30.63	89.01	119.64
T_2 - Pretilachlor @ 625 g *a.i* ha^{-1} as PE at 3 DAT + power weeder at 15, 30 & 45 DAT	34.72	94.93	113.59	30.61	91.82	122.43
T_3 - Flucetosulfuron 10 % WG @ 25 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	39.63	106.44	126.80	34.82	101.03	135.85
T_4 - Penoxsulam 1.02 % W/W + cyhalofop- p- butyl 5.1 % W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	42.01	112.58	136.97	37.84	107.70	145.54
T_5 - Penoxsulam 0.97 % W/W + butachlor 38.8 % W/W @ 820 g ha^{-1} at 7 DAT + power weeder at 30 - 40 DAT.	36.22	96.93	118.64	31.86	95.57	127.43
T_6 - Bentazone @ 960 g *a.i* ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30 - 40 DAT.	28.03	81.12	104.00	28.11	84.33	112.44
T_7 - Weedy check (control).	25.53	69.18	83.55	21.39	67.79	89.18
T_8 - Hand weeding at 20, 40 DAT.	45.08	118.06	144.25	39.94	113.69	153.64
SEm±	1.43	2.94	3.68	0.98	2.96	3.95
CD	4.38	9.12	11.28	3.02	9.08	12.11

Decreased weed competition in machine transplanted rice might have augmented the uptake of applied nutrients as well as soil nutrients. Higher nutrient uptake is due to better control of weeds leading to lower depletion of nutrients by weeds and higher nutrient uptake by rice. The results are in conformity with the findings of Yadav et al. [8] and Prasanth et al. [9]. Weedy check treatment was attributed to uncontrolled weed growth and higher crop weed competition and thus, prevented rice crop from adequate nutrients. Uma et al. [10] also reported similar results.

4. CONCLUSION

Based on the results obtained, it can be concluded that among the different weed management treatments penoxsulam 1.02% W/W + cyhalofop-p-butyl 5.1% W/W @ 153 g ha^{-1} at 2-3 leaf stage of weeds + power weeder at 30-40 DAT was found to be an effective weed management practice in machine transplanted rice since it gave competitive advantage to the crop over weeds both at early stage and later stages.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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