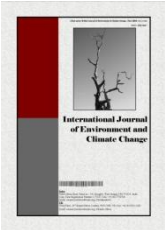

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Effect of Weed Management Practices on Nutrient Uptake and Removal in Transplanted Rice

B. Venkatesh [a*], Y. S. Parameswari [b], M. Madhavi [c#] and T. Ram Prakash [d]

[a] Department of Agronomy, College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana-500 030, India.
[b] Department of Agronomy, College Farm, PJTSAU, Rajendranagar, Hyderabad, Telangana-500 030, India.
[c] Department of Agronomy, Agriculture College Aswaraopet, PJTSAU, Rajendranagar, Hyderabad, Telangana-500 030, India.
[d] Department of Soil Science and Agricultural Chemistry, AICRP on Weed Management, PJTSAU, Rajendranagar, Hyderabad, Telangana-500 030, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Different pre and post emergence herbicides, herbicide mixtures along with hand weeding in transplanted rice were evaluated at PJTSAU, Rajendranagar during *Kharif* season of 2019 in a randomized block design with three replications. Higher nutrient uptake by grain and straw were recorded with application of flopyrauxifen-benzyl 2.7% + cyhalofop-butyl 10% EC 150 g ha $^{-1}$(PoE) *fb* hand weeding at 40 DAT and lower nutrient removal by weeds were recorded with application of herbicide mixtures along with hand weeding than single herbicide application followed by hand weeding. Where as in case of unweeded control lower nutrient uptake and higher nutrient removal by weeds over all the treatments.

Keywords: Herbicide mixtures; hand weeding; nutrient uptake; nutrient removal; transplanted rice.

[#] Associate Dean;
**Corresponding author: E-mail: venkateshbathulvenkychinna@gmail.com;*

1. INTRODUCTION

Rice crop suffers from various biotic and abiotic production constraints. Weed infestation has been established as one of the important biotic factor responsible for lower productivity. The degree of competition and extent of yield losses vary greatly with period of weed competition. Weed competition under transplanted conditions caused yield reductions up to 45% [1]. Weeds compete with crop plants for moisture, nutrients, light, space and other growth factors. Fertilizer usage in rice and it's consumption has increased substantially in the past decades. The quantity of rice grain produced per unit of applied fertilizer (partial factor productivity) has constantly decreased to very low values [2]. It has been observed that more than 60% of applied fertilizer was taken up by weeds which results lower nutrient availability for crop [3]. And the quantity of nutrient losses due to weeds again depends on the period of weed growth but, control of weeds in transplanted rice at critical stages by hand weeding only is very difficult nowadays due to labour scarcity and higher wages. Usage of herbicides with single mode of action will not control broad spectrum of weeds and continuous use of herbicide with single mode of action may lead to development of herbicide resistance in weeds making them more notorious. So, for control of these broad spectrum weeds we need to depends on herbicides mixtures with different modes action and integrated with hand weeding will results effective control of weeds, lower nutrient depletion by weeds and higher nutrient uptake by crop. In this context we need to investigate which herbicide mixture is most effective for control of weeds and higher nutrient use efficiency in transplanted rice.

2. MATERIALS AND METHODS

A field experiment was conducted at College Farm, College of Agriculture Rajendranagar, Professor Jayashankar Telangana State Agricultural University, Rajendranagar, Hyderabad during *Kharif* 2019. The soil of experimental site was sandy loam in texture with p^H of 7.85, low available nitrogen (235.2), medium phosphorus (38.8) and high potassium availability (379). The experiment was consisted of twelve weed management practices T_1: penoxsulam 0.97% + butachlor 38.8% SE 820 g ha^{-1} (PE) *fb* hand weeding at 30 DAT, T_2: pyrazosulfuron-ethyl 0.15% + pretilachlor 6% GR 600g ha^{-1} (PE) *fb* hand weeding at 30 DAT, T_3: orthosulfamuron + pretilachlor 6% GR 600g ha^{-1} (PE) *fb* hand weeding at 30 DAT, T_4: ipfencarbazone 25% SC 156.25 g ha^{-1} (PE)*fb* hand weeding at 30 DAT, T_5: penoxsulam 2.65% OD 25 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT, T_6: penoxsulam 1.02% + cyhalofop butyl 5.1% OD 150 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT, T_7: pretilachlor 50% EC 0.75 kg ha^{-1} (PE) *fb* 2,4 D WP 1.0 kg ha^{-1} (PoE), T_8: bispyribac sodium 10% SC 25 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT, T_9: flopyrauxifen- benzyl 2.7% + penoxsulam 12% EC 40.64 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT, T_{10}: flopyrauxifen-benzyl 2.7% + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT, T_{11}: Hand weeding at 20 and 40 DAT and T_{12}: unweeded control, Laid out in randomized block design with three replications. RNR – 15048 (*Telangana sona*) variety was transplanted in main field on 8th August at the age of 28 days old seedlings with a spacing of 15 X 10 cm. All pre-emergence herbicides were applied on (10-08-2019) and post emergence herbicides treatments were applied at 2 – 3 leaf stage of weeds (30-08-2019). Weeds were collected at critical crop weed competition stages *i.e.* 30 DAT (07-09-2019) and 60 DAT (07-10-2019) by using quadrate (1m × 1m). And randomly five plants from each plot were collected at the time of harvest (17-11-2019). Both the weed and crop samples were dried (at 65ºC for 24 hours) and ground to fine powder using willey mill and can be used for analysis of uptake of nutrients by crop and nutrient removal by weeds. Nitrogen content (%) in the plant and weed samples were estimated by the micro kjeldhal method [4] using Kelplus N analyser after digesting the samples with H_2SO_4 and H_2O_2 [5]. The tri-acid (HNO_3 and $HCLO_4$) in the ratio of (3:1) respectively digested plant and weed samples were analyzed for phosphorus and potassium. The nutrient uptake and depletions were calculated by using of below formula. The data was statistically analyzed.

Nutrient uptake/Depletion = (Nutrient content (%) / 100) X Dry matter of crop/weed (kg ha^{-1})

3. RESULTS AND DISCUSSION

3.1 Effect on Crop Dry Matter

All the weed management practices significantly recorded higher crop dry matter production over control plot (Table 1). The higher dry matter production were registered with hand weeding at 20 and 40 DAT which was statistically on par with flopyrauxifen- benzyl (2.7%) + cyhalofop

butyl 10% EC 150 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT, penoxsulam 1.02% (20 g ha^{-1}) + cyhalofop butyl 5.1% OD (100 g ha^{-1}) (PoE) *fb* hand weeding at 40 DAT and flopyrauxifen-benzyl 2.7% + penoxsulam 12% EC 40.64 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT. Among the weed management practices application of herbicide mixture *fb* hand weeding recorded higher growth parameters compared to single herbicides *fb* hand weeding flopyrauxifen- benzyl (2.7%) + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT. This might be due to control of complex weed flora in time and avoids competition so, resulted in higher tillers and crop dry matter production Yadav et al*.,* [6].

3.2 Effect on Nutrient Uptake by Grain and Straw

Higher nutrient uptake was noticed with herbicide mixture flopyrauxifen- benzyl (2.7%) + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT which is statistically on par with hand weeding at 20 and 40 DAT (Tables 1&2). In the present experiment, higher nutrient uptake by grain and straw due to better availability of resources that maintained the favorable environment for the crop with limited competition from weeds and availability of nutrients throughout the growth stages leading to better uptake of nutrients. The results were in accordance with findings of Singh et al. [7] and Parameshwari et al. [8]. Phosphorus accumulation is more in grain compared to straw because of higher content of organic compounds like inositol phosphate, phospholipids, nuclic acids and phosphoprotiens [9].

3.3 Effect on Weed Dry Matter

Significantly the lowest weed dry matter was recorded with the application of broad spectrum herbicide mixture flopyrauxifen- benzyl (2.7%) + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* hand weeding at 40 DAT. Initial herbicide application followed by hand weeding results in extended period of weed control will resulted in lower weed dry matter. Results are corroborated with the research finding of Mohapatra et al*.* [10] and Sreedevi et al. [11].

Table 1. Influence of weed management practices on crop dry matter production and nutrient uptake (kg ha $^{-1}$) by grain at harvest

Treatments	Dry matter (kg ha^{-1})	N	P	K
T_1 - Penoxsulam 0.97% (20 g ha^{-1}) + butachlor (38.8%) SE 820 g ha^{-1} (PE) *fb* HW at 30 DAT	13375	73.0	12.7	30.0
T_2 - Pyrazosulfuron-ethyl 0.15% (15 g ha^{-1}) + pretilachlor 6% GR (600g ha^{-1}) (PE) *fb* HW at 30 DAT	13517	75.0	14.3	34.3
T_3 - Orthosulfamuron + pretilachlor 6% (600g ha^{-1}) GR (PE) *fb* HW at 30 DAT	13453	74.0	13.0	31.7
T_4 - Ipfencarbazone 25% SC 156.25 g ha^{-1} (PE)*fb* HW at 30 DAT	12568	64.0	11.3	28.0
T_5 - Penoxsulam 2.65% OD 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	12474	62.0	10.5	27.3
T_6 - Penoxsulam 1.02% (20 g ha^{-1}) + cyhalofop butyl 5.1% OD (100 g ha^{-1}) (PoE) *fb* HW at 40 DAT	14663	81.0	16.0	38.0
T_7 - Pretilachlor (PE) 50% EC 0.75 kg ha^{-1}*fb* 2,4 D 1.0 kg ha^{-1} (PoE)	11835	60.7	10.0	24.3
T_8 - Bispyribac sodium 10% SC 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	12167	61.3	10.2	26.7
T_9 - Flopyrauxifen- benzyl + penoxsulam 12% EC 40.64 g ha^{-1} (PoE) *fb* HW at 40 DAT	14448	79.0	15.5	37.0
T_{10} - Flopyrauxifen- benzyl + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* HW at 40 DAT	14953	83.0	16.7	38.7
T_{11} - Hand weeding at 20 and 40 DAT	15014	83.3	17.3	40.7
T_{12} - Unweeded control	7732	38.5	7.1	15.3
SE(m)±	254.58	1.83	0.66	1.6
CD (P=0.05)	746.5	5.37	1.94	4.68

Table 2. Influence of weed management practices on nutrient uptake (kg ha $^{-1}$) by straw at harvest

Treatments	N	P	K
T_1 - Penoxsulam 0.97% (20 g ha^{-1}) + butachlor (38.8%) SE 820 g ha^{-1} (PE) *fb* HW at 30 DAT	52.0	8.0	98.0
T_2 - Pyrazosulfuron-ethyl 0.15% (15 g ha^{-1}) + pretilachlor 6% GR (600g ha^{-1}) (PE) *fb* HW at 30 DAT	54.8	8.8	101.0
T_3 - Orthosulfamuron + pretilachlor 6% (600g ha^{-1}) GR (PE) *fb* HW at 30 DAT	54.0	8.3	99.0
T_4 - Ipfencarbazone 25% SC 156.25 g ha^{-1} (PE)*fb* HW at 30 DAT	48.0	6.0	92.0
T_5 - Penoxsulam 2.65% OD 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	46.5	5.6	90.0
T_6 - Penoxsulam 1.02% (20 g ha^{-1}) + cyhalofop butyl 5.1% OD (100 g ha^{-1}) (PoE) *fb* HW at 40 DAT	59.0	11.4	106.0
T_7 - Pretilachlor (PE) 50 % EC 0.75 kg ha^{-1}*fb* 2,4 D 1.0 kg ha^{-1} (PoE)	43.0	5.0	87.7
T_8 - Bispyribac sodium 10% SC 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	45.0	5.0	89.7
T_9 - Flopyrauxifen- benzyl + penoxsulam 12% EC 40.64 g ha^{-1} (PoE) *fb* HW at 40 DAT	57.7	11.0	103.3
T_{10} - Flopyrauxifen- benzyl + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* HW at 40 DAT	61.7	12.0	108.0
T_{11} - Hand weeding at 20 and 40 DAT	62.0	12.6	110.0
T_{12} - Unweeded control	32.3	4.6	51.3
SE(m)±	2.05	0.51	2.75
CD (P=0.05)	6.00	1.50	8.06

Table 3. Influence of weed management practices on weed dry matter (g m^{-2}) and nutrient removal (kg ha $^{-1}$) by weeds at 30 DAT

Treatments	Dry weight of weeds	N	P	K
T_1 - Penoxsulam 0.97% (20 g ha^{-1}) + butachlor (38.8%) SE 820 g ha^{-1} (PE) *fb* HW at 30 DAT	3.9(14.5)	1.13	0.37	1.48
T_2 - Pyrazosulfuron-ethyl 0.15 % (15 g ha^{-1}) + pretilachlor 6% GR (600g ha^{-1}) (PE) *fb* HW at 30 DAT	3.8(13.3)	1.01	0.30	1.20
T_3 - Orthosulfamuron + pretilachlor 6% (600g ha^{-1}) GR (PE) *fb* HW at 30 DAT	3.9(14.0)	1.05	0.35	1.42
T_4 - Ipfencarbazone 25% SC 156.25 g ha^{-1} (PE)*fb* HW at 30 DAT	4.2(16.8)	1.28	0.43	1.71
T_5 - Penoxsulam 2.65% OD 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	4.3(18.0)	1.35	0.44	1.81
T_6 - Penoxsulam 1.02% (20 g ha^{-1}) + cyhalofop butyl 5.1% OD (100 g ha^{-1}) (PoE) *fb* HW at 40 DAT	2.9 (7.4)	0.63	0.20	0.77
T_7 - Pretilachlor (PE) 50 % EC 0.75 kg ha^{-1}*fb* 2,4 D 1.0 kg ha^{-1} (PoE)	4.5(19.2)	1.44	0.47	1.86
T_8 - Bispyribac sodium 10% SC 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	4.4(18.6)	1.39	0.45	1.84
T_9 - Flopyrauxifen- benzyl + penoxsulam 12% EC 40.64 g ha^{-1} (PoE) *fb* HW at 40 DAT	2.9 (7.7)	0.69	0.21	0.80
T_{10} - Flopyrauxifen- benzyl + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* HW at 40 DAT	2.7 (6.3)	0.50	0.18	0.69
T_{11} - Hand weeding at 20 and 40 DAT	2.6 (6.0)	0.44	0.16	0.59
T_{12} - Unweeded control	8.2(65.7)	6.63	1.15	4.91
SE(m)±	0.17	0.09	0.02	0.12
CD (P=0.05)	0.51	0.25	0.08	0.35

** PE: application: 3 DAT, PoE: Application: 2-3 leaf stage of weeds ** Values in the parenthesis are original and (√x+1) transformed*

Table 4. Influence of weed management practices on weed dry matter (g m^{-2}) and nutrient removal (kg ha^{-1}) by weeds at 60 DAT

Treatments	60 DAT	N	P	K
T_1 - Penoxsulam 0.97% (20 g ha^{-1}) + butachlor (38.8%) SE 820 g ha^{-1} (PE) *fb* HW at 30 DAT	6.1(35.7)	2.93	0.93	2.40
T_2 - Pyrazosulfuron-ethyl 0.15 % (15 g ha^{-1}) + pretilachlor 6% GR (600g ha^{-1}) (PE) *fb* HW at 30 DAT	5.7(32.0)	2.80	0.81	2.20
T_3 - Orthosulfamuron + pretilachlor 6% (600g ha^{-1}) GR (PE) *fb* HW at 30 DAT	5.9(34.0)	2.83	0.92	2.30
T_4 - Ipfencarbazone 25 % SC 156.25 g ha^{-1} (PE)*fb* HW at 30 DAT	6.2(37.0)	3.07	0.95	2.63
T_5 - Penoxsulam 2.65 % OD 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	4.0(15.3)	1.39	0.42	1.19
T_6 - Penoxsulam 1.02% (20 g ha^{-1}) + cyhalofop butyl 5.1% OD (100 g ha^{-1}) (PoE) *fb* HW at 40 DAT	3.8(13.3)	1.26	0.41	1.12
T_7 - Pretilachlor (PE) 50 % EC 0.75 kg ha^{-1} *fb* 2,4 D 1.0 kg ha^{-1} (PoE)	7.7(58.0)	4.20	1.24	3.62
T_8 - Bispyribac sodium 10% SC 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	4.1(16.7)	1.43	0.44	1.24
T_9 - Flopyrauxifen- benzyl + penoxsulam 12% EC 40.64 g ha^{-1} (PoE) *fb* HW at 40 DAT	3.9(14.3)	1.34	0.43	1.14
T_{10} - Flopyrauxifen- benzyl + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* HW at 40 DAT	3.7(13.0)	1.23	0.41	1.02
T_{11} - Hand weeding at 20 and 40 DAT	3.6(12.0)	1.18	0.39	0.89
T_{12} - Unweeded control	12.1(144.)	10.13	3.48	8.23
SE(m)±	0.29	0.13	0.05	0.23
CD (P=0.05)	0.87	0.44	0.15	0.69

** PE: application: 3 DAT, PoE: Application: 2-3 leaf stage of weeds ** Values in the parenthesis are original and (√x+1) transformed*

Table 5. Influence of weed management practices on weed dry matter (g m^{-2}) and nutrient removal (kg ha^{-1}) by weeds at 60 DAT

Treatments	60 DAT	N	P	K
T_1 - Penoxsulam 0.97% (20 g ha^{-1}) + butachlor (38.8%) SE 820 g ha^{-1} (PE) *fb* HW at 30 DAT	6.1(35.7)	2.93	0.93	2.40
T_2 - Pyrazosulfuron-ethyl 0.15 % (15 g ha^{-1}) + pretilachlor 6% GR (600g ha^{-1}) (PE) *fb* HW at 30 DAT	5.7(32.0)	2.80	0.81	2.20
T_3 - Orthosulfamuron + pretilachlor 6% (600g ha^{-1}) GR (PE) *fb* HW at 30 DAT	5.9(34.0)	2.83	0.92	2.30
T_4 - Ipfencarbazone 25 % SC 156.25 g ha^{-1} (PE)*fb* HW at 30 DAT	6.2(37.0)	3.07	0.95	2.63
T_5 - Penoxsulam 2.65 % OD 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	4.0(15.3)	1.39	0.42	1.19
T_6 - Penoxsulam 1.02% (20 g ha^{-1}) + cyhalofop butyl 5.1% OD (100 g ha^{-1}) (PoE) *fb* HW at 40 DAT	3.8(13.3)	1.26	0.41	1.12
T_7 - Pretilachlor (PE) 50 % EC 0.75 kg ha^{-1} *fb* 2,4 D 1.0 kg ha^{-1} (PoE)	7.7(58.0)	4.20	1.24	3.62
T_8 - Bispyribac sodium 10% SC 25 g ha^{-1} (PoE) *fb* HW at 40 DAT	4.1(16.7)	1.43	0.44	1.24
T_9 - Flopyrauxifen- benzyl + penoxsulam 12% EC 40.64 g ha^{-1} (PoE) *fb* HW at 40 DAT	3.9(14.3)	1.34	0.43	1.14
T_{10} - Flopyrauxifen- benzyl + cyhalofop butyl 10% EC 150 g ha^{-1} (PoE) *fb* HW at 40 DAT	3.7(13.0)	1.23	0.41	1.02
T_{11} - Hand weeding at 20 and 40 DAT	3.6(12.0)	1.18	0.39	0.89
T_{12} - Unweeded control	12.1(144.)	10.13	3.48	8.23
SE(m)±	0.29	0.13	0.05	0.23
CD (P=0.05)	0.87	0.44	0.15	0.69

** PE: application: 3 DAT, PoE: Application: 2-3 leaf stage of weeds ** Values in the parenthesis are original and (√x+1) transformed*

3.4 Effect on Nutrient Removal by Weeds

Unweeded control recorded significantly higher nutrient removal by weeds than the other treatments (Tables 3 & 4). At 30 DAT lower nutrient removal was observed with hand weeding at 20 which was statistically similar to flopyrauxifen-benzyl (2.7%) + cyhalofop-butyl 10% EC 150 g ha $^{-1}$(PoE) *fb* hand weeding at 40 DAT, penoxsulam 1.02% @ 20 g ha $^{-1}$ + cyhalofop butyl 5.1% OD @ 100 g ha $^{-1}$ (PoE)*fb* hand weeding at 40 DAT and flopyrauxifen-benzyl (2.7%) + penoxsulam 12% EC @ 40.64 g ha $^{-1}$ (PoE)*fb* hand weeding at 40 DAT. Lower nutrient removal by weeds in weed management practices might be due to effective control of weeds during critical period and after that, weeds effectively suppressed by crop Gupta et al. [12]. Similar findings were reported by Mohapatra et al. [13] and Yadav et al [14].

4. CONCLUSION

From this investigation, the application of herbicides mixtures followed by hand weeding will results higher nutrient uptake by rice crop and reduces the nutrient removal by weeds compared to their alone application followed by hand weeding. Among all weed management practices application of flopyrauxifen-benzyl (2.7%) + cyhalofop-butyl 10% EC 150 g ha $^{-1}$(PoE) *fb* hand weeding at 40 DAT was most effective treatment.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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