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INFLUENCE OF HERBIGATION BASED INTEGRATED WEED MANAGEMENT PRACTICES ON GROWTH AND YIELD OF AEROBIC RICE

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ABSTRACT
A field experiment was conducted during the summer season of 2015 at Zonal Agricultural Research Station, University of Agricultural Sciences (UAS), Gandhi Krishi Vignana Kendra (GKVK), Bengaluru to assess the herbigation based integrated weed management in aerobic rice. The experiment consisted of 12 treatments laid out in randomized complete block design with three replications comprising pre-emergent herbigation of two herbicides at three doses integrated with one hand weeding, post emergent herbigation at two doses, post emergent herbigation with one hand weeding, one hand weeding and one intercultivation compared with weedy check and weed free check. The results revealed that pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one hand weeding + one inter-cultivation recorded significantly higher growth parameters viz., plant height, number of tillers, leaf area and total dry matter accumulation (35.5 cm, 25.1 hill^{-1}, 3954.3 cm^2 hill^{-1} and 153.8 g hill^{-1}, respectively) yield parameters like number of productive tillers, panicle length, panicle weight, total number of grains, grain and straw yield (33.2 hill^{-1}, 25.8 cm, 204.3 g hill^{-1}, 291.0 panicle^{-1}, 8954 kg ha^{-1} and 11371 kg ha^{-1}), net returns(98865 Rs. ha^{-1}). Further, higher availability of major nutrients (N, P_2O_5 and K_2O) higher uptake by crop and lower uptake by weeds were also recorded in the same treatment.

KEY WORDS: Aerobic rice, herbigation, growth and yield, Econimics, Integrated weed management.

INTRODUCTION

Rice (*Oryza sativa* L.) is major food crop for more than half of the world's population. It occupies the enviable prime place among the food crops cultivated around the world and is grown in 162.3 million hectares with a production of 738.1 million tonnes with a productivity of 4.54 tonnes per hectare (Anon, 2015). It is considered to be primarily an irrigated crop. Since olden days it was cultivating under traditional puddled soil and transplanting method. Their, it was consuming around 4000-5000 litres of water to produce 1 Kg grain which is 2 to 3 times higher than that of other cereals. Water shortage is becoming severe in many rice growing areas of the world, the introduction of aerobic rice which means growing of high yielding rice in nonpuddled and non-flooded aerobic soil with the support of external inputs like supplementary irrigation, manures and fertilizers; aerobic rice systems can reduce water use in rice production by as much as 50% (Bouman, 2001). However, direct-seeded aerobic rice is subject to more severe weed infestation than transplanted lowland rice, because in aerobic rice systems weeds germinate simultaneously with rice, and there is no water layer to suppress weed growth. In aerobic rice, weeds cause yield loss to an extent of 56.4 to 90.70 per cent (Paradkar *et al.,* 1997). In such condition to ensure high yield, we should take necessary and time bound weed management practices. Since many years research on weed control methods like hand weeding, intercultivation, herbicide spray and their integration has achieved good progress. Apart from this to overcome water shortage problems there is more scope for micro irrigation systems like drip and sprinkler. Herbigation is "the process of injecting an approved chemical (herbicide) into irrigation water and applying through the irrigation system to crop, weed or field". In aerobic rice there is possibility to follow herbigation through drip irrigation system along with other weed control methods, whose efficiency needs to be worked out. Hence, the present investigation was undertaken to study the effect of herbigation based integrated weed management practices on growth, yield and economics of aerobic rice.

MATERIALS & METHODS

A field experiment was conducted during the summer season of 2015 at Zonal Agricultural Research Station, Gandhi Krishi Vignana Kendra (GKVK), University of Agricultural Sciences (UAS), Bengaluru. The soil of the experimental site was red sandy clay loam in texture, acidic in reaction (6.28), medium in available nitrogen (294.6 kg ha^{-1}), available phosphorus (44.2 kg ha^{-1}) and available potassium (233.2 kg ha^{-1}). The organic carbon content was medium in range (0.58 %). KRH 4, a medium duration hybrid was sown on February 16 at a spacing of 25 x 25 cm. Experiment consisting 12 treatments *i.e.*, T_1: PE herbigation of pyrazosulfuron ethyl 10% WP @ 250 g ha^{-1} + one HW, T_2: PE herbigation of pyrazosulfuron ethyl 10% WP @ 375 g ha^{-1} + one HW, T_3: PE herbigation of pyrazosulfuron ethyl 10% WP @ 500 g ha^{-1} + one HW, T_4: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one HW, T_5: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 15 kg ha^{-1} + one HW, T_6: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 20 kg ha^{-1} + one HW, T_7: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium

10% SC @ 200 ml ha^{-1}, T_8: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium 10% SC @ 300 ml ha^{-1}, T_9: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1} + one HW, T_{10}: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one HW + one intercultivation, T_{11}: Weedy check, T_{12}: Weed free check. The trial was laid out in randomized complete block design (RCBD) with three replications. Pre-emergent herbigation at one day after sowing and post emergent herbigation at 23 DAS was done through drip irrigation system. The data on growth parameters viz., plant height, number of tillers, leaf area and dry matter accumulation, yield parameters viz., number of productive tillers, panicle length, panicle weight, total number of grains, 1000 grain weight, grain and straw yield were recorded adopting standard procedure. After harvest of the crop data on nutrient (N,P and K) uptake by crop and weeds, nutrient remained in the soil was analysed. Nutrient use efficiency was calculated by using the formulae. The collected data was subjected to Fisher's method of "Analysis of Variance" (Panse and Sukhatme, 1967). Wherever, F- test was significant an appropriate value of critical difference (C.D.) was worked out for comparison among the treatment means, otherwise, against C.D. values NS (Non-significant) was indicated.

$$\text{Nutrient use efficiency (kg kg}^{-1}) = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Plant nutrient applied (kg ha}^{-1})}$$

RESULTS AND DISCUSSION

Effect on crop growth

Among the treatments, weed free check recorded has recorded higher plant height (36.5 cm), number of tillers (28.3 $hill^{-1}$), leaf area (4108.0 cm^2 $hill^{-1}$) and total dry matter accumulation (167.7 g $hill^{-1}$) which was on par with pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one hand weeding + one intercultivation (35.5 cm, 25.1 tillers $hill^{-1}$, 3954.3 cm^2 $hill^{-1}$ and 153.8 g $hill^{-1}$ respectively) (Table 1). This is due to better suppression of weeds during the initial stage and provided optimal condition for crop to establish. These results are in line with the findings of Kusuma (2007) and Bhagirath Singh *et al.* (2015).

Effect on Yield and Yield Parameters

Among herbigation treatments pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one hand weeding + one intercultivation has recorded higher yield components like, productive tillers $hill^{-1}$ (33.2), Panicle length (25.8 cm), Panicle weight (204.3 g $hill^{-1}$), Total No. of grains $panicle^{-1}$ 291.0), Grain yield (8954 kg ha^{-1}) and straw yield (11371 kg ha^{-1}) (Table 2) followed by pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + post emergent herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1} + one hand weeding (32.1 $hill^{-1}$, 25.7 cm, 197.5 g $hill^{-1}$, 288.8 $panicle^{-1}$, 8767 kg ha^{-1} and 11085 kg ha^{-1} respectively). This was due to better weed control in these treatments resulted in higher growth, because of the better growth, photosynthates were translocated into economic part. Similar results have been obtained by Jagadish (2015).

TABLE 1: Effect of herbigation practices on growth parameters of aerobic rice at 90 DAS

Treatments	Plant height (cm)	No. of tillers ($hill^{-1}$)	Leaf area (cm^2 $hill^{-1}$)	Total dry matter accumulation (g $hill^{-1}$)
T_1	34.2	23.4	2744.9	126.7
T_2	33.5	23.7	2833.3	128.7
T_3	33.8	24.3	3320.0	133.1
T_4	33.6	24.4	3430.0	136.1
T_5	34.4	24.6	3673.3	139.8
T_6	34.9	24.0	3052.8	130.4
T_7	34.3	24.5	3547.7	137.8
T_8	34.5	24.9	3766.7	142.4
T_9	35.0	25.1	3863.3	147.1
T_{10}	35.5	25.1	3954.3	153.8
T_{11}	38.1	18.3	1223.7	98.1
T_{12}	36.5	28.2	4108.0	167.7
S.Em.±	1.22	1.07	109.31	3.69
CD @ 5%	3.57	3.15	320.61	10.83

T_1: PE herbigation of pyrazosulfuron ethyl 10% WP @ 250 g ha^{-1} + one HW. T_2: PE herbigation of pyrazosulfuron ethyl 10% WP @ 375 g ha^{-1} + one HW. T_3: PE herbigation of pyrazosulfuron ethyl 10% WP @ 500 g ha^{-1} + one HW. T_4: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one HW. T_5: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 15 kg ha^{-1} + one HW. T_6: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 20 kg ha^{-1} + one HW. T_7: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1}. T_8: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} and PoE herbigation of bispyribac sodium 10% SC @ 300 ml ha^{-1}. T_9: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1} + one HW. T_{10}: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one HW + one intercultivation. T_{11}: Weedy check T_{12}: Weed free check

(**Note:** HW: Hand Weeding, PE: Pre-emergent, PoE: Post emergent)

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TABLE 2: Effect of herbigation practices on yield parameters and economics of aerobic rice

Treatments	Productive tillers hill^{-1}	Panicle length (cm)	Panicle weight (g hill^{-1})	Total No. of grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	B:C ratio
T_1	25.1	21.4	176.4	251.7	23.1	7545	9066	129797	53570	76227	2.42
T_2	26.1	21.6	170.5	253.0	23.2	7671	9230	131971	53920	78051	2.45
T_3	29.1	22.3	180.9	265.7	23.5	8512	9996	146188	54270	91918	2.69
T_4	29.5	22.5	184.9	270.7	23.3	8519	10186	146491	55270	91221	2.65
T_5	31.1	23.2	193.1	277.3	23.1	8645	10693	149013	56470	92543	2.64
T_6	28.0	21.8	180.5	261.0	23.3	8164	9800	140429	57670	82759	2.44
T_7	30.2	22.9	190.5	273.2	23.2	8525	10279	146679	52230	94449	2.81
T_8	31.5	23.3	195.7	284.3	23.4	8672	10808	149565	52510	97055	2.85
T_9	32.1	25.7	197.5	288.8	23.3	8767	11085	151368	55830	95538	2.71
T_{10}	33.2	25.8	204.3	291.0	23.7	8954	11371	154635	55770	98865	2.77
T_{11}	14.0	20.6	92.5	207.7	23.9	1379	1676	23750.7	49270	-25520	0.48
T_{12}	35.3	26.1	215.1	302.0	24.0	9460	12235	163595	60070	103525	2.72
S.Em.±	1.14	0.91	6.56	10.61	0.50	344	417	-	-	-	-
CD @ 5%	3.35	2.67	19.23	31.13	NS	1010	1223	-	-	-	-

T_1: PE herbigation of pyrazosulfuron ethyl 10% WP @ 250 g ha^{-1} + one HW. T_2: PE herbigation of pyrazosulfuron ethyl 10% WP @ 375 g ha^{-1} + one HW. T_3: PE herbigation of pyrazosulfuron ethyl 10% WP @ 500 g ha^{-1} + one HW. T_4: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one HW. T_5: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 15 kg ha^{-1} + one HW. T_6: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 20 kg ha^{-1} + one HW. T_7: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1}. T_8: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} and PoE herbigation of bispyribac sodium 10% SC @ 300 ml ha^{-1}. T_9: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1} + one HW. T_{10}: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one HW + one intercultivation. T_{11}: Weedy check T_{12}: Weed free check (**Note:** HW: Hand Weeding, PE: Pre-emergent, PoE: Post emergent)

TABLE 3: Effect of herbigation on available nutrient status in soil after harvest, nutrient uptake by crop (kg ha^{-1}), weeds (kg ha^{-1}) and nutrient use efficiency (kg kg^{-1}) in aerobic rice

Treatments	Available nutrient status in soil (kg ha^{-1})			Nutrient uptake by crop (kg ha^{-1})			Nutrient uptake by weeds (kg ha^{-1})			Nutrient use efficiency (kg kg^{-1})		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
T_1	260.00	29.80	208.67	55.77	14.77	49.30	47.67	16.43	42.73	50.30	107.80	83.84
T_2	263.00	30.63	212.00	57.27	15.63	52.47	48.43	15.50	40.30	51.14	109.59	85.24
T_3	262.20	31.33	210.33	63.43	17.70	59.40	41.07	11.97	42.40	56.75	121.60	94.58
T_4	258.53	30.80	213.33	67.73	18.30	63.00	28.47	11.37	31.13	56.79	121.70	94.66
T_5	267.63	31.33	221.40	75.63	20.20	68.93	20.73	10.07	26.60	57.63	123.50	96.06
T_6	265.47	31.77	211.33	59.30	16.60	54.40	35.70	12.50	33.63	54.43	116.63	90.71
T_7	261.93	30.67	219.73	69.90	19.20	64.90	25.67	10.87	29.70	56.83	121.79	94.72
T_8	273.63	33.60	230.03	81.67	21.17	70.77	17.10	8.90	22.00	57.82	123.89	96.36
T_9	286.00	35.00	235.43	85.53	22.33	73.83	14.33	7.33	19.27	58.45	125.25	97.42
T_{10}	287.33	36.77	249.00	88.07	23.73	76.33	12.27	6.20	17.07	59.69	127.91	99.49
T_{11}	243.10	29.50	207.67	36.97	8.20	29.30	62.73	19.43	49.33	9.20	19.71	15.33
T_{12}	294.83	38.57	258.77	94.20	24.77	79.70	0.00	0.00	0.00	63.07	135.14	105.11
S.Em.±	10.06	1.86	8.13	2.10	1.37	3.19	2.54	0.77	3.01	2.30	4.92	3.83
CD @ 5%	29.51	5.44	23.86	6.15	4.01	9.35	7.44	2.25	8.83	6.74	14.44	11.23

T_1: PE herbigation of pyrazosulfuron ethyl 10% WP @ 250 g ha^{-1} + one HW. T_2: PE herbigation of pyrazosulfuron ethyl 10% WP @ 375 g ha^{-1} + one HW. T_3: PE herbigation of pyrazosulfuron ethyl 10% WP @ 500 g ha^{-1} + one HW. T_4: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one HW. T_5: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 15 kg ha^{-1} + one HW. T_6: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 20 kg ha^{-1} + one HW. T_7: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1}. T_8: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} and PoE herbigation of bispyribac sodium 10% SC @ 300 ml ha^{-1}. T_9: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + PoE herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1} + one HW. T_{10}: PE herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one HW + one intercultivation. T_{11}: Weedy check T_{12}: Weed free check (**Note:** HW: Hand Weeding, PE: Pre-emergent, PoE: Post emergent)

Economics

Among herbigation treatments, maximum gross and net returns were observed with pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one hand weeding + one intercultivation (154635 and 98865 Rs. ha^{-1} respectively) with the B:C ratio of 2.77 (Table 2). This was associated with higher grain and straw yield. whereas, highest B:C ratio was obtained in pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} and post emergent herbigation of bispyribac sodium 10% SC @ 300 ml ha^{-1} (2.85) Similar results have been obtained by Jagadish (2015).

Nutrient uptake and availability

Among the treatments pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one hand weeding + one intercultivation recorded more available soil nutrients (N, P_2O_5 and K_2O) after harvest (287.33, 36.77 and 249.00 kg ha^{-1} respectively), higher uptake of nutrients by crop (88.07, 23.73 and 76.33 kg ha^{-1}) and lesser uptake by weeds (12.27, 6.20 and 17.07 kg ha^{-1} respectively) was observed(Table 3) followed by pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + post emergent herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1} + one hand weeding. These results are in line with Gopinath *et al.* (2012). Nutrient use efficiency was also higher in these treatments because of higher grain and straw yield.

CONCLUSION

Pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + one hand weeding + one intercultivation resulted in higher yield weed control followed by pre-emergent herbigation of pretilachlor + bensulfuron methyl 6.6% GR @ 10 kg ha^{-1} + post emergent herbigation of bispyribac sodium 10% SC @ 200 ml ha^{-1} + one hand weeding. These herbigation treatments were found to be promising to control weeds in aerobic rice and would play an important role in areas where labour is too expensive and time is short.

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