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Weed Management Practices on Nutrient Uptake, Yield Attributes and Yield of Rice Under System of Rice Intensification

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An experiment was conducted at wetland farm of Tamil Nadu Agricultural University, Coimbatore during August to January 2009 to test the effect of different weed management practices on the nutrient uptake by weeds and SRI rice. The major weeds found in the experimental field were *Echinochloa crus-galli* (L.), *Cyperus difformis* (L.), *Eclipta alba* (L.) and *Ammania baccifera* (L.). The application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5) has recorded significantly lower uptake of N, P, K by weeds and it was on par with the application of butachlor as pre-emergence at 1 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_4) and application of almix as post-emergence at 20 g a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_3). The highest uptake of N, P, K and maximum yield by SRI rice was recorded by application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5).

Key words: SRI, weed management, Almix™, butachlor, pretilachlor, nutrient uptake, yield attributes, yield.

India is the leading rice producing country in terms of area and it is the second largest producer next to China. Rice is grown in an area of 45 million ha annually with a production of 90 million tonnes, which contributes 45% of the total food grain production of the country. Weed competition is one of the prime yield-limiting biotic constraints in rice. The components of System of Rice Intensification (SRI) are young seedlings, limited irrigation, aerated soil conditions by frequent soil disturbance and the use of organic manure. The conservation of land, water and biodiversity and utilization of the hitherto ignored biological power of plant and solar energy, are the novelties of SRI. Weeds compete with crops for water, light, nutrients and space. Weeds are the important competitors in their early growth stages than the later and hence the growth of crops slows down and finally grain yield decreases (Jacob and Syriac, 2005). Transplanted rice in particular, is infested by heterogeneous types of weed flora under rainfed shallow lowland, which reduces yield up to 48% (Singh and Bhan, 1986).

Materials and Methods

Field experiment was conducted during *Kharif,* 2009 at wetland farm of Tamil Nadu Agricultural University, Coimbatore to test the effect of different weed management practices on the nutrient uptake by weeds and SRI rice. The soil was deep clay loam (*vertic ustochrep*) having P^H 8.0, EC 0.45 dS m^{-1}, organic carbon 0.68 per cent, available N, P_2O_5 and K_2O of 231.0, 18.6 and 458.0 kg ha^{-1}, respectively. Seeds of CO(R) 49 rice variety were sown on raised bed nursery on 19.08.2009 and transplanted at 25 cm × 25 cm spacing on 01.09.2009. There were nine treatments including recommended weed management practice *i.e.* 4 times conoweeding from 10 DAT at 10 days interval and conoweeding 3 times at 20, 30 and 40 DAT either alone or in combination with three herbicides like almix @ 20 g a.i. ha^{-1}, butachlor @ 1 kg a.i. ha^{-1} and pretilachlor @ 0.75 kg a.i. ha^{-1} along with an unweeded control fitted in randomized block design with three replication.

As per treatment schedule, pre-emergence herbicide butachlor @1 kg a.i. ha^{-1} was applied on 3rd DAT (T_4 and T_7). The other pre-emergence herbicide pretilachlor was also applied @ 0.75 kg a.i. ha^{-1} on 3rd DAT (T_5 and T_8). The post-emergence herbicide almix @ 20 g a.i. ha^{-1} was applied on 15th DAT (T_3 and T_6). A thin film of water was maintained at the time of herbicide application. The unweeded check (T_9) was kept undisturbed for the entire cropping period. As per the treatment schedule, hand operated conoweeder was operated 4 times (T_1, T_3, T_4 and T_5) and 3 times (T_2, T_6, T_7 and T_8) between the rows in both the directions to incorporate weeds with simultaneous stirring up of soil. The left over weeds were taken out by hand weeding. The data on weed dry weight (DMP) crop DMP of rice was recorded at 30, 45 and 60 DAT.

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Results and Discussion

Nutrient uptake by weeds

Nutrient depletion from the soil is a function of dry weight and nutrient content in weed plants. Weeds usually grow faster than crop plants and thus absorb the available nutrients quicker, resulting in inadequate supply of nutrients to the crop. Herbicide application followed by conoweeding reduced nutrients depletion appreciably by checking the weed growth. This might be due to comparatively lower weed density and dry weight accumulation of weeds with pre-emergence application of herbicides like pretilachlor (0.75 kg ha^{-1}), butachlor (1.0 kg ha^{-1}) and post-emergence almix (20 g ha^{-1}) followed by conoweeding. Application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5) recorded the lowest removal of nutrients by the weeds (Table 1).

Table 1. Effect of weed management practices on nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by weeds

Treatment	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
T_1 - Recommended weed management practice i.e. 4 times conoweeding from 10 DAT at 10 days interval	0.70	0.60	0.81	0.06	0.06	0.04	1.06	1.12	4.87
T_2 - Conoweeding 3 times at 20, 30 and 40 DAT	0.97	0.91	0.97	0.10	0.09	0.09	1.34	1.85	7.82
T_3 - AlmixTM at 20 g a. i. ha^{-1} as POE + T_1	0.63	0.57	0.78	0.04	0.05	0.03	0.97	1.02	4.60
T_4 - Butachlor 50 EC at 1 kg a. i. ha^{-1} as PE + T_1	0.56	0.55	0.72	0.03	0.03	0.02	0.83	0.96	3.91
T_5 - Pretilachlor 50 EC at 0.75 kg a. i. ha^{-1} as PE + T_1	0.41	0.51	0.63	0.02	0.02	0.01	0.80	0.91	3.06
T_6 - AlmixTM at 20 g a. i. ha^{-1} as POE + T_2	0.82	0.82	0.93	0.08	0.07	0.08	1.23	1.67	6.67
T_7 - Butachlor 50 EC at 1 kg a. i. ha^{-1} as PE + T_2	0.80	0.76	0.91	0.07	0.07	0.06	1.19	1.58	6.32
T_8 - Pretilachlor 50 EC at 0.75 kg a. i. ha^{-1} as PE + T_2	0.72	0.68	0.87	0.07	0.06	0.05	1.18	1.45	5.52
T_9 - Unweeded control	6.10	8.20	10.70	0.43	0.97	1.04	8.20	8.87	15.32
SEd	0.09	0.17	0.09	0.02	0.01	0.02	0.17	0.22	0.76
CD (P=0.05)	0.20	0.37	0.20	0.04	0.02	0.03	0.37	0.47	1.63

PE - Pre-emergence POE - Post emergence

Rana and Angiras (1999) confirmed that N, P and K removal by weeds was limited in herbicide applied plots compared to unweeded control, where the dry weight of weeds was higher. Unweeded control resulted in the highest depletion of nutrients throughout the crop growth period. Madhu and Nanjappa (1997) also reported substantial removal of N, P and K by weeds in unweeded plots and corresponding saving in nutrients with effective weed control treatments.

The treatments *viz.*, application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5), application of butachlor as pre-emergence at 1 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_4) and application of almix as post-emergence at 20 g a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_3) resulted in restricted weed growth and thus reduced the nutrient depletion by weeds.

Nutrient uptake by SRI rice

Application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5) recorded significantly higher N uptake of 23.00, 35.33 and 57.30 kg ha^{-1} at 30, 45 and 60 DAT, respectively. This treatment was on par with the application of butachlor as pre-emergence at 1 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_4) with N uptake of 22.52, 34.64 and 56.28 kg ha^{-1} at 30, 45 and 60 DAT, respectively (Table 2). The next best treatment was the application of almix as post-emergence at 20 g a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_3) with N uptake of 21.92, 33.24 and 54.77 kg ha^{-1} at 30, 45 and 60 DAT, respectively.

Weed management practices exerted positive influence on phosphorus uptake. With regard to uptake of P, application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5) registered significantly higher P uptake of 4.68, 8.63 and 12.44 kg ha^{-1} at 30, 45 and 60 DAT, respectively. The two treatments T_3 and T_4 were on par with T_5.

The potassium uptake was high with the application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5) (14.97, 50.54 and 95.72 kg ha^{-1} at 30, 45 and 60 DAT, respectively) and was comparable with application of butachlor as pre-emergence at 1 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_4) which registered K uptake of 14.29, 48.46 and 93.37 kg ha^{-1} at 30, 45 and 60 DAT, respectively. Application of almix as post-emergence at 20 g a.i. ha^{-1} + 4 times conoweeding

Table 2. Effect of weed management practices on nitrogen, phosphorus and potassium uptake (kg ha^{-1}) by SRI Rice

Treatment	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT	30 DAT	45 DAT	60 DAT
T_1 - Recommended weed management practice i.e. 4 times conoweeding from 10 DAT at 10 days interval	21.81	33.10	54.02	4.06	7.83	11.26	13.19	45.16	89.03
T_2 - Conoweeding 3 times at 20, 30 and 40 DAT	19.02	30.67	50.67	3.07	6.67	10.53	10.47	41.64	84.15
T_3 - Almix™ at 20 g a. i. ha^{-1} as POE + T_1	21.92	33.24	54.77	4.25	8.37	11.58	13.61	47.45	91.24
T_4 - Butachlor 50 EC at 1 kg a. i. ha^{-1} as PE + T_1	22.52	34.64	56.28	4.62	8.47	11.72	14.29	48.46	93.37
T_5 - Pretilachlor 50 EC at 0.75 kg a. i. ha^{-1} as PE + T_1	23.00	35.33	57.30	4.68	8.63	12.44	14.97	50.54	95.72
T_6 - Almix™ at 20 g a. i. ha^{-1} as POE + T_2	19.04	31.00	51.26	3.42	6.93	10.50	11.07	42.36	86.29
T_7 - Butachlor 50 EC at 1 kg a. i. ha^{-1} as PE + T_2	19.37	31.22	52.17	3.61	7.20	10.70	12.19	44.10	87.86
T_8 - Pretilachlor 50 EC at 0.75 kg a. i. ha^{-1} as PE + T_2	19.77	31.96	53.13	3.84	7.57	10.62	12.67	45.47	88.01
T_9 - Unweeded control	10.31	18.84	27.71	1.51	4.23	6.58	7.18	31.85	48.61
SEd	0.97	0.68	1.51	0.29	0.20	0.46	0.94	1.85	2.67
CD (P=0.05)	2.09	1.47	3.23	0.63	0.43	1.00	2.01	3.96	5.73

PE - Pre-emergence POE - Post emergence

from 10 DAT at 10 days interval (T_3) has recorded a K uptake of 13.61, 47.45 and 91.24 kg ha^{-1} at 30, 45 and 60 DAT, respectively which was on par with T_5 at 30, 45 and 60 DAT.

Unweeded control (T_9) recorded the lowest nutrient uptake by plants. This might be due to depletion of nutrients by weeds in higher amount resulted in limited nutrients availability to the crop. Balasubramanian *et al.* (1996) stated that unchecked weed growth caused significantly higher nutrient drain, which might otherwise be available to the crop.

Yield attributes

Adoption of different weed management practices significantly influenced the yield attributes of SRI rice (Table 3). Application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5) recorded higher yield attributes *viz.*, number of panicles hill^{-1} (17.40), panicle length (21.27 cm) and number of filled grains panicle^{-1} (249.3). It was comparable with the treatments like application of butachlor as pre-emergence at 1 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_4) and application of almix as post-emergence at 20 g a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_3) with regard to the yield attributes. Decreased weed competition and minimum nutrient removal by weeds provided a competition free environment for rice. This might have increased the capacity of N, P and K uptake and enhanced source (LAI) and sink sizes which in turn increased the entire yield attributes *viz.*, the panicle number hill^{-1}, panicle length and number of filled grains panicle^{-1}.

Table 3. Effect of weed management practices on yield attributes, yield and harvest index (HI) in SRI rice

Treatment	Yield attributes						
	No. of panicles hill^{-1}	Panicle length (cm)	No. of filled grains panicle^{-1}	1000 grain weight (g)	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (HI)
T_1 - Recommended weed management practice i.e. 4 times conoweeding from 10 DAT at 10 days interval	16.35	20.71	240.0	19.23	5161	9011	0.36
T_2 - Conoweeding 3 times at 20, 30 and 40 DAT	14.80	19.26	218.7	19.00	4150	8261	0.33
T_3 - Almix™ at 20 g a. i. ha^{-1} as POE + T_1	16.67	21.03	240.4	19.26	5411	9217	0.37
T_4 - Butachlor 50 EC at 1 kg a. i. ha^{-1} asPE + T_1	16.87	21.25	244.8	19.30	5606	9500	0.37
T_5 - Pretilachlor 50 EC at 0.75 kg a. i. ha^{-1}as PE + T_1	17.40	21.27	249.3	19.38	5863	9772	0.38
T_6 - Almix™ at 20 g a. i. ha^{-1} as POE + T_2	15.67	19.96	210.9	19.01	4589	8461	0.35
T_7 - Butachlor 50 EC at 1 kg a. i. ha^{-1} asPE + T_2	15.41	20.13	214.9	19.00	4656	8522	0.35
T_8 - Pretilachlor 50 EC at 0.75 kg a. i. ha^{-1}as PE + T_2	15.96	20.42	220.5	19.03	4819	8717	0.36
T_9 - Unweeded control	10.47	17.08	103.9	18.97	1808	3094	0.33
SEd	0.76	0.52	9.9	0.21	298	291	0.02
CD (P=0.05)	1.62	1.12	21.3	NS	638	625	NS

PE - Pre-emergence POE - Post emergence

Comparatively weed free condition at critical crop growth stage with these treatments enhanced all the yield components. This was confirmed by Mukherjee and Bhattacharya (1999). Unweeded control (T_9) recorded the lowest number of panicle hill^{-1}, panicle length and number of filled grains panicle^{-1}. This was due to severe competition exerted by weeds for space, light and nutrients throughout the crop growth period as reported by Choudhary and Thakuria (1998).

Grain and straw yield

Adoption of different weed management practices increased the grain yield from 1808 kg ha^{-1} to 5863 kg ha^{-1}. The increase ranged from 56.42 to 69.15 % over unweeded control. With respect to straw yield, the increase was from 3094 kg ha^{-1} to 9772 kg ha^{-1} which ranged from 62.54 to 68.33% over unweeded control.

Among the different weed control treatments, application of pretilachlor as pre-emergence at 0.75 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_5) registered higher grain yield of 5863 kg ha^{-1} and straw yield of 9772 kg ha^{-1}. This treatment was comparable with application of butachlor as pre-emergence at 1 kg a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_4) and application of almix as post-emergence at 20 g a.i. ha^{-1} + 4 times conoweeding from 10 DAT at 10 days interval (T_3). This trend might be due to weed free environment created from the early stage up to harvest, leading to the production of effective tillers, longer panicles and more number of grains panicle^{-1} compared to all other treatments.

However, unweeded control (T_9) recorded 69.15 per cent lesser yield due to higher weed competition and lower availability of nutrients to the crops which resulted in lower grain and straw yield in control plot and this was in conformity with the findings of Vinod Kumar *et al.* (1998) and Narayanan *et al.* (2001).

Conclusion

Application of pretilachlor at 0.75 kg a.i. ha^{-1} as pre-emergence + 4 times conoweeding from 10 DAT at 10 days interval recorded better N, higher P and K uptake by SRI rice. It was comparable with application of butachlor at 1 kg a.i. ha^{-1} as pre-emergence + 4 times conoweeding from 10 DAT at 10 days interval in N, P, K uptake and with application of almix at 20 g a.i. ha^{-1} as post-emergence + 4 times conoweeding from 10 DAT at 10 days interval in P and K uptake only. With regard to yield attributes *viz.*, panicles hill^{-1}, panicle length (cm) and filled grains panicle^{-1} application of pretilachlor at 0.75 kg a.i. ha^{-1} as pre-emergence + 4 times conoweeding from 10 DAT at 10 days interval was proved better and was comparable with application of butachlor at 1 kg a.i. ha^{-1} as pre-emergence + 4 times conoweeding from 10 DAT at 10 days interval, application of almix at 20 g a.i. ha^{-1} as post-emergence + 4 times conoweeding from 10 DAT at 10 days interval and with recommended weed management practice i.e. 4 times conoweeding from 10 DAT at 10 days interval. Among the weed control treatments, application of pretilachlor at 0.75 kg a.i. ha^{-1} as pre-emergence + 4 times conoweeding from 10 DAT at 10 days interval registered higher grain yield of 5863 kg ha^{-1} followed by application of butachlor at the rate of 1 kg a.i. ha^{-1} as pre-emergence + 4 times conoweeding from 10 DAT at 10 days interval, application of almix at 20 g a.i. ha^{-1} as post-emergence + 4 times conoweeding from 10 DAT at 10 days interval. All these three treatments were comparable with each other. The highest straw yield of 9772 kg ha^{-1} was registered with application of pretilachlor at 0.75 kg a.i. ha^{-1} as pre-emergence + 4 times conoweeding from 10 DAT at 10 days interval and it was comparable with application of butachlor at 1 kg a.i. ha^{-1} as pre-emergence + 4 times conoweeding from 10 DAT at 10 days interval and application of almix at 20 g a.i. ha^{-1} as post-emergence + 4 times conoweeding from 10 DAT at 10 days interval.

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