Response of herbicides in different rice varieties under wet direct-seeded ecosystem

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ABSTRACT

The present study was conducted to evaluate the imazethapyr tolerant variety with different weed management methods. A field experiment was conducted in the experimental farm of the Department of Rice, TNAU, Coimbatore, Tamil Nadu during rabi season 2020 in split plot design with three replications. The treatments in main plot consisted of nine rice varieties viz HTM-N 22, N 22, Anna (R) 4, CO 53, CO 51, ADT 53, ADT 37, ADT 43 and ADT 45. In sub-plot weed management methods included early post-emergence herbicide application of imazethapyr @ 75 g ai/ha at 30 DAS, early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 15-20 DAS, pre-emergence herbicide application of pretilachlor @ 0.75 kg ai/ha at 8 DAS followed by early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 20-25 DAS, hand weeding twice at 20 and 40 DAS and un-weeded check. There were marked variations in the effect of various weed management practices in direct-seeded rice. In weed management methods, pre-emergence herbicide application of pretilachlor @ 0.75 kg ai/ha at 8 DAS followed by early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 20-25 DAS effectively controlled the weeds in wet direct-seeded rice ecosystem. Among the varieties tested, HTM-N 22 and N 22 only survived with the early post-emergence herbicide application of imazethapyr @ 75 g ai/ha at 30 DAS. The varieties HTM-N 22 and N 22 can be utilised for rice breeding programme for the development of herbicide tolerant varieties.

Keywords: Direct-seeded rice; herbicide; varieties; weed index

INTRODUCTION

Rice is the main source of food for more than half the population of the world especially in southeast Asia and Latin America. Change in the method of crop establishment from traditional manual transplanting of seedlings to direct seeding has occurred in many Asian countries in the last two decades in response to rising production costs especially for labour and water. Direct seeding refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting. Once germination and seedling establishment are complete, the crop can then be sequentially flooded and water regimes maintained as for transplanted rice. Alternatively the crop can remain rainfed, the upper surface soil layers fluctuating from aerobic to non-aerobic conditions (Grigg 1974, Pandey and Velasco 2005). Weeds are one of the major constraints in the production of wet direct-seeded rice. Effective weed management in direct-seeded rice depends on several factors including the timeliness of the control operations during the early crop growth stages and in some cases good control in preceding crops. In transplanted rice, weed control is conducted just before transplant and the rice has a significant size and competitive advantage over subsequently emerging weeds. Direct-seeded rice has no such advantage and yield losses to weed competition can approach even up to 90 per cent in poorly managed fields. In India, the cost towards controlling the weeds accounts up to 30 per cent of the total cost of cultivation (Rao et al 2015). Moreover the problem of weedy rice is being reported widely in direct-seeded rice areas in India for which herbicide tolerant rice varieties is one of the feasible and practical long term solution (Kumar et al 2008b, Rathore et al 2013).

Herbicides primarily act by disrupting key enzymes/proteins involved in essential metabolic or

physiological processes associated with growth and development of plants. Of the various herbicides, imidazolinones are the most widely targeted ones for developing herbicide tolerant crops through non-GM approach. Imazethapyr tolerant mutant resource was developed by EMS mutagenesis approach from a drought tolerant variety Nagina 22 which is named as HTM-N 22 (Shoba et al 2017). Glyphosate, glufosinate, synthetic auxins, sulfonylurea, imidazolinones, triketones, isoxazoles, callistemone, cyclohexanediones, aryloxyphenoxy propionates and phenylpyrazolines are common herbicides for which herbicide tolerance (HT) mechanisms are well known and exploited for development of herbicide tolerant crops (Endo and Toki 2013).

Some of the herbicide tolerant crops have been developed by introducing mutations in the target site of herbicide action whereas others have introduced genes detoxifying the herbicide molecule (Endo and Toki 2013). Both the above mechanisms have been exploited in developing HT transgenic crops while the former approach has been achieved through mutagenesis (non-GM approach) as well (Green and Owen 2010). Non-GM herbicide tolerant crops have the advantage of easier registration/release for commercial cultivation as well as wider public acceptance.

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MATERIAL and METHODS

A field experiment was conducted at the Department of Rice, TNAU, Coimbatore, Tamil Nadu during rabi season 2020. The soil of the experimental field was clay in texture with pH of 8.02, EC of 0.53 ds/m and organic carbon content of 0.55 per cent. The experiment was laid out in split plot design. The treatments in main plot consisted of nine rice varieties viz HTM-N 22, N 22, Anna (R) 4, CO 53, CO 51, ADT 53, ADT 37, ADT 43 and ADT 45. Sub-plot weed management methods consisted of early post-emergence herbicide application of imazethapyr @ 75 g ai/ha at 30 DAS (S_1), early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 15-20 DAS (S_2), pre-emergence herbicide application of pretilachlor @ 0.75 kg ai/ha at 8 DAS followed by early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 20-25 DAS (S_3), hand weeding twice at 20 and 40 DAS (S_4) and un-weeded check (S_5). The seed rate recommended for direct sowing was 60 kg/ ha and row to row spacing of 20 cm was adopted. The recommended doses of 150:50:50 kg/ha of N:P:K in the form of urea, single super phosphate and muriate of potash were applied. Nitrogen was applied in four equal splits at 21 DAS, active tillering, panicle initiation and heading whereas the entire dose of P was applied basal before sowing. Need-based irrigation and plant-protection measures were followed. The crop was harvested when plants turned yellow and attained maturity. The border rows all around the plots were harvested first and then the plants from the net plots were harvested and threshed. The grain weight was expressed in 14 per cent moisture basis (Yoshida et al 1972) and the yield was expressed in kg/ha. Weed index indicates per cent reduction in grain yield due to weed competition. The weed index was calculated by using the formula as suggested by Gill and Kumar (1969).

RESULTS and DISCUSSION

Total weed population was recorded under different weed management practices and the results are presented in Table 1. The predominant weeds present in the experimental field were *Echinochloa colona* and *Chloris barbata*among grasses; *Cyperus difformis* among sedges; *Marselia quadrifolia, Monochoria vaginalis* and *Eclipta prostrata* among broad-leaved weeds.

Effect of imazethapyr herbicide on the rice varieties

Imazethapyr belongs to imidazolinones group of herbicides which acts as non-selective herbicide in rice when sprayed @ 75 g ai/ha at 30 days after sowing. As a result, the varieties viz Anna (R) 4, CO 53, CO 51, ADT 53, ADT 37, ADT 43 and ADT 4522 were dried completely whereas in HTM-N 22 and N 22 the number of plants dried were very less because of their herbicide tolerance capacity (Shoba et al 2017). Apart from imazethapyr sprayed plots, hand weeding on 20 and 40 DAS (S_1) resulted in very less number of weeds than other plots but was more labour intensive which increased the cost of cultivation. Whereas un-weeded check (S_5) had more number of weeds compared to all other plots (Table 1). In herbicide application, early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 15-20 DAS (S_2) and pre-emergence herbicide application of pretilachlor @ 0.75 kg ai/ha on 8 DAS followed by early post-emergence application of bispyribac sodium @ 25 g ai/ha at 20-25 DAS (S_3) also controlled the weeds effectively.

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Table 1. Effect of treatments on total number of weed population at 40 DAS under direct-seeded rice

Treatment	HTM-N 22	N 22	Anna (R) 4	CO 53	CO 51	ADT 53	ADT 37	ADT 43	ADT 45	Mean
EPOE of imazethapyr @ 5 g ai/ha at 30	0	0	0	1	0	0	0	1	1	0.33
[illegible] ($_1$)	(0.71)	(0.71)	(0.71)	(1.22)	(0.71)	(0.71)	(0.71)	(1.22)	(1.22)	(0.88)
EPOE of bispyribac sodium @ 25 g ai/ha	4	7	6	4	5	8	2	5	3	4.89
at 15-20 DAS (S_2)	(2.12)	(2.74)	(2.55)	(2.12)	(2.35)	(2.92)	(1.58)	(2.35)	(1.87)	(2.29)
PE of pretilachlor @ 0.75 kg ai/ha on 8	5	3	5	3	3	4	3	3	3	3.56
DASfollowed by EPOE of bispyribac	(2.35)	(1.87)	(2.35)	(1.87)	(1.87)	(2.12)	(1.87)	(1.87)	(1.87)	(2.00)
sodium @ 25 g ai/ha at 20-25 DAS (S_3)										
Hand weeding twice at 20 & 40 DAS (S_4)	2	2	1	3	1	0	0	2	0	1.22
		(1.58)	(1.58)	(1.22)	(1.87)	(1.22)	(0.71)	(0.71)	(1.58)	(0.71) (1.24)
Un-weeded check (S_5)	40	46	28	34	17	26	32	20	5	27.56
		(6.36)	(6.82)	(5.34)	(5.87)	(4.18)	(5.15)	(5.70)	(4.53)	(2.35) (5.14)
Mean	10.2	11.6	8	9	5.2	7.6	7.4	6.2	2.4	
		(2.62)	(2.74)	(2.43)	(2.59)	(2.07)	(2.07)	(2.11)	(2.31)	(1.60)

	S	V	S at V	V at S
SEd	0.22	0.37	0.82	0.84
$CD_{0.05}$	0.61	0.76	1.70	1.69

EPOE= Early post-emergence application, PE= Pre-emergence application, DAS Days after sowing

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Table 2. Effect of treatments on weed index (%) under direct-seeded rice

Treatment	HTM-N 22	N 22	Anna (R) 4	CO 53	CO 51	ADT 53	ADT 37	ADT 43	ADT 45	Mean
EPOE of imazethapyr @ 75 g ai/ha at 30 DAS (S_1)	3.67	20.25	-	-	-	-	-	-	-	11.96
EPOE of bispyribac sodium @ 25 g ai/ha at 15-20 DAS (S_2)	6.99	5.66	5.01	13.89	11.24	11.57	7.23	5.35	4.65	7.96
PE of pretilachlor @ 0.75 kg ai/ha on 8 DAS followed by EPOE of bispyribac sodium @ 25 g ai/ha at 20-25 DAS (S_3)	3.46	3.38	3.22	5.48	5.30	4.39	2.74	3.43	3.54	3.88
Hand weeding twice at 20 & 40 DAS (S_4)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Un-weeded check (S_5)	45.22	42.73	30.42	36.56	43.28	40.92	35.40	43.55	36.81	39.43
Mean	11.87	14.40	9.66	13.98	14.96	14.22	11.34	13.08	11.25	

EPOE= Early post-emergence application, PE= Pre-emergence application, DAS Days after sowing

Grain yield

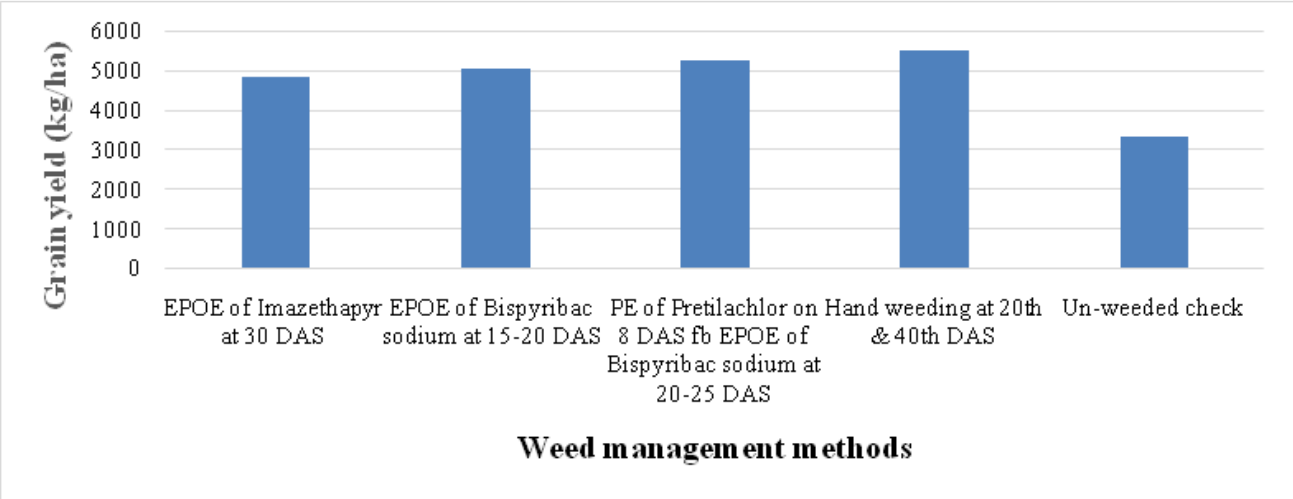
The varieties HTM-N 22 and N 22 could withstand in the imazethapyr sprayed plots because of their herbicide tolerance capacity. Among them HTM-N 22 resulted in higher grain yield of 5,321 kg/ha which was followed by N-22 which resulted in the grain yield of 4,324 kg/ha whereas other varieties were completely dried off as high dosage of imazethapyr acted as non- selective herbicide in rice when sprayed @ imazethapyr @ 75 g ai/ha at 30 days after sowing. Among other weed management methods, higher grain yield was recorded in hand weeding twice at 20 and 40 DAS in which Anna (R) 4 variety recorded higher grain yield of 5,651 kg/ha followed by CO 51 (5,561 kg/ha) and HTM-N 22 (5,524 kg/ha) (Figs 1, 2) because of less weed population and competition (Kumar et al 2008a). The next best treatment was pre-emergence herbicide application of pretilachlor @ 0.75 kg ai/ha at 8 days after sowing followed by early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 20-25 days after sowing (S_3). The lower grain and straw yield was observed in un-weeded check (S_5) in all the varieties because of crop weed competition.

Weed index

Weed index was minimum in pre-emergence herbicide application of pretilachlor @ 0.75 kg ai/ha at 8 DAS followed by early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 20-25 DAS (S_3) which was significantly superior to all other treatments (Table 2). In HTM-N 22 variety, the weed index was also minimum (3.46%) in S_3 which was followed by early post-emergence herbicide application of imazethapyr @ 75 g ai/ha at 30 DAS (S_1) (3.67%). This might be due to effective control of weeds thereby reduction in crop weed competition and improvement in the crop growth and the grain yield loss due to weeds in HTM-N 22. This is because of more competition of weeds with crop for nutrients, moisture, space and light (Rao et al 2015).

CONCLUSION

In weed management methods, pre-emergence herbicide application of pretilachlor @ 0.75 kg ai/ha at 8 days after sowing followed by early post-emergence herbicide application of bispyribac sodium @ 25 g ai/ha at 20-25 DAS effectively controlled the weeds in wet direct-seeded rice ecosystem. Among the varieties tested, HTM-N 22 and N 22 only survived with the early post-emergence herbicide application of imazethapyr @ 75 g ai/ha at 30 days after sowing.



EPOE= Early post-emergence application, PE= Pre-emergence application, DAS Days after sowing

Fig 1. Effect of weed management treatments on grain yield (kg/ha) of rice

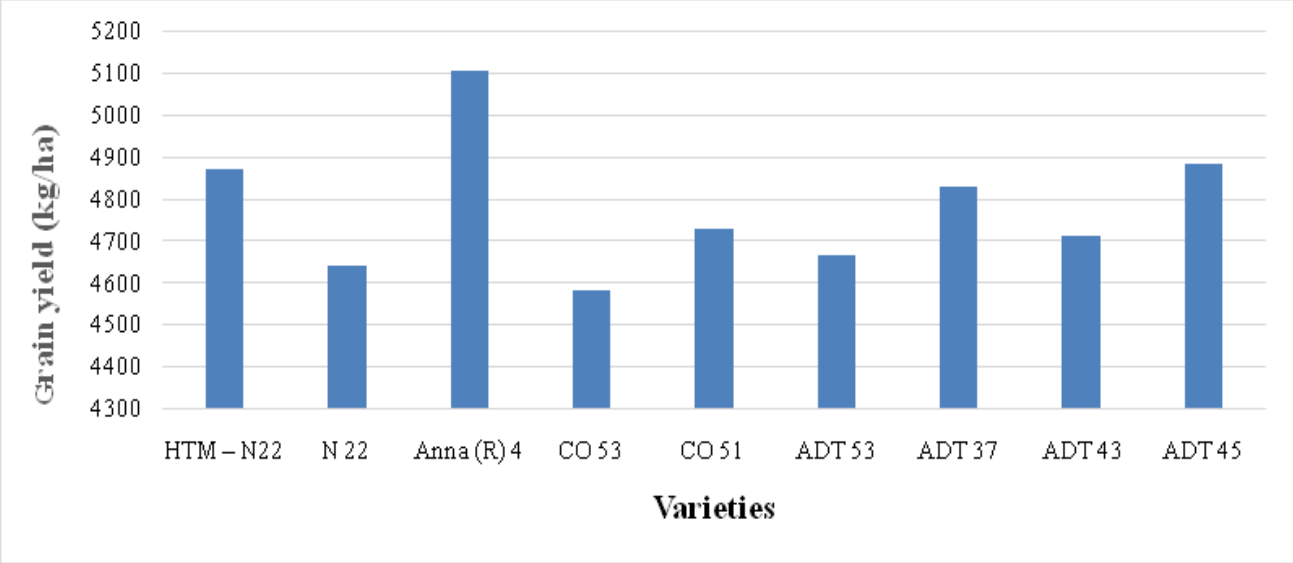


Fig 2. Performance of varieties in grain yield (kg/ha) of rice

The varieties HTM-N 22 and N 22 can be utilised for rice breeding programme for the development of herbicide tolerant rice varieties.

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