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Herbicide mixtures for weed management in wet-seeded rice

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ABSTRACT

Three herbicidal mixtures, *viz*. triafamone 20% + ethoxysulfuron 10% (pre-mix) 67.5 g/ha, 12 days after sowing (DAS), cyhalofop-butyl+ penoxsulam 6% OD (pre-mix) 150 g/ha, 20 DAS, and fenoxaprop-p-ethyl 6.9 EC 60 g/ha+ ethoxysulfuron 15 WDG (tank mix) 15 g/ha, 20 DAS were evaluated for their efficacy against weeds in wet-seeded rice. These treatments were compared with bispyribac-sodium, hand weeding twice and unweeded control. Application of triafamone + ethoxysulfuron, and cyhalofop-butyl + penoxsulam, significantly reduced the weed biomass followed by the treatments bispyribac-sodium, and hand weeding at 60 DAS. Fenoxaprop-p-ethyl + ethoxysulfuron had significantly lower weed control efficiency, probably due to its inability to control *Echinochloa crus-galli* effectively. Considering rice grain and straw yields, all herbicide treatments were at par except for fenoxaprop-p-ethyl + ethoxysulfuron, which recorded significantly lower values. Among yield attributes, significantly higher number of panicles/ m^2 was recorded in the treatments triafamone + ethoxysulfuron, and hand weeding, followed by cyhalofop-butyl+ penoxsulam. Grain and straw yields were lowest in unweeded control.

Weed complexes in rice are difficult to control as they include grasses, sedges and broad leaf weeds. Single application of a pre- or post-emergence herbicide cannot control the wide array of weeds present in direct-seeded rice. Broad-spectrum herbicides can control most of these weeds, but there are tolerant species which are susceptible only to specific herbicides. Application of weed specific herbicides in sequence to manage all types of weeds is neither practical nor economic. Herbicide mixtures would be more acceptable option as the operation would be completed in a single application and would save time. Several new pre-mix herbicides are now available, the efficacy of which have been less studied and which could manage the weed populations to acceptable levels. However, the weed species present, which depends on the climate, soil and environmental conditions, would determine the weed control efficiency. Three herbicide mixtures were evaluated in the Agricultural Research Station, Mannuthy, Thrissur in Kerala to study their action against a mixed population of weeds and also to assess their effects on growth and yield of rice.

The experimental site is located at 12^0 32' N latitude and 74^0 20' E longitude at an altitude of 22.25 m above MSL. The soil is sandy loam in texture and has a pH of 5.84. The experiment was conducted in *Kharif*, 2018. The crop was wet-seeded on 10-07-18 and harvested on 1-10-18. The experiment consisted of six treatments laid out in randomised block design with four replications. The rice variety cultivated was '*Jyothi*' and the gross plot size was 20 m^2. The treatments were: triafamone 20% + ethoxysulfuron 10% (pre-mix) 67.5 g/ha at 12 days after sowing (DAS), cyhalofop-butyl + penoxsulam 6% OD (pre-mix) 150 g/ha at 20 DAS, fenoxaprop-p-ethyl 6.9 EC 60 g/ha+ ethoxysulfuron 15 WDG (tank mix) 15 g/ha at 20 DAS, bispyribac-sodium 25 g/ha at 20 DAS, hand weeding twice at 20 and 40 DAS and an unweeded control.

Weed flora

The major weed flora of the field included *Echinochloa crus-galli* and *Ludwigia perennis*. *Hydrolea zeylanica*, *Phyllanthus niruri*, *Eclipta alba* and *Scoparia dulcis* were minor weeds. At 30 DAS, weed density was not affected by treatments except in the case of *Echinochloa crus-galli* and *Eclipta alba* (**Table 1**).

Echinochloa crus-galli density was highest in unweeded control, and lowest in the treatment triafamone + ethoxysulfuron. Bispyribac-sodium

Table 1. Effect of treatments on weed density at 30 DAS

Treatment	Weed density (no./m^2)					
	Echinochloa crus-galli	*Eclipta alba*	*Ludwigia perennis*	*Hydrolea zeylanica*	*Phyllanthus niruri*	*Scoparia dulcis*
Triafamone + ethoxysulfuron	ǂ0.22(0)	4.13 (17.3)	1.10 (2.7)	0.82 (1.3)	0.82 (1.3)	0.82 (1.3)
Cyhalofop-butyl + penoxsulam	3.62 (13.3)	3.65(13.3)	1.10 (2.7)	0.22 (0)	0.22 (0)	0.22 (0)
Fenoxaprop + ethoxysulfuron	4.21 (20.0)	0.82(1.3)	0.22 (0)	0.22 (0)	0.22 (0)	0.22 (0)
Bispyribac-sodium	2.18(6.7)	0.22 (0)	1.48 (5.3)	0.22 (0)	0.22 (0)	0.22 (0)
Hand weeding	4.67 (25.3)	0.22(0)	0.22 (0)	0.22 (0)	0.22 (0)	0.22 (0)
Unweeded control	6.68 (44.7)	1.31 (4)	1.97 (5.3)	0.22 (0)	0.22 (0)	0.22 (0)
LSD (p=0.05)	2.23	1.83	NS	NS	NS	NS

*$(\sqrt{x+1})$ transformed values; Original values are given in parentheses

application was at par with this treatment. *Eclipta alba* density was found to be significantly higher in the treatments triafamone + ethoxysulfuron, and cyhalofop-butyl + penoxsulam at this stage.

At 60 DAS, only two weeds were seen in the field, *viz*. *Echinochloa crus-galli* and *Ludwigia perennis* (**Table 2**). Of these two, *Ludwigia perennis* was found not significantly affected by treatments. Significantly higher density of *Echinochloa crus-galli* was seen in unweeded control. Lowest density was seen in the treatment triafamone + ethoxysulfuron, and this treatment was on par with hand weeding. This was followed by other herbicidal treatments, which were on par.

Table 2. Effect of treatments on weed density at 60 DAS

Treatment	Weed density (no./m^2)	
	Echinochloa crus-galli	*Ludwigia perennis*
Triafamone + ethoxysulfuron	*2.29(5.3)	0.22 (0)
Cyhalofop-butyl + penoxsulam	3.74(14.7)	0.22 (0)
Fenoxaprop + ethoxysulfuron	4.42(20.0)	0.22 (0)
Bispyribac-sodium	4.13(17.3)	0.22 (0)
Hand weeding	3.16(10.7)	0.22 (0)
Unweeded control	7.26(52.7)	0.82 (1.3)
LSD (p=0.05)	1.446	NS

*$(\sqrt{x+1})$ transformed values; Original values are given in parentheses

Table 3. Effect of treatments on weed biomass and weed control efficiency

Treatment	Weed biomass (kg/ha)		Weed control efficiency (%)
	30 DAS	60 DAS	60 DAS
Triafamone + ethoxysulfuron	*18.3(3)	56.6(32)	92.3
Cyhalofop-butyl + penoxsulam	57.8(40)	69.7(50)	88.0
Fenoxaprop + ethoxysulfuron	62.7(44)	170.5(291)	30.0
Bispyribac-sodium	29.7(12)	87.5(77)	81.6
Hand weeding	65.2(56)	87.6(81)	80.7
Unweeded control	49.4(24)	204.3(418)	-
LSD(p=0.05)	NS	27.25	-

*$(\sqrt{x+1})$ transformed values; Original values are given in parentheses

Weed biomass

Data on weed dry matter production are presented in **Table 3**. At 30 DAS, effect of treatments was non-significant. But at 60 DAS, the treatment triafamone + ethoxysulfuron was significantly better in reducing weed growth. Triafamone + ethoxysulfuron was reported to bring about lowest weed count and weed dry matter at 42 days after application by Deivasigamani (2016). Cyhalofop-butyl + penoxsulam was at par with this treatment. Kailkhura *et al.* (2015) also reported the efficacy of ready-mix of cyhalofop butyl+ penoxsulam in reducing weed biomass. Treatments bispyribac-sodium and hand weeding came next, while fenoxaprop-p-ethyl + ethoxysulfuron was significantly inferior to other herbicide treatments. Highest weed biomass was recorded in the unweeded control. At 60 DAS, highest weed control efficiency was recorded in the treatment triafamone + ethoxysulfuron (92%), followed by cyhalofop-butyl + penoxsulam (88%). Other treatments also recorded weed control efficiencies greater than 80% except for fenoxaprop-p-ethyl + ethoxysulfuron, which had considerably lower efficiency. This is contrary to the results of Tiwari *et al.* (2010) who noticed the highest weed control efficiency on mixing fenoxaprop-p-ethyl with ethoxysulfuron.

The results showed that the pre-mix herbicide mixtures were highly effective in controlling weed growth as compared to the popularly used bispyribac-sodium, and even to hand weeding. However, fenoxaprop-p-ethyl + ethoxysulfuron had significantly less effect, probably due to the inability of fenoxaprop-p-ethyl to control *Echinochloa crus-galli* effectively.

Rice yield and yield attributes

Higher rice grain yields were obtained in treatments with lower weed dry matter production (**Table 4**). All herbicide treatments were at par except

Table 4. Effect of treatments on yield and yield attributes

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	No. of panicles/m	No. of grains/panicle	No. of filled grains /panicle	1000 grain weight (g)
Triafamone + ethoxysulfuron	3.80	5.98[a]	121.67	104.00	94.33	29.60
Cyhalofop-butyl + penoxsulam	3.67	5.97[a]	110.66	115.00	87.00	29.20
Fenoxaprop + ethoxysulfuron	2.52	4.99	92.00	97.33	72.67	27.67
Bispyribac-sodium	3.17	5.90	98.33	116.33	92.00	29.93
Hand weeding	3.62	5.30	120.67	115.67	93.00	28.97
Unweeded control	1.96	3.95	63.67	99.00	62.67	26.20
LSD (p=0.05)	0.71	0.50	8.52	NS	21.76	1.74

for fenoxaprop-p-ethyl + ethoxysulfuron, which recorded significantly lower grain yields. Straw yields followed the same trend as grain yields, with the treatment fenoxaprop-p-ethyl + ethoxysulfuron resulting in significantly lower value, although it was on par with hand weeding. Lowest grain and straw yields were observed in unweeded control.

Number of panicles/m^2 differed significantly with highest values recorded in the treatments triafamone + ethoxysulfuron and hand weeding. Number of grains per panicle were not significantly affected by treatments. However, all treatments were found to be significantly superior to unweeded control with respect to number of filled grains per panicle. This was true when considering 1000 grain weight also. Comparing the herbicide mixtures, the treatment fenoxaprop-p-ethyl + ethoxysulfuron resulted in significantly lower grain yield, which could be related to the lower number of panicles/m^2. Higher weed competition might have caused lower panicle production, which adversely affected the yield. The 1000-grain weight, was also seen to be lower in this treatment, though the effect was not statistically significant.

The study shows that mixtures of herbicides applied in one dose are effective in managing weed populations, thereby leading to yields at par with hand weeding. Moreover, if climatic factors make the application of a pre-emergence herbicide difficult, a mixture of herbicides applied at a later stage would still control weeds effectively and produce high yields. An added advantage is that applications of different herbicides as a tank mixture may prove helpful in delaying the problem of herbicide resistance as well as a shift in weed flora, which is invariably associated with the use of a single herbicide (Wrubel and Gressel 1994).

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