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# Effectiveness of triafamone + ethoxysulfuron (pre-mix) against complex weed flora in transplanted rice and its residual effects on wheat

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**ABSTRACT**

Bio-efficacy of triafamone (20%) + ethoxysulfuron (10%) (ready-mix, 30% WG) was evaluated as early post-emergence (1-2 leaf stage of weeds, 15 days after transplanting) against complex weed flora in transplanted rice at CCS Haryana Agricultural University Regional Research Station, Karnal during *Kharif* 2011 and 2012, phyto-toxicity on transplanted rice during *Kharif* 2012 and 2013 and its residual phyto-toxicity on wheat during *Rabi* 2012-13 and 2013-14. Triafamone + ethoxysulfuron 60-67.5 g/ha proved superior or at par with other herbicidal treatments in reducing the dry weight of grassy and broad-leaf weeds to the extent of >99% and 85-94%, respectively, and provided almost complete control of sedges (*Cyperus difformis* and *Fimbristylis miliaceae*) during both the years. There was no significant effect of different treatments on the plant height and panicle length of the rice during both the years. Application of triafamone + ethoxysulfuron 60 g/ha resulted in number of effective tillers (58.7/mrl in 2011 and 78.2/mrl in 2012) at par with triafamone 45 g/ha, butachlor 1250 and 1500 g/ha, and also weed free check during both the years. The grain yield of rice (6.08 t/ha in 2011 and 7.06 t/ha in 2012) due to triafamone + ethoxysulfuron 60 g/ha was higher than its lower dose (52.5 g/ha) but at par with the higher dose (67.5 g/ha), triafamone 45 g/ha, butachlor 1500 g/ha and weed free check during 2011 and 2012; butachlor 1250 g/ha and pretilachlor 1000 g/ha during 2012; but superior to all other herbicidal treatments during both the years. There were no visual phyto-toxicity symptoms of triafamone + ethoxysulfuron on rice crop and also no residual phyto-toxicity on succeeding wheat crop even up to 120 g/ha.

## INTRODUCTION

Weed infestation in transplanted rice has been reported to cause yield reductions of 27-68% in India (Singh *et al.* 2003, Yadav *et al.* 2009, Manhas *et al.* 2012, Duary *et al.* 2015, Hossain and Malik 2017). Most of the herbicides recommended for transplanted rice (butaclor, pretilachlor, anilofos and oxadiargyl) are applied as pre-emergence. But, dry spell or lack of irrigation particularly during initial growth stage after transplanting reduces the efficacy of pre-emergence herbicides and the crop suffers from serious infestation of complex weed flora. There is thus a need of some post-emergence herbicide with broad spectrum weed control. Bispyribac-sodium is currently the most commonly used herbicide for post-emergence (20-25 days after transplanting) control of weeds in transplanted rice (Yadav *et al.* 2009). Penoxsulam is another option as an early post-emergence (10-12 days after transplanting) herbicide in transplanted rice (Mishra *et al.* 2007, Yadav *et al.* 2008). However, it has been observed that single application of either pre-emergence or post-emergence herbicide does not provide effective control of complex weed flora throughout the crop season. Some of broad-leaf weeds and sedges are not controlled effectively by alone application of these herbicides. Farmers often use 2,4-D, metsulfuron + chlorimuron, ethoxysulfuron or pyrazosulfuron as sequential post-emergence herbicides, which add to the cost of weed management. Bispyribac-sodium and penoxsulam based combinations were found less effective against *Leptochloa chinensis* and *Ludwigia parviflora* as compared to premix of triafamone + ethoxysulfuron (Menon *et al.* 2016). Farmers desire to achieve satisfactory weed control through single shot application of ready-mix or tank-mix combination of compatible herbicides at reduced cost and energy. Therefore, information on bio-efficacy of

herbicide combinations particularly new herbicides is essential to achieve more efficient weed management. The objective of the present investigation was to evaluate the bio-efficacy of triafamone + ethoxysulfuron (ready-mix) as post-emergence herbicide against complex weed flora in transplanted rice and also its residual effects in succeeding wheat crop.

## MATERIALS AND METHODS

A field experiment was conducted to evaluate the performance of triafamone (20%) + ethoxysulfuron (10%) 30% WG against complex weed flora in transplanted rice at CCS HAU Regional Research Station, Karnal during *Kharif* 2011 and 2012. The treatments included triafamone + ethoxysulfuron at 52.5, 60, 67.5 g/ha, triafamone 20% SC 45 g/ha, ethoxysulfuron 15%WG 22.5 g/ha at 1-2 leaf stage *i.e.* 15 days after transplanting (DAT), butachlor 50% EC 1250 or 1500 g/ha, pretilachlor 50%EC 625 or 1000 g/ha at 0-3 DAT, pyrazosulfuron ethyl 10% WP 15 g/ha at 15 DAT, along with weed free (two hand weedings at 25 and 45 DAT) and untreated checks. The experiment was laid out in randomized block design with three replications. Transplanting of rice cultivar *HKR 47* was done on 22 July, 2011 and 11 July 2012. The transplanting was done at a spacing of 20 x 15 cm in a plot size of 6.1 x 2.4 m. The post-emergence herbicides were applied as spray using knap-sack sprayer fitted with flat fan nozzle in a spray volume of 300 litres/ha, and the pre-emergence herbicides as sand mix broadcast using 150 kg sand/ha. Water was drained out at the time of application of the post-emergence herbicides and re-irrigated 24 hours after spray. Crop was raised as per the recommendations of the state University and harvested on 27 October, 2011 and 23 October, 2012. Density and dry weight of weeds were recorded at 60 DAT and yield and yield attributes at maturity. Visual pyto-toxicity (yellowing, chlorosis, stunting or scorching) (on 0-10 point scale) under different treatments in rice was also recorded at 15 days after herbicide application (DAA).

Another experiment was conducted to assess the phyto-toxicity of triafamone + ethoxysulfuron on transplanted rice during *Kharif* 2012 and 2013 and residual phyto-toxicty on succeeding wheat during *Rabi* 2012-13 and 2013-14. Three treatments, *viz.* triafamone + ethoxysulfuron at 60 and 120 g/ha and untreated check were also kept with three replications with plot size of 6.1 x 2.4 m. The herbicide was applied at 15 DAT in rice (Var. *HKR 47*) transplanted on 11 July 2012 and 7 July 2013 at spacing of 20 x 15 cm. After harvest of rice in October, wheat was sown on 20 November, 2012 (*DPW 621-50*) and 17 November 2013 (*WH 711*) using the seed rate of 100-112.5 kg/ha (row spacing 20 cm). Visual pyto-toxicity (yellowing, chlorosis, stunting or scorching) (on 0-10 point scale) under different treatments in rice was also recorded at 3, 7, 15 and 30 days after herbicide application (DAA), and in wheat at 15 and 30 days after sowing (DAS).

Before statistical analysis, the data on density of weeds was subjected to square root $(\sqrt{x+1})$ transformation to improve the homogeneity of the variance. The data were subjected to the analysis of variance (ANOVA) separately for each year. The significant treatment effect was judged with the help of 'F' test at the 5% level of significance. The 'OPSTAT' software of CCS Haryana Agricultural University, Hisar, India was used for statistical analysis (Sheoran *et al.* 1998).

## RESULTS AND DISCUSSION

Major weed flora of the experimental field consisted of *Echinochloa crus-galli, Ammannia baccifera, Cyperus difformis* and *Fimbristylis miliaceae.*

### Effect on weeds

**Grassy weeds**: Density of grassy weed *Echinochloa crus-galli* decreased with increase in dose of triafamone + ethoxysulfuron from 52.5 g/ha to 67.5 g/ha during both the years, however, the differences between successive doses were not significant (**Table 1**). Traifamone + ethoxysulfuron 67.5 g/ha was significantly superior to its lower dose 52.5 g/ha during 2012. Triafamone + ethoxysulfuron 60 g/ha resulted decrease in density of grassy weeds (1.3/$m^2$ in 2011 and 0.7/$m^2$ in 2012) at par with weed free check/ two hand weedings (2 HW) and the check herbicides butachlor 1250-1500 g/ha and pretilachlor 1000 g/ha, but significantly lower than pyrazosulfuron 15 g/ha, ethoxysulfuron 22.5 g/ha and pretilachlor 650 g/ha. Similarly triafamone 20%SC 45 g/ha was also at par with weed free check and the check herbicides butachlor 1250-1500 g/ha and pretilachlor 1000 g/ha, but superior to pretilachlor 625 g/ha in respect of density of *E. crus-galli.*

Dry weight of grassy weeds decreased with increase in dose of triafamone + ethoxysulfuron, however, the differences between 52.5 g/ha and its higher doses were significant only during 2011 (**Table 2**). Triafamone + ethoxysulfuron 60-67.5 g/ha (0.0-0.6 g/$m^2$ in 2011 and 0.0-0.2 g/$m^2$ in 2012) was at par

**Table 1. Effect of different herbicides on density of weeds (no./m$^2$) in transplanted rice (*Kharif* 2011 and 2012)**

| Treatment | Dose (g/ha) | *Echinochloa crus-galli* | | *Ammannia baccifera* | | *Cyperus difformis* | | *Fimbristylis miliaceae* |
|---|---|---|---|---|---|---|---|---|
| | | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 |
| Triafamone+ethoxysulfuron-30%WG | 35+17.5 | 2.20(4.0) | 2.10(4.0) | 6.36(40.0) | 5.66(31.3) | 1.0(0) | 1.0(0) | 1.0(0) |
| Triafamone+ethoxysulfuron-30%WG | 40+20 | 1.41(1.3) | 1.24(0.7) | 5.82(34.0) | 3.48(11.3) | 1.0(0) | 1.0(0) | 1.0(0) |
| Triafamone+ethoxysulfuron-30%WG | 45+22.5 | 1.0(0) | 1.0(0) | 5.60(30.7) | 3.95(14.7) | 1.0(0) | 1.0(0) | 1.0(0) |
| Triafamone 20%SC | 45 | 1.41(1.3) | 1.41(1.3) | 7.71(58.7) | 6.88(46.7) | 1.0(0) | 1.0(0) | 1.0(0) |
| Ethoxysulfuron 15%WG | 22.5 | 5.46(29.3) | 6.12(36.7) | 5.80(33.3) | 4.67(21.3) | 1.0(0) | 1.0(0) | 1.0(0) |
| Pyrazosulfuron ethyl 10%WP | 15 | 4.18(16.7) | 5.62(30.7) | 4.51(20.0) | 5.95(34.7) | 1.0(0) | 1.0(0) | 1.0(0) |
| Butachlor 50%EC | 1250 | 2.32(4.7) | 1.96(3.3) | 5.59(30.7) | 2.10(4.0) | 2.8(8.7) | 1.0(0) | 1.0(0) |
| Butachlor 50%EC | 1500 | 1.24(0.7) | 1.0(0) | 6.02(35.3) | 1.90(2.7) | 1.0(0) | 1.0(0) | 1.0(0) |
| Pretilachlor 50%EC | 625 | 2.71(8.0) | 3.05(8.7) | 5.80(32.7) | 4.31(18.0) | 2.5(6.7) | 1.0(0) | 1.0(0) |
| Pretilachlor 50%EC | 1000 | - | 1.0(0) | - | 2.08(4.0) | - | 1.0(0) | - |
| Two hand weedings | | 1.0(0) | 1.0(0) | 1.00(0.0) | 1.00(0.0) | 1.0(0) | 1.0(0) | 1.0(0) |
| Weedy check | | 5.90(34.0) | 6.43(40.7) | 10.68(113.3) | 8.36(69.3) | 3.6(12.7) | 2.2(4.0) | 2.1(4.0) |
| LSD p=0.05 | | 1.29 | 0.95 | 1.11 | 1.10 | 1.07 | 0.22 | 0.52 |

*Original figures in parentheses were subjected to square root ($\sqrt{x+1}$) transformation before statistical analysis

**Table 2. Effect of different herbicides on dry weight of weeds (g/m$^2$) in transplanted rice (*Kharif* 2011 and 2012)**

| Treatment | Dose (g/ha) | Grassy weeds | | Broad-leaf weeds | | Sedges | |
|---|---|---|---|---|---|---|---|
| | | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| Triafamone+ethoxysulfuron-30%WG | 35+17.5 | 25.4 | 11.8 | 1.6 | 1.0 | 0 | 0 |
| Triafamone+ethoxysulfuron-30%WG | 40+20 | 0.6 | 0.2 | 0.4 | 0.6 | 0 | 0 |
| Triafamone+ethoxysulfuron-30%WG | 45+22.5 | 0 | 0 | 0.4 | 0.6 | 0 | 0 |
| Triafamone 20%SC | 45.0 | 5.6 | 3.3 | 2.9 | 1.7 | 0 | 0 |
| Ethoxysulfuron 15%WG | 22.5 | 193.1 | 203.2 | 0.5 | 0.6 | 0 | 0 |
| Pyrazosulfuron ethyl 10%WP | 15.0 | 115.0 | 195.4 | 1.1 | 0.7 | 0 | 0 |
| Butachlor 50%EC | 1250 | 35.5 | 0 | 1.0 | 0.9 | 0.5 | 0 |
| Butachlor 50%EC | 1500 | 6.3 | 0 | 1.1 | 0.3 | 0 | 0 |
| Pretilachlor 50%EC | 625 | 23.0 | 42.0 | 0.8 | 1.2 | 0.4 | 0 |
| Pretilachlor 50%EC | 1000 | - | 0 | - | 0.8 | - | 0 |
| Two hand weedings | | 0.0 | 0 | 0 | 0 | 0 | 0 |
| Weedy check | | 231.5 | 236.5 | 6.2 | 4.0 | 2.9 | 2.1 |
| LSD p=0.05 | | 20.9 | 50.6 | 1.3 | 0.7 | 0.7 | 0.4 |

with triafamone 45 g/ha, butachlor 1500 g/ha and two hand weeding, and was better than all other herbicidal treatments in respect of dry weight of grassy weeds during 2011, but better than ethoxysulfuron 22.5 g/ha and pyrazosulfuron 15 g/ha and at par with all other herbicidal treatments during 2012.

**Broad-leaf weeds**: The different treatments of triafamone + ethoxysulfuron were at par with each other in respect of density of *Ammannia baccifera*, except that at 52.5 g/ha, it was inferior to the higher doses during 2012 (**Table 1**). All the treatments of triafamone + ethoxysulfuron were better than triafamone 45 g/ha alone in respect of density of *Ammannia baccifera* during both the years. During 2011, triafamone + ethoxysulfuron 60 g/ha reduced the density of broad-leaf weeds statistically similar to ethoxysulfuron 22.5 g/ha and inferior to pyrazosulfuron 15 g/ha, but it was superior to these herbicides during 2012. During 2011, triafamone + ethoxysulfuron 60 g/ha was also similar to butachlor and pretilachlor treatments; while during 2012, it had more density of *Ammannia baccifera* than butachlor 1250-1500 g/ha and pretilachlor 1000 g/ha but at par with pretilachlor 625 g/ha.

Different doses of triafamone + ethoxysulfuron were at par with each other in respect of dry weight of broad-leaf weeds during both the years (**Table 2**). Triafamone + ethoxysulfuron 60 g/ha was at par while 52.5 g/ha was inferior to 2-HW. Triafamone + ethoxysulfuron 60 g/ha (0.4 g/m$^2$ in 2011 and 0.6 g/ m$^2$ in 2012) was at par with all other herbicidal treatments in respect of dry weight of broad-leaf weeds during both the years.

**Sedges**: There was almost complete control of sedges *Cyperus difformis* and *Fimbristylis miliaceae* with triafamone + ethoxysulfuron at all the doses and was similar to all other herbicidal treatments and better than the untreated check, in respect of density (**Table 1**) and dry weight (**Table 2**) of sedges during both the years.

Compared to combination of bispyribac-sodium with chlorimuron + metsulfuron, premix of triafamone + ethoxysulfuron 60 g/ha was more

effective against *Leptochloa chinensis* and it recorded lowest weed dry matter production in transplanted rice (Menon *et al*. 2016), however, it was relatively less effective against *E. crusgalli*. Abeysekhara and Wickrama (2004) have also reported that bispyribac-sodium does not control *L. chinensis*. Therefore, such information would be useful for farmers to make appropriate choice depending on weed flora in their fields.

**Effect on crop**

There was no significant effect of different treatments on the plant height and panicle length of the crop during both the years (**Table 3**). Number of effective tillers/mrl increased with increase in dose of triafamone + ethoxysulfuron but the differences were not always significant. Triafamone + ethoxysulfuron 60 g/ha produced effective tillers (58.7 mrl in 2011 and 78.2 mrl in 2012) at par with triafamone 45 g/ha, butachlor 1250, 1500 g/ha and weed free check during both the years. It was at par with pretilachlor 625 g/ha during 2011 and with pretilachlor 1000 g/ha during 2012.

The grain yield of rice under triafamone + ethoxysulfuron 60 g/ha (6.08 t/ha in 2011 and 7.06 t/ha in 2012) was higher than its lower dose (52.5 g/ha) and at par with the higher dose (67.5 g/ha) during both the years (**Table 3**), indicating it to be the optimum dose. Triafamone + ethoxysulfuron 60-67.5 g/ha was at par with triafamone 45 g/ha, butachlor 1500 g/ha and weed free check during both the years; butachlor 1250 g/ha and pretilachlor 1000 g/ha during 2012 and it was superior to all other herbicidal treatments in respect of grain yield of rice during both the years. Menon *et al*. (2016) have also reported that among different herbicidal treatments, the grain yield of rice was maximum in plots treated with triafamone + ethoxysulfuron 60 g/ha as it controlled complex weed flora very effectively. Hossain and Malik (2017) also reported that triafamone + ethoxysulfuron 60 g/ha produced grain yield of transplanted rice similar to other herbicidal combinations. Contrarily, Kailkhura *et al*. (2015) found that penoxsulam + cyhalofop-butyl (ready-mix) 135 g/ha and pre-emergence application of pendimethalin 1000 g/ha *fb* post-emergence application of bispyribac-sodium 25 g/ha due to better weed control produced more grain yield of transplanted rice than triafamone + ethoxysulfuron 60 g/ha.

Weeds allowed to grow throughout the crop season reduced the grain yield of transplanted rice to the extent of 31.2% and 39.4% during 2011 and 2012, respectively. This is in agreement with earlier reports elsewhere (Singh *et al*. 2003, Yadav *et al*. 2009, Manhas *et al*. 2012, Duary *et al*. 2015, Hossain and Malik 2017)

**Crop injury**

There was no visual crop injury of any of the herbicidal treatments in the bio-efficacy trial in respect of phyto-toxicity symptoms (yellowing, chlorosis, stunting or scorching), indicating that all the herbicides were safe to the transplanted rice crop during *Kharif* 2011 and 2012 (**Table 3**). Triafamone + ethoxysulfuron did not cause any phyto-toxicity on rice crop even up to 120 g/ha, indicating its safety up to 2X dose. Also, there was no residual phyto-toxicity of triafamone + ethoxysulfuron up to 120 g/ha on succeeding wheat crop during *Rabi* seasons of 2012-13 and 2013-14 (**Table 4**).

Based on the present investigation, it was concluded that triafamone + ethoxysulfuron 30%WG

**Table 3. Effect of different herbicides on phyto-toxicity, plant height, yield attributes and yield of transplanted rice (*Kharif* 2011 and 2012)**

| Treatment | Dose (g/ha) | Visual phy-toxicity (%) | | Plant height (cm) | | No. of effective tillers/ mrl | | Panicle length (cm) | | Grain yield (t/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 | 2011 | 2012 |
| Triafamone+ethoxysulfuron-30%WG | 35+17.5 | 0 | 0 | 95.8 | 121.8 | 55.0 | 73.3 | 20.3 | 21.7 | 5.70 | 6.58 |
| Triafamone+ethoxysulfuron-30%WG | 40+20 | 0 | 0 | 96.1 | 121.7 | 58.7 | 78.2 | 20.3 | 22.0 | 6.08 | 7.06 |
| Triafamone+ethoxysulfuron-30%WG | 45+22.5 | 0 | 0 | 94.9 | 122.0 | 59.0 | 77.2 | 20.3 | 21.7 | 6.01 | 7.07 |
| Triafamone 20%SC | 45 | 0 | 0 | 96.2 | 121.9 | 57.8 | 75.8 | 20.3 | 21.9 | 5.88 | 6.75 |
| Ethoxysulfuron 15%WG | 22.5 | 0 | 0 | 94.9 | 121.2 | 46.8 | 53.3 | 20.3 | 21.7 | 4.66 | 5.20 |
| Pyrazosulfuron ethyl 10%WP | 15.0 | 0 | 0 | 96.6 | 121.7 | 49.8 | 59.8 | 20.1 | 21.7 | 5.13 | 5.55 |
| Butachlor 50%EC | 1250 | 0 | 0 | 96.1 | 121.4 | 55.3 | 76.3 | 20.3 | 21.9 | 5.69 | 6.76 |
| Butachlor 50%EC | 1500 | 0 | 0 | 95.3 | 121.5 | 58.2 | 78.3 | 20.5 | 21.9 | 6.0 | 7.02 |
| Pretilachlor 50%EC | 625 | 0 | 0 | 95.5 | 122.1 | 55.7 | 72.5 | 20.5 | 21.5 | 5.71 | 6.56 |
| Pretilachlor 50%EC | 1000 | 0 | 0 | - | 121.1 | - | 78.2 | - | 22.1 | - | 7.14 |
| Two hand weeding | | 0 | 0 | 96.3 | 121.7 | 59.7 | 79.7 | 20.6 | 22.1 | 6.18 | 7.23 |
| Weedy check | | 0 | 0 | 94.7 | 121.6 | 41.8 | 47.2 | 19.6 | 21.4 | 4.25 | 4.38 |
| LSD p=0.05 | | | | NS | NS | 3.9 | 5.4 | NS | NS | 0.36 | 0.48 |

**Table 4. Phyto-toxicity (0-10 scale) of triafamone + ethoxysulfuron 30% WG on transplanted rice (*Kharif* 2012 and 2013) and succeeding wheat crop (*Rabi* 2012-13 to 2013-14)**

| Treatment | Dose (g/ha) | 3 DAA* | | 7 DAA | | 15 DAA | | 30 DAA | |
|---|---|---|---|---|---|---|---|---|---|
| | | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 | 2012 | 2013 |
| *Rice* | | | | | | | | | |
| Triafamone+ethoxysulfuron-30%WG | 60 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Triafamone+ethoxysulfuron-30%WG | 120 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Untreated check | - | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| *Wheat* | | | | | | 2012-13 | 2013-14 | 2012-13 | 2013-14 |
| | | | | | | 15 DAS | | 30 DAS | |
| Triafamone+ethoxysulfuron-30%WG | 60 | | | | | 0.0 | 0.0 | 0.0 | 0.0 |
| Triafamone+ethoxysulfuron-30%WG | 120 | | | | | 0.0 | 0.0 | 0.0 | 0.0 |
| Untreated check | - | | | | | 0.0 | 0.0 | 0.0 | 0.0 |

*DAA, days after herbicide application

60-67.5 g/ha applied at 1-2 leaf stage of weeds (15 DAT) in a spray volume of 300 liter water/ha provided effective control of complex weed flora with significant improvement in grain yield of transplanted rice. There was no phyto-toxicity of this herbicide up to 120 g/ha on transplanted rice and also no residual toxicity on succeeding wheat crop.

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