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Promising post-emergence herbicides for effective management of broad-leaved weeds in soybean

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ABSTRACT

A field experiment was conducted during rainy (*Kharif*) seasons of 2013 and 2014 at Agriculture Research Station, Mahatma Phule Agricultural University, Kasbe Digraj, Sangli, Maharashtra. Significant weed density reduction was recorded with fluthiacet-methyl at increased application rates of 5 g/ha to 15 g/ha. Fluthiacet-methyl 15 g/ha + 0.25% NIS controlled broad-leaved weeds effectively. Biomass and total broad-leaved weed density were the lowest with fluthiacet-methyl 15 g/ha + 0.25% NIS. Weed control efficiency was higher (80.86%) with fluthiacet-methyl 15 g/ha + 0.25% NIS. Seed yield was the highest (1.91 and 1.93 t/ha during 2013 and 2014, respectively) in weed free plot followed by fluthiacet-methyl 15 g/ha + 0.25% NIS applied as post-emergence (2-5 leaf stage of weeds) with the highest B:C ratio.

Soybean (*Glycine max* L.) is mostly grown for oil (20%) and protein (40%) around the world. Weeds are the major biotic factor responsible for poor soybean yield. Malik *et al*. (2006) have reported 55% soybean yield reduction with broad-leaved weeds (80%), grasses and sedges (20%) infestation throughout the crop season. Major broad-leaved weeds of soybean are *Celosia argentia, Digera arvensis, Commelina benghalensis,* and *Amaranthus viridis* (Pratap Singh and Rajkumar 2008). Soybean yield can be enhanced by almost 50% by adopting timely weeding (Tewari *et al*. 1991). Farmers are mostly using pre-plant incorporated or pre-emergence herbicides for weed control in soybean, but their efficacy is reduced due to variation in climatic and edaphic factors (Mahendra Singh *et al.* 2013). Hence, there is a need to explore the possibility of post-emergence herbicides for effective control of weeds in soybean. Therefore, an experiment was conducted to assess the efficacy of fluthiacet-methyl in managing the broad-leaved weeds in soybean.

A field experiment was conducted at Agriculture Research Station (ARS), Mahatma Phule Agricultural University, Kasbe Digraj, Sangli, Maharashtra, India during *Kharif* seasons of 2013 and 2014. Average rainfall of station is 692.4 mm in 49 rainy days. The experiment was laid out in medium black deep soil (0-45 cm depth) which is low in available nitrogen (167 kg/ha) and phosphorus (11.50 kg/ha) content, and high in available potash content (632 kg/ha) with pH 8.27. Twelve treatments, *viz*. control, fluthiacet-methyl (10.3% EC) 7.5, 10.0, 12.8 and 15 g/ha, fluthiacet-methyl + 0.25% NIS EC 7.5, 10.0, 12.8 and 15 g/ha, imazethapyr (10% SL) 100 g/ha, chlorimuron (25% WP) 9 g/ha, weed free and untreated check (UTC) were replicated thrice in a randomized block design. The gross and net plot size of the experiment were 5 x 3.6 m and 4.5 x 2.7 m, respectively. Soybean seed (75 kg/ha) of variety *'KDS-344'* was sown on 15 July, 2013 and 10 July, 2014 at 45 x 5 cm spacing. Crop was applied with recommended dose of fertilizer *i.e*. 75:50:0 N: P_2O_5:K_2O kg/ha. All the herbicides were sprayed with knapsack sprayer fitted with flat-fan nozzle using 500 litres of water per hectare.

Data on weeds (weed density, weed biomass) were subjected to square root transformation. Crop was harvested on 6 November, 2013 and 1 November, 2014. All the herbicides were applied as post-emergence at 2-5 leaf stage of weed. Data on species wise weed density at pre-spray (before herbicide application) and 30 DAA of fluthiacet-methyl was recorded. Individual broad-leaved weeds were recorded using a quadrant of 1 × 1m from three random spots per plot and the average was reported as weed density (no./m^2). The total broad-leaved weeds were oven dried and weed dry matter was recorded at 30 DAA and expressed as biomass

(g/m^2). Data of both weed density and biomass was analyzed statistically using suitable square root transformation. Weed control efficiency (WCE) was calculated for total broad-leaved weeds using the weed biomass with the following formula.

$$WCE = \frac{\text{Weed biomass in UTC} - \text{Weed biomass of weeds in treatments}}{\text{Biomass of weeds in UTC}}$$

The crop was harvested at physiological maturity. After the harvest, threshing was done and seed yield of each treatment was recorded and expressed as t/ha. The yield attributes, *viz*. number of pods/plants; number of seeds/pod and 100 seed weight (g) were recorded. Gross returns, net returns as well as B:C ratio were worked out using prevailing prices of inputs and outputs.

Effect on weeds

Major broad-leaved weed species in soybean field before spraying were *Acalypha indica* (24.37% during 2013 and 19.18% during 2014), *Digera arvensis* (21.52% during 2013 and 16.48% during 2014), *Commelina benghalensis* (17.45% during 2013 and 21.15% during 2014), *Amaranthus viridis* (19.13% during 2013 and 20.96% during 2014), and other species include *Parthenium hysterophorus, Trianthema portulacastrum* and *Portulaca oleracea* (18.49% during 2013 and 21.27% during 2014) (**Table 1**). Total broad-leaved weed species were controlled effectively by fluthiacet-methyl 15 g/ha + 0.25% NIS (applied at 2-5 leaf stage of weeds) resulting in significantly reduced weed density as reported by Hayes (2008). Number of broad-leaved weed species, at 30 days after application, was higher (56.64 no./m^2) in weedy check and lowest with fluthiacet-methyl 15 g/ha + 0.25% NIS (4.68 no./m^2). Among the broad-leaved weed species, weed density at 30 days after application was highest for *Acalypha indica* (13.02 no./m^2), *Digera arvensis* (12.06 no./ m^2), *Commelina benghalensis* (11.98 no./m^2) and *Amaranthus viridis* (10.66 no./m^2) in untreated plot.

The species *Acalypha indica*, *Commelina benghalensis* were controlled effectively by fluthiacet-methyl 15 g/ha + 0.25% NIS, which has recorded significantly lower weed density than rest of the treatments except fluthiacet-methyl 12.8 g/ha + 0.25% NIS and fluthiacet-methyl 15 g/ha. Effective control with significantly lower weed density of *D.*

Table 1. Broad-leaved weed density, weed biomass and weed control efficiency as influenced by fluthiacet-methyl in soybean (average of two years)

Treatment	Broad-leaved weed density before spraying (no./m^2)						Broad-leaved weed density at 30 DAA (no./m^2)						Weed Biomass at 30 DAA (g/m^2)	WCE (%)
	CB	AI	DA	AV	Others	Total	CB	AI	DA	AV	Others	Total		
Fluthiacet-methyl 7.5 g/ha	2.9 (7.67)	3.0 (8.03)	2.8 (6.89)	2.9 (7.42)	2.6 (5.88)	6.1 (35.9)	2.2 (3.98)	2.2 (3.82)	2.5 (5.45)	2.2 (3.95)	2.1 (3.34)	4.6 (20.5)	7.3 (52.3)	51.67
Fluthiacet-methyl 10 g/ha	2.9 (7.49)	3.0 (7.99)	2.9 (7.56)	2.8 (6.96)	2.8 (6.67)	6.1 (36.7)	2.1 (3.45)	2.2 (3.89)	2.3 (4.08)	2.0 (3.12)	1.9 (2.68)	4.3 (17.2)	7.1 (49.7)	53.79
Fluthiacet-methyl 12.8 g/ha	2.6 (5.98)	2.9 (7.52)	2.7 (6.35)	2.9 (7.55)	2.8 (7.12)	5.9 (34.5)	2.0 (3.02)	2.0 (2.92)	2.0 (2.89)	1.9 (2.56)	1.8 (2.18)	3.8 (13.6)	5.5 (29.0)	67.47
Fluthiacet-methyl 15 g/ha	2.9 (7.36)	2.9 (7.45)	2.8 (6.98)	2.8 (6.84)	2.7 (6.13)	6.0 (34.8)	1.1 (0.24)	1.4 (0.89)	1.6 (1.60)	1.8 (2.12)	1.6 (1.56)	2.7 (6.39)	4.3 (17.9)	74.35
Fluthiacet-methyl 7.5 g/ha + 0.25% NIS	3.0 (7.82)	3.1 (8.32)	2.8 (6.72)	3.0 (7.96)	3.0 (8.30)	6.3 (39.1)	2.4 (4.78)	2.3 (4.26)	2.3 (4.20)	2.3 (4.45)	1.9 (2.52)	4.6 (20.2)	7.0 (47.8)	55.87
Fluthiacet-methyl 10 g/ha + 0.25% NIS	2.6 (5.78)	2.9 (7.67)	2.9 (7.67)	2.8 (7.05)	2.9 (7.28)	6.0 (35.4)	2.0 (3.04)	2.1 (3.34)	2.1 (3.22)	1.9 (2.75)	1.6 (1.58)	3.9 (13.9)	5.5 (29.5)	67.02
Fluthiacet-methyl 12.8 g/ha + 0.25% NIS	2.7 (6.24)	3.0 (8.24)	2.8 (6.82)	2.9 (7.68)	3.0 (7.84)	6.14 (36.8)	1.2 (0.32)	1.4 (0.95)	1.4 (1.06)	1.7 (1.78)	1.5 (1.36)	2.5 (5.47)	4.3 (17.2)	74.92
Fluthiacet-methyl 15 g/ha + 0.25% NIS	2.6 (6.02)	3.0 (7.92)	2.8 (6.94)	2.9 (7.44)	3.1 (8.92)	6.2 (37.2)	1.1 (0.18)	1.4 (0.89)	1.3 (0.79)	1.7 (1.86)	1.4 (0.96)	2.4 (4.68)	3.8 (13.2)	80.86
Imazethapyr 100 g/ha	2.7 (6.42)	2.8 (7.04)	2.5 (5.42)	2.5 (5.36)	2.6 (5.62)	5.5 (29.9)	2.0 (3.08)	2.1 (3.44)	2.2 (3.72)	2.2 (3.67)	1.8 (2.15)	4.1 (16.1)	5.4 (28.4)	69.56
Chlorimuron ethyl 9 g/ha	2.7 (6.05)	2.7 (6.08)	2.5 (5.18)	2.5 (5.32)	2.5 (5.04)	5.3 (27.7)	2.2 (3.64)	2.2 (3.88)	2.1 (3.58)	2.1 (3.48)	1.8 (2.39)	4.2 (17.0)	6.1 (36.3)	61.91
Weed free	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)	100.00
Untreated	2.9 (7.67)	3.0 (7.95)	2.8 (6.96)	3.0 (7.82)	3.0 (7.96)	6.2 (38.4)	3.6 (12.0)	3.7 (13.0)	3.6 (12.1)	3.4 (10.7)	2.6 (8.92)	7.36 (56.6)	11.0 (120.7)	0
LSD (p=0.05)							0.21	0.20	0.20	0.18	0.14	0.44	0.7	

Others include broad-leaved weed species *viz.*,*Parthenium hysterophorus*, *Trianthema portulacastrum* and *Portulaca oleracea.* CB – *Commelina benghalensis;* AI – *Acalypha indica;* DA – *Digera arvensis*; AV – *Amaranthus viridis*

Data in parentheses are original weed density values; Data was subjected to square root transformation

NIS: Non-ionic surfactant adjuvant; DAA: Days after application

Table 2. Yield attributes and economics of soybean as influenced by various treatments

Treatment	No. of pods/plant		No. of seeds/pod		100 seed weight (g)		Seed yield (t/ha)		Gross returns (x10^3 `/ha)		B:C ratio	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Fluthiacet-methyl 7.5 g/ha	23.3	25.0	3.44	3.48	10.4	11.5	0.91	0.93	27.60	29.15	1.26	1.31
Fluthiacet-methyl 10 g/ha	25.0	25.7	3.44	3.46	10.5	11.1	0.92	0.94	27.90	29.46	1.27	1.33
Fluthiacet-methyl 12.8 g/ha	29.8	31.7	3.50	3.54	10.5	11.0	1.22	1.28	37.00	40.11	1.69	1.81
Fluthiacet-methyl 15 g/ha	40.0	41.1	3.37	3.39	10.7	11.0	1.53	1.63	46.40	51.08	2.11	2.30
Fluthiacet-methyl 7.5 g/ha + 0.25% NIS	26.0	27.5	3.53	3.55	11.0	10.8	0.93	0.97	28.21	30.40	1.28	1.37
Fluthiacet-methyl 10 g/ha + 0.25% NIS	33.0	33.3	3.29	3.27	10.8	10.9	1.19	1.27	36.09	39.80	1.64	1.79
Fluthiacet-methyl 12.8 g/ha + 0.25% NIS	41.0	43.0	3.31	3.33	11.1	10.4	1.65	1.66	50.35	51.40	2.28	2.31
Fluthiacet-methyl 15 g/ha + 0.25% NIS	41.8	43.7	3.43	3.45	10.9	10.8	1.67	1.71	50.65	53.59	2.30	2.40
Imazethapyr 100 g/ha	34.4	35.0	3.53	3.51	10.9	11.0	1.35	1.33	40.95	41.68	1.85	1.87
Chlorimuron ethyl 9 g/ha	31.2	31.8	3.47	3.49	10.7	11.0	1.21	1.23	36.70	38.55	1.66	1.73
Weed free	43.2	45.5	3.46	3.44	10.8	10.9	1.91	1.93	57.93	60.48	2.08	2.10
Untreated	19.0	19.7	3.51	3.53	10.8	10.9	0.72	0.74	21.84	23.19	1.03	1.05
LSD (p=0.05)	2.7	2.7	NS	NS	NS	NS	0.26	0.28				

arvensis, P. hysterophorus, T. portulacastrum and *P. oleracea* was recorded with fluthiacet-methyl 15 g/ha + 0.25% NIS. *Amaranthus viridis* was controlled effectively recording reduced weed density with fluthiacet-methyl 12.8 g/ha + 0.25% NIS compared to rest of the treatments except fluthiacet-methyl 15 g/ha + 0.25% NIS.

Biomass of broad-leaved weeds was reduced with increase in rate of application of fluthiacet-methyl from 7.5 to 15 g/ha. Lowest weed biomass was recorded in fluthiacet-methyl 15 g/ha + 0.25% NIS (13.20 g/m^2). Weed control efficiency was higher (80.86%) in treatment fluthiacet-methyl 15 g/ha + 0.25% NIS.

Yield attributes and economics

The highest seed yield (1.91 and 1.93 t/ha during 2013 and 2014, respectively) was recorded in weed free plot which was significantly higher over rest of the treatments and was at par with fluthiacet-methyl 15 g/ha + 0.25% NIS and fluthiacet-methyl 12.8 g/ha + 0.25% NIS. The lowest seed yield was recorded in untreated plot (**Table 2**). The seed yield of soybean was increased with increased rate of application of fluthiacet-methyl from 7.5 g/ha to 15 g/ha. Number of pods/plant was highest (43.25 and 45.50 during 2013 and 2014, respectively) in weed free plot and found significantly higher over rest of the treatments and was on-par with fluthiacet-methyl 15 g/ha + 0.25% NIS and fluthiacet-methyl 12.8 g/ha + 0.25% NIS. Number of pods/plant was increased as the rate of application of fluthiacet-methyl was increased from 7.5 g/ha to 15 g/ha. The lowest pods/plant was recorded in untreated plot. No. of seeds/pod and 100 seed weight (g) were not significantly different among treatments.

Maximum gross returns was realized under the weed free treatment and it was followed by fluthiacet-methyl 15 g/ha + 0.25% NIS. However, among the different herbicide treatments, fluthiacet-methyl 15 g/ha + 0.25% NIS recorded the highest B:C ratio (2.30 and 2.40 during 2013 and 2014, respectively) followed by fluthiacet-methyl 12.8 g/ha + 0.25% NIS.

It may be concluded that fluthiacet-methyl 15 g/ha + 0.25% NIS controls annual broad-leaved weeds effectively in soybean when applied as an early post-emergence (2-5 leaf stage of weeds) with higher yield and monetary returns.

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