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Short communication

Bio-efficacy of flumioxazine for weed management in soybean and its residual effect on succeeding crops

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Soybean [*Glycine max* (L.) Merrill] is the third largest oilseed crop of India after rapeseed and mustard. It has been observed that soybean yields can be reduced if weeds are not controlled (Vollmann *et al*. 2011 and Mohammadi and Amiri 2011). The reduction in soybean yield due to weed infestation varied from 20-77% depending on the type of soil, season and intensity of weed infestation (Kuruchania *et al*. 2000). Thus, efficient weed management is an essential pre-requisite for increasing the crop productivity. Several new herbicides have been evaluated for their weed control efficacy in soybean. Although, the research has provided a few options involving pre-plant incorporation (trifluralin and fluchloralin), pre-emergence (alachlor, pendimethalin, metolachlor and clomazone) and post-emergence (imazethapyr, quizalofop-ethyl and chlorimuron-ethyl), there is a need to identify newer herbicides for selective management of weeds and to overcome the problem of acquiring resistance by certain weeds against recommended herbicides. Flumioxazine (N-phenylphthalimide) is a new contact herbicide which acts on weeds by inhibiting protoporphyrinogen oxidase, an enzyme important in the synthesis of chlorophyll. In this study, an attempt was made to find the effectiveness of flumioxazine to control broad-leaved weeds and some grassy weeds in soybean and its residual effect on succeeding crops.

The experiment was conducted at Agricultural Research Station, Bhavanisagar, in the Western zone of Tamil Nadu during *Rabi* 2013-14. The experiment was laid out in a randomized block design replicated thrice with eight treatments. The experimental field is located at 11^0 29'N latitude and 77^0 08'E longitude with an altitude of 256 m above MSL. The soil of the experimental field was red sandy clay loam in texture belonging to Typic Paleustalfs, pH 7.4, EC 0.14 dS/m and organic carbon 0.55%. Soil was low in available nitrogen (215 kg/ha), medium in available phosphorus (17.5 kg/ha) and high in available potassium (260 kg/ha). Soybean variety '*CO Soy 3*' with duration of 85-90 days released by TNAU during 2005 was selected for this study. The recommended package and practices was followed as per the; TNAU Crop production guide 2012.

After the harvest of soybean in the monsoon season, two test crops, *viz*. sunflower and pearl millet were raised. The observations such as germination percentage at 10 DAS, plant height and dry matter production at 30 DAS were taken for these test crops. Statistical analysis for all the data pertaining to crop and weeds were carried out using the method suggested by Gomez and Gomez (1984). The original values of weed density were transformed using square root transformation and analyzed statistically. The least significant difference (LSD) at 5% level of probability was worked out for comparison.

Weed flora and density

The major proportion of the weed flora comprised of grasses at all the stages of growth. At later stages of crop growth, the weed density was higher when compared with early stages. Obviously unweeded control resulted in higher grasses, sedge and broad leaved weed densities. Weed density increased significantly from 25 DAS onwards. Higher density of weeds was observed upto 60 DAS. Results are in corroboration with the finding of Nagaraju and Mohankumar (2009) who have recorded maximum density of weeds upto 60 DAS compared to other stages of the soybean crop covering greater portion of the soil at this stage. Halford *et al.* (2001) reported that critical period of weed control in soybean was reported to begin at the first or second node development stage, whereas the end was at the early flowering.

Chemical weed control methods significantly reduced the weed density over unweeded control. Pre emergence (PE) application of flumioxazine at 250,

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150, 125 g/ha and PE application of pendimethalin 1.0 kg/ha recorded lower weed density at all stages of crop growth. It was followed by PE application of flumioxazine at 112.5 g/ha (**Table 1**). The reason might be the PE control of broad spectrum weed control at all stages. It is in conformity with the results of Sangeetha *et al.* (2011). Weed control efficiency indicated the extent of effectiveness of weed biomass reduction by weed control treatments over unweeded control. Different weed control treatments significantly influenced the weed control efficiency. Weed control treatments *viz.*, PE application of flumioxazine at 250, 150, 125, 112.5 and 100 g/ha and PE application of pendimethalin at 1.0 kg/ha recorded more than 70 per cent WCE. During the cropping period higher weed control efficiency was obtained with PE application of flumioxazine at 250 g/ha, followed by PE application of flumioxazine at 150 g/ha. More reduction of weed dry weight by reducing the weed density in these treatments might have resulted in higher WCE (**Table 1**). These finding were in accordance with the results of PE application of flumioxazin in soybean by Billore *et al.* (2007).

Yield attributes and yield

The main yield contributing factors, *viz.* number of pods per plant, number seeds per pod and hundred grain weight were significantly influenced by different weed control treatments. Among the treatments, unweeded check recorded significantly lower number of pods and seeds per pod due to weed competition. Durigan *et al.* (1983) reported that number of pods per plant was the most affected character among yield parameters due to heavy infestation of weeds. Pre-emergence application of flumioxazine at 112.5 g/ha recorded higher value for yield attributes (**Table 2**). This enhanced yield attributes could be due to reduced weed-crop and interplant competition, which resulted in higher availability of moisture and nutrients to the crop and increased light interception. These results were in line with earlier finding of Billore *et al.* (2007) in soybean.

Among the weed control treatment, pre-emergence application of flumioxazine 112.5 g/ha has recorded higher grain and haulm yields. Pre-emergence application of pendimethalin at 1.0 kg/ha, PE flumioxazine at 100 g/ha and hand weeding twice also recorded higher yield (**Table 2**). The increased yield may be due to lesser competition and no phytotoxity resulted in better vegetative growth and favorable yield attributes. Similar results were reported by Sunil Kumar *et al.* (1996) who obtained maximum seed yield of soybean crop from weed free environment by different weed control treatments.

The cost of cultivation was least in unweeded check due to less maintenance. But it was higher in hand weeding twice, because of higher labour input. Gross return, net return and B:C ratio were higher in pre emergence application of flumioxazine at 112.5 g/ ha (**Table 2**). This could be due to higher growth parameters and yield attributes as a result of reduced competition between weeds and crop for water and nutrients. Similar findings were reported by Kushwah and Kushwaha (2001) who reported that highest B:C ratio and monetary returns per rupee invested was obtained by the use of herbicides.

Residual effect of herbicides on succeeding crop

Residual effect of herbicide is one of the important factors for recommending herbicide to the farmers in order to avoid the residual phytotoxity in the succeeding crops. Results indicated that there was no significant difference among the treatments in germination (%), Plant height (cm) and dry matter

Table 1. Effect of treatments on total weed density and weed control efficiency in soybean

Treatment	Total weed density (no./m^2)			Weed control Efficiency (%) at 60 DAS
	25 DAS	45 DAS	60 DAS	
Flumioxazine PE 112.5 g/ha 3 DAS	5.84(32.3)	7.31(51.7)	8.30(67.0)	78
Flumioxazine PE 125 g/ha 3 DAS	5.29(26.0)	6.43(39.3)	7.28(51.1)	82
Flumioxazine PE 150 g/ha 3 DAS	4.51(18.3)	5.80(31.7)	6.56(41.3)	84
Flumioxazine PE 250 g/ha 3 DAS	3.83(12.7)	5.03(23.3)	5.50(28.3)	88
Pendimethalin PE 1000 g/ha 3 DAS	5.94(33.3)	7.01(47.3)	8.25(66.7)	74
Oxyflourfen PE 125 g/ha 3 DAS	7.94(61.3)	9.04(80.0)	10.5(109)	66
Chlorimuron-ethyl 9 g/ha 10 DAS	10.2(103)	11.1(122)	11.7(136)	60
Hand weeding twice at 25 and 45 DAS	16.3(265)	8.48(70.0)	7.95(61.3)	76
LSD (p=0.05)	0.93	1.05	1.25	-

DAS = Days after seeding; PE = Pre-emergence; Figures in parentheses are mean of original values; Data were subjected to square root transformation

Table 2. Effect of treatments on soybean yield attributes, yield and economics

Treatment	No. of pods/ plant	No. of seeds/ pod	100 seed weight (g)	Grain yield (t/ha)	Haulm yield (t/ha)	Harvest index (%)	Net returns (x10³ `/ha)	B:C ratio
Flumioxazine PE112.5 g/ha 3 DAS	85.9	3.7	12.1	1.90	2.44	43.77	30.95	2.19
Flumioxazine PE 125 g/ha 3 DAS	79.3	3.3	10.3	1.43	2.41	37.24	19.38	1.75
Flumioxazine PE 150 g/ha 3 DAS	76.3	3.0	10.5	1.40	2.33	37.48	15.98	1.61
Flumioxazine PE 250 g/ha 3 DAS	63.9	2.9	10.3	1.32	2.07	38.96	13.46	1.51
Pendimethalin PE1000 g/ha 3 DAS	84.3	3.6	11.6	1.88	2.43	43.61	29.14	2.07
Oxyflourfen PE 125 g/ha 3 DAS	77.2	3.5	11.0	1.60	2.23	41.82	21.33	1.80
Chlorimuron-ethyl 9 g/ha 10 DAS	76.3	3.3	10.9	1.45	2.11	40.71	17.31	1.66
Hand weeding twice 25 and 45 DAS	81.3	3.5	11.1	1.81	2.30	44.06	17.41	1.47
LSD (p=0.05)	5.75	NS	0.85	0.26	0.29	-	-	-

DAS = Days after seeding; PE = Pre-emergence

production (kg/ha) at 30 DAS and it was evident that there was no residual toxicity due to the application of flumioxazine at all doses in the succeeding crops. It is in conformity with the results by Raskar and Bhoi (2002) who reported no carry over effect of PE application of various herbicides on succeeding crop of potato.

It was concluded that the application of flumioxazine at 112.5 g/ha as pre-emergence provides an option to farmers to manage weeds effectively without any phytotoxic effect on succeeding sunflower and pearl millet crops.

SUMMARY

A Field experiment was conducted at Agricultural Research Station, Bhavanisagar of Tamil Nadu Agricultural University during *Rabi* 2013-14 to study the bio-efficacy evaluation of flumioxazine for weed control in soybean. Higher weed control efficiency was obtained with pre-emergence application of flumioxazine at 250 g/ha followed by its lower dose of 150 g/ha. Among the treatments, pre-emergence application of flumioxazine at 112.5 g/ha recorded increased yield and economic returns in soybean. Hence, the pre-emergence application of flumioxazine at 112.5 g/ha was found to reduce the weed density below the economic threshold level and increased the yield and net return in soybean without any phytotoxic effect on the crop and residual effect on the succeeding crop.

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