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Bioefficacy and phytotoxicity of imazethapyr on the predominant weeds in soybean (*Glysine max* [L.] Merill)

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Soybean [*Glysine max* (L.) Merill] is a crop of global importance. From nutritional point of view, soybean seed contains 39-43 per cent protein and 20 per cent fat. As a leguminous crop, it can fix a large amount of atmospheric nitrogen through its root nodule, and produces the highest yield of edible protein per hectare. The loss of soybean yield due to weeds as high as 43% in untreated control (Kundu *et al*., 2011) indicating the necessity of weed management for exploiting the yield potential of soybean.

The manual and mechanical methods of weed control, besides being less effective, are costly and time consuming. Mechanical weeding was partially effective due to non-removal of weeds in intra-rows. Kamalabai and Nanjappa (2003) reported that all herbicidal treated plots gave significantly lower weed dry weight compared to weedy check in soybean. Thus use of herbicides plays a pivotal role in control of weeds at initial stages of crop growth. In search of new herbicides, the efficiency of imazethapyr 10% SL supplied by M/S Insecticides (India) Ltd., Delhi against predominant weeds in soybean was evaluated, apart from crop safety.

The field experiment was conducted during rainy season at the Instructional farm of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, situated at $23^0$24'N latitude, $88^0$31'E longitude with an elevation of 9.75 meters above mean sea level. The soil type of the experimental site was sandy loam in texture and grouped under inceptisol, having pH 6.89, organic carbon 0.568, total nitrogen 0.0566%, available phosphorus 26.1 kg ha^{-1}, and available potassium 119.8 kg ha^{-1}. The experimental site belongs to the sub-tropical humid climate, the mean maximum temperatures falling from June and reaches minimum in January, temperature ranges during crop period 15.1 to 33.9^0 C and the rainfall ranges from 0 to 406.1 mm per week and maximum and minimum relative humidity was 99% and 51% respectively.

The field experiment was laid out in randomized block design with eight different weed management practices with three replications. The treatments were imazethapyr 10% SL (IIL Sample) at 50, 100 and 200g ha^{-1}, imazethapyr 10% SL (market Sample) 100g ha^{-1}, pendimethalin 30% EC 1.0 kg ha^{-1}, alachlor 50% EC 2.5 kg ha^{-1}, weedy check and weed free check. Soybean cv. PK-327 was sown at 100 kg ha^{-1} in furrows at 5 cm depth with a spacing of 30×10 cm and a fertilizer dose of 20:40:40 kg ha^{-1} of N, P_2O_5 and K_2O as basal and thoroughly mixed with the soil. The herbicides were sprayed on 3 DAS using spray volume of 500 l ha^{-1} with knapsack sprayer having flat fan nozzle. Bio-efficacy evaluation was done by recording the density and biomass of the major weed flora on 50×50cm quadrate in soybean field on 25 and 40 DAS.

Phytotoxicity observations on leaf injury on tips/surface, necrosis, wilting, vein clearing, epinasty and hyponasty on soybean plants were recorded 15, 20, 30, 40, 50 DAS in all treatments. The leaf injury on tips or surface was estimated based on phytotoxicity rating scale (PRS) of 0 (no toxicity) to 10 (100% toxicity) scale.

The weed flora observed were *Echinochloa colona*, *Dactyloctanium aegyptium*, *Eleusine indica* (among grassy weeds); *Cyperus rotundus* (a sedge) and *Alternanthera sessilis*, *Amaranthus viridis*, *Corchorus acutangulus*, *Digera arvensis*, *Euphorbia hirta*, *Melilotus alba*, *Phyllanthus niruri*, *Croton sparsiflorus* (among the broad leaved weeds) at one or the other stage of crop growth. The dominant weeds were *Dactyloctanium aegyptium*, *Echinochloa colona*, *Cyperus rotundus*, *Corchorus acutangulus* and *Digera*

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Table 1: Bio-efficacy of imazethapyr on density of major weed species (no. m^{-2}) in soybean at 25 and 40 days after application

Treat-ment	*D. aegyptium*		E. colona		Other grasses		*C. rotundus*		*C. acutangulus*		*D. arvensis*		Other BLW	
	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA
T_1	2.8	3.8	4.2	10.5	14.2	21.5	28.2	48.5	3.8	5.5	3.8	5.5	13.2	22.5
T_2	2.2	3.2	3.8	10.2	13.8	21.2	27.5	47.2	3.8	5.2	3.5	4.5	12.5	21.2
T_3	2.2	2.5	3.5	9.2	13.2	20.2	25.5	44.5	3.2	4.5	2.8	4.2	11.2	19.5
T_4	3.2	3.8	4.5	10.5	14.5	21.5	28.5	48.8	3.8	6.2	4.2	5.5	13.5	23.8
T_5	3.5	4.8	5.5	12.5	19.5	24.2	37.2	58.8	4.5	7.5	5.2	6.5	19.5	27.8
T_6	3.2	4.2	5.2	11.2	15.2	23.5	30.5	51.8	4.5	6.5	4.8	5.8	14.5	24.5
T_7	9.2	12.8	15.8	32.2	53.2	62.8	92.2	170.2	14.2	20.8	16.5	16.8	56.8	76.2
T_8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.8	0.5
SEm(±)	**0.41**	**0.48**	**0.79**	**1.24**	**0.66**	**1.11**	**2.90**	**2.9**	**0.62**	**0.71**	**0.66**	**1.05**	**2.79**	**3.58**
LSD (0.05)	**1.02**	**1.19**	**1.99**	**3.12**	**1.66**	**2.56**	**7.28**	**7.27**	**1.56**	**1.78**	**1.67**	**2.64**	**7.00**	**8.99**

Table 2: Bio-efficacy of imazethapyr on weed biomass of major species (g m^{-2}) in soybean at 25 and 40 days after application

Treat-ment	*D. aegyptium*		*E. colona*		Other grasses		*C. rotundus*		*C. acutangulus*		*D. arvensis*		Other BLW	
	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA
T_1	1.4	2.5	1.8	3.5	4.7	7.4	2.8	4.7	1.7	3.6	3.4	4.2	8.0	15.7
T_2	1.2	2.2	1.5	3.2	4.5	7.1	2.8	4.5	1.6	3.5	3.0	4.0	7.3	15.5
T_3	1.0	1.9	1.3	2.9	4.3	6.4	2.7	4.4	1.2	3.4	2.4	3.7	7.1	14.5
T_4	1.6	2.8	1.9	3.6	4.7	7.4	3.0	5.6	1.8	4.1	3.4	4.3	8.2	16.0
T_5	1.8	3.4	2.1	4.2	6.6	8.0	3.4	6.2	2.3	4.5	3.9	5.2	10.3	18.6
T_6	1.6	2.9	2.0	3.8	4.9	7.9	3.1	5.8	2.2	4.3	3.5	4.8	8.2	16.8
T_7	6.1	8.4	5.8	10.1	18.0	24.6	8.9	17.2	8.2	11.8	9.6	12.1	37.6	52.5
T_8	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
SEm(±)	**0.45**	**0.40**	**0.38**	**0.36**	**0.41**	**0.66**	**0.35**	**0.27**	**0.47**	**0.45**	**0.44**	**0.87**	**1.19**	**1.92**
LSD (0.05)	**1.14**	**1.00**	**0.95**	**0.91**	**1.02**	**1.65**	**0.87**	**0.69**	**1.18**	**1.12**	**1.10**	**2.18**	**2.99**	**4.83**

Note: *T_1-imazethapyr 10SL (IIL Sample) at 500ml ha^{-1}, T_2-imazethapyr 10SL (IIL Sample) at 1000ml ha^{-1}, T_3-imazethapyr 10SL (IIL Sample) at 2000 ml ha^{-1}, T_4-imazethapyr 10SL (Market Sample) 1000ml ha^{-1}, T_5-Pendimethalin 30EC 3300 ml ha^{-1}, T_6-Alachlor 50EC 5000 ml ha^{-1}, T_7-Weedy check, T_8-Weed free check.Weed density and biomass was analysed using square root transformed data*

arvensis. As observed in the present study, Kundu *et al*. (2011) reported similar weed flora in soybean.

At the second and third observation i.e. 25 DAA and 40 DAA it was observed (Table 1) that all the treatments significantly controlled the weed population as compared to weedy check control. It was also observed that the gradual increase in the doses of the testing herbicide Imazethapyr 10% SL (IIL Sample) showed the better results in controlling all categories of weeds which were more or less equally effective to Imazethapyr 10% SL (market sample) and better than the Pendimethalin 30% EC and Alachlor 50% EC. Similar trend was also observed (Table 2) in dry matter production. Similar work was reported by Angris and Rana (1995). However, the maximum number and dry weight of all categories was recorded in weeded check control treatment and minimum was recorded under imazethapyr 10% (IIL sample) @ 200g ha^{-1} treatment.

The weed control efficiency was calculated at 25 DAS and 40 DAS based on the dry weight of dominant weed species (m^{-2}) presented for 40 DAS only (Table 3). The results indicated that all the treatments effectively controlled all the species of dominant weeds over weedy check control. Imazethapyr 10% (IIL sample) @ 500, 1000 and 2000 ml ha^{-1} level of application was best with WCE ranging from 64.52 to 84.95% at 25 DAS and from 65.49 to 77.84% at 40 DAS. In comparison the market sample of imazethapyr 10% SL @ 1000ml ha^{-1} resulted in WCE from 64.52 to 78.21% at 25 DAS and 64.05 to 69.83% at 40 DAS, which was also equally effective. Pendimethalin 30% EC @ 3300 ml ha^{-1} and alachlor 50% EC @ 5000 ml ha^{-1} were next in order of effectiveness at each level of observation. Kundu *et al*. (2011) reported that pre-emergence application of pendimethalin showed the lower weed control efficiency in soybean. However, weed free check control treatment was the best treatment with WCE ranging from 91.32 to 98.67% at 25 DAS and from 94.01 to 9.05% at 40 DAS. It confirms that Imazethapyr 10% (IIL sample) was effective for the control of weed species in soybean crop.

The maximum yield attributes i.e. number of pods $plant^{-1}$, number of seeds pod^{-1}, 100 seed weight and seed yield were recorded under weed free check treatment. Among the herbicidal treatments (Table 4), the maximum yield attributes and yield were recorded under imazethapyr 10% (IIL sample) @ 200g ha^{-1} followed by successive lower doses. The seed yield was on par with doses of imazethapyr at 50 to 200g ha^{-1} (IIL samples and market sample). But the seed yield obtained in treatments of imazethapyr at 50 to 100 g ha^{-1} was statistically *at par* with two standard test herbicides such as pendimethalin and alachlor. Yield loss in weedy check was 41% due to competition of weeds (Fig. 1). This is in uniformity with the earlier findings of Angris and Rana (1995) and Deore *et al*. (2008). Significantly higher seed and straw yield of soybean were obtained with imazethapyr 200g ha^{-1} (pre-emergence) and were significantly *at par* with its early post-emergence application and hand weeding twice. Tewari *et al*. (2004) also found that imazethapyr at 100 g ha^{-1} as pre emergence excelled all the herbicide treatments with respect to effective weed control (64.4 per cent WCE) and increased grain yield at par to manual weeding twice in green gram. However, the lesser yield attributes and seed yield of soybean was recorded under treatment weedy check. No phytotoxicity symptoms in soybean were observed in all herbicidal treatments.

It is concluded that higher economic yields can be achieved in soybean with imazethapyr 10% at 100g ha^{-1} due to effective control of weeds, as there was not much difference in the effectiveness of the product when applied at higher level of imazethapyr 10% at 200g ha^{-1}.

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Table 3: Bio-efficacy of imazethapyr on weed control efficiency (%) in soybean at 25 and 40 days after application

Treatments	*D. aegyptium*		*E. colona*		Other grasses		*C. rotundus*		*C.acutangulus*		*D. arvensis*		Other BLW	
	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA	25 DAA	40 DAA
T_1	77.1	70.4	68.8	65.7	74.1	70.0	68.2	73.0	79.0	70.0	64.5	65.5	78.7	70.1
T_2	80.4	73.7	74.7	68.5	75.1	71.3	68.6	74.1	81.1	70.1	68.5	67.1	80.5	70.5
T_3	83.7	77.8	77.1	71.1	75.9	73.9	70.1	74.4	85.0	71.5	75.1	69.8	81.1	72.3
T_4	73.6	67.1	67.5	64.1	73.7	69.8	66.4	67.4	77.9	65.0	64.5	64.3	78.2	69.6
T_5	69.6	58.8	63.9	58.6	63.4	67.4	61.6	64.2	72.7	61.8	59.9	57.3	72.7	64.6
T_6	73.4	65.8	66.0	62.7	72.7	68.0	64.9	66.3	73.7	64.0	64.1	60.9	78.1	68.0
T_7	-	-	-	-	-	-	-	-	-	-	-	-	-	-
T_8	91.8	94.0	91.3	95.0	97.2	97.7	94.4	97.1	93.9	95.8	94.8	95.9	98.7	99.1

Table 4: Bio-efficacy of imazethapyr on yield attributes and yield of soybean at harvest

Treat-ments	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 seed weight (g)	Seed yield (q ha^{-1})
T_1	31.67	2.10	124.33	23.01
T_2	32.23	2.07	125.00	23.71
T_3	33.00	2.33	125.66	27.70
T_4	31.27	2.13	122.00	22.85
T_5	28.33	2.20	120.33	20.61
T_6	28.43	2.30	120.66	22.17
T_7	22.00	2.00	124.67	17.74
T_8	35.23	2.36	125.90	30.03
SEm(±)	**2.16**	**-**	**-**	**2.32**
LSD (0.05)	**5.42**	**-**	**-**	**5.82**

Note: *T_1-imazethapyr 10SL (IIL Sample) at 500ml ha^{-1}, T_2-imazethapyr 10SL (IIL Sample) at 1000ml ha^{-1}, T_3-imazethapyr 10SL (IIL Sample) at 2000 ml ha^{-1}, T_4-imazethapyr 10SL (Market Sample) 1000ml ha^{-1}, T_5-Pendimethalin 30EC 3300 ml ha^{-1}, T_6-Alachlor 50EC 5000 ml ha^{-1}, T_7-Weedy check, T_8-Weed free check.*

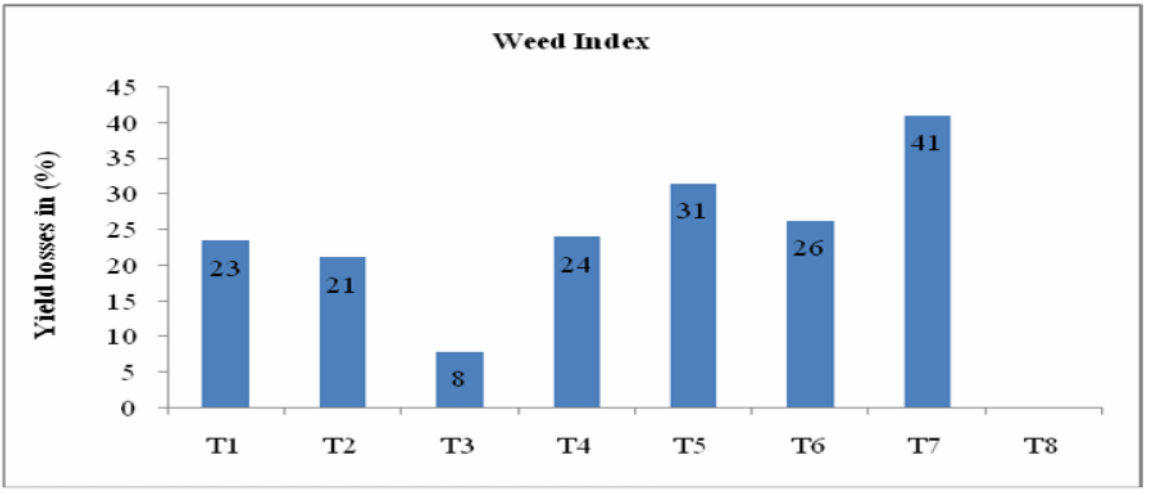

Fig. 1: Effect of weed control measures on weed index (%) of soybean