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Bio-efficacy and phytotoxicity of new molecule herbicides for weed management in soybean

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ABSTRACT

Field experiment was conducted with 12 treatments replicated thrice following Randomized Block Design during consecutive two kharif seasons of 2008 and 2009. Weed flora in soybean consisted of Echinochloa colonum, Eleusine indica, Dactyloctanium aegyptium, Digitaria sanguinalis, Cyperus rotundus, Euphorbia hirta, Digera arvensis, Physalis minima, Phylanthus niruri, Alternanthera philoxeroides, and Amaranthus viridis. All weed control treatments significantly decreased population of grass, sedge and broadleaf weeds and their dry weights over untreated control. No phytotoxic symptoms such as epinasty / hyponasty, leaf yellowing, necrosis, stunting growth, wilting etc. were exhibited. Considering the Net Production Value (NPV) it can be concluded that the treatment UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1} was the best among all the treatments used in this experiment. Though twice hand weeding treatment recorded highest yield but it failed to obtain most profitable result in respect to NPV due to higher cost of cultivation particularly labour wages.

***Key words*:** Bio-efficacy, NPV, phytotoxicity, yield

Soybean, *Glycine max* L. (Merrill.) is grown principally for the oil (20.35%) and protein (39.84%) [Yadav *et al*., 2009]. Soybean oil is rich in oleic acid, a mono-unsaturated fatty acid and contains no cholesterol; the protein contains eight amino acids essential to the human diet. Soybean is also a good source of minerals and vitamins.

Successful weed control is one of the most important practices for economical soybean production in India. Due to increasing labour wages and scarcity of labours at the crucial time, less costly and safer herbicides are gaining popularity. Controlling the weeds in proper time is a necessary for improving or maintaining the yield of soybean. Several herbicides have been reported to control weeds in soybean, but none of these can manage all the weeds efficiently (Bhowmik and Mandal, 2001). Suitable herbicides and their doses either alone or in combination need to be established for proper and timely control of weeds.

With this background, the study was carried out to find out the bio-efficacy and phytotoxicity of UPH-203, Na-Acifluorfen 10 % SL alone or in combination with standard Imazethapyr 10 % SL in soybean was attempted.

MATERIALS AND METHODS

The experiment was conducted with 12 treatments, replicated thrice in Randomized Block Design. Plot size was 5m × 3m. The crop was grown during two consecutive *kharif* seasons of 2008 and 2009 at the 'C' Block farm (latitude: 22°57'E, longitude: 88°20'N and altitude: 9.75 m) of Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The experimental soil was well drained, alluvial in nature and sandy loam in texture, having pH 6.9, organic carbon 0.59%, available nitrogen 245 kg ha^{-1}, available phosphorus 17 kg ha^{-1} and available potassium 160 kg ha^{-1} respectively were estimated by Combined glass electrode pH meter method, Walkley and Black's rapid titration method, Modified macro Kjeldahl method, Olsen's method and Flame photometer method, respectively (Jackson, 1967). The variety used in this experiment was PK–327. The treatments were as follows: UPH-203 @ 60.0 g ha^{-1}, UPH-203 @ 80.0 g ha^{-1}, UPH-203 @ 100.0 g ha^{-1}, UPH-203 @ 60.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 123.7 g ha^{-1}, UPH-203 @ 80.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 165.0 g ha^{-1}, UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1}, Na-Acifluorfen 10 % SL @ 123.7 g ha^{-1}, Na-Acifluorfen 10 % SL @ 165.0 g ha^{-1}, Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1}, Imazethapyr 10 % SL @ 1000.0 g ha^{-1}. All the herbicides were applied at 23 DAS (except imazethapyr10% SL @1000.0 g ha^{-1} at 10 DAS). Hand weeding twice (15 and 30 DAS) was also included in the experiment besides the unweeded control. Soybean was sown at the middle of the June of two consecutive years with the fertilizer dose @ 20:40:40 kg ha^{-1} of N, P_20_5 and K_20 as basal and thoroughly mixed with the soil. One day before sowing, the seeds were treated by using *Trichoderma viridis* @ 4 g kg^{-1} of Soybean seeds besides the *Rhizobium* treatment. The treated seeds were kept under shade for overnight before sowing in the main field and sown at 30 cm x 15 cm spacing at was done with knapsack sprayer with floodjet deflector WFN 040 nozzle with 500 litres of water ha^{-1}. Category wise predominant weed biomass, weed control efficiency were recorded at 30, 60 DAS and at harvest, and phytotoxicity observation as per CIB guidelines

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(observations on yellowing, stunting, necrosis, leaf injure on tips & leaf surface, wilting, epinasty and hyponasty) was recorded accordingly. At the time of harvest, the crop yield was measured. As the error mean squares of the individual experiments were homogenous, combined analysis over the years were done through unweighted analysis. Here, the interaction between years and treatments were not significant.

RESULTS AND DISCUSSION

Weed flora in soybean consisted of *Echinochloa colonum, Eleusine indica, Dactyloctanium aegyptium, Digitaria sanguinalis, Cyperus rotundus, Euphorbia hirta, Digera arvensis, Physalis minima, Phylanthus niruri, Alternanthera philoxeroides, Amaranthus viridis* (Table 1).

All weed control treatments significantly decreased dry weight of grass, sedge and broadleaf weeds over untreated control. No phytotoxic symptoms such as epinasty/hyponasty, leaf yellowing, necrosis, stunting growth, wilting etc were found. This is in conformity with the earlier findings of Bhattacharya *et al*. (1998).

Regarding weed control efficiency % (Table 2) it is quite clear that at the very early stage of crop growth (30 DAS), T_{11} offered high weed control efficiency (%) as compared to the other treatments mainly due to the fact that hand weeding was done for T_{11} and it gave less weed dry weight. From 60 DAS to at harvest hand weeding twice (T_{11}) maintained its superiority regarding weed control efficiency (%) over the chemical treatments up to the harvest of crop which may be due to the fact that twice hand weeding at 15 and 30 DAS prevents the weeds regeneration in addition to shading effect of the crop after 30 DAS of crop growth. Combined chemical treatments (T_4, T_5, and T_6) gave better weed control efficiency over the sole applied chemical treatments (T_1, T_2, T_3, T_7, T_8, and T_9) mainly because of the fact that the weed species regenerated more after certain periods where only herbicide was applied. So the sole applied chemical treatments gave more weed dry weight and less weed control efficiency as compared to treatments T_4 (UPH-203 @ 60.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 123.7g ha^{-1}), T_5 (UPH-203 @ 80.0 g ha^{-1}+Na-Acifluorfen 10 % SL @ 165.0 g ha^{-1}) and T_6 (UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1}). The result is in agreement with the findings of Jain *et al.* (1995) where they found that hand weeding twice gave the highest weed control efficiency (%) followed by integrated treatments.

Highest grain yield (2.349 t ha^{-1}) was recorded to the treatment of hand weeding twice (T_{11}) which gave significantly higher (Kushwah and Vyas, 2006) than any of the treatments used in the experiment followed by T_6 (2.163 t ha^{-1}) and T_{10} (2.042 t ha^{-1}) where the chemical UPH-203 @ 100.0g ha^{-1}+Na-Acifluorfen10% SL @206.2 g ha^{-1} and Imazethapyr10%SL@ 1000.0 g ha^{-1} were applied respectively. Treatment T_1, T_2 and T_3 where only UPH-203 chemicals were applied gave significantly higher seed yield over unweeded control (T_{12}). But these treatments gave significantly lower yield than the hand weeding twice treatment (T_{11}). The treatments T_7 (Na-Acifluorfen 10 % SL @ 123.7 g ha^{-1}), T_8(Na-Acifluorfen 10 % SL @ 165.0 g ha^{-1}), and T_9 (Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1}) also gave significantly lower yields when they were compared with their combined herbicides treatments [T_4 (UPH-203 @ 60.0 g ha^{-1}+Na-Acifluorfen 10 % SL @ 123.7 g ha^{-1}), T_5 (UPH-203 @ 80.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 165.0 g ha^{-1}) and T_6 (UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1})]. Among all the treatments unweeded control (T_{12}) gave the lowest seed yield (1.120 t ha^{-1}) over all other treatments. From the above discussion it is quite evident that hand weeding twice (T_{11}) produced the maximum seed yield of soybean mainly due to the fact that this treatment allowed minimum crop-weed competition at the critical period of crop growth resulting in maximum number of pods $plant^{-1}$ as well as maximum number of seeds pod^{-1}. Further the treatments T_4, T_5 and T_6 gave higher yield as compared to the treatments where chemicals were applied alone (T_1, T_2, T_3, T_7, T_8 and T_9). This may be due to the reason that with initial application of chemicals offered less crop weed competition at critical period of crop weed competition. Regarding percentage increase in yield over unweeded control, the highest yield increase (109.64%) was obtained from the treatment hand weeding twice (T_{11}) followed by the treatments T_6 (93.04%) and T_{10} (82.27%). The lowest yield increment (35.41%) was obtained from the treatment T_7 (Na-Acifluorfen 10 % SL @ 123.7 g ha^{-1}) over the unweeded control (T_{12}). The results were in accordance with the findings of Pandey *et al*., 2007.

The calculated weed index values presented in the table 2 clearly indicated that unweeded control treatment (T_{12}) gave the highest value (52.16) (Sanjay *et al*., 2011) whereas, T_6 (UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1}) recorded the lowest value (7.81). Therefore, it is clear that the treatment T_6 was the most effective among all the treatments used in this experiment. It is due to the fact that the herbicide treatments showed the better weed controlling ability as compared to other treatments and so they facilitated better crop growth and ultimately higher yield in soybean and lower weed index value.

Table 1: Effect of treatments on weed biomass (g m^{-2}) at 30 DAS, 60 DAS and at harvest [pooled]

Treatment	30 DAS				60 DAS				At Harvest			
	GW	SW	BW	TW	GW	SW	BW	TW	GW	SW	BW	TW
T_1:UPH-203@60.0 g ha^{-1}	8.44	4.31	13.84	26.59	12.43	4.88	18.75	36.06	15.81	6.31	23.74	45.86
T_2:UPH-203@80.0 g ha^{-1}	8.20	4.28	12.45	24.93	11.99	4.74	17.00	33.73	15.94	5.66	22.33	43.93
T_3:UPH-203@100.0 g ha^{-1}	7.19	4.24	11.57	23.00	11.31	4.55	16.57	32.43	15.58	5.60	22.38	43.56
T_4:UPH-203@ 60.0 g ha^{-1}+Na-Acifluorfen10%SL@123.7 g ha^{-1}	6.49	3.63	10.42	20.54	10.02	4.09	16.49	30.60	14.09	5.44	20.86	40.39
T_5:UPH-203@80.0 g ha^{-1}+Na-Acifluorfen10%SL@165.0 g ha^{-1}	6.76	3.33	9.45	19.54	11.13	3.98	14.96	30.07	13.43	5.13	18.65	37.21
T_6:UPH-203@100.0 g ha^{-1}+Na-Acifluorfen10%SL@206.2 g ha^{-1}	4.55	2.40	5.63	12.58	7.95	3.29	11.01	22.25	10.85	4.80	14.29	29.94
T_7:Na-Acifluorfen10%SL@123.7 g ha^{-1}	9.12	5.47	16.8	31.39	13.05	6.00	19.19	38.24	16.23	7.00	25.21	48.44
T_8:Na-Acifluorfen10%SL@165.0 g ha^{-1}	9.05	5.40	14.98	29.43	12.42	5.52	17.92	35.86	16.13	6.79	24.84	47.76
T_9:Na-Acifluorfen10%SL@206.2 g ha^{-1}	7.96	4.61	14.52	27.09	11.36	4.97	18.04	34.37	15.25	6.50	24.08	45.83
T_{10}:Imazethapyr10%SL@1000.0 g ha^{-1}	4.99	2.94	8.15	16.08	8.94	3.80	11.75	24.49	12.07	4.86	16.10	33.03
T_{11}: Twice hand weeding at 15 and 30 DAS	2.96	1.85	3.68	8.49	7.08	2.74	8.23	18.05	9.18	3.29	11.53	24.00
T_{12}:Weedy check (Untreated)	13.44	5.80	21.26	40.50	17.56	7.80	27.42	52.78	25.62	9.14	33.30	68.06
SEm (±)	0.129	0.034	0.176	0.245	0.111	0.120	0.249	0.117	0.145	0.311	0.229	0.198
LSD (0.05)	0.379	0.099	0.517	0.718	0.326	0.353	0.730	0.343	0.424	0.912	0.672	0.582

*Grassy weeds (GW): *Digitaria sanguinalis, Dactyloctenium aegyptium, Echinochloa colona, Eleusine indica.* **Sedge Weed (SW): *Cyperus rotundus, Fimbristylis littoralis*
***Broadleaf Weeds (BW): *Digera arvensis, Physalis minima, Phylanthus niruri, Alternenthera philoxeroides, Amaranthus viridis, Euphorbia hirta.*Total Weeds (TW)

Table 2: Effect of treatments on weed control efficiency (%), seed yield, stover yield, harvest index (%), weed index (%) and NPV [pooled]

Treatment	WCE (%)			Seed Yield (t ha^{-1})	Stover Yield (t ha^{-1})	Harvest Index (%)	Weed Index (%)	NPV
	30DAS	60DAS	At harvest					
T_1:UPH-203@60.0 g ha^{-1}	32.95	31.63	21.85	1.678	2.411	41.04	28.35	0.74
T_2:UPH-203@80.0 g ha^{-1}	37.14	36.05	23.04	1.689	2.437	40.94	27.83	0.74
T_3:UPH-203@100.0 g ha^{-1}	41.87	38.47	27.10	1.731	2.450	41.38	26.19	0.78
T_4:UPH-203@ 60.0 g ha^{-1}+Na-Acifluorfen10%SL@123.7 g ha^{-1}	48.21	42.00	33.32	1.783	2.589	40.80	24.03	0.81
T_5:UPH-203@80.0 g ha^{-1}+Na-Acifluorfen10%SL@165.0 g ha^{-1}	50.57	42.96	35.56	1.844	2.615	41.37	21.27	0.85
T_6:UPH-203@100.0 g ha^{-1}+Na-Acifluorfen10%SL@206.2 g ha^{-1}	68.69	58.57	47.01	2.163	2.684	45.02	07.81	1.15
T_7:Na-Acifluorfen10%SL@123.7 g ha^{-1}	20.99	27.50	18.82	1.517	2.061	42.43	35.31	0.56
T_8:Na-Acifluorfen10%SL@165.0 g ha^{-1}	26.55	32.04	21.43	1.607	2.156	42.73	31.48	0.64
T_9:Na-Acifluorfen10%SL@206.2 g ha^{-1}	31.71	34.91	25.36	1.646	2.224	42.54	29.87	0.67
T_{10}:Imazethapyr10%SL@1000.0 g ha^{-1}	59.44	53.56	38.73	2.042	2.587	44.27	12.81	0.99
T_{11}:Twice hand weeding at 15 and 30 DAS	78.45	65.86	63.58	2.349	2.893	44.80	-----	1.10
T_{12}:Weedy check (Untreated)	-	-	-	1.120	2.014	35.94	52.16	0.18
SEm (±)				0.0487	0.1271	0.519		
LSD (0.05)				0.1427	0.3727	1.522		

So far as harvest index (Table 2) is concerned the value was highest (45.02%) with T_6 (UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1}) and the lowest (35.94 %) with T_{12} (Weedy check (Untreated)). All the treatments were significantly higher than $T_{12.}$

In respect of net production value (NPV), the highest value was obtained with the treatment T_6 (UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1}) (1.15) which was closely followed by the treatment T_{11} (Twice hand weeding at 15&30 DAS) (T_{11}:1.10) and T_{10} (Imazethapyr 10 % SL @ 1000.0 g ha^{-1}) (T_{10}:0.99). Hand weeding treatment (T_{11}) showed lower NPV value in comparison to the above mentioned herbicidal treatment (T_6) due to higher expenditure on labour wages. On the contrary the lowest value of cost benefit ratio was obtained in the treatment unweeded control (T_{12}:0.18).

Therefore, the laborious, time consuming, costly and back-breaking hand weeding process can be replaced by the combined herbicide treatment T_6 (UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1}).

Considering the NPV it can be concluded that the treatment UPH-203 @ 100.0 g ha^{-1} + Na-Acifluorfen 10 % SL @ 206.2 g ha^{-1} was the best among all the treatments used in this experiment. Though twice hand weeding treatment had highest yield (Priya *et al*.2009, Tiwari *et al*.2007). It failed to obtain most profitable result (8.60% less yield) in this respect due to higher cost of cultivation particularly labour wages and this was due to the hand weeding twice is laborious, time consuming, costly and also the labourers are not available at the critical period of crop weed competition.

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