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Bioefficacy of imazethapyr on the predominant weeds in soybean

R. KUNDU, K. BRAHMACHARI, P. S. BERA, C. K. KUNDU AND S. ROYCHOUDHURY

Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya
Mohanpur -741 252, Nadia, West Bengal, India
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ABSTRACT

A field experiment was undertaken to assess the bio-efficacy of imazethapyr against predominant weeds in soybean and the crop safety at different doses of imazethapyr. The predominant weed species in experimental field were Echinochloa colona (L.) Link, Echinochloa crussgalli (L.) Beauv, Cyperus difformis L., Euphorbia hirta L., Croton sparsiflorus Morong and Digera arvensis Forsk. The maximum suppression of all the weed density, weed biomass, and highest weed control efficiency vis-a-vis crop yield were obtained where twice hand weeding done at 20 and 40 days after sowing, and closely followed by the treatment with imazethapyr 150 g ha^{-1} and imazethapyr 125 g ha^{-1} respectively. Among the herbicidal treatment imazethapyr 150 g ha^{-1} recorded the highest herbicide efficiency index, but produced relatively lower yield than imazethapyr 125 g ha^{-1} and also showed delay maturity due to its phytotoxic effect on soybean, whereas weedy check treatment produced lowest yield of soybean among all the treatments.

Key words: Herbicide, hand weeding, imazethapyr, soybean, weed management

From nutritional point of view, soybean (*Glycine max* [L.] Merrill) 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 of all crops. Though the area and production of soybean are increasing, the average productivity remained constant during the last decade even after development of high yielding varieties and dissemination of new agro-technologies. One of the major constraints in soybean production is crop-weed competition (Vollmann *et al.,* 2010); being a rainy season crop, as it is heavily infested with grasses, sedges and broadleaved weeds. They fight for food, water, light and space against the soybean crop, thus affect the crop yield ultimately. The loss of soybean yield due to weeds ranges from 40 to 85 per cent (Jha *et al.,* 1993). Controlling the weeds in due 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. Unavailability of adequate labourers during peak weeding time and difficulty in use of mechanical means for weed management due to rains also add more problems. However, exclusive reliance on chemical herbicides has led to concern about contamination of environment by the pressure of herbicidal residue in soil, water and plants, shift in weed flora, appearance of resistant weed species, threats to human health, etc. (Bhowmik and Mandal, 2001).

With this thought keeping in background, the present research work on bio-efficacy of imazethapyr in soybean was conducted at the 'C' Block farm, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during *kharif* 2008 and 2009 with the boarder objectives to assess the efficiency of this herbicide against predominant weeds in soybean and find out the crop safety at different doses of imazethapyr.

METERIALS AND METHODS

The field experiment was conducted during rainy season (*kharif*) of 2008 and 2009 at the 'C' Block farm (latitude: 22^{0}57$^/$ E, longitude: 88^{0}20$^/$ N and altitude: 7.8 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 6.8, organic carbon 0.66%, available nitrogen 154 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 experimental site belongs to the sub-tropical humid climate, the temperature of the experimental period was moderate, ranges from 22 to 36°C and the rainfall of the experimental period ranges from 0 mm to 167 mm per day^{-1} and maximum and minimum relative humidity was 98% and 60% respectively. The experiment was laid out in Randomized Block Design (RBD) with eight different weed management practices with each replicated thrice. The treatments were Imazethapyr @ 75 g *a.i.* ha^{-1} at 10 days after sowing (T_1), Imazethapyr @ 100 g *a.i.* ha^{-1} at 10 DAS (T_2), Imazethapyr @ 125 g *a.i.* ha^{-1} at 10 DAS (T_3), Imazethapyr @ 150 g *a.i.* ha^{-1} at 10 DAS (T_4), Pendimethalin 30% EC @ 750 g *a.i.* ha^{-1} at pre-emergence (T_5), Hand weeding at 20 DAS (T_6), Hand weeding twice at 20 and 40 DAS (T_7) and untreated control (T_8).

Soybean, cv. Bragg was sown at the end of the June of two consecutive years with the fertilizer dose @ 25:60:40 kg ha^{-1} of N, P_2O_5 and K_2O as basal and thoroughly mixed with the soil. The seeds were inoculation with selected *Rhizobium* culture and sown @ 100 kg ha^{-1} in furrows at 30 cm x 15 cm spacing at

Email: rajibagro2007@gmail.com

a depth of 5 cm below the soil surface. Foliar spray was done with Knapsack Sprayer using Flat Fan or Flood Jet nozzle with 600 Littre of water ha^{-1}. Species wise predominant weed count, weed biomass, weed control efficiency were recorded at 15, 30 and 45 days after post emergence spray (DAP), and phytotoxicity observation as per CIB guidelines (observations on yellowing, stunting, necrosis, leaf injure on tips & leaf surface, wilting, epinasty and hyponasty) was recorded accordingly. Finally the crop yield was measured at the time of harvest. The herbicide efficiency index (HEI) was calculated by using formula describe by Sharma and Gangaiah (2009).

RESULTS AND DISSCUSSION

Weed flora:

Six predominant weed species were observed in experimental field during the rainy (*kharif*) season of 2008 and 2009, among them *Echinochloa colona* and *Echinochloa crussgalli* were grasses; *Cyperus difformis* was the sedge and the broad leaf weeds were *Euphorbia hirta, Croton sparsiflorus,* and *Digera arvensis.* Similar observation was also reported by Das *et al.,* (1997) and Kumar *et al.,* (2001).

Weed density:

Species wise weed density in soybean field *i.e.* number of the weed m^{-2} of a particular weed species was recorded at 15, 30 and 45 days after post emergence spray (DAP), and differed significantly with the different weed management treatments (Table-1). Density of grasses (*Echinochloa colona* and *Echinochloa crussgalli*) and sedge (*Cyperus difformis*) weeds were much higher than the density of broad leaved weeds (*Euphorbia hirta, Croton sparsiflorus,* and *Digera arvensis*) at throughout the crop growing season, as because rainy reason is highly favourable for grass and sedge population, similar opinion also reported by Tiwari *et al.,* (2007). Again, population of *Echinochloa crussgalli* found to be greater than the *Echinochloa colona.* Weed density at 45 DAP was higher as compared to those recorded at early stages irrespective of species. The treatment T_7 where twice hand weeding done at 20 and 40 days after sowing (DAS) showed the maximum reduction of *Echinochloa colona* and *Echinochloa crussgalli* at all the stages and it was closely followed by the treatment T_3 (imazethapyr @ 125 g ha^{-1} at 10 DAS) and T_4 (imazethapyr @ 150 g ha^{-1} at 10 DAS). The weedy check treatment (T_8) showed the highest population of *Echinochloa colona* and *Echinochloa crussgalli* which was significantly inferior to any other treatments. At all the growth stage of soybean crop, the pre-emergence herbicidal treatments (T_5) continued to show higher population of *Echinochloa colona* and *Echinochloa crussgalli* in comparison to other treatments, except weedy check treatment (T_8). As a particular weed species, sedge *Cyperus difformis* recorded the maximum number m^{-2}, compared to any other species, and the highest suppression of this weed flora at early growth stage was found under T_4, but in at latter stage, twice hand weeding was found to superior than T_4 and T_3. Pendimethalin (T_5) and weedy check treatment (T_8) were recorded the maximum population of *Cyperus difformis* at throughout the growing season. Among the broad leaved weeds, *Euphorbia hirta* showed the highest population throughout the crop season followed by *Croton sparsiflorus,* and *Digera arvensis* respectively. The results also showed that T_4 performed the better with respect to control of different broad leaved weeds, and this treatment had no far difference with the treatment T_3 and T_7. The populations of different broad leaved weed flora were maximum in the plots under untreated control (T_8). From the findings, it may be stated that post emergence application of imazethapyr reduced the density of broad as well as narrow leaved weeds significantly as compared to pre-emergence herbicides under study (Arregui *et al.,* 2005; Mosjidis and Wehtje, 2011). The lowest weed density were recorded with twice hand weeding followed by imazethapyr.

Weed biomass:

Biomass (g m^{-2}) of different weed spices in each plot of the experiment recorded at 15, 30 and 45 days after post emergence spray (DAP), and differed significantly under different treatments (Table-2). Throughout the soybean growing season, the significantly highest biomass of all categories of weed flora was observed in weedy check treatment (T_{10}) among all the treatments. At all the stages of crop growth, higher reduction in biomass of *Echinochloa colona and Echinochloa crussgalli* were recorded with T_7 (twice hand weeding at 20 and 40 DAS) which had no far difference with T_4 (imazethapyr @ 150 g ha^{-1} at 10 DAS), T_3 (imazethapyr @ 125 g ha^{-1} at 10 DAS) and T_2 (imazethapyr @ 100 g ha^{-1} at 10 DAS) respectively. The biomass of different broad leaved weed flora in soybean field at all the crop growth season reflect the same trend with those of the biomass of different grass weed flora. In case of sedge, *Cyperus difformis,* T_4 recorded the least biomass at early growth stage, and it was closely followed by the treatment T_7 and T_3 respectively. Whereas in at latter stage, T_7 was found to be superior than the any other weed management practices. The pre-emergence herbicidal treatments, T_5 showed the maximum biomass of all categories of weed flora in comparison to other treatments, except weedy check treatment (T_8) at throughout the growing season. Similar work was also reported by and Kushwah and Vyas 2006.

Weed control efficiency:

Species wise weed control efficiency (%) in soybean field was recorded at 15, 30 and 45 days after post emergence spray (DAP), and it was higher at 15 DAP

as compared to those recorded at 30 DAP and 45 DAP irrespective of species (Table-3). From the table it can stated that the weed control efficiency (%) at throughout the crop growing season of all the weed flora was maximum under the treatment T_7, where twice hand weeding done at 20 and 40 DAS, which could not made far difference with T_4 and T_3. But in case the weed control efficiency of *Cyperus difformis* at 15 DAP and *Echinochloa colona* at 30 DAP was found to be maximum in T_4, followed by the treatment T_7 and T_3. The pre-emergence application of pendimethalin (T_5) showed the lower weed control efficiency in soybean at throughout the growing season. The bio-efficacy of imazethapyr on weed control efficiency in soybean was in order to $T_4 > T_3 > T_2 > T_1$, irrespective of all predominant weed species.

Crop yield:

Seed yield and stover yield of soybean were observed at the time of harvest, and were varied significantly with the variation in weed management practices (Table-4). Hand weeding twice at 20 and 40 DAS (T_7) produced the significantly highest seed yield (2529 kg ha^{-1}) of soybean and found to be superior to the other weed management practices. The herbicidal treatment, T_3 (imazethapyr @ 125 g ha^{-1} at 10 DAS) recorded the next to highest seed yield of soybean (2305 kg ha^{-1}), and it was statistically similar with the treatment T_4 (imazethapyr @ 150 g ha^{-1} at 10 DAS) and T_2 (imazethapyr @ 100 g ha^{-1} at 10 DAS) producing 2277 and 2219 kg ha^{-1} of soybean seeds respectively. The significantly lowest seed yield (1433 kg ha^{-1}) was observed in weedy check treatment (T_8) among all the treatments. The pre-emergence application of pendimethalin (T_5) produced the significant lower seed yield (1920 kg ha^{-1}) as compared to all other herbicidal practices. Treatment effects on stover yield followed as same trend as found in seed yield of soybean. From the results, it may be expressed that higher weed infestation was responsible for reducing seed yield of the soybean during rainy season. This was quite clear from the seed yield produced in weedy check treatment, which faced the tremendous competition with vigorous weed infestation, similar observation also found by Vollmann *et al.,* (2010). Twice hand weeding at 20 and 40 DAS reduced the weed infestation most efficiently throughout the growing period of the crop and as a consequence it produced the highest seed yield of rainy season soybean (Kushwah and Vyas, 2006). The post emergence herbicide, imazethapyr @ 125 g ha^{-1}, produced higher seed yield of soybean, but further increment of the doses may not increase the soybean production as a whole. Similar result was also reported by Norsworthy *et al.*, (2008) and Soltani *et al.,* (2008). From the Table-4 it can be conclude that the highest harvest index (26.09 %) and increase in yield over control (76.48 %) were found with the treatment T_7, where twice hand weeding done at 20 and 40 DAS and could not make far difference with the treatment T_3 (imazethapyr @ 125 g ha^{-1}). The weedy check treatment (T_8) was recorded the lowest harvest index (22.37 %) as well as maximum weed index (43.34 %) among all the weed management practices. The treatments T_3, T_4 and T_2 could not make far difference with each other, and showed minimum weed index (8.86, 11.15 and 12.26 % respectively).

Herbicide efficiency index:

Herbicide efficiency index (HEI) of different herbicides in each plot of the experiment was recorded at 15, 30 and 45 DAP, and vary with each other (Figure-1). At early growth stage of soybean, the highest herbicide efficiency index was recorded with imazethapyr @ 150 g ha^{-1} (T_4), followed by imazethapyr @ 125 g ha^{-1} (T_3). However, the application of pendimethalin @ 750 g ha^{-1} resulted in lowest herbicide efficiency index at all the stages of crop growth. Throughout the growing season of soybean, herbicide efficiency index showed a positive response with the increasing dose of imazethapyr, however difference between T_4 and T_3 varied by increasing levels of crop age.

Phytotoxicity:

None of the treatments used in the experiment showed any of the phytotoxicity symptoms on soybean crop; excepting the case of a little beat yellowing symptom in the plots treated with treatment T_4 (imazethapyr @ 150 g ha^{-1}). Crop maturity was also affected by the plot treated with imazethapyr @ 150 g ha^{-1} as compare to lower level of imazethapyr in soybean field. Phytotoxcity of this herbicide also observed in other leguminous crop, application of imazethapyr as pre-emergence at higher dose, reduced plant height, delayed plant maturity, and caused leaf chlorosis in chickpea (Lyon and Wilson, 2005).

To conclude from the above finding, it can be stated that the imazethapyr can effectively control of different categories of weeds, especially of sedge in soybean field. Higher level of imazethapyr *i.e.* 150 g ha^{-1} showed the better suppression of all predominant weeds throughout crop growing season and also recorded high herbicide efficiency index, but produced relatively lower yield than imazethapyr @ 125 g ha^{-1} and showed delay maturity due to its phytotoxic effect on soybean crop. Though the yields are the maximum in the twice hand weeded plot, but still it involves more labour cost. So it may be safely be concluded that higher economic yields may be achieved in soybean crop without any phytotoxic effect under the treatment T_3 (imazethapyr @ 125 g ha^{-1} at 10 DAS), where crops matured earlier than the control plots.

Table 1: Bio-efficacy of Imazethapyr on density of different weeds (no. m^{-2}) in soybean field at 15, 30 and 45 days after post emergence spray (pooled data)

Treat-ment	*Echinochloa colona*			*Echinochloa crussgalli*			*Cyperus difformis*			*Euphorbia hirta*			*Croton sparsiflorus*			*Digera arvesis*		
	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP
T_1	1.7	2.9	4.4	2.5	3.6	5.3	5.8	7.4	9.2	1.0	2.1	2.7	1.7	2.8	3.6	1.1	2.0	2.9
T_2	0.4	1.9	2.7	1.0	1.9	3.2	3.7	5.6	7.9	0.7	1.5	1.8	1.0	1.9	2.5	0.5	1.0	1.6
T_3	0.0	1.0	2.3	0.5	1.2	2.8	2.3	3.5	5.1	0.0	1.0	1.3	0.3	1.0	1.4	0.0	0.8	1.2
T_4	0.0	1.0	2.0	0.3	1.2	2.5	1.2	3.0	4.7	0.0	0.5	1.0	0.0	1.0	1.2	0.0	0.7	1.2
T_5	2.8	5.2	8.3	3.1	5.5	9.5	11.4	14.7	18.3	2.7	3.5	4.2	2.5	3.8	4.7	1.9	3.1	3.9
T_6	0.5	2.3	4.2	1.2	3.4	5.8	4.0	8.3	11.2	1.0	1.7	2.5	1.5	2.7	3.8	0.8	1.7	2.4
T_7	0.0	1.0	1.5	0.3	1.0	2.0	1.7	2.3	2.6	0.0	0.3	0.3	0.0	1.0	1.0	0.0	0.6	1.0
T_8	7.6	10.6	16.6	8.7	12.3	19.2	20.2	29.5	35.6	6.6	8.3	9.8	4.7	6.3	8.0	3.7	6.1	7.5
SEm(±)	0.15	0.13	0.05	0.16	0.03	0.07	0.06	0.09	0.12	0.08	0.10	0.04	0.06	0.09	0.18	0.07	0.04	0.06
LSD(0.05)	0.44	0.40	0.16	0.47	0.09	0.20	0.19	0.27	0.38	0.24	0.29	0.12	0.19	0.29	0.54	0.22	0.13	0.19

Table 2: Bio-efficacy of Imazethapyr on biomass of different weeds (g m^{-2}) in soybean field at 15, 30 and 45 days after post emergence spray (pooled data)

Treatment	*Echinochloa colona*			*Echinochloa crussgalli*			*Cyperus difformis*			*Euphorbia hirta*			*Croton sparsiflorus*			*Digera arvensis*		
	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP
T_1	0.39	1.67	6.46	0.69	2.14	12.11	0.39	1.67	6.46	0.69	2.14	12.11	0.39	1.67	6.46	0.69	2.14	12.11
T_2	0.10	0.99	3.65	0.25	1.06	7.22	0.10	0.99	3.65	0.25	1.06	7.22	0.10	0.99	3.65	0.25	1.06	7.22
T_3	0.00	0.45	2.95	0.09	0.46	5.09	0.00	0.45	2.95	0.09	0.46	5.09	0.00	0.45	2.95	0.09	0.46	5.09
T_4	0.00	0.41	2.78	0.07	0.48	4.13	0.00	0.41	2.78	0.07	0.48	4.13	0.00	0.41	2.78	0.07	0.48	4.13
T_5	0.79	2.99	13.29	0.72	3.21	18.69	0.79	2.99	13.29	0.72	3.21	18.69	0.79	2.99	13.29	0.72	3.21	18.69
T_6	0.12	1.27	6.81	0.23	1.46	10.12	0.12	1.27	6.81	0.23	1.46	10.12	0.12	1.27	6.81	0.23	1.46	10.12
T_7	0.00	0.54	1.86	0.05	0.37	3.13	0.00	0.54	1.86	0.05	0.37	3.13	0.00	0.54	1.86	0.05	0.37	3.13
T_8	1.99	5.99	20.58	2.83	5.78	31.05	1.99	5.99	20.58	2.83	5.78	31.05	1.99	5.99	20.58	2.83	5.78	31.05
SEm(±)	0.09	0.15	0.32	0.13	0.17	0.56	0.09	0.15	0.32	0.13	0.17	0.56	0.09	0.15	0.32	0.13	0.17	0.56
LSD (0.05)	0.27	0.47	0.95	0.40	0.52	1.67	0.27	0.47	0.95	0.40	0.52	1.67	0.27	0.47	0.95	0.40	0.52	1.67

DAP: *Days after post emergence spray*

Treatments Details: *Imazethapyr @ 75 g ha^{-1} at 10 days after sowing (T_1), Imazethapyr @ 100 g ha^{-1} at 10 DAS (T_2), Imazethapyr @ 125 g ha^{-1} at 10 DAS (T_3), Imazethapyr @ 150 g ha^{-1} at 10 DAS (T_4), Pendimethalin @ 750 g ha^{-1} at pre-emergence (T_5), Hand weeding at 20 DAS (T_6), Hand weeding twice at 20 and 40 DAS (T_7) and untreated control (T_8).*

Table 3: Bio-efficacy of Imazethapyr 10% SL on weed control efficiency (%) in soybean field at 15, 30 and 45 days after post emergence spray (pooled data)

Treatment	*Echinochloa colona*			*Echinochloa crussgalli*			*Cyperus difformis*			*Euphorbia hirta*			*Croton sparsiflorus*			*Digera arvensis*		
	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP	15 DAP	30 DAP	45 DAP
T_1	80.40	72.12	68.61	75.62	62.98	61.00	78.65	72.70	67.64	87.33	73.00	66.14	65.66	54.04	41.51	78.70	70.81	60.16
T_2	94.97	83.47	82.26	91.17	81.66	76.75	84.72	80.07	71.68	92.99	81.67	79.62	85.28	71.22	62.66	91.74	85.68	74.57
T_3	100.00	92.49	85.67	96.82	92.04	83.61	91.69	88.84	84.08	100.00	88.71	82.39	95.47	85.92	81.69	100.00	90.00	84.53
T_4	100.00	93.16	86.49	97.53	91.70	86.70	96.63	91.22	84.23	100.00	94.11	89.78	100.00	85.30	83.02	100.00	92.43	86.24
T_5	60.30	50.08	35.42	74.56	44.46	39.81	46.52	43.55	42.92	67.12	49.75	43.83	51.70	36.02	20.32	58.26	49.73	34.60
T_6	93.97	78.80	66.91	91.87	74.74	67.41	86.07	77.79	68.75	89.76	78.07	72.10	76.23	65.84	41.26	86.09	82.70	62.52
T_7	100.00	90.98	90.96	98.23	93.60	89.92	95.51	93.17	91.64	100.00	96.56	95.78	100.00	86.34	84.71	100.00	93.24	87.94
T_8	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---

DAP: *Days after post emergence spray*

Treatments Details: *Imazethapyr @ 75 g ha^{-1} at 10 days after sowing (T_1), Imazethapyr @ 100 g ha^{-1} at 10 DAS (T_2), Imazethapyr @ 125 g ha^{-1} at 10 DAS (T_3), Imazethapyr @ 150 g ha^{-1} at 10 DAS (T_4), Pendimethalin @ 750 g ha^{-1} at pre-emergence (T_5), Hand weeding at 20 DAS (T_6), Hand weeding twice at 20 and 40 DAS (T_7) and untreated control (T_8).*

Table 4: Bio-efficacy of Imazethapyr on Soybean yield (kg ha^{-1}) at harvest (pooled data)

Treatment	Soybean yield (kg ha^{-1})		Harvest Index (%)	Weed Index (%)	Increase in yield over control (%)
	Seed yield	Stover yield			
T_1	2048	6223	24.76	19.02	42.92
T_2	2219	6450	25.60	12.26	54.85
T_3	2305	6849	25.18	8.86	60.85
T_4	2277	6783	24.88	11.15	56.80
T_5	1920	5847	24.72	24.08	33.98
T_6	2155	6411	25.16	14.79	50.38
T_7	2529	7165	26.09	---	76.48
T_8	1433	4972	22.37	43.34	---
SEm(±)	41.24	98.71	---	---	---
LSD (0.05)	125.75	297.26	---	---	---

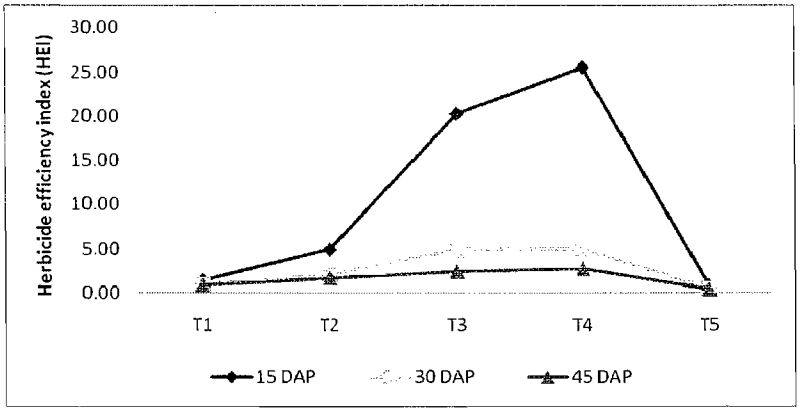

Figure 1: Effect of herbicide efficiency index (HEI) of different herbicide on soybean field at 15, 30 and 45 days after post emergence spray

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