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Research Communication

Boosting productivity and profitability of soybean (*Glycine max*) in Uttarakhand by weed management through herbicides and mulch

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2015 at Pantnagar, Uttarakhand, to assess the effect of 3 herbicides, viz. pendimethalin, imazethapyr and sulfentrazone and wheat (*Triticum aestivum* L.) straw mulch on weed dynamics, yield and economics of soybean [*Glycine max* (L.) Merr.]. Unchecked weed growth caused 55% reduction in seed yield of soybean. Pendimethalin @ 1.0 kg/ha followed by (*fb*) imazethapyr @ 0.1 kg/ha + mulch @ 5 t/ha at 25 days after sowing (DAS) being at par with mulch @ 5 t/ha after the first weeding and mulch @ 5 t/ha *fb* sulfentrazone @ 0.3 kg/ha recorded significantly lower weed density and weed dry weight and therefore higher weed-control efficiency at harvesting. The highest seed yield (2.79 t/ha) was obtained under weed-free check, which was at par with pendimethalin @1.0 kg/ha *fb* imazethapyr @ 0.1 kg/ha + mulch @ 5 t/ha at 25 DAS (2.60 t/ha), mulch @ 5 t/ha after the first weeding (2.59 t/ha) and mulch @ 5 t/ha *fb* sulfentrazone @ 0.3 kg/ha (2.51 t/ha). The highest benefit: cost ratio was recorded under pre-emergence application of pendimethalin @1.0 kg/ha *fb* post-emergence application of sulfentrazone @ 0.3 kg/ha (2.93), which was at par with mulching of wheat straw @ 5 t/ha *fb* sulfentrazone @ 0.3 kg/ha (PoE) (2.82). The new herbicide sulfentrazone provided satisfactory control of all types of weed flora.

Key words : Imazethapyr, Mulch, Pendimethalin, Seed yield, Soybean, Sulfentrazone, Weeds

Soybean, also known as 'Golden Bean' is rich in protein (40–42%) and oil (20–22%), lysine, vitamins A, B and D, mineral salts and essential amino acids. Soybean's curative powers and its iron and protein content make it an excellent meat substitute. In Uttarakhand, soybean is grown in an area of 15,000 ha with an annual production of 20,000 tonnes and an average productivity of 1.67 t/ha (GoI, 2015). Being a rainy (*kharif*) crop, soybean receives heavy competition from a diverse range of weed flora which competes with the crop for essential nutrients, space and moisture. Late emergence, slow initial growth, wider spacing, poor canopy development provide ideal conditions for weed to grow and compete with the crop leading to seed yield reduction to an extent of 25–77% (Kurchania *et al*., 2001).

Chemical weed management in soybean through herbicides is recently gaining popularity over manual and mechanical weeding, owing to their lower cost, easy and timely application and effectiveness in controlling weeds. A single pre-emergence application of soil-active herbicides are often inadequate in controlling the diverse range of weed flora throughout the critical period of crop-weed competition. This necessitates the sequential application of pre- and post-emergence herbicides with different mode of actions, which also avoids/delays weed shifts and weed-resistance phenomenon. Furthermore, herbicides can be integrated with non-chemical methods (cultural/mechanical/biological) which would lead to savings in herbicide amount and costs, leading to an eco-friendly and sustainable weed-management programme. Such an integrated weed management can be formulated using straw mulch, which retards weed seed germination by reducing light penetration to the weed seed layer, creates mechanical resistance for seedling emergence and inhibits weed growth through allelopathic effects besides having other beneficial effects in the soil.

A field experiment was carried out in 2015 at NE

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Borlaug Crop Research Centre, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, to investigate the effect of herbicides and mulch on weed control and yield of soybean. The experimental soil was neutral (*p*H 7.2), medium in available nitrogen (320 kg/ha), available potassium (268 kg/ha) and organic carbon (0.55%) but high in available phosphorus (28.82 kg/ha). Three herbicides, viz. pendimethalin 30 EC @ 1.0 kg/ha (PE), sulfentrazone 39.6 EC @ 0.3 kg/ha (PoE) and imazethapyr 10 EC @ 0.1 kg /ha (PoE) along with mulching of wheat straw @ 5 t/ha were applied singly (T_1 to T_4) and in different combinations (T_5 to T_{10}) and were compared with weedy check and weed-free check. Total 12 treatments were tested using randomized block design having 3 replications. Soybean cv. 'PS 1347' was sown @ 80 kg seeds/ha at row-to-row spacing of 45 cm. Pre-and post-emergence applications of herbicide were done 1 and 20 days after sowing respectively. A knapsack sprayer fitted with a flat-fan nozzle was used with 500 litres water/ha for herbicide application. The weed-control efficiency was calculated by using the following formula (Mani *et al*., 1981). Data on various yield attributes, seed and straw yields of soybean were statistically analysed as per standard statistical procedure. The data pertaining to the number and dry weight of weeds were subjected to [$\sqrt{(x+1.0)}$] transformation before ANOVA. The economics was worked out on the basis of prevailing rates of inputs and produce.

Out of total weed species, *Dactyloctenium aegyptium* and *Celosia argentea* were the dominant grassy and non-grassy weeds respectively. The contribution of grassy weed, non-grassy weed and sedges to total weed population was to the tune of 51.0, 26.5 and 22.4%, respectively, in weedy check at harvesting. At harvesting, significantly lower total weed density and weed dry weight were recorded with pre-emergence application of pendimethalin -1.0 kg/ha *fb* imazethapyr 0.1 kg/ha as post-emergence + mulching of wheat straw @ 5 t/ha (25 DAS), which was at par with mulching of wheat straw @ 5 t/ha after first weeding and mulching of wheat straw @ 5 t/ha *fb* sulfentrazone @ 0.3 kg/ha as post-emergence. The highest weed-control efficiency (WCE) was obtained under weed-free check and was at par with pre-emergence application of pendimethalin - 1.0 kg/ha *fb* imazethapyr 0.1 kg/ha as post-emergence + mulching of wheat straw @ 5 t/ha (67.65%). These findings are in conformity with that of Monsefi *et al.* (2013), who reported WCE to the tune of 79.5% in wheat straw mulch + imazethapyr. The new herbicide molecule sulfentrazone gave satisfactory control of all types of weed flora, resulting in higher soybean yields at remunerative prices and this result was in conformity with the findings of Yelverton and Travis, (2012).

The number of branches, seeds/pod and 100-seed weight were found to be non-significant. Weed-free check increased the number of pods to the tune of 80.29, 44.83 and 37.93% over weedy check, mulching of wheat straw @ 5 t/ha and imazethapyr 0.1 kg/ha. Mulching of wheat straw @ 5 t/ha after first weeding and pendimethalin @1.0 kg/ha (PE) *fb* imazethapyr @ 0.1 kg/ha (PoE) + mulching of wheat straw @ 5 t/ha (25 DAS) were the next best treatments after weed-free check which produced 75.31 and 70.12% more pods/plant over the weedy check. Higher

Table 1. Effect of weed-control treatments on weed growth and weed-control efficiency at harvesting of soybean

Treatment	Weed count (No./m²)				Total weed dry weight (g/m²)	Weed-control efficiency (%)
	Grass	Sedge	Broad leaf weeds	Total		
Pendimethalin (PE) 1.0 kg/ha	4.57* (20)	2.20 (4)	2.98 (8)	5.73 (32)	8.48 (71.22)	53.48
Sulfentrazone (PoE) 0.3 kg/ha	4.23 (17)	1.98 (3)	2.62 (6)	5.18 (26)	8.13 (65.39)	57.29
Imazethapyr (PoE) 0.1 kg/ha	4.89 (23)	1.00 (0)	3.15 (9)	5.73 (32)	8.41 (70.12)	54.20
Mulching 5 t/ha at 1 DAS	4.64 (21)	2.64 (6)	3.13 (9)	6.07 (36)	9.52 (89.95)	41.25
Pendimethalin *fb* sulfentrazone	3.73 (13)	1.71 (2)	2.20 (4)	4.45 (19)	7.92 (62.13)	59.43
Pendimethalin *fb* imazethapyr	3.98 (15)	1.00 (0)	2.44 (5)	4.56 (20)	7.79 (60.06)	60.77
Pendimethalin *fb* mulching at 7 DAS	4.35 (18)	1.73 (2)	2.60 (6)	5.18 (26)	8.23 (67.12)	56.16
Pendimethalin *fb* imazethapyr + mulching (25 DAS)	2.9 7(8)	1.00 (0)	1.71 (2)	3.29 (10)	7.08 (49.53)	67.65
Mulching after first weeding (25 DAS)	3.15 (9)	1.00 (0)	1.98 (3)	3.63 (12)	7.27 (52.08)	65.98
Mulching at 1 DAS *fb* sulfentrazone	3.45 (11)	1.41 (1)	1.98 (3)	3.98 (15)	7.53 (56.22)	63.02
Weedy check	5.09 (25)	3.45 (11)	3.73 (13)	7.05 (49)	12.40 (153.15)	0
Weed-free check	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	1.00 (0)	100
SEm±	0.19	0.12	0.17	0.23	0.37	3.15
CD (P=0.05)	0.58	0.35	0.51	0.68	1.07	9.24

*Data subjected to $(x+1)^{1/2}$ transformation and figures in parentheses are original values; *f*b, followed by

Table 2. Effect of weed-control treatments on yield attributes and yield of soybean

Treatment	Branches/ plant	Pods/ plant	Seeds/ pod	1,000-seed weight (g)	Seed yield (t/ha)	Straw yield (t/ha)	Benefit: cost ratio
Pendimethalin (PE) 1.0 kg/ha	5.9	64.2	2.2	112.4	1.92	3.81	2.18
Sulfentrazone (PoE) 0.3 kg/ha	5.7	67.8	2.3	109.7	1.97	4.02	2.24
Imazethapyr (PoE) 0.1 kg/ha	5.8	63.0	2.2	104.2	1.88	3.81	2.19
Mulching 5 t/ha at 1 DAS	5.7	60.0	2.2	103.3	1.84	3.46	1.93
Pendimethalin *fb* sulfentrazone	5.7	75.0	2.3	114.5	2.49	4.37	2.93
Pendimethalin *fb* imazethapyr	6.3	77.5	2.3	113.8	2.41	4.13	2.68
Pendimethalin *fb* mulching at 7 DAS	6.0	57.5	2.3	113.0	1.95	3.91	1.90
Pendimethalin *fb* imazethapyr + mulching (25DAS)	6.2	82.0	2.4	118.2	2.60	5.29	2.59
Mulching after first weeding (25 DAS)	6.0	84.5	2.4	116.5	2.59	5.27	2.42
Mulching at 1 DAS *fb* sulfentrazone	5.9	79.2	2.4	114.2	2.51	5.08	2.82
Weedy check	4.7	48.2	2.1	102.0	1.26	3.07	1.25
Weed-free check	6.5	86.9	2.4	119.0	2.79	5.42	2.00
SEm±	0.33	3.9	0.1	5.9	0.13	0.26	0.19
CD (P=0.05)	NS	11.7	NS	NS	0.37	0.76	0.55

fb, followed by

pods/plant under these treatments might be owing to more number of branches/plant, higher dry-matter accumulation/plant and less competition between crop plants and weeds as compared to others.

The highest seed yield (2.79 t/ha) and straw yield (5.42 t/ha) were obtained under weed-free check, which was at par with pre-emergence application of pendimethalin @ 1.0 kg/ha *fb* imazethapyr @ 0.1 kg/ha as post-emergence + mulch @ 5 t/ha (25 DAS), mulching of wheat straw @ 5 t/ha after first weeding, and mulching of wheat straw @ 5 t/ha *fb* sulfentrazone @ 0.3 kg/ha as post-emergence and recorded higher seed yield than remaining treatments. Similar were the findings of Younesabadi *et al.* (2013), who concluded that pendimethalin 0.5 kg/ha + imazethapyr 0.075 kg/ha being comparable with weed-free check gave higher seed yield of soybean in 2010 and 2011. On an average, the increase in seed yield was to the tune of 55.13% in case of weed-free check as compared to weedy check. Pendimethalin @ 1.0 kg/ha *fb* sulfentrazone @ 0.3 kg/ha exhibited the highest benefit: cost ratio (2.93) owing to higher net returns and low cost of cultivation. Devi *et al*. (2012) reported that imazethapyr 75 g/ha + *in situ* mulching with weeds after hand-weeding at 30 DAS gave the highest benefit: cost ratio (1.79).

Based on the findings of the present study, it may be inferred that pre-emergence application of pendimethalin @ 1.0 kg/ha *fb* imazethapyr @ 0.1 kg/ha as post-emergence + mulching of wheat straw @ 5 t/ha (25 DAS) and mulching of wheat straw @ 5 t/ha after first weeding and mulching of wheat straw @ 5 t/ha *fb* sulfentrazone @ 0.3 kg/ha were the superior treatments in controlling weed population and providing higher soybean yields.

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