Herbicidal weed control in soybean (*Glycine max*, L. Merrill) crop

Abstract

An experiment was conducted at 'The Research Farm, College of Agriculture, Tikamgarh,during *kharif* season, 2016-17. The field was mainly infested with monocot weeds like *Brachiariaramosa*, *Commelinabenghalensis*, *Cyperus rotundus* and *Echinochloacrusgalli*. Dicot weeds *Digera arvensis*, *Phyllanthus niruri* and *Mollugo pentaphylla* were less dominant in the soybean ecosystem. The treatments comprised of pre-emergence herbicides; clomazone @ 1 kg/ha, pendimethalin @ 1 kg/ha and alachlor @ 1 kg/ha and post-emergence herbicides; imazethapyr @ 75 g/ha, imazethapyr + imazamox @ 70 g/ha, quizalofop-p-ethyl @ 50 g/ha+ chlorimuron-ethyl @ 9 g/ha,quizalofop-p-ethyl @ 50 g/ha, chlorimuron-ethyl @ 9 g/ha, two hand weeding at 20 and 40 DAS and weedy check., dry matter and weed index. It was also found superior in respect of various growth and yield attributes. The highest seed yield (825 kg/ha) and straw yield (1152 kg/ha) of soybean and maximum gross return (₹ 37,611 ha-1) and net return (₹ 23,951 ha-1) were also recorded in imazethapyr + imazamox 70 kg/ha as postemergencewith highest B:C ratio of 2.75. It was also found responsible for the highest N, P and K uptake by soybean crops and the lowest uptake of these plant nutrients by weed plants.

Key words: Imazamox, imazethapyr, pendimethalin, quizalofop-p-ethyl, soybean, weed control.

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1. Introduction

Soybean (*Glycine max*), is an important oil-yielding rainy season (*Kharif*) crop having multiple uses. It has revolutionized the rural economy and improved the farmers' socio-economic status. Soybean has emerged as a potential crop for changing the ecological position of the farmers in India, particularly in Madhya Pradesh. Although the ecological conditions of the state are congenial for soybean conditions, the yield is substantially low, despite best management practices.Poor weed management practices deprive the crop of nutrients, soil moisture, sunlight, and space, resulting in poor crop growth and yield. The soybean crop grows slowly during the

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initial period, which results in vigorous growth and proliferation of weeds. In *kharif* season, ~~the~~ weed competition is one of the most important causes of low yield, estimated at 31-84% (Kachroo*et al*., 2003). Thus, intense weed completion is one of the main constraints for increasing soybean productivity. The weed is not controlled during a critical period of weed crop competition, may reduce soybean yield from 58-85% depending upon type and weed intensity (Singh and Singh, 1987, Kolhe *et al*.,1998). Hand weeding is a traditional and effective method of weed control, but untimely and continuous rains and unavailability of labour during peak periods of demand are the main limitations of manual weeding. Therefore, there is a need for alternative methods of reducing the weed load duringthe early crop growth period of soybean i.e. first 30-45 DAS (Chhokar *et al*., 1995).

Several herbicides*viz.*,fluchoralin, pendimethalin, metalochlor, alachlor and trifluralin *etc*. are presently being used for controlling weeds associated with soybean, but these herbicides were found not much effectivein controllingmany broad-leaved weeds existing in soybean. Recently, some ~~of the~~ post-emergence herbicides have been found effective in controlling weeds in soybean (Khope*et al*., 2011). Therefore, it is imperative to evaluate the efficacy of suitable early postemergence herbicide, which could be able to control the dominating weeds in soybean fields. According to Chauhan *et al*., (2013) and Dixit *et al*., (2003) chlorimuron may be an effective post-emergence herbicide for controlling both sedges and broad-leaved weeds in soybean, but it is not tested under agroclimatic condition of Jabalpur. Hence, the present investigation was carried out to assess the efficacy of chlorimuron alone and its mixture with quizalofop-p–ethyl against weeds in soybean.

2. Material and Methods

The field was infested with location-specific weeds representative of this area. All herbicides werecombined and applied 14 Days after sowing (DAS) in 500 liters of water per ha with a knapsack sprayer using a flat fan nozzle. Before sowing, the seed was treated with Thiram 2.5 g/kg of seed, followed by inoculation with *Rhizobium japonicum* culture at 5 g/kg of seed. Soybean variety 'JS-20-29' was sown @ 80 kg/ha on 18 July with a row spacing of 30 cm in2016. A full dose of major plant nutrients (20 kg N+ 60 kg P2O5 + 20 kg K2O/ha) was applied as basal application through urea, SSP and Muriate of potash during sowing. All the fertilizers

were applied manually at the time of sowing in the furrows about 3 cm below the seed. The species-wise weed population was recorded by the least count quadrate (0.25 m × 0.25 m) method at 45 DAS, whereas the weed biomass was recorded at harvest and weed control efficiency was calculated accordingly. While observations on grain yield and yield attributing parameters viz., pods/plant, seeds/pod, seed index and harvest index wererecorded at harvest. The experiment was laid down in randomized block design replicated thrice with ten weed control treatments comprised of:

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T_1 - Clomazone @ 1 kg/ha,

T_2- Pendimethalin @1kg/ha,

T_3-Alachlor @ 1 kg/ha,

T_4- imazethapyr@ 75 g/ha,

T_5 -Imazethapyr + Imazamox @ 70 g/ha,

T_6 - Quizalofop-p-ethyl @ 50 g/ha,

T_7- Chlorimuron-ethyl @ 9 g/ha,

T_8 - Quizalofop-p-ethyl @ 50 g/ha + Chlorimuron-ethyl 9 g/ha,

T_9- Hand weeding (20 and 40 DAS),

T_{10}- Weedy check.

2.1. Weed control efficiency (WCE)

It is the efficiency of treatment expressed in percent for controlling weeds comparedto the weedy check. It was worked out based onthe following formula as suggested by (Mallikarjun *et al.*, 2014).

$$WCE = \frac{DWC - DWT}{DWC} \times 100$$

Where,

WCE = weed control efficiency

DWC =dry weight of weeds in weedy check plot

DWT = dry weight of weeds in the treated plot

2.2. Harvest Index (HI):

It refers to the ratio of economic yield (seed yield) to the biological (seed + stover) yield under a particular treatment and ~~it~~ is expressed in percentage. It was computed by using the following formula.

Economic yield

$$\textbf{HI (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

Where,

Economic yield = Seed yield

Biological yield = Seed yield + Stover yield

2.3. Leaf area index (LAI)

The leaf area of leaves from five selected plants drawn for biomass observation wasused for measuring leaf area. The leaf area index (LAI) was determined plot-wise for each observation in all plots by using the following formula:

$$\textbf{LAI} = \frac{\text{Total leaf area (A)}}{\text{Ground area covered (P)}}$$

Where,

A = leaf area (m^{-2})

P = Ground area (m^{-2})

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Where,

Economical yield = Seed yield

Biological yield = Seed yield + stover yield

3. Results and Discussion

Effect on weed flora predominant weed species observed in the experimental field consisted of grassy weeds *viz.Brachiariaramosa, Commelinabenghalensis, Cynodondactylon, Cyperus rotundus, Echinochloacrusgalli, and broad leaved weeds. Digeraarvensis,Mollugo pentaphylla* and *Phyllanthus niruri*. The weeds' population and dry matter accumulation were recorded at 15, 30, 45, and 60 DAS and harvest stages.Herbicides significantly reduced weed intensity at all crop growth stages. Pre-emergence application of clomazone@ 1 kg/ha, alachlor @ 1 kg/ha and pendimethalin @ 1 kg/ha recordeda lower number of weeds per m^{-2} and post-

emergence application ofimazethapyr + imazamox @ 70 g/ha, imazethapyr @ 75 g/ha,quizalofop-p-ethyl @ 50 g/ha + chlorimuron-ethyl @ 9g/ha which is on par withquizalofop-p-ethyl @ 50 g/ha, chlorimuron-ethyl @ 9g/haand control recorded highest weed number at 45 DAS. Higher numbers of weeds per m^2 was recorded in control at all the stages. All treatments effectively decreased the weed infestation compared to control. Whereas, dry matter of weeds also showed similar results as number of weeds per m^2. Low weed dry matter accumulation was recorded in the treatments of pre-emergence herbicides clomazone @ 1 kg/ha and post-emergence herbicides imazethapyr + imazamox @ 70 g/ha, quizalofop-p-ethyl @ 50 g/ha + chlorimuron-ethyl @ 9 g/ha and imazethapyr @ 75 g/ha, followed by quizalofop-p-ethyl @ 50 g/ha,alachlor@ 1 kg/ha, pendimethalin @ 1 kg/ha and chlorimuron-ethyl @ 9 g/ha (Table 1). Lowest weed index and highest weed control efficiency was found in imazethapyr + imazamox @ 70 g/ha, quizalofop-p-ethyl @ 50 g/ha + chlorimuron-ethyl @ 9 g/ha and imazethapyr @ 75 g/ha.

Hand weeding twice at 20 and 40 DAS gave significantly higher crop biomass and LAI as compared to the other treatments and it was at par with combined application of chlorimuron+quizalofop-p-ethyl+vit-o-vit @ 9+75+750g/ ha as post- emergence. Application of chlorimuron + quizalofop-p-ethyl (12+50 g/ha) and imazethapyr (75 g/ha) was comparable with chlorimuron + quizalofop-p-ethyl+ vito-vit(9+75+750 g/ha) and significantly superior over weedy check in respect to crop biomass and LAI. The higher crop biomass is might be due to better weed control by herbicidal mixture. Whereas lower rate of chlorimuron (6 g/ha) applied as post-emergence were ineffective in curbing the weed menace and there by produced inferior crop biomass.

Different weed control treatments significantly affected various growth and yield attributing characters in soybean over control treatment. Taller plants and the highest plant dry matter were observed in application of imazethapyr + imazamox @ 70 g/ha, quizalofop-p-ethyl @ 50 g/ha + chlorimuron-ethyl @ 9 g/ha and imazethapyr @ 75 g/ha as post-emergence over allthe other treatments. This might be due to providinga favorable environment for crops with controlling weeds, which reduces the competition of cropswith weeds for space, air, sunlight, moisture and nutrients. A significantly higher number of pods and seed weight per plant were found in imazethapyr + imazamox @ 70 g/ha, quizalofop-p-ethyl @ 50 g/ha + chlorimuron-ethyl

@ 9 g/ha and imazethapyr @ 75 g/ha as post-emergenceapplication over all the other treatments. Similar results were earlier reported by Prachand*et al.* (2015).

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Table1. Effect of different herbicidal doses against weed intensity in soybean 45 DAS

Treatment	*Cyperus rotundus*	*Echinochloa crusgalli*	*Cynadond actylon*	*Commelinab enghalensis*	*Brachiariara mosa*	*Phyllanthus niruri*	*Digera arvensis*	*Mollugo pentaphylla*
T_1 - Clomazone @ 1 kg/ha	19.94 (4.50)	15.66 (4.01)	3.55 (1.99)	3.44 (1.98)	3.44 (1.97)	4.89 (2.32)	3.00 (1.85)	1.77 (1.45)
T_2 - Pendimethalin @ 1 kg/ha	23.00 (4.84)	17.00 (4.14)	5.33 (2.41)	3.14 (1.88)	4.11 (2.14)	4.72 (2.28)	3.22 (1.90)	2.00 (1.54)
T_3 - Alachlor @ 1 kg/ha	21.50 (4.69)	16.44 (4.09)	5.67 (2.48)	3.44 (1.98)	4.22 (2.16)	4.55 (2.24)	3.22 (1.93)	1.89 (1.54)
T_4 - Imazethapyr @ 75 g/ha	16.50 (4.11)	12.89 (3.63)	2.55 (1.75)	1.61 (1.44)	1.89 (1.51)	2.55 (1.74)	1.11 (1.26)	0.77 (1.13)
T_5 - Imazethapyr + Imazamox @ 70 g ha^{-1}	12.67 (3.62)	4.55 (2.12)	2.44 (1.71)	1.00 (1.17)	1.55 (1.43)	1.67 (1.46)	0.22 (0.83)	0.66 (1.07)
T_6 - Quizalofop-p-ethyl @ 50 g/ha	18.33 (4.32)	6.22 (2.57)	2.44 (1.68)	3.55 (2.00)	1.55 (1.42)	9.33 (3.13)	4.11 (2.14)	5.22 (2.39)
T_7 - Chlorimuron-ethyl @ g/ha	32.67 (5.76)	28.00 (5.32)	6.50 (2.68)	1.55 (1.41)	7.22 (2.77)	2.33 (1.68)	0.72 (1.10)	1.00 (1.18)
T_8 - Quizalofop-p-ethyl @ 50 g/ha + Chlorimuron-ethyl 9 g/ha	18.33 (4.33)	8.00 (2.91)	3.11 (1.87)	1.78 (1.50)	2.11 (1.60)	2.67 (1.77)	1.44 (1.30)	1.00 (1.22)
T_9 - Hand weeding (20 & 40 DAS)	1.33 (1.27)	0.00 (0.71)	0.67 (1.05)	0.00 (.0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{10} - Weedy check	36.00 (6.04)	34.33 (5.90)	6.33 (2.61)	5.44 (2.43)	8.67 (3.03)	9.22 (3.11)	5.44 (2.44)	5.00 (2.34)
SEm±	0.24	0.31	0.13	0.15	0.14	0.11	0.16	0.15
CD (P=0.05)	0.70	0.94	0.37	0.45	0.40	0.33	0.49	0.47

*Figures within parentheses are √(x+0.5) transformed values

Table2. Effect of different herbicidal doses against dry weight of weed (g/m^2) in soybean at 45 DAS

Treatment	*Cyperus rotundus*	*Echinochloa crusgalli*	*Cynadon dactylon*	*Commelinab enghalensis*	*Brachiariar amosa*	*Phyllanthus niruri*	*Digera arvensis*	*Mollugo pentaphylla*
T_1 - Clomazone @ 1 kg/ha	30.79 (5.59)	19.11 (4.42)	0.76 (1.12)	6.72 (6.72)	3.33 (1.94)	1.27 (1.33)	5.90 (2.53)	0.26 (0.87)
T_2 - Pendimethalin @ 1 kg/ha	34.56 (5.91)	26.29 (5.17)	1.32 (1.37)	6.13 (2.57)	3.56 (2.01)	1.16 (1.29)	7.13 (2.76)	0.40 (0.94)
T_3 - Alachlor @ 1 kg/ha	32.44 (5.73)	25.32 (5.06)	1.27 (1.33)	6.29 (2.60)	3.83 (2.08)	1.02 (1.23)	6.90 (2.72)	0.34 (0.92)
T_4 - Imazethapyr @ 75 g/ha	15.59 (4.00)	5.95 (2.50)	0.56 (1.03)	2.42 (1.70)	2.27 (1.66)	0.75 (1.12)	2.54 (1.74)	0.16 (0.81)
T_5 - Imazethapyr + Imazamox @ 70 g ha^{-1}	6.33 (2.61)	2.15 (1.62)	0.50 (1.00)	1.00 (1.22)	1.22 (1.31)	0.45 (0.97)	0.28 (0.88)	0.08 (0.76)
T_6 - Quizalofop-p-ethyl @ 50 g/ha	14.91 (3.92)	4.74 (2.29)	0.58 (1.04)	4.54 (2.24)	1.44 (1.39)	4.27 (2.18)	7.26 (2.78)	1.53 (1.42)
T_7 - Chlorimuron-ethyl @ g/ha	47.02 (6.89)	33.79 (5.83)	3.19 (1.92)	1.99 (1.57)	6.10 (2.57)	0.77 (1.12)	1.11 (1.27)	0.15 (0.81)
T_8 - Quizalofop-p-ethyl @ 50 g/ha + Chlorimuron-ethyl 9 g/ha	7.39 (2.79)	6.16 (2.58)	0.73 (1.11)	2.18 (1.64)	2.17 (1.63)	0.78 (1.13)	1.62 (1.45)	0.41 (0.95)
T_9 - Hand weeding (20 & 40 DAS)	0.82 (1.14)	0.20 (0.84)	0.08 (0.76)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)
T_{10} - Weedy check	56.18 (7.52)	61.89 (7.87)	4.13 (2.15)	11.90 (3.52)	6.64 (2.67)	6.33 (2.60)	8.22 (2.95)	1.70 (1.48)
SEm±	0.20	0.21	0.05	0.08	0.07	0.07	0.07	0.04
CD (P=0.05)	0.60	0.63	0.14	0.24	0.20	0.20	0.21	0.12

*Figures within parentheses are √(x+0.5) transformed values

Table3. Effect of different weed control treatments on various growth and yield attributing characters, yield and economics of soybean

Treatment	Plant height (cm)	LAI (60 DAS)	Plant dry weight (g)	Number of pods/plant	100 seed weight (g)	Seed yield/plant (g)	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index
T_1 - Clomazone @ 1 kg/ha	33.00	2.57	154.79	10.93	2.47	0.19	644	797	43.80
T_2 - Pendimethalin @ 1 kg/ha	31.43	2.46	148.87	10.52	2.37	0.17	586	763	43.46
T_3 - Alachlor @ 1 kg/ha	32.03	2.51	150.68	10.70	2.40	0.17	630	775	43.64
T_4 - Imazethapyr @ 75 g/ha	34.67	2.81	161.59	11.52	2.63	0.20	713	777	44.08
T_5 - Imazethapyr + Imazamox @ 70 g ha^{-1}	36.62	2.87	177.70	12.67	2.83	0.22	825	1152	45.33
T_6 - Quizalofop-p-ethyl @ 50 g/ha	33.10	2.57	153.76	11.33	2.60	0.18	663	861	43.54
T_7 - Chlorimuron-ethyl @ g/ha	31.00	2.55	154.44	10.66	2.37	0.17	588	755	42.21
T_8 - Quizalofop-p-ethyl @ 50 g/ha + Chlorimuron-ethyl 9 g/ha	36.33	2.84	159.53	12.17	2.77	0.19	733	894	44.33
T_9 - Hand weeding (20 & 40 DAS)	38.28	3.09	182.12	13.33	3.13	0.24	1033	1166	47.28
T_{10} - Weedy check	30.00	1.95	129.53	9.85	2.13	0.14	402	583	38.15
SEm±	0.62	0.08	1.45	0.33	0.07	0.01	25	33	0.98
CD (P=0.05)	1.85	0.23	4.29	0.99	0.21	0.02	74	98	2.89