Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

J P P Journal of Pharmacognosy and Phytochemistry

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2017; SP1: 102-110

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Study on Effect of Different Herbicides on Weed intensity and Dry weightunder rain- fed Condition of central India in Soybean [Glycine max (L.) Merrill]

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Abstract
The experiment was laid out tostudy on 'Effect of Different Herbicides on Weed intensity and dry weight under rain-fed Condition of Central India in Soybean [*Glycine max* (L.) Merrill]*'*. The experiment was laid out in "randomized block design" with nine treatments, and replicated thrice. The major weeds *viz; Echinochloacolonum*and *Commelinabenghalensis* among the monocots and *Digeraarvensis*, *Phyllanthusniruri, Trianthemamonogyna*,*Corchorusolitorious*, and*Leucasaspera*among dicots were present whereas *Cyperusrotundus*was only sedge present in the experimental area. The relative density of dicots was 65.17% at harvest while monocots were to the extent of 34.82% of total weed population. All the herbicidal treatments and hand weeding reduced the weed intensity as compared to weedy check. Hand weeding twice was most effective and recorded minimum weed intensity among all the treatments. The result indicated that pendimathalin and imazethapyr + imazamox (Odyssey) was effectively reduced the population of both grassy and broad leaved weeds and was found effective as quizalofop-ethyl *fb*chlorimuron ethyl and all these herbicidal treatments were not significantly differing with hand weeding twice which registered the lowest intensity of grassy and dicot weeds among all the treatments, whereas weedy check recorded significantly the highest intensity of weeds. The weed control efficiency (WCE) among herbicides and its combination varied from 27.51- 82.40%. The highest weed control efficiency was recorded under hand weeding twice at 20 and 40 DAS (96.27%) followed by post emergence application of imazethapyr + imazamox (82.40%).Seed yield and Stover yield was significantly higher under two hand weeding at 20 & 40 DAS recorded the higher seed yield (922.22 kg ha^{-1}) followed by imazethapyr + imazamox @ 70 g a.i. ha^{-1} (797.22 kg ha^{-1}). Stover yield under all the herbicidal treatments (except glyphosate) and hand weeding twice at 20 and 40 DAS (1152.78 kg ha^{-1}) was significantly higher than weedy check (805.56 kg ha^{-1}). Similarly, harvest index increased significantly under all the herbicides varied from 39.95 – 42.73% than weedy check. The weed index was maximum under glyphosate (35.63%) followed by quizalofop-ethyl (29.57%), alachlor (27.39%) and pendimathalin (25.17%) among the herbicidal treatments, whereas the highest yield losses were recorded under weedy check (52.25%).

Keywords: Weed intensity, weed dry weight, Weed species, Yield

1. Introduction
Soybean [*Glycine max* (L.) Merrill] is an important oil seed crop among the oil seed crops. It has been termed as miracle bean because of higher protein (40%) and oil (20%) content (Chouhan and Joshi, 2005). The soil and climate of Madhya Pradesh are congenial for soybean production but being a rainy season crop it suffers severely due to competitional stress of grasses, sedges and broad leaved weeds resulting reduction in yield to the tune of 20 to 71% depending upon the type and intensity of weeds and their occurrence. Despite of the best management practices the poor weed management practices deprive the crop of its major requirement of nutrients, soil moisture, sunlight and space to poor crop growth yield. The stress is mainly due to presence of dominating grassy weeds viz; *Echinochloacrusgalli*, *Cyperus spp.* and broad leaved weeds viz; *Commelinabenghalensis*, *Commelinacommunis*, *Phyllanthusniruri* (Tiwari and Kurchania, 1990) [10].
The period of crop-weed competition lies between 15 to 45 DAS, after that the crop cover and take care of emergent late shift of weeds, which are smothered by the lush canopy of soybean crop. The production potential of the crop could not be realized fully, if weeds are not controlled within the critical period of crop-weed competition. Competition between crops and weeds generally begin at the early stages after emergence of the crop.
If the weeds are checked during this period, the soybean gets an advantage over the weeds and smothers them afterwards.

To overcome the deleterious effects of weeds in soybean, it is imperative that weeds population be kept below the economic threshold level. In soybean, weed is generally managed through manual weeding and hoeing but due to intermittent rainfall during rainy season and scanty labour, timely inter culture becomes a very difficult task. Adverse weather conditions also limit the use of tools and implements for clearing weeds in the field. Under such situations, different pre and post-emergence herbicides can control annual grass and broad-leaved weeds effectively in soybean (Vyas and Jain, 2003) [12].

Herbicide combinations are more effective tool in taking weed menace and thereby nutrient depletion by them than a single herbicide approach (Upadhyay *et al*., 2013) [11] For this purpose, several pre-plant incorporated, pre-emergence and post emergence herbicides have been recommended to control the weeds in soybean, which can be applied in combinations. Keeping this in view, the present investigation entitled Study on Effect of Different Herbicides on Weed intensity and dry weight under rain- fed Condition of Central India in Soybean [*Glycine max* (L.) Merrill].

Methods and Materials

The present investigation entitled "Effect of Different Herbicides on Weed intensity and dry weight under rain- fed Condition of Central India in Soybean [*Glycine max* (L.) Merrill]" was conducted during *Kharif* season of 2014. The materials used and methodologies employed to conduct the field experiment at The Research Farm, College of Agriculture, Tikamgarh, Madhya Pradesh during *Kharif*season, 2014. The treatments comprised of pre plant incorporation of glyphosate 41% SL @ 1.0 kg a.i. ha^{-1}, pre-emergence herbicides; pendimethalin @ 1 kg a.i. ha^{-1} and alachlor @ 1.0 kg a.i. ha^{-1} and post-emergence herbicides; imazethapyr + imazamox @ 70 g a.i. ha^{-1}, quizalofop-ethyl @ 50 g a.i ha^{-1}, chlorimuron-ethyl @ 9 g a.i. ha^{-1} and quizalofop-ethyl @ 50 g a.i. ha^{-1} *fb* chlorimuron-ethyl @ 9 g a.i. ha^{-1} and these treatments were compared with two hand weeding at 20 and 40 DAS and weedy check. The topography of the experimental area was fairly uniform. The field was infested with location specific weeds representative of this area. The analytical works were done in the laboratory of Department of Agronomy, College of Agriculture, Tikamgarh, JNKVV, Jabalpur.Tikamgarh is situated at $24^0$45‟ N latitude and $78^0$53‟E longitude at an altitude of 426.7 meter above the mean sea level. It falls under subtropicalclimatic conditions soil analysis data that the soil of experimental area was clayey in texture and almost neutral in reaction (pH 7.3). It was medium in organic carbon, low in available nitrogen and available phosphorus but medium in available potassium content.

In weedy check plots, weeds were permitted to grow without any control measures throughout the crop growing period. The herbicidal spray solution was prepared by mixing the required quantity of herbicide as per the recommended dose required per plot in water @ 500 litters ha^{-1}. Knapsack sprayer was used for the spraying. Uniform pressure was maintained to pump out nearly equal quantity of the herbicide uniformly as fine mist with flat fan nozzle during the spray

Weed population and relative weed density

The observations on population of major weeds *viz; Cyperusrotundus, Echinochloacolonum, Commelinabenghalensis,Trianthemamonogyna,Digeraarvensis,Phyllanthusniruri, Corcorusolitorious, Leucasaspera* and other associated weeds were recorded.

The quadrate of one m^{-2} (square meter) was randomly placed at three places in each plot and then the species wise and total weed count was recorded. The percentage composition of weed flora was estimated from weedy check plot.

The relative density of individual weed was worked out as per formula proposed by Mishra (1968).

$$\text{Relative Density (\%)} = \frac{\text{Number of individuals of the same species}}{\text{Number of individuals of all species}} \times 100$$

Weed biomass (g m^{-2})

The biomass was recorded at 40 DAS at harvest of the crop. All the associated weeds were collected, randomly from 1.00 m^{-2} quadrate at four places in each plot. The weeds were kept in paper begs and dried in oven at 60^0C for 24 hours and weight was recorded.

Weed control efficiency (%)

It is the efficiency of treatment expressed in percentage for controlling weeds in comparison to unweeded control and worked out on the basis of the formula suggested by Mani *et al.* (1973). Weed control efficiency (%) was computed based on the following formula:

$$W.C.E = \frac{\text{Dry weight of weeds in control plot} - \text{Dry weight of weeds in treated plot}}{\text{Dry weight of weeds in control plot}} \times 100$$

Harvest Index (%)

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 (Nichiporovich, 1967).

$$HI\ (\%) \frac{\text{Economical yield (Seed yield)}}{\text{Biological yield (Seed yield + Stover yield)}} \times 100$$

Weed Index (%)

It refers to the ratio of the percent reduction in the seed yield under a particular treatment due to the presence of weeds as compared to the seed yield determined in weed free plot (hand weeded plot) as suggested by Gill and Kumar (1969). It is expressed in percentage and determined with the formula.

$$WI\ (\%) \frac{X - Y}{X} \times 100$$

Where,

WI = Weed index

X= Seed yield from weed free plot (hand weeded plot)

Y= Seed yield from the treated plot for which weed index is to be worked out

Result and Discussion

The major weed species in the experimental plots were *Cyperusrotundus, Echinochloacolonum, Commelinabenghalensis, Digeraarvensis, Phyllanthusniruri, Trianthemamonogyna, Corchorusolitorious,* and *Leucasaspera.* These eight species were most dominant, contributing about 90 per cent of the total weed flora.

Relative density and weed intensity

The population of dominant weeds prevailed in weedy check and their relative density at 40 DAS and at harvest have been presented in the Table 1.

Table 1: Weed intensity and relative density of dominant weeds at 40 DAS and at harvest stage

			Days after sowing		
			40 DAS	At harvest	
	Weed species	Weedintensity(m^{-2})	Relative density(%)	Weedintensity(m^{-2})	Relative density(%)
A	Monocotyledonous/ Grasses				
1	*Echinochloacolonum*(L.)	26.40	15.15	28.53	15.99
2	*Cyperusrotundus*(L.)	20.00	11.48	20.27	11.36
3	*Commelinabenghalensis* (L.)	13.07	7.50	13.33	7.47
	Sub total	59.47	34.14	62.13	34.82
B	Dicotyledonous				
1	*Digeraarvensis*(L.)	26.40	15.15	25.87	14.50
2	*Phyllanthus niruri*(L.)	40.27	23.12	40.27	22.57
3	*Trianthemamonogyna*(L.)	20.27	11.63	19.47	10.91
4	*Corchorusolitorious*(L.)	12.27	7.04	13.87	7.77
5	*Leucas aspera*(L.)	15.47	8.88	16.80	9.41
	Sub total	114.68	65.85	116.28	65.17
	Total	174.15	100	178.41	100

At 40 DAS, relative density of monocotyledonous weed was less (34.14%) as compared to dicotyledonous weeds(65.85%). *Echinochloacolonum* (15.15%) and *Cyperusrotundus*(11.48%)had the higher density among monocotyledonous whereas among the dicotyledonous weeds *Phyllanthusniruri* recordedthe highest relative density of 23.12% followed by *Digeraarvensis* (15.15%) and *Trianthemamonogyna* (11.63%). At harvest, relative density of monocotyledonous weed was less (34.82%) as compared to dicotyledonous weeds (65.17%).*Echinochloacolonum*(15.99%) and*Cyperusrotundus*(11.36%)had the higher density among monocotyledonous whereas among the dicotyledonous weeds*Phyllanthusniruri* recordedthe highest relative density of 22.57% followed by *Digeraarvensis*(14.50%) and *Trianthemamonogyna* (10.91%). The higher density of *Phyllanthus niruri* may be due to the fact that the favourable environment condition *viz*; temperature and moisture which the provide quick germination, vegetative growth and survival capacity as well as the greater competitive ability than the other weeds. The density of all weeds was maximum under weedy check at each stage due to undisturbed growth of weeds as no weed control measures were adopted. However, identical reduction in density of weeds was recorded under various weed controltreatments, due to impose and influence of chemical and mechanical weed control measures.

At 40 DAS, hand weeding twice registerd significantly the lowest intensity of *Echinocloa colonum* followed by alachlor (2.04 m^{-2}) which was at par with post emergence application of quizalofop-ethyl (2.15 m^{-2}) and quizalofop-ethyl *fb* chlorimuron-ethyl (2.36 m^{-2}) was equally effective as pre emergence application of pendimethalin(2.57 m^{-2}). At harvest lowest intensity of *Echinocloa colonum* with the treatment hand weeding (0.71 m^{-2})followed by quizalofop-ethyl (1.62 m^{-2}) which was found at par with the treatment quizalofop-ethyl *fb* chlorimuron-ethyl (1.82 m^{-2}), alachlor (1.82 m^{-2}) and pendimethalin (2.16 m^{-2}).

At 40 DAS and at harvest stage hand weeding twice (1.00 & 0.85 m^{-2}) registered significantly the lowest intensity of *Cypreus rotundus* followed by imazethapyr + imazamox (1.43 & 1.24 m^{-2}). The highest weed intensity was found with weedy check (4.53 & 4.56 m^{-2}).

At 40 DAS, hand weeding twice registered significantly the lowest intensity of *Commelina benghalensis* and it was at par with post emergence application of imazethapyr + imazamox(1.24 m^{-2}), and chlorimuron-ethyl (1.53 m^{-2}). quizalofop-ethyl *fb* chlorimuron-ethyl (1.53 m^{-2}) were effective as pre emergence application of pendimethalin and alachlor and at harvest significantly highest intensity of *Commelina benghalensis*was recorded under quizalofop-ethyl (3.61 $m^{-2)}$ and weedy check (3.71 m^{-2}).

At 40 DAS and at harvest all the weed control treatments recorded significantly lower intensity of *Digera arvensis* than post emergence application of quizalofop-ethyl (5.13 m^{-2}&5.08 m^{-2})and weedy check (5.18 m^{-2}& 5.13 m^{-2})

Application of imazethapyr + imazamox, recorded significantly the lowest weed intensity of *Phyllanthus niruri* and was found at par withchlorimuron-ethyl (T_6) and quizalofop-ethyl *fb* chlorimuron-ethyl (T_7) at 40 DAS and at harvest sgtage lower intensity of *Phyllanthus niruri* than application of quizalofop-ethyl (6.06 m^{-2}) and weedy check (6.38 m^{-2}). Post emergence application of chlorimuron-ethyl (T_6) was found at par with quizalofop-ethyl *fb* chlorimuron-ethyl (T_7), whereas pre emergence application of pendimethalin and alachlor reduced the intensity of *Phyllanthus niruri* significantly over weedy check.

Intensity of *Trienthema monogyna* at harvest stage all pre and post emergence application recorded significantly the lower weed intensity than post emergence application of quizalofop-ethyl (4.37m^{-2}), imazethapyr + imazamox(4.16 m^{-2}) and weedy check (4.47 m^{-2}).

At 40 DAS and at harvest lowest Intensity of *Corchorus olitorious* was found with the treatment under two hand weeding (1.10 & 1.20 m^{-2}) and these treatments at par with imazethapyr + imazamox (1.40 & 1.33m^{-2}).

lowest Intensity of *Leucas aspera*was found with hand weeding (1.62 & 1.24 m^{-2}) twice followed by pendimethalin(1.69 & 1.76 m^{-2}) and alachlor (1.92 & 1.98 m^{-2}) and being at par with post emergence application of imazethapyr + imazamox (2.04 & 2.03 m^{-2}). Pre emergence herbicides; pendimethalin and alachlor andpost emergence; imazethapyr + imazamox, proved significantly effective over pre plant incorporation of glyphosate (2.95 & 2.91 m^{-2}).

The effectiveness of pre emergence herbicides pendimethalin and alachlor against weeds was higher because these herbicides do not allow the weeds to emerge and keep them under control up to critical period of crop–weed competition. Gaikwad and Pawar (2002) [4] at Rahuri noted that critical period for weed control in soybean is 20-40 days after sowing.

Hand weeding twice at 20 and 40 DAS was recorded significantly the lowest weed intensity as compared to all

other herbicidal treatments and weedy check. The weed intensity was significantly declined in hand weeded plots as compared to herbicidal treatments and weedy check because weeds were exterminated in hand weeding from inter and intra row spaces physically by *khurpi*, consequently, the crop attained luxuriant growth and suppressed the future weed flushes effectively. Similar results on hand weeding was obtained by Jain *et al*. (2001). After 40 DAS, pendimethalin (5.91 m^{-2}), imazethapyr + imazamox (6.11 m^{-2}), quizalofop-ethyl *fb* chlorimuron-ethyl (6.40 m^{-2}) alachlor (6.79 m^{-2}) and chlorimuron-ethyl (8.40 m^{-2}) were recorded significantly lower weed density as compared to weedy check (13.21 m^{-2}). Although the glyphosate (10.10 m^{-2}) and alone application of quizalofop-ethyl (11.33 m^{-2}) significantly reduced the population of weeds over weedy check but its application was not effective for controlling all type of weeds. This trend was observed in successive observations at harvest.

Application of glyphosate was significantly less effective as compared to other herbicidal treatments because before sowing the rainfall was lower which attributed to less weed intensity at the time of sowing and the rainfall received after sowing increased weed population in later stages therefore pre plant incorporation application of glyphosate was less effective.

Glyphosate is non-selective systemic herbicide absorbed by the foliage, with rapid translocation throughout the plant. Inactivated on contact with soil. Glyphosate is used to control of annual and perennial grasses and broad-leaved weeds. Glyphosate binds to and block the activity of the enzyme enolpyruvylshikimate-3-phosphate synthase (EPSPS). The active site of the EPSPS enzyme is highly consistent in higher plants, glyphosate affects a broad spectrum of weeds indiscriminately. Inhibiting the function of the shikimic acid pathway causes a deficiency in aromatic amino acids, eventually leading to the plant's death by starvation.

Pre emergence application of pendimethalin and alachlor significantly reduced the weed population as compared to post emergence application of quizalofop-ethyl. Prabhakaran *et al.* (1992) [8] found that two hand weeding at 25 and 45 DAS and pendimethalin @ 1.0 kg ha^{-1} gave effective weeds control and seed yield and resulted in lower weed index, weed dry matter and less nutrient uptake. Rani and Kodondaromaiah (1997) [9] found that the application of alachlor @ 1.0 kg ha^{-1} gave greater crop yield, was on par with alachlor + manual weed control.

Application of pendimethalin and alachlor were controlled the grassy and broad leaved weeds. There application reduced weed intensity as compared to pre plant incorporation of glyphosate, post emergence application of quizalofop-ethyl and weedy check.

Pendimethalin and alachlor is aselective systemic pre-emergence herbicides, which controls annual grasses and broad-leaved weeds. Pendimethalin control the weeds by inhibiting seed germination and seedling development, whereas alachlor is absorbed by germinating shoots and by roots. Alachlor works by interfering with a plant's ability to produce protein and by interfering with root elongation. Pre emergence application of herbicides are active in the surface layer of soil, where it controls annual weeds, as they germinate. It does not readily leach out and can move through a coarse soil into large inferential space, i.e. channeling

Application of imazethapyr + imazamox was controlled the grassy and broad leaved weeds. Its application reduced weed intensity as compared to other post emergence herbicidal treatments except quizalofop-ethyl *fb* chlorimuron-ethyl. Among post emergence herbicides, combined product of imazamox + imazethapyr at 75 g ha^{-1} were effective against both monocot and dicot weeds and has highest weed control efficiency and significantly increased the value of yield attributes and yield (1622 kg ha^{-1}) and it was significantly on par with 2 hand weeding (1710 kg ha^{-1}). The conformity view was endorsed by the findings of Vyas and Jain (2003) [12].

Imazethapyr inhibited acetoacetate synthase (ALS), also called acetohydroxy acid synthase (AHAS) a key enzyme in biosynthesis of the branched chain amino acid, isoleucine, leucine and valine, plant death result from event occurring in response to ALS inhibition, but the actual sequence of phytotoxic processes is unclear. Some secondary effect may include discruption of photosynthate translocation, hormone imbalance due to interruption of source/ sink relationship and interference in DNA synthesis and cell growth.

Imazamox kills the weeds by inhibiting the enzymesynthesis. This inhibition disrupts protein synthesis and subsequently interference with DNA synthesis and cell growth. It is readily absorbed by foliage but less by roots. Susceptible weeds die within 4 to 6 weeks. After application of the herbicide in sandy loam soil it is degraded rapidly by microbial degradation and is stable to photolysis.

Application of quizalofop-ethyl and its followed application with chlorimuron-ethyl significantly reduced the weed intensity with varying degree compared to weedy check. This trend was observed in successive observations (60 DAS and at harvest) also. The effectiveness of quizalofop-ethyl as post-emergence against weed control in soybean was also reported by Idapuganti *et al.* (2005) [6] at IARI, New Delhi suggested that quizalofop-ethyl @ 50 g ha^{-1} caused the highest reduction in the population of *Echinochloa colona and Cyperus rotundus*. Quizalofop-ethyl is a translocated weedicide recommended for crop like soybean, cotton etc.Quizalofop-ethyl inhibit acetyl CoA carboxylase (AC Case), the enzyme catalyzing the first committed step in denove fatty acid synthesis, inhibition of fatty acid synthesis presumably block the production of tri-glycerides used in building new membrane required to aryloxyphenoxy propionate and cyclohexanedione herbicides because of an intensitive AC Case.

Chlorimuron-ethyl is broad leaved weed killer to reduce the population of dicot weed viz, *Phyllanthus niruri*, *Commelina benghalensis*, *Convolvulous arvensis* etc. Theintensity of broad leaved weeds were higher in the field as compared to monocot weeds therefore alone application of chlorimron-ethyl and its combination quizalofop-ethyl *fb* chlorimuron-ethyl reduced the weed intensity significantly as compare to quizalofop-ethyl and weedy check. Balyan and Malik (2003) [1] conducted a field experiment in Hisar (Haryana) to evaluate the efficiency of herbicide alone and in combination, in controlling weeds in soybean. They found that chlorimuron-ethyl (6, 9 and 12 g ha^{-1}), prometryn (1000g ha^{-1}) application alone provided good control of both non grassy and grassy weeds. Among the herbicides, application of chlorimuron-ethyl at 9 and 12 g ha^{-1} provided satisfactory crop yield.

Chlorimuron-ethyl is a post emergence herbicide. It is absorbed readily into leaves and is thoroughly systematic after

absorption by roots and foliage. Inhibit acetolactate synthase (ALS), also called acetohydroxy acid synthase (AHAS), a key enzyme in the biosynthasis of the branched- chain amino acid isoleucine, leucine, and valine, plant death result from event occurring in ALS inhibition.

Weed dry weight and Weed control efficiency

At 40 DAS, hand weeding twice registered significantly the lowest weed dry weight of *Echinochloa colonum* among all the treatments whereas the lowest weed dry weight among all the herbicidal treatments was recorded under post emergence application of quizalofop-ethyl (0.94 g m^{-2}) followed by imazethapyr + imazamox, (0.97 g m^{-2}) and quizalofop-ethyl *fb* chlorimuron-ethyl (1.82 g m^{-2}). At harvest indicated that all the herbicidal treatments recorded significantly lower weed dry weight of *Echinochloa colonum*over chlorimuron-ethyl (3.47 g m^{-2}) and weedy check (3.73 g m^{-2}).

At 40 DAS and at harvest, hand weeding twice (0.95 g m^{-2} & 0.92 g m^{-2}) registered significantly the lowest dry weight of *Cyperus rotundus*followed by imazethapyr + imazamox (1.17 g m^{-2} & 1.19 g m^{-2}). Post emergence application of quizalofop-ethyl *fb* chlorimuron-ethyl (T_7) (1.25 g m^{-2} & 1.31 g m^{-2}) and quizalofop-ethyl (1.50 g m^{-2} & 1.39 g m^{-2}) was effective as compared to pre emergence application of pendimethalin (1.89 g m^{-2} & 1.83 g m^{-2}) and alachlor (1.97 g m^{-2} & 1.90 g m^{-2}).

At 40 DAS, hand weeding twice (1.11 g m^{-2}) registered significantly the lowest dry weight of *Commelina benghalensis*and it was at par with post emergence application of imazethapyr + imazamox (1.15 g m^{-2}). Post emergence application of chlorimuron-ethyl (T_6) (1.32 g m^{-2}) was found at par with quizalofop-ethyl *fb* chlorimuron-ethyl (T_7) (1.47 g m^{-2}) similarly the result at harvest indicated that all the herbicidal treatments recorded significantly lower dry weight of *Commelina benghalensis*over quizalofop-ethyl (2.57 g m^{-2}), glyphosate (2.70 g m^{-2}) and weedy check (2.81 g m^{-2}).

At 40 DAS, the significantly lowest dry weight of *Digera arvensis* was recorded under two hand weeding at 20 and 40 DAS and post emergence application of imazethapyr + imazamox, whereas the highest weed dry weight was recorded under weedy check (4.26 g m^{-2}) followed by quizalofop-ethyl (4.16 g m^{-2}) among all the treatments. Post emergence application of quizalofop-ethyl *fb* chlorimuron-ethyl (T_7) (1.85 g m^{-2} &1.66 g m^{-2}) was found at par with chlorimuron-ethyl (T_6) (1.71 g m^{-2}). Whereas pre emergence application of pendimethalin (3.57 g m^{-2}) and alachlor (4.07 g m^{-2}) reduced the dry weight of *Digera arvensis* significantly over weedy check (4.96 g m^{-2}).

The lowest dry weight of*Phyllanthus ninuri*wasrecorded under two hand weeding (0.71 g m^{-2}) followed by application of imazethapyr + imazamox, (0.71 g m^{-2}), whereas the highest dry weight was recorded under weedy check (2.08 g m^{-2}) and at harvest stage, all the weed control treatments recorded significantly lower weed dry weight than application of quizalofop-ethyl (2.17 g m^{-2}) and weedy check (2.42 g m^{-2}).

At 40 DAS and at harvest, the lowest dry weight of*Trianthema monogyna* was recorded under hand weeding twice at 20 and 40 DAS (1.24 m^{-2} & 1.20 m^{-2}) followed by pre emergence application of pendimethalin (1.57 g m^{-2}& 1.64 g $m^{-2)}$ and alachlor (1.65 g m^{-2}& 1.84 g m^{-2}) over weedy check (3.31 g m^{-2}& 3.35 g m^{-2}).

At 40 DAS, the significantly lowest dry weight of *Corchorus olitorious* was recorded under two hand weeding at 20 and 40 DAS (0.71 g m^{-2}) and post emergence application of imazethapyr + imazamox, whereas the highest weed dry weight was recorded under weedy check (2.02 g m^{-2}) followed by quizalofop-ethyl (1.86 g m^{-2}) and pre plant incorporation of glyphosate (1.80 g m^{-2}) and at harvest lowest dry weight among all the treatments was recorded under hand weeding twice at 20 and 40 DAS (0.71 g m^{-2}). Pre plant incorporation application of glyphosate significantly reduced dry weight of*Corchorus olitorious*but not proved as effective as pre and post emergence herbicides,

At 40 DAS, the lowest dry weight of*Leucas aspera* was recorded under hand weeding twice at 20 and 40 DAS followed by pendimethalin and alachlor and being at par with post-emergence application ofchlorimuron-ethyl. Pre emergence herbicides, pendimethalin and alachlor andpost emergence chlorimuron-ethyl herbicides proved significantly effective over pre plant incorporation of glyphosate. Among all the post emergence herbicidal treatments (T_4-T_7) application of chlorimuron-ethyl (T_6), imazethapyr + imazamox (T_4) and combination of quizalofop-ethyl *fb* clorimuron-ethyl (T_7) recorded significantly lower dry weight over quizalofop-p-ethyl (T_5) and weedy check (2.16 g m^{-2}). The lowest weed dry weight among all the treatments was recorded under hand weeding twice at 20 and 40 DAS (1.24 g m^{-2} & 1.19 g m^{-2}). Pre emergence application of pendimethalin and alachlor recorded significantly lower weed dry weight over quizalofop-ethyl (T_5) and weedy check (2.34 g m^{-2} &2.20 g m^{-2}) and proved equally effective as post emergence application of chlorimuron-ethyl (T_6) and quizalofop-ethyl *fb* chlorimuron-ethyl (T_7).

The weed control efficiency of various treatments as against unweeded control was worked out on the basis of weed dry weight at harvest. The highest weed control efficiency was recorded under hand weeding twice at 20 and 40 DAS (96.27%) followed by post emergence application of imazethapyr + imazamox (82.40%). Post emergence application of chlorimuron-ethyl and its combination viz; quizalofop-ethyl *fb* chlorimuron-ethyl were also reduced weed biomass considerably and attained weed control efficiency 67.88 and 79.18% over pre emergence application of alachlor (55.61%) and pendimethalin (63.86%). However, among the herbicidal treatments significantly the lowest weed control efficiency was recorded under pre plant incorporation application of glyphosate followed by post emergence application of quizalofop-ethyl.

On the basis of weed biomass recorded under particular treatment, the competitional stress of weeds on crop can be understood. All the herbicidal treatments and hand weeding twice at 20 and 40 DAS significantly reduced weed biomass as compared to weedy check. Among the treatments, hand weeding removed almost all the weeds completely, stirred the soil and created the conditions which were more favourable for the crop growth. Later

emerged weeds in these plots were dwarfed owing to good canopy development and failed to contribute much in dry matter production and ultimately resulted in reduced weed biomass with weed control efficiency of 96.27%. Kushwaha and Vyas (2005) [7] reported that two hand weeding at 20 and 40 DAS showed higher weed control efficiency (WCE) of 95.05 and 96.29% during 2001 and 2002 respectively.

Imazethapyr + imazamox (82.40%) followed by quizalofop-ethyl *fb* chlorimuron-ethyl (79.17%) and chlorimuron-ethyl (70.59%) recorded higher weed control efficiency. Pre-emergence application of pendimethalin and alachlor reduced weed biomass over PPI application of glyphosate and weedy check and registered higher weed control efficiency of 63.86% and 55.61%, respectively. Pre emergence application of pendimethalin reduced mean weed intensity as compared to other herbicidal treatments but the weed dry weight was the lowest under imazethapyr + imazamox, because post emergence application of imazethapyr + imazamox, quizalofop-ethyl *fb* chlorimuron-ethyl, and chlorimuron-ethyl suppress the weed growth at later stages as compared to pre emergence application of pedimethalin and alachlor which resulted in higher biomass in pre emergence treatments.

The lowest weed control efficiency recorded under pre plant incorporation of glyphosate (27.51%) and post emergence application of quizalofop-ethyl (28.65%), these treatments may not able to kill optimum weed stand.

Seed yield (kg ha^{-1}), Stover yield (kg ha^{-1}), Harvest index (%) and weed index

The result of herbicidal weed control treatments on seed yield revealed that it was significantly higher under all the herbicidal treatments (588.89–797.22 kg ha^{-1}) compared to weedy check (436.11 kg ha^{-1}). Two hand weeding (20 and 40 DAS) gave significantly the highest seed yield (922.22 kg ha^{-1}) among all the treatments. The weed competition was negligible in hand weeded plots as they were almost completely removed from inter and intra row spaces. The crop plants grew well in weed free environment with the results that yield attributes attained relatively greater values and finally the highest seed yield. Chouhan *et al.* (2002) reported that two hand weeding at 20 and 35 DAS in soybean crop drastically reduced weed intensity, weed biomass and increased the yield of crop. Among all the herbicides, imazethapyr + imazamox produced significantly higher seed yield except chlorimuron-ethyl and its combination. Halvankar *et al.* (2005) in an experiment found that application of imazamox + imazethapyr 75 g ha^{-1} effectively controlled the weeds over weedy check and also increased the yield of soybean.

The lowest yield in glyphosate, quizalofop-ethyl and weedy check was obviously owing to severe weed competitional stress throughout the crop span which was reflected in term of lowest value of all the yield attributes and ultimately the lowest seed yield ha^{-1}.

Soybean crop contributes to differently stover yield due to various weed control treatments.All the herbicidal treatments produced significantly higher stover yield over weedy check (805.56 kg ha^{-1}) except pre plant incorporation of glyphosate (888.89 kg ha^{-1}). Two hand weeding produced significantly higher stover yield (1152.78 kg ha^{-1}) followed by imazethapyr + imazamox (1069.44 kg ha^{-1}), quizalofop-ethyl *fb* chlorimuron-ethyl (1041.67 kg ha^{-1}) and chlorimuron-ethyl (1019.44 kg ha^{-1}). Pre emergence application of pendimethalin (950.00 kg ha^{-1}) and alachlor (944.44 kg ha^{-1}) was equally effective as post emergence application of quizalofop-ethyl (930.56 kg ha^{-1}) in producing the stover yield.

Harvest index among various treatments varied from (39.95–44.38%) as against 38.42% in weedy check. Two hand weeding recorded significantly the higher harvest index (44.38%) among all the treatments. However, among the herbicidal treatments (T_1 – T_7) the lowest harvest index was noted under alone application of glyphosate (39.95%) whereas it was higher under imazethapyr + imazamox and quizalofop-ethyl *fb* chlorimuron-ethyl.

Weed index varied in proportion to seed yield in herbicide treated plots as against hand weeded plots. This was in accordance with the degree of weed control under these treatments. The yield loss was relatively higher under pre plant incorporation of glyphosate among the herbicidal treatments, obviously owing to lower weed control efficiency. Among all the herbicidal treatments weed index varied from 12.89-35.63% and the highest value of weed index in weedy check (52.25%) was mainly on account of greater competitional stress, which in turn, resulted in sharp decline in seed yield.

Conclusions

Major dominant weeds infesting the soybean crop were *Cyperus rotundus, Echinochloa colonum,Commelina benghalensisDigera arvensis, Phyllanthus niruri, Trianthema monogyna, Corchorus olitorious* and *Leucas aspera.*Quizalofop-ethyl controlled grassy weeds, particularly *Cyperus rotundus, Cynodon dactylon, Saccharam spontanium* while chlorimuron-ethyl proved effective against broadleaved weeds lik*e Convolvulous arvensis* and *Phyllanthus niruri*. Imazethapyr + imazamox was effective to control the mixed weed flora. Pre emergence herbicides proved effective against monocots as well as dicots weeds. The application of hand weeding twice at 20 and 40 DAS recorded significantly the lowest weed intensity as well as weed biomass followed by pendimathalin in weed intensity

and imazethapyr + imazamox in weed biomass. The seed yield per hectare of soybean was higher under two hand weeding at 20 and 40 DAS (922.22 kg ha^{-1}) followed by imazethapyr + imazamox @ 70g a.i. ha^{-1} (797.22 kg ha^{-1}), quizalofop-ethyl @ 50 g a.i. ha^{-1} *fb* chlorimuron-ethyl @ 9 g a.i. ha^{-1} (769.44 kg ha^{-1}) and chlorimuron-ethyl @ 9 g a.i. ha^{-1} (741.67 kg ha^{-1}) than pre plant incorporation of glyphosate, pre emergence application of pendimethalin and alachlor and post emergence application of quizalofop-ethyl @ 50 g a.i. ha^{-1} and weedy check (436.11 kg ha^{-1}).Uncontrolled weeds in weedy check resulted yield loss of 52.25% in soybean.

Table 2: Effect of herbicides on weeds intensity (no. m^{-2}) at 40 DAS and at harvest stage

		Echinochloa colonum(L.)		*Cyperus rotundus*(L.)		*Commelina benghalensis* (L.)		*Digera arvensis*(L.)		*Phyllanthus niruri*(L.)		*Trianthema monogyna*(L.)		*Corchorus olitorious*(L.)		*Leucas aspera*(L.)	
S.N.	**Treatments**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**
T_1	Glyphosate 41% SL @ 1 kg a. i. ha^{-1}(PPI)	15.47 (3.99)	13.60 (3.74)	9.07 (3.09)	8.00 (2.91)	9.33 (3.13)	9.60 (3.17)	21.87(4.72)	18.33 (4.31)	16.00(4.05)	15.47 (3.99)	13.07(3.68)	12.27 (3.57)	8.53 (2.98)	8.27 (2.96)	8.27 (2.95)	8.00 (2.91)
T_2	Pendimethal in @ 1 kg a. i. ha^{-1}(PE)	6.13 (2.57)	4.27 (2.16)	3.73 (2.06)	2.93 (1.83)	2.13 (1.62)	2.40 (1.69)	9.60 (3.18)	7.47 (2.79)	4.80 (2.30)	4.53 (2.22)	2.93 (1.83)	2.67 (1.77)	2.93 (1.83)	3.20 (1.90)	2.40 (1.69)	2.67 (1.76)
T_3	Alachlor @ 1.0 kg a. i. ha^{-1}(PE)	3.73 (2.04)	2.93 (1.82)	4.53 (2.24)	4.00 (2.12)	3.20 (1.92)	3.47 (1.98)	14.67(3.88)	11.20 (3.41)	7.20 (2.77)	6.40 (2.62)	4.00 (2.12)	4.80 (2.30)	5.07 (2.36)	4.80 (2.27)	3.20 (1.92)	3.47 (1.98)
T_4	Imazethapyr + imazamox @ 70 g a. i. ha^{-1}(Odyssey)	9.60 (3.18)	7.47 (2.82)	1.60 (1.43)	1.07 (1.24)	1.07 (1.24)	1.33 (1.29)	0.00 (0.71)	0.00 (0.71)	1.87 (1.50)	1.87 (1.53)	17.33(4.22)	16.80 (4.16)	1.60 (1.40)	1.33 (1.33)	3.73 (2.04)	3.73 (2.03)
T_5	Quizalofop-p-ethyl @ 50 g a. i ha^{-1}at 20 DAS	4.27 (2.15)	2.13 (1.62)	3.20 (1.92)	2.67 (1.78)	12.27(3.56)	12.53 (3.61)	25.87(5.13)	25.33 (5.08)	37.60(6.17)	36.27 (6.06)	18.13(4.32)	18.67 (4.37)	11.73 (3.49)	12.80 (3.65)	14.93 (3.93)	16.00 (4.05)
T_6	Chlorimuron-ethyl @ 9 g a. i. ha^{-1}at 20 DAS	25.60(5.10)	26.13 (5.16)	18.13(4.31)	17.87 (4.28)	1.87 (1.53)	1.60 (1.43)	2.67 (1.76)	1.60 (1.43)	2.93 (1.83)	2.40 (1.63)	4.80 (2.30)	2.93 (1.83)	3.20 (1.92)	3.47 (1.99)	10.93 (3.38)	11.47 (3.45)
T_7	Quizalofop-p-ethyl @ 50 g a.i. ha-1 *fb* chlorimuron ethyl @ 9 g a. i. ha^{-1}at 20 DAS	5.07 (2.36)	2.93 (1.82)	3.73 (2.04)	2.93 (1.84)	2.40 (1.69)	2.67 (1.76)	3.20 (1.92)	1.87 (1.50)	3.20 (1.92)	2.67 (1.76)	7.73 (2.86)	6.13 (2.57)	3.73 (2.04)	4.00 (2.12)	11.47 (3.45)	12.27 (3.57)
T_8	Two Hand weeding at 20 & 40 DAS	0.80 (1.10)	0.00 (0.71)	0.53 (1.00)	0.27 (0.85)	0.80 (1.10)	0.53 (1.00)	0.00 (0.71)	0.00 (0.71)	0.80 (1.10)	0.80 (1.41)	1.33 (1.35)	1.07 (1.18)	0.80 (1.10)	1.07 (1.20)	2.13 (1.62)	1.07 (1.24)
T_9	Weedy check	26.40(5.19)	28.53 (5.39)	20.00(4.53)	20.27 (4.56)	13.07(3.67)	13.33 (3.71)	26.40(5.18)	25.87 (5.13)	40.27(6.38)	40.27 (6.38)	20.27(4.55)	19.47 (4.47)	12.7 (3.56)	13.87 (3.79)	15.47(3.99)	16.80 (4.15)
	S.Em.+	(0.16)	(0.18)	(0.13)	(0.11)	(0.16)	(0.18)	(0.13)	(0.17)	(0.16)	(0.14)	(0.16)	(0.16)	(0.15)	(0.15)	(0.14)	(0.16)
	CD (P=0.05)	(0.50)	(0.54)	(0.39)	(0.34)	(0.49)	(0.55)	(0.41)	(0.52)	(0.50)	(0.44)	(0.48)	(0.51)	(0.47)	(0.46)	(0.43)	(0.50)

Table 3: Effect of herbicides on weeds dry weight (g m^{-2}) at 40 DAS and at harvest stage

		Echinochloa colonum (L.)		*Cyperus rotundus* (L.)		*Commelina benghalensis* (L.)		*Digera arvensis* (L.)		*Phyllanthus niruri* (L.)		*Trianthema monogyna* (L.)		*Corchorus olitorious* (L.)		*Leucas aspera* (L.)	
S.N.	**Treatments**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**	**40 DAS**	**At harvest**
T_1	Glyphosate 41% SL @ 1 kg a. i. ha^{-1} (PPI)	10.83 (3.36)	9.98 (3.23)	4.77 (2.29)	4.97 (2.33)	7.07 (2.75)	6.83 (2.70)	12.29 (3.57)	20.65 (4.60)	1.05 (1.24)	1.94 (1.56)	5.38 (2.41)	5.43 (2.43)	2.77 (1.80)	5.05 (2.35)	2.85 (1.82)	2.82 (1.82)
T_2	Pendimethal in @ 1 kg a. i. ha^{-1} (PE)	3.98 (2.11)	3.58 (2.02)	3.09 (1.89)	2.84 (1.83)	3.42 (1.98)	2.99 (1.86)	13.55 (3.75)	12.29 (3.57)	0.57 (1.03)	0.73 (1.11)	1.97 (1.57)	2.20 (1.64)	1.70 (1.48)	3.11 (1.90)	0.80 (1.14)	1.10 (1.26)
T_3	Alachlor @ 1.0 kg a. i. ha^{-1} (PE)	4.17 (2.16)	4.15 (2.15)	3.38 (1.97)	3.13 (1.90)	4.75 (2.29)	3.16 (1.91)	14.06 (3.81)	16.10 (4.07)	0.62 (1.06)	1.14 (1.28)	2.24 (1.65)	2.91 (1.84)	1.76 (1.50)	3.26 (1.93)	0.83 (1.15)	1.58 (1.44)
T_4	Imazethapyr + imazamox @ 70 g a. i. ha^{-1} (Odyssey)	0.45 (0.97)	2.65 (1.77)	0.89 (1.17)	0.91 (1.19)	0.84 (1.15)	0.82 (1.15)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	7.71 (2.86)	7.20 (2.77)	0.00 (0.71)	0.00 (0.71)	2.22 (1.64)	2.44 (1.70)
T_5	Quizalofop-p-ethyl @ 50 g a. i ha^{-1} at 20 DAS	0.39 (0.94)	2.02 (1.58)	1.76 (1.50)	1.43 (1.39)	6.78 (2.69)	6.15 (2.57)	16.90 (4.16)	22.12 (4.74)	3.29 (1.94)	4.24 (2.17)	9.81 (3.21)	9.36 (3.13)	2.98 (1.86)	5.61 (2.46)	3.68 (2.03)	3.84 (2.06)
T_6	Chlorimuron-ethyl @ 9 g a. i. ha^{-1} at 20 DAS	11.23(3.42)	11.63 (3.47)	6.67 (2.68)	7.33 (2.79)	1.26 (1.32)	0.95 (1.20)	1.88 (1.54)	2.45 (1.71)	0.84 (1.16)	0.98 (1.21)	3.38 (1.97)	2.95 (1.86)	0.91 (1.18)	1.76 (1.50)	1.50 (1.41)	1.22 (1.30)
T_7	Quizalofop-p-ethyl @ 50 g a. ha-1 *fb* chlorimuron ethyl @ 9 g a. i ha^{-1} at 20 DAS	2.85 (1.82)	3.01 (1.87)	1.10 (1.25)	1.23 (1.31)	1.69 (1.47)	1.23 (1.31)	1.16 (1.29)	2.27 (1.66)	0.82 (1.15)	0.81 (1.14)	4.55 (2.24)	3.63 (2.03)	1.97 (1.57)	2.34 (1.67)	2.25 (1.65)	2.12 (1.61)
T_8	Two Hand weeding at 20 & 40 DAS	0.34 (0.92)	0.0 (0.71)	0.40 (0.95)	0.35 (0.92)	0.75 (1.11)	0.76 (1.12)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	0.00 (0.71)	1.04 (1.24)	0.95 (1.20)	0.00 (0.71)	0.00 (0.71)	0.62 (1.06)	0.92 (1.19)
T_9	Weedy check	12.41(3.59)	13.43 (3.73)	7.03 (2.74)	7.78 (2.87)	7.86 (2.89)	7.43 (2.81)	17.62 (4.26)	24.11 (4.96)	3.88 (2.08)	5.41 (2.42)	10.47 (3.31)	10.72 (3.35)	3.58 (2.02)	6.64 (2.67)	4.18 (2.16)	4.35 (2.20)
	S.Em.+	(0.08)	(0.10)	(0.08)	(0.07)	(0.09)	(0.09)	(0.12)	(0.14)	(0.08)	(0.09)	(0.10)	(0.09)	(0.08)	(0.10)	(0.10)	(0.12)
	CD (P=0.05)	(0.25)	(0.30)	(0.24)	(0.22)	(0.26)	(0.29)	(0.36)	(0.42)	(0.24)	(0.26)	(0.30)	(0.28)	(0.25)	(0.31)	(0.32)	(0.36)

Table 4: Stover yield (kg ha^{-1}), Grain yield (kg ha^{-1}), Harvest index (%), Weed index (%), Weed control efficiency (%)

S.N.	Treatments	Stover yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest index (%)	Weed index (%)	Weed control efficiency (%)
T_1	Glyphosate 41% SL @ 1 kg a. i. ha^{-1} (PPI)	888.89	588.89	39.95	35.63	27.51
T_2	Pendimethal in @ 1 kg a. i. ha^{-1} (PE)	950.00	686.11	41.95	25.17	63.86
T_3	Alachlor @ 1.0 kg a. i. ha^{-1} (PE)	944.44	664.89	41.31	27.39	55.61
T_4	Imazethapyr + imazamox @ 70 g a. i. ha^{-1} (Odyssey)	1069.44	797.22	42.73	12.89	82.40
T_5	Quizalofop-p-ethyl @ 50 g a. i ha^{-1} at 20 DAS	930.56	644.44	40.99	29.57	31.32
T_6	Chlorimuron-ethyl @ 9 g a. i. ha^{-1} at 20 DAS	1019.44	741.67	42.11	19.35	67.88
T_7	Quizalofop-p-ethyl @ 50 g a. i. ha^{-1} *fb* chlorimuron ethyl @ 9 g a. i. ha^{-1}at 20 DAS	1041.67	769.44	42.58	15.77	79.18
T_8	Two Hand weeding at 20 & 40 DAS	1152.78	922.22	44.38	0.00	96.27
T_9	Weedy check	805.56	436.11	38.42	52.25	0.00
	S.Em.+	30.32	25.26	1.30	-	2.32
	CD (P=0.05)	93.19	77.65	4.01	-	7.14

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