Legume Research, 42 (3) 2019: 385-391
Print ISSN:0250-5371 / Online ISSN:0976-0571

AGRICULTURAL RESEARCH COMMUNICATION CENTRE
www.arccjournals.com

Tank-mix insecticide and herbicide application effects on weeds, insect-pest menace and soybean productivity in semi-arid northern plains of India

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Received: 18-02-2017 Accepted: 02-09-2017 DOI: 10.18805/LR-3855

ABSTRACT

The effects of herbicides, alone application or in combination with insecticides, on performance of soybean [*Glycine max* (L.) Merrill] were examined at ICAR- Indian Agricultural Research Institute, New Delhi during rainy seasons of 2013 and 2014. Alone application of imazethapyr 10 SL @ 1.0 l/ha or in combination with indoxacarb 14.5 SC @ 300 ml/ha and rynaxypyr 20 SC @ 100 ml/ha lowered monocot and dicot weed count, reduced weed dry matter and increased weed control efficiency in comparison with other herbicide and insecticide applications, individual or in combinations. These results suggested that the imazethapyr can effectively control different categories of weeds, especially of monocots in soybean field. However, seed yield, net returns and B: C ratios were higher in the quizalofop ethyl 5 EC (1.0 l/ha) applied plots followed by combined application of rynaxypyr 20 SC (100 ml/ha) + quizalofop ethyl 5 EC (1.0 l/ha).

Key words: Disease, Herbicides, Insecticides, Insect-pest, Soybean, Weed.

INTRODUCTION

Soybean [*Glycine max* (L.) Merrill] is the leading oilseed crop of India and the world. This widely adapted crop offers multiple benefits to mankind, such as source of minerals and vitamins, immense nutritional value (protein 40%, edible oil 20%), functional health benefits and variety of end usages (food, feed and non-edible), and high productivity potential. In-fact, the soybean production supports the livelihood of a large number of people associated with cultivation, trading, processing, industrial usages, value addition, and export of soybean and its products, in India and overseas (Dass *et al.*, 2016). Argaw (2012) stated that soybean has acquired status of an important and useful commodity in livelihood of human being world-over. Soybean fits well in cropping systems/rotations and improves soil fertility by fixing atmospheric nitrogen (N) to the extent of 50–300 kg/ha depending upon agro-climatic conditions, variety, strains, etc. (Keyser and Fudi, 1992) and adding about 1.0-1.5 t/ha leaf-litter per season (Dass *et al.*, 2016). World-wide, it fixes 16 Tg of atmospheric-N each year representing 77% of the N biologically fixed by crop legumes (Herridge *et al.*, 2008).

In India, area under soybean increased from 0.032 m ha producing 0.14 mt with average productivity of 0.43 t/ha in 1970-71 to 11.07 mha area, 8.64 mt production and 0.78 t/ha average yield in 2015 (SOPA, 2015). Accordingly, the per cent share of soybean in total oilseeds production increased from 0.14 in 1970 to 40.1 in 2013 (GOI, 2013). Thus, although, India has witnessed phenomenal growth in the area and production of soybean during the last four decades, yet, the average productivity of soybean in the country has been below half of the world average of 2.65 t/ha (FAO, 2016). However, under ideal management conditions convincingly high yields of 2.5 to 3.5 t/ha have also been recorded from the farmers' fields in some districts of Maharashtra state (Tiwari, 2014) that indicated the huge scope for the improvement of soybean yields in India. Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Andhra Pradesh are the leading soybean producing states of India.

Management tactics, such as better cropping rotations, suitable row widths and planting dates are more recently developed strategies to maximize yields. Almost all the area under soybean crop is rainfed and crop is cultivated during rainy season (June to October). One of the major constraints in soybean production is crop-weed competition (Vollmann *et al.*, 2010) and insects (Buckelew *et al.*, 2000); being a rainy season crop, it is heavily infested with monocot- and dicot-weeds, thus acts as breeding rooms for insects.The infestation of weeds and a variety of insect-pests seriously damage soybean crop and causes huge yield losses. Weeds may cause yield reduction up to 67% depending on the intensity of weeds, crop variety, season, soil type, rainfall, duration and period of weed competition (Gaikwad and Pawar, 2002). Weed infestation is persistent and complex constraint in soybean, as it influences soybean growth and development through competition for nutrients, water, light, space and production of allelopathic compounds

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(Vollmann *et al.*, 2010). The continuous rains during the rainy season often do not allow timely inter-cultivation operations and manual weeding becomes impractical on account of high cost and paucity of labour during weeding peaks (Singh *et al.*, 2014). Moreover, weedy condition in the soybean field increases the incidence of insect-pest infestations and severe infestation of pests causes soybean yield losses of 40–50%. Several researchers have reported that any modification in the management practices that gives poorer weed control increases the density and diversity of insect populations within the habitat (Buckelew *et al.*, 2000). This necessitates the suppression of weeds by using herbicides and insect-pests by insecticides. Herbicides and insecticides when applied in isolation add to cost, thus their combined application is desirable. Understanding the changes under combined application that affect the ecological integrity of soybean systems, could help in deciding whether or not to adopt these changes in production agriculture (Buckelew *et al.*, 2000). Use of herbicides alone or in combination with insecticides could generate some critical ideas that will be immensely helpful in reducing the drudgery in soybean cultivation. Hence, the current investigation was carried out to determine the effect of different insecticides and herbicides applied in isolation and of their combined application on composition and severity of insect-pests, weeds and on growth and yield of soybean.

MATERIALS AND METHODS

The field experiment was conducted at ICAR-Indian Agricultural Research Institute, New Delhi (28°40' N' 77°12'E and 228.6 m above mean sea level) during rainy seasons of 2013 and 2014. The climate of New Delhi is of sub-tropical and semi-arid type with hot and dry summer and cold winter and falls under the agro-climatic zone 'Trans-Gangetic plains'. During the crop period, mean weekly maximum temperature was 25.9–35.4°C, while the mean minimum 7.7–26.7°C. Mean weekly maximum and minimum relative humidity, sun shine hours/day and wind speed during the growing season were 73–97.9%, 1.9–7.6 and 1.8–8.6 kmh, respectively. Crop season received rainfall of 739.4 mm in 23 rainy days during first week of August–mid of October in 2013. In 2014 season, mean weekly maximum temperature varied from 27.3–37.7°C, while the mean minimum 7.5–26.4°C, maximum relative humidity 72.4–93.9 %, minimum relative humidity 33–74.4, sunshine hours 1.8–9.5 and wind speed 2.4–9.2 kmh. There was a rainfall of 395.4 mm most of which occurred during mid-July – 1st week of September in 18 rainy days. There was no rainfall after 12 September. Soil was sandy loam in texture and had a pH of 7.3 in 2013 and 7.2 in 2014. Organic C content was 0.44 in 2013 and 0.46% in 2014. Available N, P_2O_5 and K_2O was 208, 33.5 and 335 kg/ha in 2013 and 212, 32.5 and 315 kg/ha in 2014, respectively.

The field experiment consisted of 12 treatments *viz.*, rynaxypyr 20 SC @ 100 ml/ha; indoxacarb 14.5 SC @ 300 ml/ha; quinalphos 25 EC @ 1.5 l/ha; imazethapyr 10 SL @ 1.0 l/ha; quizalofop ethyl 5 EC @ 1.0 l/ha; rynaxypyr 20 SC @ 100 ml/ha + imazethapyr 10 SL @ 1.0 l/ha; rynaxypyr 20 SC @ 100 ml/ha + quizalofop ethyl 5 EC @ 1.0 l/ha; indoxacarb 14.5 SC @ 300 ml/ha + imazethapyr 10 SL @ 1.0 l/ha; indoxacarb 14.5 SC @ 300 ml/ha + quizalofop ethyl 5 EC @ 1.0 l/ha; quinalphos 25 EC @ 1.5 l/ha + imazethapyr 10 SL @ 1.0 l/ha; quinalphos 25 EC @ 1.5 l/ha + quizalofop ethyl 5 EC @ 1.0 l/ha and untreated check. The experiment was carried out using three-time replicated RBD.

Post-emergence herbicides *viz.*, i) Imazethapyr 10 SL: *[2-[4, 5-dihydro-4-methyl-4-(1-methylethyl)-5-oxo-1H-imidazol-2-yl]-ethyl-3-pyridinecarboxylic acid]*, is a systemic broad spectrum herbicide of the imidazolinones, absorbed by the roots and foliage, and translocated through xylem and phloem, and accumulated in the meristematic regions of the weed plant. It is useful for controlling the annual grasses, broad leaved weeds and sedges in the crops, like soybean and groundnut (Masoumeh *et al.*, 2013). ii) Quizalofop ethyl 5 EC: (*R*)-*2*-[*4*-(*6-chloroquinoxalin-2-yloxy*) *phenoxy*] *propionate* is a systemic selective herbicide, absorbed from leaf surface and translocated throughout the plant in xylem and phloem and accumulates in meristematic tissue. Used to control the grassy annual and perennial weeds mostly in soybean; and insecticides for controlling pests of soybean used as: i) Rynaxypyr 20 SC: *Chlorantraniliprole*, is a selective insecticide featuring a novel mode of action. By activating the insect ryanodine receptors (RyRs), it stimulates the release and depletion of intracellular calcium stores from the sarcoplasmic reticulum of muscle cells, causing impaired muscle regulation, paralysis and ultimately death of sensitive species (Cordova *et al*. 2006). It is used to control effectively mainly the *Spodoptera litura* and other defoliating pests of soybean. ii) Indoxacarb 14.5 EC: is a non-systemic insecticide, the activity occurs via blockage of the sodium channels in the insect nervous system and mode of entry is through stomach and contact routes, resulting in impaired nerve function, cessation of feeding, paralysis and death. iii) Quinalphos 25 EC: a systemic insecticide, having acaricide and insecticidal activity with stomach and contact action by penetrating the plant tissues through translaminar action and exhibits a systemic effect. It is used to control lepidopteron, hemipteron, colepteron and dipteron insect-pests of different crops. In soybean, it is used mainly to control leaf eating caterpillars.

The crop was grown on edges of raised beds made at 75 cm interval, with bed width 40 cm and furrow width 35 cm, thus, maintaining a row spacing of 37.5 cm. The crop was planted on 2nd August 2013 and 16th July, 2014 and harvested on 25 November in 2013 and 10 November in 2014. The crop was fertilized with 30 kg N, 75 kg P_2O_5, 40 kg K_2O and 56 kg S/ha, in both years. The treatments were imposed 19 days after sowing (DAS). Insect-pest and weed infestations were monitored regularly. The crop was irrigated twice in 2013 and thrice in 2014 keeping irrigation depth of 6 cm every time.

Species – wise weed density (with monocots and dicots) in soybean field, i.e. number of the weed m^{-2} of a particular weed species were recorded at 30 and 45 days after sowing, by placing a quadrat of 1 m × 1 m randomly in each plot and their subsequent effect on growth and yield of soybean. Collected weeds from quadrant were immediately separated into monocot and dicot species and weighed to record fresh weight. After drying in an electric oven at 70^{o} C, till the weight becomes constant, the obtained biomass was expressed as g m^{-2}. Total weed – count, weed dry matter and weed control efficiency (WCE) were determined.
Weed control efficiency was calculated by using the formula given by Mani *et al*. (1973).

$$\text{WCE (\%)} = \frac{\text{DWC - DWT}}{\text{DWC}} \times 100$$

Where, WCE = weed control efficiency in per cent, DWC = dry matter weight of weed in control plot and DWT = dry matter weight of weed in treated plot.

Phytotoxicity observations on yellowing, stunting, necrosis, leaf injure on tips & leaf surface, wilting, epinasty and hyponasty were recorded consequently and insect population was observed throughout the crop growth period.

$$\text{Stem tunneling (\%)} = \frac{\text{Length of stem tunnel length (cm)}}{\text{Plant height (cm)}} \text{x100}$$

At the time of harvest, the yield parameters and seed yield were measured.

The data generated from the experimental plots were analyzed by using analysis of variance (ANOVA) technique. Variance analysis was performed for each trait in both seasons and the combined analysis over seasons after testing the homogeneity of error variances was carried out according to statistical design RBD. The significant differences between treatments were compared with the critical difference at 5%.

RESULTS AND DISCUSSION

Weed flora and insect population: The general growth of soybean was poor as soybean variety 'JS 335' used in this experiment was susceptible to insects and diseases. The major insects/diseases found include yellow mosaic virus (YMV) transmitted by *Bemisia tabaci* and stem tunneling due to stem fly, *Melanagromyzae sojae*. During both years, treatment involving application of rynaxypyr 20 SC @ 100 ml/ha + imazethapyr 10 SL @ 1.0 l/ha performed best in

Table 1: Insect-pest damage in soybean under combined application of insecticides and herbicides

Treatment	Mean stem tunneling due to stem fly (%)						White fly infestation of infected plants (%)			
	35 DAS		54 DAS		At harvest		38 DAS		54 DAS	
	2013	2014	2013	2014	2013	2014	2013	2014	2013	2014
Rynaxypyr 20 SC @ 100 ml/ha	0.50 (4.05)	0.50 (4.05)	5.15(11.94)	1.45(6.19)	1.83(7.67)	2.74(8.87)	3.33	4.66	5.66	5.00
Indoxacarb 14.5 SC @ 300 ml/ha	0.50 (4.05)	5.79 (10.66)	0.50 (4.05)	2.22(7.30)	3.38(10.39)	3.06(10.02)	3.66	3.66	5.66	4.33
Quinalphos 25 EC @ 1.5 l/ha	0.50 (4.05)	0.50 (4.05)	0.50 (4.05)	0.50(4.05)	2.55(8.85)	3.56(10.66)	3.66	4.33	5.00	4.33
Imazethapyr 10 SL @ 1.0 l/ha	0.50 (4.05)	3.58 (8.75)	2.06(7.09)	1.24(5.85)	5.41(13.34)	3.85(10.95)	3.00	5.33	4.33	6.00
Quizalofop ethyl 5 EC @ 1.0 l/ha	12.88(15.30)	-	7.10(13.64)	-	6.26(13.77)	-	2.66	-	4.33	-
Rynaxypyr 20 SC @ 100 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha	2.72(8.84)	0.50 (4.05)	8.16(16.19)	0.50 (4.05)	4.25(11.68)	4.46(11.54)	3.33	5.00	4.33	5.66
Rynaxypyr 20 SC @ 100 ml/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	2.65(7.77)	0.50 (4.05)	6.05(10.86)	0.50 (4.05)	4.86(12.19)	2.04(7.77)	3.33	4.33	4.66	4.66
Indoxacarb 14.5 SC @ 300 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha	14.76(22.00)	0.50 (4.05)	5.54(12.33)	1.80(6.73)	7.44(15.32)	2.06(8.24)	3.00	5.33	5.00	6.33
Indoxacarb 14.5 SC @ 300 ml/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	0.50(4.05)	0.50 (4.05)	4.03(10.52)	3.00(8.17)	4.19(10.86)	3.72(10.61)	3.66	4.00	5.33	1.43
Quinalphos 25 EC @ 1.5 l/ha + Imazethapyr 10 SL @ 1.0 l/ha	4.97(11.48)	-	0.50 (4.05)	-	2.89(9.68)	-	3.00	-	5.00	-
Quinalphos 25 EC @ 1.5 l/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	4.94(9.97)	0.50 (4.05)	0.50 (4.05)	0.50 (4.05)	6.84(14.19)	4.48(11.51)	3.66	3.33	5.66	5.00
Untreated check	12.66(15.19)	8.15 (14.78)	10.34(18.31)	5.29(12.93)	7.84(15.92)	7.34(15.70)	4.66	5.66	7.00	7.00
SEm±	7.05	-	6.24	-	2.96	-	1.05	-	0.35	-
CD (P=0.05)	NS	-	NS	-	NS	-	NS	-	1.28	-

terms of lowering pest infestations (Table 1). The major weeds found in the treatment plots include *Dinebra retroflexa, Cyprus rotundus, Leptocloa chinensis, Dactyloctinium aegyptium*, among monocot weeds and *Trianthema portulacastrum* and *Eclipta alba* among the dicot weeds. Moreover, a very high rainfall, especially at crop establishment stage also affected the growth of crop. The growth of weeds was also poor due to continuous and heavy rainfall. At 30 and 45 DAS weed count was the lowest in the treatments having imazethapyr 10 SL (1.0 l/ha) either alone or in combination with insecticides.

Weed density/ weed count: The weed count/density of monocot weeds was much higher than the density of dicot weeds throughout the crop growing seasons at both 30 and 45 DAS, because rainy reason is highly favourable for grass and sedge population, similar opinion has also been reported by Tiwari *et al*. (2007). Pooled weed density at 45 DAS was higher as compared to those recorded at early stages irrespective of species. Among the herbicide applications, imazethapyr either alone application or in combination with insecticides resulted in significantly lower pooled monocot, dicot weeds and total weed density (Table 2, Fig 1). Alone

Table 2: Total weed count, weed dry matter and weed control efficiency in soybean under combined application of insecticides and herbicides (pooled data of 2 years).

Treatment	Total weed count at 30 DAS	Total weed dry matter at 30 DAS	WCE(%)	Total weed count at 45 DAS	Total weed dry matter at 45 DAS (g m^{-2})	WCE(%)
Rynaxypyr 20 SC @ 100 ml/ha	9.88	12.7	13.7	10.94	16.2	10.8
Indoxacarb 14.5 SC @ 300 ml/ha	9.15	11.9	18.6	9.90	15.0	16.0
Quinalphos 25 EC @ 1.5 l/ha	10.35	13.2	9.6	11.17	16.3	9.4
Imazethapyr 10 SL @ 1.0 l/ha	6.73	8.0	44.4	7.23	10.8	38.6
Quizalofop ethyl 5 EC @ 1.0 l/ha	7.46	9.1	37.1	8.56	13.0	25.5
Rynaxypyr 20 SC @ 100 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha	6.35	8.2	43.2	7.43	11.1	35.3
Rynaxypyr 20 SC @ 100 ml/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	6.87	8.7	39.8	8.08	12.0	31.0
Indoxacarb 14.5 SC @ 300 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha	6.57	8.3	42.1	7.19	10.6	38.5
Indoxacarb 14.5 SC @ 300 ml/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	7.55	9.2	37.1	8.46	13.2	25.6
Quinalphos 25 EC @ 1.5 l/ha + Imazethapyr 10 SL @ 1.0 l/ha	7.03	8.3	41.3	7.62	10.6	39.1
Quinalphos 25 EC @ 1.5 l/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	8.03	9.7	33.0	9.08	13.3	24.9
Untreated check	11.63	14.6	-	12.22	18.0	-
SEm±	0.33	0.52	3.32	0.40	0.59	3.65
CD (P=0.05)	1.00	1.56	9.92	1.19	1.77	10.89

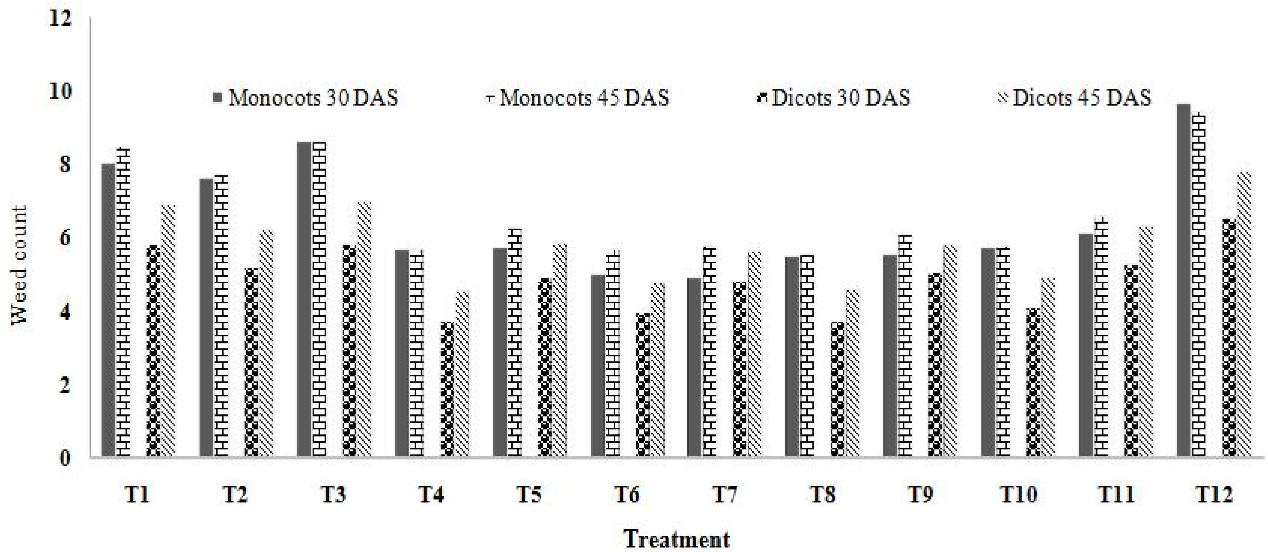

Fig 1: Monocots and dicot weed counts as influenced by combined application of insecticides and herbicides in soybean (pooled data of 2 years).

application of insecticides did not influence significantly the pooled weed density at all growth stages as compared to sole herbicide and combination of insecticide and herbicide application. Total pooled weed count was significantly higher under these treatments during both crop seasons as compared to herbicide application. As expected the weedy check treatment showed the highest population of monocots, dicots and total weed count, and hence was significantly inferior to any other treatments. From the findings, it could be inferred that post emergence application of imazethapyr reduced the density of monocots as well as dicot weeds significantly as compared to quizalofop-ethyl herbicide under the study (Mosjidis and Wehtje, 2011).

Weed biomass: Pooled biomass (g m^{-2}) of different weed spices in each plot of the experiment differed significantly under herbicide and insecticide alone application or in combinations (Table 2, Fig 2). Throughout the soybean growing season, significantly higher pooled biomass of all categories of weed flora was observed in weedy check and insecticide applied plots as compared to herbicide applied treatments. Application of imazethapyr (10 SL @ 1.0 l/ha) resulted in significantly lower pooled total weed biomass with monocots and dicot weeds as compared to other post emergence herbicide (quizalofop ethyl 5 EC @ 1.0 l/ha) and other inserctticides and their combinations. In general, application of all the three insecticides alongwith imazethapyr recorded significantly lower pooled weed biomass. Of which, indoxacarb14.5 SC @ 300 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha resulted in significantly lower pooled weed dry weight during both the crop seasons. Similar findings have been reported by Kundu *et al*. (2011) also.

Weed control efficiency: Species-wise pooled WCE (%) in soybean field was computed at 30 and 45 DAS, which

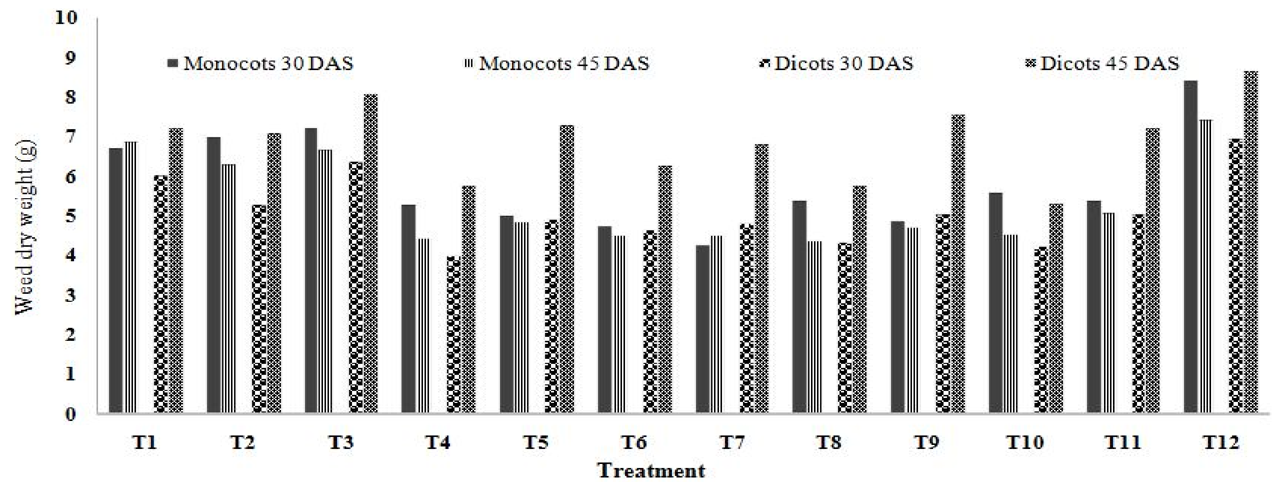

Fig 2: Dry weight of monocots and dicot weeds as influenced by combined application of insecticides and herbicides in soybean (pooled data of 2 years).

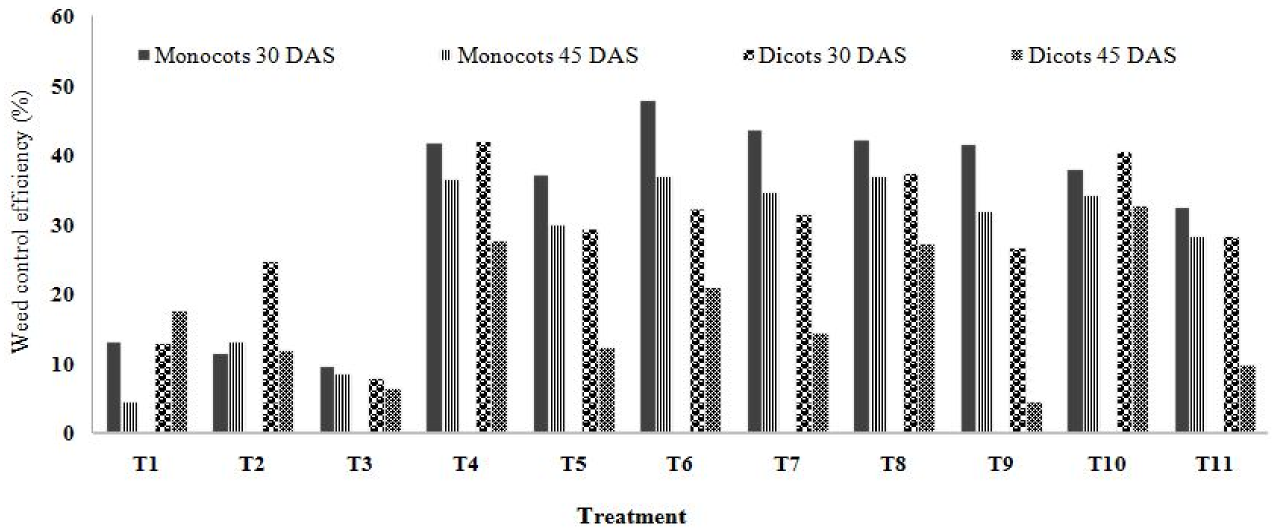

Fig 3: Weed control efficiency of monocots and dicot weeds as influenced by combined application of insecticides and herbicides in soybean (pooled data of 2 years).

differed significantly among the herbicide and insecticide application treatments (Table 2, Fig 3). The WCE (%) throughout the crop growing seasons of all the weed-flora was maximum under imazethapyr (10 SL @ 1.0 l/ha) alone applied plots, followed by indoxacarb 14.5 SC @ 300 ml/ha + imazethapyr 10 SL @ 1.0 l/ha applied treatments in comparison with other treatment combinations. Both monocot and dicot pooled WCE were also significantly higher under the above said treatments. Alone application of insecticides resulted in lower pooled WCE than its combinations with herbicides. It is quite clear that at the very early stage of crop growth (30 DAS), imazethapyr 10 SL @ 1.0 l/ha and rynaxypyr 20 SC @ 100 ml/ha + imazethapyr 10 SL @ 1.0 l/ha offered higher WCE as compared to the other treatments mainly due to less pooled weed count and weed dry weight. Combined chemical treatments like imazethapyr with rynaxypyr and quinalphos gave better WCE over the sole applied chemical treatments mainly because of the fact that the weed species regenerated more vigorously after certain periods where only herbicide was applied (Bera *et al.*, 2012).

Growth and seed yield: Pooled seed yield of soybean differed significantly during both crop seasons (Table 2). Soybean seed yield was highest with alone application of quizalofop ethyl 5 EC (1.0 l/ha) followed by combined application of indoxacarb 14.5 SC @ 300 ml/ha and quizalofop ethyl 5 EC @ 1.0 l/ha, which was significantly higher than untreated weedy check (Table 3). The other treatments showing significantly higher seed yields were alone application of imazethapyr 10SL (1.0 l/ha), and indoxacarb 14.5 SC (300 ml/ha), and combined application of quinalphos 25 EC (1.5 l/ha) with either imazethapyr10 SL (1.0 l/ha) or with quizalofop l 5 EC (1.0 l/ha). The highest number of pooled pods/plant and seed index were recorded with alone application of quizalafof ethyl 5 EC (1.0 l/ha). The better growth parameters observed under the respective treatment could lead to superior seed yield than other treatments. Efficient weed control plots allowed less weed species and thus, were found to have smaller insect population densities and *vice versa*. These findings conform to other studies of habitat preference by some insects for weedy areas (Buckelew *et al.*, 2000). From the above discussion it is quite evident that alone application of quizalofop l5 EC (1.0 l/ha) and imazethapyr 10 SL (1.0 l/ha) or combined application of rynaxypyr 20 SC (100 ml/ha) + quizalofop ethyl 5 EC (1.0 l/ha) with either imazethapyr10 SL (1.0 l/ha) or with quinalphos 25 EC (1.5 l/ha) produced the higher seed yields of soybean mainly due to the fact that minimum crop-weed competition and insect damage at the critical period of crop growth resulting in higher yield attributes and higher weed control efficiency. Kundu *et al.* (2011) and Upadhyay *et al.* (2012) have reported higher soybean yield due to better weed control by use of imazethapyr 10 SL @ 1.0 l ha^{-1}.

Economics: The highest net returns and B: C ratio were recorded with quizalofop ethyl 5 EC (1.0 l/ha) and combined application of rynaxypyr 20 SC (100 ml/ha) + quizalofop ethyl 5 EC (1.0 l/ha). The yield and growth parametrs were better with treaments involving the application of quizalofop ethyl 5 EC (1.0 l/ha) in isolation or combined with insecticides, and thus these treatments were more economical evincing higher net returns (Table 3). Overall lower net returns and B: C ratio

Table 3: Effect of combined application of insecticides and herbicides on growth, yield and economics of soybean (pooled data of 2 years).

Treatment	Branches / plant	Pods/ plant	Seed index (g)	Seed yield (kg/ha)	Cost of cultivation(Rs/ha)	Net returns (Rs/ha)	Net B:C ratio
Rynaxypyr 20 SC @ 100 ml/ha	4.12	25.05	8.25	691	17590	4098	0.24
Indoxacarb 14.5 SC @ 300 ml/ha	4.54	30.45	8.96	806	17232	7731	0.45
Quinalphos 25 EC @ 1.5 l/ha	4.02	23.40	8.38	651	18154	2049	0.12
Imazethapyr 10 SL @ 1.0 l/ha	4.57	31.00	9.23	796	17775	7078	0.41
Quizalofop ethyl 5 EC @ 1.0 l/ha	5.35	37.80	9.99	948	17642	11688	0.67
Rynaxypyr 20 SC @ 100 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha	4.45	29.65	9.21	804	19517	5402	0.29
Rynaxypyr 20 SC @ 100 ml/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	4.75	33.10	9.26	882	19384	7813	0.41
Indoxacarb 14.5 SC @ 300 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha	4.40	29.90	8.73	804	19159	5684	0.30
Indoxacarb 14.5 SC @ 300 ml/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	4.35	27.20	8.72	711	19025	3020	0.16
Quinalphos 25 EC @ 1.5 l/ha + Imazethapyr 10 SL @ 1.0 l/ha	4.65	31.60	8.89	805	20081	4977	0.26
Quinalphos 25 EC @ 1.5 l/ha + Quizalofop ethyl 5 EC @ 1.0 l/ha	4.72	31.95	9.54	828	19948	5662	0.29
Untreated check	4.19	23.70	8.65	665	16873	3743	0.23
SEm±	0.45	1.68	0.84	57.7	-	900	0.06
CD (P=0.05)	NS	5.02	NS	180.0	-	2689	0.18

in this study was because a susceptible soybean variety (JS-335) was used in the experiment for obtaining better effects of herbicide and insecticide treatments. Reddy *et al.* (2013) reported that application of imazethapyr 10% SL @ 100g/ha elicited higher economic yield of soybean and effective control of weeds compared to other herbicides.

CONCLUSION

Based on the two-year experiment results, it could be concluded that application of imazethapyr10 SL (1.0 l/ha) either in isolation or in combination with insecticides was more rewarding in terms of higher weed control efficiency. Among the insecticides, rynaxypyr 20 SC @ 100 ml/ha was more effective in controlling insect-pests. However, combined application of rynaxypyr along with quizalofop ethyl resulted in the highest seed yield and net returns.

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