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Bio-Efficacy of Combined Application of Herbicide and Insecticide for Weed and Insect Pest Management in Soybean (*Glycine max* L.)

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ABSTRACT

Keywords

Imazethapyr, Chlorimuron, Chlorantraniliprole, soybean, Weed, Caterpillar, Bio-efficacy and Compatible

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Soybean (*Glycine max L.*) is an important leguminous oil seed crop among all the seed crops of country grown during rainy season. The higher incidence of weed and pests during growth period are one of the important menaces in getting higher yield of crop.A field experiment was conducted during rainy season 2019 at Agricultural Research Station, Banswara (Raj.), India to evaluate bio-efficacy of compatible tank-mix combinations of herbicide and insecticides to manage the weed and insect-pests in crop. The lower weed density and weed dry matter were recorded in combine application of imazethapyr+chlorimuron compared to sole application of imazethapyr and chlorimuron. Tank mix application of imazethapyr 10 SL @ 75 g a.i./ha + chlorimuron 25 WP @ 9 g a.i./ha) with chlorantraniliprole@0.3ml/L. resulted in significantly lowest weed density (33.14/m^2) followed by profenofos with imazethapyr + chlorimuron (36.22/m^2) at 30 DAS. These similar results were recorded at 45 and 60 DAS. Application of imazethapyr+chlorimuron with chlorantraniliprole was recorded lowest weed dry matter (11.56 g/m^2) and highest weed control efficiency (87.22%) at 60 DAS followed by imazethapyr+chlorimuron with profenofos and significantly superior over rest treatments. Number of leaf roller and caterpillar larvae per meter row length/mrl at one week after treatment was significantly less in treatments involving insecticides. Visual defoliation score was significantly less in treatments involving insecticides than weedy check and sole herbicide.

Introduction

Soybean is richest, cheapest and easiest source of best quality protein and fats and having a multiplicity of uses as food and industrial products therefore it is called “Wonder crop”. India ranks fifth in soybean production in the world. The per capita consumption of the vegetable oil is increasing very rapidly due to increase in population and improved economic status of the population. The demand has increased to about 12.6 kg/year compared to 4 kg/year in 1961 and the projected demand for the year 2020 and 2050 is 16.443 and 19.16 kg/year, respectively. To meet this demand, the country will require nearly 25.26 and 35.90 million tons of edible oil. In this scenario, soybean has played and will play a pivotal role in the future. Area under the soybean crop in India is increasing steadily. Presently, it is cultivated on 11.84 m ha with production of 10.5 m t and productivity of 0.88 t/ha (SOPA, 2020). As compared to the world and Asian average, the soybean productivity is low in India. Madhya Pradesh, Maharashtra, Rajasthan, Karnataka and Andhra Pradesh are the leading soybean producing states of India. Majority of the area under the soybean crop is rainfed and crop is cultivated from June to October. Weeds and insect-pests are the major limiting factors in the production of this crop. Being a rainy season crop, infestation of weeds is high due to high moisture and temperature. 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 (Hargilas, 2020). 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 (Vollmann *et al.,* 2010). Weeds are not only competing with crop for water, nutrient, light and space but also provide harbor for insect-pests (Hargilas *et al.,* 2015). Due to weedy condition in the field of soybean, the incidence of insect-pests also increases. Severe incidence of pests may cause yield loss up to 40-50%. The mechanical weeding is partially ineffective because weeds also grow in intra row space and manual weeding is also impossible due to incessant rains during critical period of crop-weed competition makes the situation worse (Hargilas, 2020). The use of chemicals is an alternative option to control weeds in these situations. The abundance of some weed species is likely to be strongly influenced by environmental and cultural conditions and its infestation could be more efficiently managed by proper selection of herbicides (Pinke *et al.,* 2016). Hence, the present study was undertaken to evaluate the bio-efficacy of compatible tank mix combinations of herbicides and insecticides to reduce the weed infestation, damage by insect pests, and to increase the yield of soybean.

Materials and Methods

Experimental site

A field experiment was conducted during rainy season 2019 at Agricultural Research Station (MPUAT), Banswara (Rajasthan), India to investigate the effect of tank mix application of post-emergence herbicide and insecticides on weed and insect-pests of soybean. The experimental site was located at 23° 33’ N latitude, 74° 27’ E longitude and altitude of 220 m amsl. The soil of experimental field was clay loam in texture, slightly alkaline in reaction and low in organic carbon (0.43%), available N (234 kg/ha), available P_2O_5 (18kg/ha) and high in available K_2O (385kg/ha). The total rainfall was 985 mm received during crop season.

Field layout and treatments details

The experiment was laid out in Randomized Block Design (RBD) and replicated thrice, containing two post emergence herbicides and three insecticides, as a sole and combined application to soybean crop as given Table 1.

All recommended package of practices, except hand weeding, were followed for raising a good crop. Soybean variety JS 93-05 was sown on 1st July, 2019 with seed rate of 80 kg/ha. Row to row and plant to plant distance was maintained at 30 cm and 5-7 cm, respectively. The plot size was 3.0 ×3.0 m (gross) with ten rows. Tank mix application of post emergence herbicides and insecticides were sprayed 20 days after sowing using knapsack sprayer with 500 liter water /ha per the quantity given in the treatment details as (T_1) Imazethapyr 10 SL@ 75g a.i./ha, (T_2)

Chlorimuron ethyl 25 EC @ 9g a.i./ha, (T_3) Imazethapyr 10 SL @ 75 g a.i./ha +Chlorimuron ethyl 25 EC @ 9g a.i./ha, (T_4) Chlorantraniliprole @ 0.3ml/L, (T_5) Indoxacarb @ 0.6ml/L, (T_6) Profenofos @ 2.0ml/L, (T_7) Imazethapyr 10 SL @ 75 g a.i./ha + Chlorantraniliprole @ 0.3ml/L, (T_8) Chlorimuron 25WP @ 9g a.i./ha (POE) + Indoxacarb @ 0.6ml/L,(T_9) Imazethapyr 10SL @ 75g a.i. / ha + Chlorimuron 25WP @ 9g a.i./ha (POE)+Profenofos @ 2.0ml/L, (T_{10}) Imazethapyr 10SL@75 g a.i./ha + Chlorimuron 25WP @ 9g a.i./ha + Chlorantraniliprole @ 0.3ml/L and (T_{11}) Weedy check to control leaf eating caterpillars. Herbicide and insecticides were sprayed 20 DAS separately and in combination as per the recommended dose and water volume. Sole application of herbicide was restricted to weeds to escape the crop plant, while sole application of insecticide was made only on soybean plants. The combined herbicide and insecticide mixture was applied over both plants and weeds.

Collection of Data

The effect of different treatment was studied in terms of all types of weed flora (monocot and dicot species), weed density, and weed dry matter at 30, 45 and 60 days after sowing of the crop by placing a quadrate of 1×1 m randomly in each plot, and their subsequent effect on growth and yield of soybean. The collected weeds from each quadrate were immediately separated into monocot and dicot species and weighed to record fresh weight. After drying in an electric oven at 70 ^{0}C, till the weight became constant, the obtained biomass was expressed as g /m^2. The weed index was computed by using the formula given below:

$$\text{Weed Index (WI)} = \frac{X - Y}{X} \times 100$$

Where, *X*= Weight of seed yield (q ha^{-2}) in treatment which has highest yield and *Y*= Weight of seed yield (q/ha) in treatment for which weed index is to be calculated). Weed Control Efficiency (WCE) was calculated by using the formula given by Mani *et al.*, (1973).

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

Where, *WCE*= Weed Control Efficiency in percent, *DWC*= Dry matter Weight of weed in Control plot and *DWT*= Dry matter Weight of weed in Treated plot.

Moderate infestation of leaf roller and tobacco caterpillar was noticed on the trial plot in 2019. Data on number of leaf roller and tobacco caterpillar larvae per meter row length (mrl) was recorded one day before treatment (DBT) and one week after treatment (WAT) at random three places per plot and averaged. Visual Defoliation Score (VDS) was recorded in 1-9 scale based on visual observation on leaf damage by leaf roller and tobacco caterpillar. Stem fly damage was recorded on 10 random plants as length of stem tunneled in centimeter at physiological maturity stage. Percentage stem tunneling was calculated as:

$$\text{Stem tunneling (\%)} = \frac{\text{Length of stem tunneled (cm)}}{\text{Plant height (cm)}} \times 100$$

The percentage stem tunneling data was transformed in square root before analysis of variance. Data on growth parameters like plant height (cm), number of branches per plant, yield attributes like number of pods per plant, 100 seed weight (g), biological yield (kg/plot) and yield (kg/plot) of soybean was recorded at harvest. Harvest index (%) was determined using the formula as:

$$\text{Harvest index (\%)} = \frac{\text{Seed yield (kg /plot)}}{\text{Biological yield (kg/plot)}} \times 100$$

Seed yield obtained per plot was converted into kilogram per hectare. Economics of combined application of herbicide and insecticide was calculated in terms of gross returns (Rs/ha) by multiplying seed yield (kg/ha) with the prevailing market price of soybean in the market, and net returns were calculated subtracting the cost of cultivation (Rs/ha) of each treatment from gross returns obtained. Cost of cultivation was calculated taking into consideration the prevailing prices of inputs and labour charges to carry out different operations for the years under the study.

Statistical analysis

The collected data were subjected to Analysis of Variance (ANOVA) using standard variance techniques suggested by Gomez and Gomez (1984). Means of all treatments were calculated and the differences were tested for significance using the Least Significant Differences (LSD) test at 0.05 Probability (P) level.

Results and Discussion

Effect on weeds

Weed flora observed in the experimental field during rainy season 2019 as given in Table 1. The weed count significantly differed with the combined spray of herbicide and insecticides. Among the different combinations of herbicide and insecticides at 30 DAS, imazethapyr 10SL @ 75g +chlorimuron 25WP @ 9g a.i./ha+chlorantraniliprole @ 0.3ml/liter recorded significantly lowest weed density (53.14/m^2) followed by imazethapyr 10SL@75g+chlorimuron 25WP@ 9g a.i./ha+Profenofos@2.0ml/liter (56.22/m^2). However, the weed density in untreated weedy check plot was higher (216.03/m^2) at 30 DAS. Weed density at 45 DAS was significantly low in plots treated with combined application of imazethapyr+chlorimuron (28.26/m^2) compared to sole application of imazethypr (47.73/m^2) and chlorimuron (64.32/m^2). Post-emergence herbicide imazethapyr belong to herbicide family of Imidazolinone and chlorimuron belong to herbicide family of sulfonylurea were responsible for inhibition of Aceto-Lactate Synthase (ALS) or Aceto-Hydroxy Acid Synthase (AHAS) in weed flora, which caused destruction of these weeds at 3-4 leaf stage and resulted in low weed density. The lowest weed density (19.89/m^2) was recorded in the combine application of imazethapyr+chlorimuron with chlorantraniliprole @0.3ml/liter (T_{10}) and highest weed density (79.55/m^2) was recorded in weedy check. Differences for weed density at 60 days after sowing were significant (Table 1). The combine application of imazethapyr+chlorimuron with chlorantraniliprole showed lowest weed index compared to the other treatment combinations. Lowest weed index showed the decreased magnitude of the yield reduction due to presence of weeds and insects in comparison with the treatment of imazethapyr+chlorimuron with chlorantraniliprole which yielded higher than other treatments or combinations.

Spray of imazethapyr+chlorimuron with chlorantraniliprole at 30 DAS (21.29g/m^2) recorded significantly lowest weed dry matter followed by spray of imazethapyr + chlorimuron with profenofos (23.28g/m^2) and it was significantly lower than rest treatments (Table 2). Application of imazethapyr at 45 DAS was significantly recorded lowest weed dry matter (26.00 g/m^2) compared to chlorimuron, insecticides and untreated weedy check (43.33g/m^2). At 45 DAS, combined application of imazethapyr+

chlorantraniliprole ($24.04 g/m^2$) was significantly lower than combined application of insecticide with chlorimuron. The combined application of imazethapyr + chlorimuron with chlorantraniliprole was recorded lowest weed dry matter ($10.83 g/m^2$), whereas, highest weed dry matter was recorder in untreated weedy check (34.03 g/m^2). Application of imazethapyr alone and in combination with insecticide recorded the lowest weed density and weed dry matter at 30, 45, and 60 days after sowing. Jadhav and Gadade (2012) reported that imazethapyr 1.0 kg/ ha as post-emergence application showed the reduced weed density and weed dry weight. Similarly, Yousefi *et al.,* (2012) reported the application of imazethapyr at reduced rate greatly affected the growth and biomass production of *X. strumarium or A. retroflexus* in soybean as compared to untreated plots. The weed control efficiency was higher with the combined application of imazethapyr + chlorimuron with chloantraniprole (87.22%) followed by application of imazethapyr + chlorimuron with profenofos (87.06%) and it was significantly superior over rest treatments. The results regarding the combined application of imazethapyr with insecticides are in corroboration with Singh (2007) and Barkhade *et al.,* (2013) who reported that imazethapyr at the rate of 75 g/ha was effective against both monocot and dicot weeds and were at par with one hand weeding done at 20 days after sowing.

Table.1 Effect of combined application of herbicide and insecticides on weed count and weed index (%)

Treatments	Weed count at 30 DAS	Weed count at 45 DAS	Weed count at 60 DAS	Weed index (%)
T_1: Imazethapyr 10SL@75 g a.i./ha (POE)	94.54	47.73	22.88	29.68
T_2: Chlorimuron 25WP @ 9g a.i./ha (POE)	117.08	64.32	29.12	51.73
T_3: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)	64.51	28.26	9.36	19.23
T_4:Chlorantraniliprole @ 0.3ml/lit.	122.83	70.30	31.21	45.40
T_5: Indoxacarb @ 0.6ml/lit.	116.41	69.60	49.94	44.08
T_6: Profenofos @ 2.0ml/lit	94.33	70.47	46.82	45.00
T_7: Imazethapyr 10SL@75 g a.i./ha (POE) + Chlorantraniliprole @ 0.3ml/lit	91.46	44.14	15.61	17.66
T_8: Chlorimuron 25WP @ 9g a.i./ha (POE) + Indoxacarb @ 0.6ml/lit.	113.99	64.02	24.97	26.14
T_9: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Profenofos @ 2.0ml/lit	56.22	21.98	7.27	12.68
T_{10}: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Chlorantraniliprole @ 0.3ml/lit	53.14	19.89	7.18	0.00
$T_{11.}$ Weedy	216.03	79.55	56.18	76.71
CD (p=0.05)	9.07	6.49	4.24	10.6

Table.2 Effect of combined application of herbicides and insecticides on weed dry matter (g) and Weed control efficiency (WCE %) in soybean

Treatments	Weed DM at 30 DAS	Weed DM at 45 DAS	Weed DM at 60 DAS	WCE at 60DAS
T_1: Imazethapyr 10SL@75 g a.i./ha (POE)	60.75	26.00	36.85	59.28
T_2: Chlorimuron 25WP @ 9g a.i./ha (POE)	75.23	35.03	46.90	48.17
T_3: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)	41.45	15.39	15.08	83.33
T_4: Chlorantraniliprole @ 0.3ml/lit.	78.93	38.29	64.45	28.78
T_5: Indoxacarb @ 0.6ml/lit.	74.81	37.91	76.27	15.71
T_6: Profenofos @ 2.0ml/lit	60.62	38.38	68.44	24.36
T_7: Imazethapyr 10SL@75 g a.i./ha (POE) + Chlorantraniliprole @ 0.3ml/lit	58.77	24.04	25.14	72.22
T_8: Chlorimuron 25WP @ 9g a.i./ha (POE) + Indoxacarb @ 0.6ml/lit.	73.25	34.87	40.22	55.56
T_9: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Profenofos @ 2.0ml/lit	23.28	11.97	11.71	87.06
T_{10}: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Chlorantraniliprole @ 0.3ml/lit	21.29	10.83	11.56	87.22
$T_{11.}$ Weedy	138.82	43.33	90.49	0.00
CD (p=0.5)	9.11	3.34	9.10	8.17

Table.3 Effect of combined application of herbicide and insecticides on growth and yield of soybean

Treatments	Plant height (cm)	Branches /plant	Pods/ plant	Seed index (g)	Harvest index (%)	Seed yield kg/ha)
T_1: Imazethapyr 10SL@75 g a.i./ha (POE)	54.35	2.18	47.21	14.48	45.66	1847
T_2: Chlorimuron 25WP @ 9g a.i./ha (POE)	47.24	1.89	44.82	14.30	42.60	1275
T_3: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)	60.51	3.03	51.30	14.56	46.53	2132
T_4:Chlorantraniliprole @ 0.3ml/lit.	43.84	1.62	42.64	13.77	43.90	1433
T_5: Indoxacarb @ 0.6ml/lit.	40.39	1.59	38.26	14.39	44.50	1464
T_6: Profenofos @ 2.0ml/lit	50.09	1.68	46.50	14.35	43.40	1435
T_7: Imazethapyr 10SL@75 g a.i./ha (POE) + Chlorantraniliprole @ 0.3ml/lit	56.88	2.25	46.19	14.74	46.93	2162
T_8: Chlorimuron 25WP @ 9g a.i./ha (POE) + Indoxacarb @ 0.6ml/lit.	50.67	2.20	51.37	14.80	46.44	1935
T_9: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Profenofos @ 2.0ml/lit	62.33	2.53	50.21	14.82	47.16	2303
T_{10}: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Chlorantraniliprole @ 0.3ml/lit	64.00	3.37	52.63	14.86	47.60	2636
$T_{11.}$ Weedy	33.84	1.12	23.73	14.24	41.49	609
CD (P=0.05)	7.74	0.54	10.72	NS	NS	424

Table.4 Effect of combine application of herbicide and insecticides on economics of soybean

Treatments	Cost of cultivation (Rs/ha)	Gross return (Rs/ha)	Net return (Rs/ha)	B:C ratio
T_1: Imazethapyr 10SL@75 g a.i./ha (POE)	25113	68520	43407	1.73
T_2: Chlorimuron 25WP @ 9g a.i./ha (POE)	24787	47303	22516	0.91
T_3: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)	25651	79081	53430	2.08
T_4:Chlorantraniliprole @ 0.3ml/lit.	26461	53164	26703	1.01
T_5: Indoxacarb @ 0.6ml/lit.	25269	54314	29045	1.15
T_6: Profenofos @ 2.0ml/lit	25189	53234	28045	1.11
T_7: Imazethapyr 10SL@75 g a.i./ha (POE) + Chlorantraniliprole @ 0.3ml/lit	27325	80223	52898	1.94
T_8: Chlorimuron 25WP @ 9g a.i./ha (POE) + Indoxacarb @ 0.6ml/lit.	25807	71784	45978	1.78
T_9: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Profenofos @ 2.0ml/lit	26591	85437	58847	2.21
T_{10}: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Chlorantraniliprole @ 0.3ml/lit	27540	97783	70243	2.55
$T_{11.}$ Weedy	24249	22594	-1655	-0.07
CD (P=0.05)				

Table.5 Effect of combined application of herbicide and insecticides on insect-pest of soybean

Treatments	Leaf roller/mrl		Tobacco caterpiller /mrl		Stem fly damage (% stem tunneling)
	1 DBT	After One week	1 DBT	After One week	
T1: Imazethapyr 10SL@75 g a.i./ha (POE)	7.23	6	8.12	6	3.54
T2: Chlorimuron 25WP @ 9g a.i./ha (POE)	7.68	6.67	7.58	7.44	2.74
T3: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)	7.4	5.8	8	6	3.54
T4:Chlorantraniliprole @ 0.3ml/lit.	7.53	0.89	9.35	0.44	3.75
T5: Indoxacarb @ 0.6ml/lit.	7.98	2.22	8.54	1.22	2.76
T6: Profenofos @ 2.0ml/lit	7.87	3.78	8.69	2.11	3.99
T7: Imazethapyr 10SL@75 g a.i./ha (POE) + Chlorantraniliprole @ 0.3ml/lit	7.46	1	7.18	1	4.27
T8: Chlorimuron 25WP @ 9g a.i./ha (POE) + Indoxacarb @ 0.6ml/lit.	7.68	2.23	8.64	1.33	2.84
T9: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Profenofos @ 2.0ml/lit	7.14	2.67	7.71	1.44	1.6
T10: Imazethapyr 10SL@75 g +Chlorimuron 25WP @ 9g a.i./ha (POE)+ Chlorantraniliprole @ 0.3ml/lit	7.46	1	7.18	1	4.27
T11. Weedy	7.32	7.33	9.78	8.78	9.14
CD (P=0.05)	7.44	5.6	7.5	6	3.8

Effect on Growth and Yield of Soybean

Sole and combined application of herbicides and insecticides recorded statistically similar plant height, branches per plant, and pods per plant. Plant growth and yield attributes recoded significantly higher over insecticidal treatments. Neither the sole application nor combination of herbicides and insecticides affected the growth parameters. The growth and yield attributes were recorded highest with the combined application of imazethypr + chlorimuron with chlorantraniliprole followed by imazethypyr + chlorimuron with profenofos and significantly superior over rest treatments. However, lowest growth and yield attributes were recorded in weedy check. Yield contributing characters *viz*.,100 seed weight and harvest index were not significantly different due to the application of herbicide and insecticides (Table 3) However, soybean yield was significantly influenced by herbicides and insecticide application.

The inhibitory effect of herbicides in combination with insecticide reduced the weed population during the important growth stages of soybean resulting in the minimum crop-weed competition for nutrition, space, sun light, aeration and led to increase in soybean yield. Among the herbicides, maximum seed yield (2175kg/ha) was recorded with combined application of imazethapyr + chlorimuron followed by sole application of imazethypr (1847kg/ha) and significantly superior over chlorimuron alone (1275kg/ha). These results clearly indicated that imazethapyr was more effect to control narrow and broad weeds whereas, chlorimuron controlled broad and sedges weeds. The seed yield was recorded at par with sole application of insecticides. The effect of herbicide and insecticides revealed that seed yield of soybean was significantly higher in application of imazethapyr + chlorimuron with chlorantraniliprole (2636 kg/ha) followed by imazethapyr + chlorimuron with profenofos (2303 kg/ha) and significantly superior over rest treatments. Higher yield of soybean in these treatments was due to weed free condition during the important growth stages of soybean.

Whereas, lowest yield (609kg/ha) recorded in weedy check due to maximum weed and insects infestations. Kundu *et al.,* (2011) and Upadhyay *et al.,* (2012) have also reported higher soybean yield due to better weed control by use of imazethapyr 10 SL @ 1.0 L /ha. Sole and in combination with insecticide, imazethapyr and quizalofop ethyl reduced the weed population competing with the soybean crop during the important growth stages leading to increased soybean yield per hectare.

Effect on insect-pests of soybean

Results on insect damage in different treatments are presented in Table 5. The data indicates that the number of larvae per/mrl of leaf roller and tobacco caterpillar one week was significantly lower than the untreated check and sole treatments of herbicides. Similar findings were reported by Barkhade *et al.*, (2013) who showed that less number of larvae/mrl of *Spodoptera* were observed with the sole insecticide and combination of insecticide and herbicides than the sole herbicide and untreated check. Similarly, visual defoliation score was significantly less in the treatments involving insecticides than the sole herbicide treatments. These results were indicated significantly less percent of stem tunneling in sole insecticide as well as their combination with herbicides than untreated check and sole treatment of imazethapyr, in which the percent stem tunneling was found to be unexpectedly significantly higher than the untreated check.

Economics of application of herbicide

The data on economic analysis presented in Table 4 revealed that among herbicides, application of imzethapyr + chlorimuron was more remunerative (2.08) than sole application of imazethapyr (1.73) and chlorimuron (0.91) and it was also found significantly superior over sole application of insecticides. The combined application of imazethapyr + chlorimuron with chlorantraniliprole gave maximum B:C ratio (2.55) which was significantly superior over rest treatments. The maximum remunerative was probably due to the better weed control efficiency which resulted in higher grain yield and higher return. However, negative B:C ratio and net return were calculated in weedy check treatment. Ram *et al.*, (2013) have also reported significantly higher gross and net returns with the application of imazethapyr 10% SL @ 100 g a.i./ha over weedy check in soybean. Higher cost of cultivation was incurred in combination of herbicide and insecticide application treatments than the sole application and weedy check. The similar results are also reported by Hargilas *et al.*, (2015) and Hargilas (2020) in cotton and maize crop. The trend of the economic gain due to combined application of herbicide and insecticides in terms of net returns was obtained in imazethapyr + chlorimuron + chlorantraniliprole and imazethapyr + chlorimuron + profenofos. All the tank-mix combinations of herbicide and insecticide showed economic feasibility over sole treatments. Singh *et al.*, (2006) reported similar variation in net returns and B: C ratio among treatments due variation in yield and expenditure incurred by herbicide and insecticide treatments.

In conclusion based on the experimental findings, the effective practice of tank mix application of herbicides with insecticide for weed and insect management with higher economic return in soybean in soybean can be achieved by combined application of imazethapyr + chlorimuron with chlorantraniliprole/profenopos without any phytotoxicity effect on crop during *kharif* season. This practice may be also reduce the cost of labour incurred in spraying insecticides and herbicides, separately.

References

Barkhade, U. P., Lambe, G. K., Thakre, S. M. and Dandge, M. S. 2013. Evaluation of compatibility of weedicides with insecticides in soybean ecosystem. *J. Plant Sci. Res.*, 29(1): 47-54.

Gomez, K. A. and Gomez, A. A. 1984. Statistical procedures for agricultural research. An International Rice Research Institute Book. A Willey-Inter Science Publication, New York.

Hargilas. 2020. Effective weeds management strategy for maize (*Zea mays* L) under rain-fed condition of Southern Rajasthan. *Ind. J. Agril. Sci.* 90(4): 693-698.

Hargilas, Ameta,G.S, Jat, Subhash Chandra and Saini, D. P.2015. Evaluation of effective weed management strategy for BT cotton. *The Bioscan*, 10 (3):1313-1316.

Jadhav, A. S. and Gadade, G. D. 2012. Evaluation of post-emergence herbicides in soybean. *Ind. J. Weed Sci.*, 44(4): 259– 260.

Kundu, R., Brahma Chari, K., Bera, P. S., Kundu, C. K. and Roychoudhary, S. 2011. Bioefficacy of imazethapyr on the predominant weeds in soybean. *J. Crop Weed*, 7(2): 173-178.

Mani, V. S., Malla, M. L., Gautam, K. C. and Bhagwandas. 1973. Weed killing chemicals in potato cultivation. *Ind. Farm.*, VXXII: 17-18

Pinke, G., Blazsek, K., Magyar, L., Nagy, K., Karacsony, P., Czucz, B. and Botta-

Dukat, Z. 2016. Weed Species Composition of Conventional Soybean Crops in Hungary is Determined by Environmental, Cultural, Weed Management and Site Variables. *Weed Res.*, doi: 10.1111/wre.12225.

Ram, H., Singh, G., Aggrawal, N., Buttar, G. S. and Singh, O. 2013. Standardization of Rate and Time of Application Imazethapyr Weedicide in Soybean. *Ind. J. Plant Prot.*, 41: 33-37.

Singh, V. P., Mishra, J. S., Dixit, A. and Singh, P. K. 2006. Comparative Efficacy of Herbicide against Spurge (*Euphobia geniculata*) in Soybean (*Glycine max*). *Ind. J. Agr. Sci.*, 76(7): 420-422.

Singh, G. 2007. Integrated Weed Management in Soybean (*Glycine max*). *Ind. J. Agr. Sci.*, 77(10): 675–676.

SOPA (The Soybean Processors Association of India).2020. *Estimates of Area, Productivity and Production of Soybean in India during kharif* 2014, Publisher: SOPA, Indore, India.

Upadhyay, V. B., Vimal Bharti and Anay Rawat.2012. Bioefficacy of post emergence herbicides in Soybean. *Ind. J.Weed Sci.*, 44(4): 261-263.

Vollmann, J., Wagentristl, H. and Hartl, W. 2010. The Effects of Simulated Weed Pressure on Early Maturity Soybeans. *Eur. J. Agron.*, 32(4): 243-248.

Yousefi, A. R., Gonzalez-Andujar, J. L., Alizadeh, H., Baghestani, M.A., Rahimian Mashhadi, H. and Karimmojeni, H. 2012. Interactions between Reduced Rate of Imazethapyr and Multiple Weed Species– Soyabean Interference in a Semi-Arid Environment. *Weed Res.*, 52: 242–251.

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