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Impact of herbicide and insecticide combinations on productivity and profitability of soybean in Jharkhand

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Abstract
A field experiment was carried out during Kharif season of 2014-15 at agricultural research farm Ranchi, Jharkhand with an objective to study the effect of insecticide and herbicide combination on productivity of soybean. There were twelve treatment combinations consisted of two herbicides, namely Imazathapyr 10 SL @ 1.0 l/ha and Quizalafop ethyl 5 EC @ 1.0 l/ha and three Insecticides Rynaxypyre 20 SC @ 100 ml/ha, Indoxacarb 14.5 SC @ 300 ml/ha, and Quinalphos 25 EC @ 1.5 l/ha. These were applied alone and in combination and the results were compared with untreared check. Results indicated that application of Rynaxypyre 20SC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha recorded significantly higher pods/plant, soybean yield (1588 kg/ha) and lower weed density as compared to other treatments and it was on par with application of Imazethapyr 10 % SL @ 1.0 l/ha alone.

Keywords: Soybean, herbicide - insecticide combination, productivity

Introduction

Soybean *(Glycine max* (L) Merill) belongs to family “Legumenaceae or Papilionaceae” has been called “Goldan bean” or “Miracle crop” of twentieth century consisting 40-42% and 18-22 % oil (Masciarelli *et al*., 2014) [7]. Soybean is an important oilseed crop playing a vital role in sustaining the oilseed production in India. 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) [3]. Being rainy season crop, it suffers from severe infestation of weeds which reduces its seed yield by 25-77 per cent (Kurchania *et al*., 2001) [5] and may also reach to 86 per cent (Mishra and Singh, 2009) [8]. The luxuriant crop growth, soft and succulent foliage attracts many insects and provides unlimited source of food, space and shelter. About 380 species of insects have been reported on soybean crop from many parts of the world. About 65 insect species have been reported to attack soybean from cotyledon stage to harvesting stage from Karnataka (Thippaiah, 1997) [12]. The defoliators [*Spodoptera litura* (Fab.), *Thysanoplusia orichalcea* (Fab.), *Spilarctia obliqua* (Walk.)] and *Helicoverpa armigera* (Hubner) are feeding on foliage, flower and pods causing significant yield loss (Singh and Singh, 1990) [9].

Increasing soybean yield continues to be an important focus today as input costs and fuel prices are on rise. Producers are progressively facing narrowing of profit margins from soybean and therefore, management decisions are vital for increasing yield and the economic returns. Although hand weeding is an effective method of weed control, but prevailing incessant rains and unavailability and high wages of labour are some constraints, which do not permit farmers to go for this option. Application of herbicides is the alternative option for control of weeds. Co-application of herbicides with an insecticide would allow growers to reduce the number of passes through the field thereby reducing fuel and labor costs, machinery depreciation, soil compaction, as well as mechanical damage to foliage. Main objective of the research was to investigate the compatibility of herbicide with insecticide in tank mix which is very important to soybean growers since incompatibility in the tank can result in plugged nozzles, equipment damage, crop injury as well as reduction in weed and insect control

Material and Method

The experiment was conducted in medium land soil of Jharkhand plateau at Birsa Agricultural University farm, Kanke, Ranchi during the *kharif* season of 2014-15. The geographical location of the farms situated at 23°17´ N latitude and longitude of 85°10´ E with an altitude of 625 m above the mean sea level. The soil of experimental site was sandy loam in texture, acidic in reaction (pH: 5.98), medium (240.21 kg/ha) in available Nitrogen (Kjeldhal method), medium (19.01 kg/ha) in available Phosphorus (Bray P-1), medium (160.3 kg/ha) in available potassium and low (0.45 g/kg) in organic carbon content (Walkely and Black,1973). Experiment was laid out in randomized block design (RBD) with twelve treatments in three replications. In these treatments application of herbicides Imazathapyr 10 SL @ 1.0 l/ha and Quizalafop ethyl 5 EC @ 1.0 l/ha and Insecticides Rynaxypyr 20 SC @ 100 ml/ha, Indoxacarb 14.5 SC @ 300 ml/ha, and Quinalphos 25 EC @ 1.5 l/ha alone and combination was applied at 20 DAS. Soybean was sown 45 cm apart from row distance and 5 cm apart from plant distance. Weed and crop samples for studying various crop and weed characters were collected from each individual plots. Weed samples were collected by placing a quadrate (0.25 x 0.25) randomly at four places in each plot at 30, 45, and 60 DAS. For recording biometric observation at regular interval, two sampling area, i.e. one for destructive and other for non destructive were marked. The observations on crop like plant height, pods/plant were taken from non destructive sampling area, *i.e.*net plot area while the observation like dry matter accumulation per plant were taken from destructive area, *i.e.* area apart from net plot area. The five plants selected from each net plot. The same five plants were harvested separately for the post harvest studies. The mean of five observational plants was taken for calculation. For determining the significance between the treatment means and to draw valid conclusion, statistical analysis was made. Data obtained from various observations were analyzed as per the standard analysis of variance (ANOVA) procedure for randomized block design. The significance of the treatment effect was judged with the 'F' test (Variance ratio). Standard error of mean was computed in all cases. The difference of the treatments mean was tested using Critical Difference (CD) at 5% level of probability where 'F' test reported significant difference among mean.

Results and Discussion

Effect on weed dynamics

The predominant weeds observed in the experimental field during the period of investigation were *Cynodon dactylon, Bracheria reuciformis, Digiteria sanguinalis, Echinolcloa colonum, Cyprus rotendus* among narrow leaf weed and *Cammelina benghalensis, Alternenthra sessilis* among broad leaf weed.

The weed biomass accumulated by weed is the real index which determines the efficiency of herbicides. The weed density of monocot weeds, dicot weeds and total weeds in untreated check was maximum throughout the growth season. The population of weeds was initially maximum then decreased subsequently because initial growth of soybean is slow and continuous rainfall helps the weeds to grow fast.

Among the treatments lowest population of weeds was recorded (Table-1) in Rynaxypyr 20 SC @ 100 ml/ha + Imazethapyr 10 SL @ 1.0l/ha followed by Imazethapyr 10 SL @ 1.0 l/ha. Application Imazethapyr 10 SL @ 1.0 l/ha either individually or with insecticides able to control the different flushes of weed than Quizalafop ethyl 5 EC @ 1.0 l/ha. The declination in weed population by the Imazethapyr is might be attributed to inhibition of acetolactate synthase (ALS) or acetohydroxy acid synthase (AHAS) enzymes which are responsible for the synthesis of three branched chain amino acids such as leusine, isoleusine and valine causing distruction of grassy and broad weeds however Quizalafop ethyl only effective on grassy weeds. These results corroborated with the findings of Teja *et al.* (2017) [11].

Effect on Growth

Vegetative growth mainly consists of formation of somatic cells which results in growth and formation of new leaves, stems and roots and these meristmatic tissues have a very active protein metabolism. Plant height was not significantly affected by combination of herbicide and insecticide application. But data (table 2) clearly indicate that Imazathapyr 10 SL @ 1.0 l/ha either applied individually or with combination of insecticides suppress the plant height throughout the growth period. Application of Quizalafop ethyl 5 EC @ 1.0 l/ha gave taller plants as compare to that of Imazathapyr 10 SL @ 1.0 l/ha in entire growth cycle. However at maturity the highest plant height was obtained in Quinalphos 25 EC @ 1.5 l /ha + Quizalafop ethyl 5 EC @ 1.0 l/ha followed by Indoxacarb 14.5 SC @ 300 ml/ha. Reduction in plant height in soybean due to application of Imazathapyr 10 SL @ 1.0 l/ha was also reported by Khairnar *et al*. (2014) [4]. It may be due to phytotoxic effect on plant hinder the physiological processes which causes some visual symptoms like yellowing, chlorosis, necrosis, epinasty, hyponasty etc.

An overview of the data (Table-2) at harvest revealed that among the different treatment combination, dry matter yield was maximum in Rynaxypyr 20 SC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha (13.77 g/plant) and lowest dry matter was observed in untreated plot. Dry matter production in only insecticide treated plot was non-significant. Between Imazathapyr 10 SL @ 1.0 l/ha and Quizalafop ethyl 5 EC @ 1.0 l/ha treated plot, the former produced 6% more dry matter per plant than late. The interaction between Rynaxypyr and Imazethapyr is additive and compatible, probable reason for more dry matter. Similar interaction observed by Soltani *et.al.* (2014) [10] in which tank mixes of s-metolachlor + imazethapyr, and s-metolachlor + imazethapyr + linuron had an adequate margin of crop safety and provided excellent control of annual broadleaf and grass species in kidney bean production in Ontario

Effect on yield attributes and yield

A close examination of the data(Table- 2) indicated that the maximum number of pods per plant recorded with application of Rynaxypyr 20 SC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha (54.33), which was notably higher than all other treatments except Imazathapyr 10 SL @ 1.0 l/ha (53.67), Indoxacarb 14.5 SC @ 300 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha (50.33) and Quinalphos 25 EC @ 1.5 l/ha + Imazathapyr 10 SL @ 1.0 l/ha (49.33). The lowest number of pods per plant was recorded in control. The probable reason of increase of pods per plant may be due to herbicidal as well as insecticidal effect on plant physiology perhaps leads to more number of flowers and pods over weed control. Hence, number of pods per plant increased with the increase in crop growth period. The above findings are in close harmony with the results of Balyan *et al.* (2016) [2].

Soybean yield (Table -2) was significantly influenced by insecticide and herbicide combination and application of Rynaxypyr 20 SC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha produced the highest grain yield (1588 kg/ha) which was significantly higher than rest of treatments and at par with alone application of Imazathapyr 10 SL @ 1.0 l/ha (1566 kg/ha).The higher yield was due to better weed and insect management from early crop growth and higher dry matter accumulation which resulted in greater translocation of food materials to the reproductive parts and reflected in superiority of yield attributing characters and ultimately to higher yield. Similar interaction was observed by Jordan *et al*., (2008) [6] in between chlorpyrifos with PoE herbicides imazapic, or paraquat plus bentazon in peanut

Effect on Economics

Combined application of insecticide and herbicide is preferable because of convenience, savings in time, reduced application costs, and freeing labor for other operations Among the different treatment highest gross return was observed in Rynaxypyr 20 SC @ 100 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha (`41275 /ha) followed by Imazethapyr 10 SL @ 1.0 l/ha. This return may be attributed due to highest seed yield because of highest weed control efficiency and maximum mortality of pest. The lowest gross return was obtained in untreated control (`8907/ha) which was mainly owing to less yield obtained due to lowest weed control efficiency and more attack of insect. But higher net return (`24325/ha) with higher B:C ratio (1.48) was observed in Imazethapyr 10 SL @ 1.0 l/ha which was at par with Rynaxypyr 20 SC @ 100 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha because of higher cost of Rynaxapyr20 SC @ 100 ml/ha. The above findings are in close harmony with the results of Ali *et al.* (2011) [1] that application of post emergence application of Imazethapyr 100 g/ha at 15-20 DAS recorded maximum net returns followed by quizalofop-ethyl 100 g/ha.

Table 1: Effect of herbicide and insecticide combination on weeds population

Treatment		30 Das			45 Das			60 Das		
		Grassy Weed	Broad weed	Total	Grassy weed	Broad weed	Total	Grassy weed	Broad weed	Total
T_1	Rynaxypyr 20 SC @ 100 ml/ha	7.69 (58.67)	3.71 (13.33)	8.51 (72.00)	8.05 (64.33)	4.01 (15.67)	8.97 (80.00)	7.20 (51.33)	4.49 (19.67)	8.45 (71.00)
T_2	Indoxacarb 14.5 SC @ 300 ml/ha	7.37 (54.00)	3.76 (13.67)	8.25 (67.67)	8.09 (65.00)	4.10 (16.33)	9.05 (81.33)	7.31 (53.00)	4.60 (20.67)	8.61 (73.67)
T_3	Quinalphos 25 EC @ 1.5 l/ha	7.73 (59.33)	3.94 (15.00)	8.65 (74.33)	8.29 (68.33)	4.18 (17.00)	9.26 (85.33)	7.49 (55.67)	4.77 (22.33)	8.86 (78.00)
T_4	Imazathapyr 10 SL @ 1.0 l/ha	3.97 (15.33)	2.27 (4.67)	4.52 (20.00)	4.74 (22.00)	2.73 (7.00)	5.42 (29.00)	3.84 (14.33)	3.43 (11.33)	5.12 (25.67)
T_5	Quizalafop ethyl 5 EC @ 1.0 l/ha	4.73 (22.00)	3.13 (9.33)	5.63 (31.33)	5.37 (28.33)	3.58 (12.33)	6.41 (40.67)	4.45 (19.33)	3.80 (14.00)	5.81 (33.33)
T_6	Rynaxypyr 20 SC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	3.76 (13.67)	1.81 (3.00)	4.13 (16.67)	4.41 (19.00)	2.41 (5.33)	4.98 (24.33)	3.67 (13.00)	3.24 (10.00)	4.85 (23.00)
T_7	Rynaxypyr 20 SC @ 100 ml/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	4.34 (18.33)	2.61 (6.33)	5.02 (24.67)	5.12 (25.67)	3.53 (12.00)	6.18 (37.67)	4.30 (18.00)	3.71 (13.33)	5.64 (31.33)
T_8	Indoxacarb 14.5 SC @ 300 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	4.14 (16.67)	2.41 (5.33)	4.74 (22.00)	4.94 (24.00)	2.94 (8.17)	5.71 (32.17)	4.10 (16.33)	3.43 (11.33)	5.30 (27.67)
T_9	Indoxacarb 14.5 SC @ 300 ml/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	5.14 (26.00)	3.29 (10.33)	6.06 (36.33)	5.73 (32.33)	4.10 (16.33)	7.01 (48.67)	4.70 (21.67)	4.13 (16.67)	6.23 (38.33)
T_{10}	Quinalphos 25 EC @ 1.5 l/ha + Imazathapyr 10 SL @ 1.0 l/ha	4.26 (17.67)	2.47 (5.67)	4.88 (23.33)	5.05 (25.00)	3.24 (10.00)	5.96 (35.00)	4.22 (17.33)	3.53 (12.00)	5.45 (29.33)
T_{11}	Quinalphos 25 EC @ 1.5 l/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	5.16 (26.33)	3.38 (11.00)	6.14 (37.33)	5.96 (35.00)	3.98 (15.33)	7.13 (50.33)	4.77 (22.33)	4.18 (17.00)	6.31 (39.33)
T_{12}	Untreated check	8.09 (65.00)	4.14 (16.67)	9.06 (81.67)	8.60 (73.67)	4.45 (19.33)	9.66 (93.00)	7.67 (58.33)	5.08 (25.33)	9.17 (83.67)
SEm ±		0.20	0.16	0.20	0.17	0.11	0.15	0.17	0.165	0.15
CD (P=0.05)		0.58	0.48	0.59	0.49	0.33	0.45	0.49	0.48	0.43
CV (%)		6.23	9.28	5.60	4.67	5.40	3.72	5.42	7.28	3.88

Data under parenthesis are original value, Transformed data is corresponds to square root transformed value

Table 2: Effect of insecticide and herbicide combinations on plant height, dry matter, pods per plant and seed yield

Treatment		Plant height (cm)	Dry matter (g/plant)	Pods/ plant (No.)	Seed yield (kg/ha)
T_1	Rynaxypyr 20 SC @ 100 ml/ha	52.43	11.68	31.73	798
T_2	Indoxacarb 14.5 SC @ 300 ml/ha	53.39	11.13	31.30	613
T_3	Quinalphos 25 EC @ 1.5 l/ha	50.97	11.07	39.97	609
T_4	Imazathapyr 10 SL @ 1.0 l/ha	47.33	13.22	40	1566
T_5	Quizalafop ethyl 5 EC @ 1.0 l/ha	50.37	12.88	36.00	1143
T_6	Rynaxypyr 20 SC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	48.52	13.77	40.80	1588
T_7	Rynaxypyr 20 SC @ 100 ml/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	50.08	13.00	38.40	1181
T_8	Indoxacarb 14.5 SC @ 300 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	49.60	13.25	39.20	1312
T_9	Indoxacarb 14.5 SC @ 300 ml/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	50.08	12.69	34.93	1101
T_{10}	Quinalphos 25 EC @ 1.5 l/ha + Imazathapyr 10 SL @ 1.0 l/ha	48.82	13.12	38.93	1240
T_{11}	Quinalphos 25 EC @ 1.5 l/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	53.90	12.59	34.40	1026
T_{12}	Untreated check	48.17	10.95	25.60	343
SEm ±		2.33	0.38	1.24	57.60
CD (P=0.05)		NS	1.11	3.64	168.95
CV (%)		8.03	5.27	6.14	9.56

Table 3: Effect of insecticide and herbicide combinations on Economics of soybean

Treatment		Cost of cultivation (`/ha)	Gross Return (`/ha)	Net returns (`/ha)	B:C ratio
T_1	Rynaxypyr 20 SC @ 100 ml/ha	16260	20748	4488	0.28
T_2	Indoxacarb 14.5 SC @ 300 ml/ha	15541	15949	408	0.03
T_3	Quinalphos 25 EC @ 1.5 l/ha	15340	15830	490	0.03
T_4	Imazathapyr 10 SL @ 1.0 l/ha	16400	40725	24325	1.48
T_5	Quizalafop ethyl 5 EC @ 1.0 l/ha	16310	29718	13408	0.82
T_6	Rynaxypyr 20 SC @ 100 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	18160	41275	23115	1.27
T_7	Rynaxypyr 20 SC @ 100 ml/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	18070	30709	12639	0.70
T_8	Indoxacarb 14.5 SC @ 300 ml/ha + Imazathapyr 10 SL @ 1.0 l/ha	17441	34121	16680	0.96
T_9	Indoxacarb 14.5 SC @ 300 ml/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	17351	28617	11266	0.65
T_{10}	Quinalphos 25 EC @ 1.5 l/ha + Imazathapyr 10 SL @ 1.0 l/ha	17240	32236	14996	0.87
T_{11}	Quinalphos 25 EC @ 1.5 l/ha + Quizalafop ethyl 5 EC @ 1.0 l/ha	17150	26676	9526	0.56
T_{12}	Untreated check	14500	8907	-5593	-0.39
SEm ±		-	1497.65	1497.65	0.09
CD (P=0.05)		-	4393	4393	0.26
CV (%)			9.56	24.75	25.50

Conclusion

On the basis of result aforesaid, it may be concluded application of Rynaxypyr 20 SC @ 100 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha in soybean crop was found most advantageous with regard to higher growth, yield attributes, grain yield and better control on weeds which lead to higher gross return. However, maximum net return and benefit cost ratio was obtained in Imazethapyr 10 SL @ 1.0 l/ha because of higher cost of Rynaxypyr which was at par with Rynaxypyr 20 SC @ 100 ml/ha + Imazethapyr 10 SL @ 1.0 l/ha.

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