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Influence of Integrated weed management on weed control efficiency and economics of soybean (*Glycine max*. (L.) Merrill)

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Abstract
A field experiment was carried out at experimental farm of Agronomy section, College of Agriculture, Latur during *Kharif* 2017. As the title indicates, the current work aims to study the effect of integrated weed management on weed control efficiency, weed index and economics of soybean (*Glycine max*. (L.) Merrill). The experiment was laid out in a Randomized Block Design with eight treatments and replicated thrice.
The work revealed that, the treatment (T_8) i.e. Weed free recorded lowest weed count at 60 DAS and lowest weed index at harvest. Which was followed by the treatment (T_4) Pendimethalin 30% EC @ 1kg a.i./ha (PE) + Imazethapyr 10% SL @ 100g a.i./ha (PoE). Highest weed control efficiency was recorded in weed free plot (T_8) i.e. 96.57 per cent followed by treatment (T_4) Pendimethalin 30% EC @ 1kg a.i./ha (PE) + Imazethapyr 10% SL @ 100g a.i./ha (PoE) 78.00%. Highest weed count and weed index (36.95%) were recorded in weedy check (T_7) which were significantly superior over rest of the treatments. Highest net monetary returns and gross monetary returns were obtained due to (T_8) weed free plot i.e. Rs. 35973 ha^{-1} and Rs.70315 ha^{-1}.
Study revealed the superiority of treatment weed free (T_8) in case of effective weed control in order to achieve higher GMR, NMR, B: C Ratio and suggesting the positive benefits of weed management which indirectly influences the yield of soybean.

Keywords: Weed management, weeds, herbicides, weed index, weed control efficiency, economics, GMR, NMR

1. Introduction

Soybean (*Glycine max* (L.) Merill) is a leguminous crop and belongs to family Leguminosae with sub family papilionaceae. It is originated in China and it was introduced in India in recent years. Soybean (*Glycine max*) is important oil yielding rainy season crop having multiple uses. Soybean which is also known as soya beans are species of legume that have become one of the most widely consumed foods in the world. They are extremely useful for human health, and they are easy to cultivate as well.

Soybean is an important crop in human and animal nutrition, because it is a major source of edible vegetable oil and high protein feed as well as food in the world. The protein content of soybean ranges from 36 to 56 percent of dry weight (Atli Arnarson 2015) [1].

During *kharif* 2016, all India estimated area, production and productivity of soybean was 109.716 lakh ha, 114.907 lakh MT and 1047 kg ha^{-1} respectively (Anonymous 2016) [2]. Major soybean growing states in India are Madhya Pradesh (58%), Maharashtra (30%), Rajasthan (6%), Karnataka, Uttar Pradesh, Andhra Pradesh, Chhattisgarh and Gujarat. During the year 2017-2018 world's soybean production was 346.919 lakh MT and India 9.500 lakh MT (Anonymous 2017) [3].

Among the major constraints, initial heavy infestation of weeds is one of the important factors, which hinders its overall growth and productivity (Malik and Malik, 1994) [4]. It is an established fact that weeds, due to their competition for water, light and nutrients reduce crop yields, but little is known about the physiological interaction between crop plants and weeds that brings about the reduction in growth which indirectly results in yield reduction (Aspinall and Milthorpe, 1959) [5].

Weed management is one of the most important factor impacting agricultural productivity. Weeds directly compete with crops for limited resources which reduce crop yield and increase the cost of production. Weeds also impede the efficiency of crop harvest and harbour insects and diseases that can be harmful to crops. There are three goals of any weed management system: reduce weed density, reduce the amount of damage that a given density of weeds

inflicts on an associated crop, and alter the composition of weed communities towards less aggressive and easier-to-manage species. Among the various weed management options herbicide use is not only efficient method but it is cost effective also. On the other hand, physical weed control measure *viz.* hand weeding are safe but labour intensive.
Crop growth attributes indirectly influences the yield. Keeping this view the present study was carried out to study the influence of integrated weed management on weed control efficiency and economics of soybean (*Glycine max*. (L.) Merrill).

2. Materials and Methods
A field experiment was conducted during *kharif* season of 2017-18 at Experimental Farm, Agronomy Section, College of Agriculture, Latur. The experimental site was low in available nitrogen (108.00 kg ha^{-1}), low in available phosphorus (8.18kg ha^{-1}), high in available potassium (430.00 kg ha^{-1}) and alkaline (p^H 7.45) in reaction. The soil was clayey in texture with moderate moisture holding capacity which was good for normal growth. Mechanical analysis of soil was done by International Pipette Method (Piper, 1966) [6], Available nitrogen by alkaline potassium permanganate method (Subbiah and Asija, 1956) [7], available phosphorous by Olsen method (Olsen *et al*., 1954) [8] and available potassium by Flame emission method (Jackson, 1967) [9].
The experiment was laid out in a Randomized Block Design with eight treatments and replicated thrice. The treatments were (T_1) Pendimethalin 30% EC @ 1 kg a. i./ha (P. E.) + Hoeing at 25-30 DAS, (T_2) Quizalofop-ethyl 5% EC @ 0.05 kg a. i./ha (PoE), (T_3) Imazethapyr 10% SL @ 100 g a.i./ha (PoE), (T_4) Pendimethalin 30% EC @ 1 kg a.i./ha (PE) + Imazethapyr 10% SL @ 100 g a.i/ha (PoE), (T_5) Pendimethalin 30% EC @ 1 kg a. i. /ha (PE) + Quizalofop-ethyl 5% EC @ 0.05 kg a.i/ha.(PoE), (T_6) Haloxyfop – ethoxyethyl 10.8 EC @ 0.05 kg a.i./ha.(PoE), (T_7) Weedy check and (T_8) Weed free check.
Gross and net sizes of plots were 5.4 m × 3.9m and 4.5m × 2.9 m respectively. Sowing was done by dibbling method on 28 June 2017 with spacing 45cm × 05 cm. Fertilizers were applied to respective plots as per the recommended dose of fertilizer i.e. 30:60:30 NPK kg ha^{-1} by using the urea (46% N), 10:26:26 and murate of potash (60% K2O). The recommended cultural practices and plant protection measures were taken. The crop was harvested on 11 Oct. 2017.

3. Studies on weeds
3.1 Weed density (No. m^{-2})
The important weed species associated with soybean crop in the experimental area were grouped according to nature of BLW, Grasses and Sedges weeds at 60 DAS.
Weed count were taken at 60 DAS and at harvest using quadrant 1.0 m^2. The number of monocot and dicot weeds falling within the quadrate were counted separately and recorded.

3.2 Weed control efficiency (%)
The weed control efficiency was calculated by using the following formula.

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

Where
WCE= Weed control efficiency in percent
DWC= weed dry weight in control plot.
DWT= weed dry weight in treated plot

3.3 Weed index (%)
According to Gill and Vijay Kumar (1969)[10] weed index may be defined as the decrease in yield due to different treatment in comparison with recommended cultivation practices or the treatment which has the highest yield. It was computed by the formula given below

$$\text{Weed index (WI)} = \frac{x-y}{x} \text{ x } 100$$

Where,
x= weight of seed yield (kg ha^{-1}) in treatment which has highest yield
y= weight of seed yield (kg ha^{-1}) in treatment for which weed index is to be calculated, it is expressed in percentage.

4. Economics
4.1 Gross monetary returns (Rs.ha^{-1})
The gross monetary returns (Rs.ha^{-1}) obtained due to different treatments in the present study were worked out by considering market prices of economic product, by product and crop residues during the experimental year.

4.2 Cost of cultivation (Rs.ha^{-1})
The cost of cultivation (Rs.ha^{-1}) of each treatment was worked out by considering the price of inputs, charges for cultivation, labour, land and other wages.

4.3 Net monetary returns (Rs.ha^{-1})
The net monetary returns (Rs.ha^{-1}) of each treatment was worked out by deducting the mean cost of cultivation (Rs.ha^{-1}) of each treatment from the gross monetary returns (Rs.ha^{-1}) gained from the respective treatments.

4.4 Benefit cost ratio
The benefit: cost ratio of each treatment was calculated by dividing the gross monetary returns by the cost of cultivation of the respective treatments.

4.5 Statistical analysis and interpretation of data
Data obtained on various variables were analyzed by "analysis of variance method" (Panse and Sukhatme, 1967) [11]. The total variance (S^2) and d. f. (n-1) divided into different possible sources. The variance due to replication and treatment effects were calculated and compared with error variance for finding out "F" values and ultimately for testing the significance at P = 0.05 wherever the results were found significant. Critical difference was calculated for comparison of treatment mean at 5% level of significance where results are significant.
The total precipitation received during crop period was only 626 mm with 27 rainy days.

5. Results and Discussion
Almost all weed study parameters *viz*., density of weeds, weed control efficiency, weed index and economics of soybean *viz*., GMR, NMR were significantly influenced by various treatments.

5.1 Weed density (No. m^{-2})
Weed count m^{-2} differed due to different weed control treatments. The BLW, grasses and sedges were 15.00, 15.21 and 5.88 respectively at 60 DAS. At 60 DAS weed free plot (T_8) recorded lowest number of weed count (Monocot and

Dicot) m^{-2} which was followed by treatment (T_4) Pendimethalin 30% EC @ 1kg a.i./ha (PE) + Imazethapyr 10% SL @ 100g a.i./ha (PoE). It might be due to effective weed control by the treatment T_8. Treatment weedy check recorded highest number of weed count m^{-2} at 60 DAS. Similar results were reported by Kulal *et al.* (2016) [12].

5.2 Weed control efficiency (%)

Weed control efficiency represents efficiency of weeds control by treatments in comparison with weedy check. Highest weed control efficiency was recorded in weed free plot (T_8) i.e. 96.57 per cent followed by treatment (T_4) Pendimethalin 30% EC @ 1kg a.i./ha (PE) + Imazethapyr 10% SL @ 100g a.i./ha (PoE) 78.00%. Treatment (T_7) weedy check recorded lowest weed control efficiency. It might be due to no competition for resources between crop plants and weeds due to effective weed control. This result found close conformity with Kulal *et al.* (2016) [12] and Shete *et al.* (2007) [13].

5.3 Weed index (%)

Highest weed index 36.95 per cent was recorded in weedy check (T_7) which was significantly superior over rest of the treatments, followed by (T_6) Haloxyfop 10.8% EC @ 0.05 kg a.i./ha (PoE) and lowest weed index was observed in weed free plot (T_8) followed by (T_4) Pendimethalin 30% EC @ 1kg a.i./ha (PE) + Imazethapyr 10% SL @ 100g a.i./ha (PoE). It might be due to effective weed control. This result found close conformity with *Kulal et al.* (2016) [12].

5.4 Economics of soybean as influenced by various treatments

The highest cost **(**Rs.34342 ha^{-1}) for cultivation of soybean crop was required for weed free plot (T_8). The lowest cost of cultivation (Rs.28342 ha^{-1}) was required in weedy check (T_7) treatment. The mean cost of cultivation for different treatment was Rs.31756 ha^{-1}.

Highest net monetary returns, gross monetary returns and benefit: cost ratio were obtained due to (T_8) weed free plot i.e. Rs. 35973 ha^{-1}, Rs.70315 ha^{-1} and 2.1 respectively, Which was followed by (T_4) Pendimethalin 30% EC @ 1kg a.i./ha (PE) + Imazethapyr 10% SL @ 100g a.i./ha (PoE) i.e. Rs. 21881 ha^{-1}, Rs.53865 ha^{-1} and 1.7 respectively and (T_1) Pendimethalin 30% EC @ 1 kg a.i./ha (PE) + 1 Hoeing at 25-30 DAS i.e. Rs. 22480 ha^{-1}, Rs.53305 ha^{-1} and 1.7 respectively and found significantly superior over rest of the treatments. These results were in conformity with the results of Nandini Devi *et al.* (2016) [14], Smita Prachad *et al.* (2012[15] and Singh and Jolly (2004) [16].

Table 1: Mean weed count m^{-2} as influenced by different treatments at 60 DAS.

Treatments	**BLW at 60 DAS**	**Grasses at 60 DAS**	**Sedges at 60 DAS**
T1 - Pendimethalin 30% EC @ 1 kg a. i./ha (P. E.) + Hoeing at 25-30 DAS	14.00	14.33	4.67
T2 - Quizalofop-ethyl 5% EC @ 0.05 kg a. i./ha (PoE)	16.00	16.33	5.67
T3 – Imazethapyr 10% SL @ 100 g a.i./ha (PoE)	14.67	15.33	5.33
T4 - Pendimethalin 30% EC @ 1 kg a.i./ha (PE) + Imazethapyr10% SL @ 100 g a.i/ha (PoE)	14.00	14.33	4.33
T5 – Pendimethalin 30% EC @ 1 kg a. i. /ha (PE) + Quizalofop-ethyl 5% EC @ 0.05 kg a.i/ha.(PoE)	17.00	17.00	6.67
T6– Haloxyfop – ethoxyethyl 10.8 EC @ 0.05 kg a.i./ha.(PoE)	17.67	17.33	7.00
T7 - Weedy check	21.33	22.67	9.67
T8 - Weed free check.	5.33	4.33	3.67
S.E.±	0.79	0.91	0.40
CD at 5%	2.4	2.7	1.2
General Mean	15.00	15.21	5.88

Table 2: Weed control efficiency (%), and weed index (%) of the weeds associated with soybean at harvest as influenced by different treatments.

Treatments	**WCE (%)**	**WI (%)**
T1 - Pendimethalin 30% EC @ 1 kg a. i./ha (P. E.) + Hoeing at 25-30 DAS	48.43	24.15
T2 - Quizalofop-ethyl 5% EC @ 0.05 kg a. i./ha (PoE)	44.49	26.23
T3 – Imazethapyr 10% SL @ 100 g a.i./ha (PoE)	47.50	24.98
T4 - Pendimethalin 30% EC @ 1 kg a.i./ha (PE) + Imazethapyr10% SL @ 100 g a.i/ha (PoE)	78.00	23.35
T5 – Pendimethalin 30% EC @ 1 kg a. i. /ha (PE) + Quizalofop-ethyl 5% EC @ 0.05 kg a.i/ha.(PoE)	37.04	29.14
T6– Haloxyfop – ethoxyethyl 10.8 EC @ 0.05 kg a.i./ha.(PoE)	26.39	35.11
T7 - Weedy check	0.00	36.95
T8 - Weed free check.	96.57	0
S.E.±	3.17	1.69
CD at 5%	9.96	5.1
General Mean	47.40	24.99

Table 3: Economics (Rs. ha^{-1}) of soybean as influenced by different treatments.

Treatments	**GMR (Rs. ha^{-1})**	**Cost of cultivation (Rs. ha^{-1})**	**NMR (Rs. ha^{-1})**	**B:C Ratio**
T1 - Pendimethalin 30% EC @ 1 kg a. i./ha (P. E.) + Hoeing at 25-30 DAS	53305	30825	22480	1.7
T2 - Quizalofop-ethyl 5% EC @ 0.05 kg a. i./ha (PoE)	51835	32438	19397	1.6
T3 – Imazethapyr 10% SL @ 100 g a.i./ha (PoE)	52780	30042	22738	1.8
T4 - Pendimethalin 30% EC @ 1 kg a.i./ha (PE) + Imazethapyr10% SL @ 100 g a.i/ha (PoE)	53865	31984	21881	1.7
T5 – Pendimethalin 30% EC @ 1 kg a. i. /ha (PE) + Quizalofop-ethyl 5% EC @ 0.05 kg a.i/ha.(PoE)	49840	34021	15819	1.5
T6– Haloxyfop – ethoxyethyl 10.8 EC @ 0.05 kg a.i./ha.(PoE)	45640	31984	13656	1.4
T7 - Weedy check	44310	28342	15968	1.6

T8 - Weed free check.	70315	34342	35973	2.1
S.E.±	3430	-	3430	-
CD at 5%	10395	-	10395	-
General Mean	52745	31756	20989	-

6. Conclusion

On the basis of above findings it may be inferred that for achieving higher GMR ($Rs.ha^{-1}$), NMR ($Rs.ha^{-1}$) , B: C ratio as well as maximum weed control efficiency (%) , lower weed index (%) and lower weed count, the treatment weed free (T_8) was found effective.

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