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Effect of integrated weed management on the growth, yield, quality and economics of soybean (*Glycine max* L.)

AJAY PRATAP SINGH[1], AMIT SINGH TIWARI[2] AND ABHAY SINGH PARIHAR[3]

Department of Agronomy, A.K.S, University, Satna, M.P. (485001)

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ABSTRACT

A field experiment was conducted during the Kharif season of 2024 at the Research Farm of the Department of Agronomy, AKS University, Satna (M.P.), to study the effect of integrated weed management on the growth, yield, quality, and economics of soybean (Glycine max L.). The experiment was laid out in a randomized block design (RBD) with three replications and comprised eleven treatments. The treatments were as follows: T_1(Control), T_2 (Weed free up to harvest), T_3 (Hand weeding at 15 and 35 DAS), T_4 (Fluchloralin @ 1.0 kg a.i ha^{-1} PPI , T_5 (Pendimethalin @ 1.0 kg a.i ha^{-1} PE), T_6 (Imazethapyr @ 100 g a.i ha^{-1} PoE), T_7 (Quizalofop-ethyl @ 50 g a.i ha^{-1} PoE), T_8 (Fluchloralin @ 0.75 kg a.i ha^{-1} PPI + hoeing at 35 DAS), T_9 (Pendimethalin @ 0.75 kg a.i ha^{-1} PE + hoeing at 35 DAS), T_{10} (Quizalofop-ethyl @ 40 g a.i ha-1 (PoE) + hoeing at 35 DAS) and T_{11} (Imazethapyr @ 75 g a.i ha^{-1} (PoE) + hoeing at 35 DAS). The results revealed that integrated weed management practices had a profound impact on the growth, yield, quality, and economic returns of soybean. Among the treatments, T_2 (Weed free up to harvest) consistently recorded the highest values for plant height, number of leaves and branches, root nodules, yield attributes, grain and stover yield, as well as seed quality parameters like protein and oil content. However, due to its higher cost of cultivation, it did not yield the highest economic return. T_{11} (Imazethapyr @ 75 g a.i ha^{-1} as PoE + hoeing at 35 DAS) emerged as the most economically efficient treatment, providing the highest net return and benefit-cost ratio, closely followed by T_8 (Fluchloralin @ 0.75 kg a.i ha^{-1} as PPI + hoeing at 35 DAS).

Keywords: B:C, DAS, INM, weed management, Growth and yield, Pendimethalin, Pre-emergence, Soyabean

INTRODUCTION

Soybean (*Glycine max* L. Merrill) is one of the most important leguminous crops, known for its high protein content (40–42%) and richness in essential nutrients such as calcium, vitamin A, and thiamine. Due to its exceptional nutritional value and versatile uses, it is often referred to as the “Golden Bean”. Soybean contains 43.2% protein, 20% fat, 31.3% carbohydrate and 432 Calories per 100 g (Kundu *et al.,* 2011). In India, soybean is cultivated over an area of 12.81 million hectares, producing approximately 12.90 million tonnes, with an average productivity of 1007 kg/ha. In Madhya Pradesh alone, the crop is grown on 6.50 million hectares, contributing 50.73 million tonnes to the national output, with an average yield of 969 kg/ha (Anonymous, 2022). Weeds possess several aggressive biological traits, enabling them to thrive even under unfavourable conditions. These include high seed production, seed dormancy, discontinuous germination, efficient dispersal mechanisms, and population heterogeneity. Such traits allow weeds to rapidly establish themselves, quickly occupy space, and outcompete crops by efficiently converting resources into biomass (Kanatas *et al.,* 2020; Peer *et al.,* 2013).

Integrated weed management (IWM) plays a vital role in soybean cultivation by ensuring effective and sustainable weed control, which is critical for maximizing crop productivity. IWM combines multiple weed control approaches—such as cultural practices, mechanical methods, chemical herbicides, and biological agents—in a complementary and environmentally sound manner. This approach minimizes over-reliance on any single method, particularly herbicides, thereby reducing the risk of herbicide resistance and environmental degradation. IWM not only enhances the efficacy of weed suppression but also promotes soil health, reduces production costs, and contributes to the long-term sustainability of soybean-based cropping systems

**Corresponding Author’s Email: amitsinghtiwari12@gmail.com, [1]P.G. Student, Agronomy, AKS University, Satna, M.P., [2]Assistant Professor, Department of Agronomy, Faculty of Agricultural Sciences and Technology, AKS University, Satna, M.P., [3]P.G. Student, Agronomy, AKS University, Satna, M.P. (485001)*

MATERIALS AND METHODS

The experiment was conducted during the *Kharif* season of 2024 at the Research Farm, Department of Agronomy, AKS University, Satna, Madhya Pradesh. The soil of the experimental field was sandy loamy in texture, neutral in reaction, and moderately fertile, containing 0.49% organic carbon with adequate levels of available nitrogen, phosphorus, and potassium. During the crop period, a total rainfall of 332.45 mm was recorded, accompanied by moderate temperatures and high relative humidity, which were favourable for the growth and development of the soyabean crop. The experiment was laid out in a randomized block design (RBD) with three replications and comprised eleven treatments. The treatments were as follows T_1(Control), T_2 (Weed free up to harvest), T_3 (Hand weeding at 15 and 35 DAS), T_4 (Fluchloralin @ 1.0 kg a.i ha^{-1} PPI) , T_5 (Pendimethalin @ 1.0 kg a.i ha^{-1} PE), T_6 (Imazethapyr @ 100 g a.i ha^{-1} PoE), T_7 (Quizalofop-ethyl @ 50 g a.i ha^{-1} PoE), T_8 (Fluchloralin @ 0.75 kg a.i ha^{-1} PPI + hoeing at 35 DAS), T_9 (Pendimethalin @ 0.75 kg a.i ha^{-1} PE + hoeing at 35 DAS), T_{10} (Quizalofop-ethyl @ 40 g a.i ha-1 (PoE) + hoeing at 35 DAS) And T_{11} (Imazethapyr @ 75 g a.i ha-1 (PoE) + hoeing at 35 DAS). The variety of Soyabean used for the study was JS-20-116, which was sown manually using a spacing of 30 ×10 cm and a seed rate of 75 kg ha^1 at about 4-5 cm depth. Fertilizer were applied as a basal dose the full quantity of Nitrogen @20 kg/ha, phosphorus @ 40 kg/ha and potassium @ 20 kg/ha was uniformly applied to each plot as basal dose before sowing. All other recommended agronomic practices including irrigation, weed control, pest and disease management, and harvesting were performed uniformly across all treatment plots.

RESULTS AND DISCUSSION

Growth Parameter

Plant height, number of trifoliate leaves, number of branches, and root nodules per plant were significantly influenced by different integrated weed management practices. The maximum plant height at all stages (30, 60, and 90 DAS) was recorded under T2: Weed free up to harvest (68.54 cm at 90 DAS). A similar trend was observed for the number of trifoliate leaves per plant, the highest value at 90 DAS was recorded in T2 (18.33). The number of branches per plant also followed this trend, the highest number of branches at 90 DAS was noted in T2: Weed free up to harvest (7.13). For root nodules per plant, the highest count was observed in T2 (19.00). Similar result on growth parameters due to integrated weed management was also reported by Wadafale *et al.,* (2011), Paudel *et al.,* (2017) and Pawar *et al.,* (2022).

Table 1: Effect of Integrated weed management in soybean on growth, yield and quality of soybean at 90 DAS

Treatment	Plant height (cm)	No. of Root Nodules/ Plant	Number of Branches/ Plant	Pods/ Plant	Seeds/ Pod	Grain yield ($kgha^{-1}$)	Protein content (%)	Oil content (%)
T_1	49.8	10.07	4.47	18.00	2.13	1069.45	36.19	18.68
T_2	68.5	19.00	7.13	32.47	3.20	1724.39	44.93	20.09
T_3	63.55	16.33	6.53	28.33	3.00	1520.68	39.92	19.58
T_4	58.87	14.13	5.67	24.13	2.60	1363.59	37.96	18.97
T_5	57.97	15.33	6.07	26.33	2.80	1420.68	38.65	19.39
T_6	57.63	13.13	5.40	23.13	2.40	1320.37	37.31	18.88
T_7	55.64	12.13	5.00	21.20	2.33	1257.10	36.87	18.42
T_8	64.59	16.47	6.60	29.00	3.00	1602.17	40.06	19.87
T_9	62.29	15.67	6.13	27.00	2.80	1494.45	39.50	19.33
T_{10}	58.58	14.33	5.67	24.47	2.60	1396.30	38.35	18.91
T_{11}	62.95	17.53	6.93	30.27	3.20	1611.73	40.95	19.80
SEm±	1.25	0.79	0.33	0.94	0.19	34.95	1.32	0.32
CD (p=0.05)	3.68	2.34	0.98	2.78	0.57	103.10	3.90	0.96

Table 2: Effect of Integrated weed management in soybean on Economic

Treatment	Cost of cultivation (₹ ha^{-1})	Gross monetary returns (₹ ha^{-1})	Net monetary returns (₹ ha^{-1})	B:C Ratio
T_1	24855.00	54568.67	29713.67	2.20
T_2	32355.00	87450.99	55095.99	2.70
T_3	27855.00	77173.32	49318.32	2.77
T_4	25695.00	69213.76	43518.76	2.69
T_5	25655.00	72103.71	46448.71	2.81
T_6	25580.00	67009.99	41429.99	2.62
T_7	25795.00	63801.12	38006.12	2.47
T_8	27195.00	81343.13	54148.13	2.99
T_9	27155.00	75902.33	48747.33	2.80
T_{10}	27295.00	70857.62	43562.62	2.60
T_{11}	27080.00	81858.96	54778.96	3.02
SEm±		1740.73	1740.73	0.07
CD (p=0.05)		5135.15	5135.15	0.19

T_1(Control), T_2 (Weed free up to harvest), T_3 (Hand weeding at 15 and 35 DAS), T_4 (Fluchloralin @ 1.0 kg a.i ha^{-1} PPI) , T_5 (Pendimethalin @ 1.0 kg a.i ha^{-1} PE), T_6 (Imazethapyr @ 100 g a.i ha^{-1} PoE), T_7 (Quizalofop-ethyl @ 50 g a.i ha^{-1} PoE), T_8 (Fluchloralin @ 0.75 kg a.i ha^{-1} PPI + hoeing at 35 DAS), T_9 (Pendimethalin @ 0.75 kg a.i ha^{-1} PE + hoeing at 35 DAS), T_{10} (Quizalofop-ethyl @ 40 g a.i ha^{-1} (PoE) + hoeing at 35 DAS) And T_{11} (Imazethapyr @ 75 g a.i ha^{-1} (PoE) + hoeing at 35 DAS)

Yield Attribute

Yield attributes such as number of pods per plant, number of seeds per pod, and seed index (100-seed weight) were significantly influenced by weed management. The highest number of pods per plant was recorded in T2: Weed free up to harvest (32.47). Similarly, the highest number of seeds per pod (3.20) was recorded in T2. Seed index was significantly affected as well. The maximum seed index (10.52 g) was noted in T2. Grain yield per plant, per plot, and per hectare followed a similar pattern, with T2 (9.41 g/plant, 1.86 kg/plot, 1724.39 kg/ha) performing the best. Stover yield was also highest in T2 (3093.83 kg/ha).

Quality Content

Protein and oil content in seeds were significantly improved by weed control measures. The highest protein content (44.93%) was recorded in T2: Weed free up to harvest. Effective weed control allowed better nitrogen uptake and utilization, contributing to increased protein synthesis. Oil content was also highest in T2 (20.09%). Reduced weed interference during seed maturation in these treatments facilitated efficient assimilate translocation to oil biosynthesis pathways.

Economic

Cost of cultivation was highest in T2 (₹32,355/ha) due to frequent weeding operations, but this was compensated by the highest gross (₹87,450.99/ha) and net returns (₹55,095.99/ha). The higher returns justify the additional investment, making T2 economically rewarding. The highest B:C ratio (3.02) was recorded in T11: (Imazethapyr @ 75 g a.i ha^{-1} + hoeing at 35 DAS). Although T2 gave the highest returns, its B:C ratio was slightly lower (2.70) due to higher operational cost.

CONCLUSION

In conclusion, the results of the present investigation clearly demonstrated that integrated weed management practices significantly influenced growth, yield attributes, productivity, and profitability of soybean. Among all treatments, T11 (Imazethapyr @ 75 g a.i ha^{-1} as PoE + hoeing at 35 DAS) emerged as the most economically viable and effective approach, closely followed by T8 (Fluchloralin @ 0.75 kg a.i ha^{-1} as PPI + hoeing at 35 DAS). Based on the overall performance, it can be concluded that the integration of chemical weed control with mechanical hoeing, as seen in T11 (Imazethapyr @ 75 g a.i ha^{-1} as PoE + hoeing at 35 DAS), provides an effective, sustainable, and profitable strategy for weed management in soybean cultivation. These integrated approaches ensure optimal growth, enhanced

yield and quality, and better economic returns, thereby fulfilling objectives of the study.

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