**Combined Effect of Diclosulam 0.9% + Pendimethalin 35% SE On Economics of Soybean Crop**

**Abstract**

A field experiment was executed at the BSP Unit, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) in the *Kharif* season of 2019-20. Eleven weed control treatments were arranged in a Randomized Block Design with three replications. The study demonstrated that the application of Diclosulam 0.9% + Pendimethalin 35% SE at 22.5 + 875 g ha-1 resulted in the highest net monetary return and benefit-cost ratio (37611 Rs and 2.00, respectively) compared to other treatments. Furthermore, this combined application achieved the greatest gross monetary return (Rs 75211 ha-1), closely succeeded by Diclosulam 0.9% + Pendimethalin 35% SE. The highest cultivation cost was observed under manual weeding done twice, amounting to Rs. 44325 ha-1.

**Keywords:** Soybean, weed management, Pre plant incorporation, GMR, NMR and B:C ratio

**Introduction:**

“Soybean *(Glycine max* (L.) Merrill) is a significant leguminous oilseed crop in the country, comprising over 50 percent of oilseeds and approximately 30 percent of the overall supply of all vegetable oils” (Tiwari, 2006). “The crop has a special attribute of enhancing soil fertility in a cropping system by the biological nitrogen fixation. The crop thrives well in tropical and sub-tropical climate. Soybean is regarded as the "Miracle Crop," "Wonder Crop," or "Golden Bean" of the 21st century. It is originated to China and was imported to India in 1968 from the United States. It has become a significant commercial crop in numerous nations. Soybean seed comprises 20 percent oil, 40 percent protein, 30 percent carbs, 4 percent saponins, 5 percent fiber, and is devoid of cholesterol. It enhances soil fertility by fixing substantial quantities of nitrogen and by the integration of leaf at maturity. Currently, it is regarded as the most significant industrial crop both nationally and globally. It possesses extensive geographical adaptability, distinctive chemical composition, substantial nutritional value, functional health advantages, and various uses (food, feed, and non-edible). The primary soybean-producing nations include the United States (34%), Brazil (30%), Argentina (18%), China (4%), and India, which contributes 3.95% to total global production (USDA, 2018). In India, soybean is cultivated on 10.84 million hectares, yielding 11.48 million tonnes. Madhya Pradesh is a prominent state in India for soybean agriculture, encompassing 5.4 million hectares and yielding a total production of 5.9 million tonnes. Madhya Pradesh is recognized as the soybean state in India. However, the soybean productivity stands at only 1094 kg ha-1, significantly lower than its yield potential of 2500 kg ha-1” (SOPA, 2018). “The highest net returns of Rs 4003/ha and a benefit-cost ratio of 1.43 were observed with pendimethalin at 1.5 kg/ha, in comparison to other pendimethalin levels and unweeded control” (Kewat and Bhan, 2003). “In the examination of the uniformity of the rate and period of Imazethapyr application in soybean, the highest net returns were recorded with Imazethapyr at 75 g/ha applied at 25 days after sowing (DAS), which was statistically comparable to Imazethapyr at 75 g/ha applied at 15 DAS, Imazethapyr at 100 g/ha applied at either 15 or 25 DAS, and Pendimethalin at 0.45 kg/ha combined with hand weeding at 40 DAS. However, it was significantly superior to Imazethapyr at 50 g/ha applied at 15 or 25 DAS, two hand weedings, and the unweeded control” (Hari *et al.* 2013). “Combination herbicides are more successful in combating weed infestations and the resultant nutrient depletion than a singular herbicide method. The application of herbicides, especially as pre-plant incorporation, can hinder the growth of weeds in the early stages and establish a weed-free environment” (Gulaiya *et al.,* 2023).

**MATERIALS AND METHODS**

A field experiment was executed at the BSP Unit, Department of Agronomy, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) in the Kharif season of 2019-20. Eleven weed control treatments were arranged in a Randomized Block Design with three replications. The chosen experimental field exhibited uniform environment and was infested with location-specific weeds characteristic of the area. All physical resources, including labor, agrochemicals, equipment, and irrigation water, etc. The analytical evaluations were carried out at the College of Agriculture, JNKVV, Jabalpur, in the laboratory of the Department of Agronomy. According to the data, the experimental field's soil had a sandy clay loam texture, a neutral pH of 7.10, and medium concentrations of potassium (310.80 kg/ha), nitrogen (360.30 kg/ha), phosphorus (15.83 kg/ha), and organic carbon (0.65%).

**Experimental details: -**

**List 1: Treatments:** 11 weed control treatments

|  |  |  |
| --- | --- | --- |
| **Treatments** | **Herbicides** | **Rate of application (g/ha)** |
| T1 | Diclosulam 0.9% + Pendimethalin 35% SE | 18 + 700 |
| T2 | Diclosulam 0.9% + Pendimethalin 35% SE | 20.25 + 787.5 |
| T3 | Diclosulam 0.9% + Pendimethalin 35% SE | 22.5 + 875 |
| T4 | Diclosulam 0.9% + Pendimethalin 35% SE | 22.5 + 875 |
| T5 | Diclosulam 84 % WG | 20.25 |
| T6 | Diclosulam 84 % WG | 22.50 |
| T7 | Pendimethalin 30 % EC  | 787.5 |
| T8 | Pendimethalin 30 % EC  | 875 |
| T9 | Pendimethalin 30 % EC+ Imazethapyr 2 % EC | 900 + 60 |
| T10 | Hand weeding (Twice) | 20 & 40 DAS |
| T11 | Weedy check | **-** |

Economics of the treatments

An economic analysis of the treatments is crucial for evaluating their practical utility from the perspective of producers. As a result, the economic feasibility of the various remedies was evaluated on a per-hectare-area basis by calculating the cost of cultivation, gross monetary returns (GMRs), net monetary returns (NMRs), and benefit-cost ratio (B:C).

Cost of cultivation

The cost of cultivation for each treatment was determined on the basis of different inputs used for raising the crop under different treatments on one-hectare area basis.

Gross monetary returns (GMRs)

The values realized from the produce obtained under each treatment was computed on the basis of existing market price of the produce (both grain and stover) as the gross monetary returns (GMRs) per hectare under different treatments as per the following formula.

Gross monetary returns = value of seed + value of Stover

Net monetary returns (NMRs)

The net monetary return (NMRs) per hectare under each treatment was determined by subtracting the cost of cultivation of a particular treatment from the GMRs of the same treatment as per the following formula.

Net monetary returns = gross monetary returns - cost of cultivation

Benefit-cost ratio (B: C)

To estimate the benefits under different treatments for each rupee of expenditure incurred, B: C ratio of each treatment was calculated as below: -

|  |  |
| --- | --- |
| Benefit: cost ratio = | Gross returns (Rs ha-1) |
| Cost of cultivation (Rs ha-1) |

**RESULTS AND DISCUSSION:**

**Effect of herbicidal treatments on Economics:**

The economic evaluation of weed control treatments was conducted on a per hectare basis, encompassing the costs of cultivation, gross monetary returns, net monetary returns, and the benefit-cost ratio (profitability per rupee of investment) across various treatments (Table 1 and Figures 1 and 2).

 Cost of cultivation

The cost of cultivation was calculated based to the treatment, based on the market prices of various common and variable agro-inputs utilized. The results obtained are shown in Table 1 and illustrated in Figure 1. The data clearly indicates that the weedy check treatment incurred the lowest cultivation cost (Rs 32625 ha-1), while the application of Diclosulam 0.9% + Pendimethalin 35% SE18 + 700 g ha-1 resulted in a slight increase in cost (Rs 36675 ha-1). The expenses associated with cultivation rose further due to the addition of various herbicidal treatments, ranging from Rs.36675 to Rs.42225 per hectare in these treatments. The expense attained its highest level (Rs. 44325 ha-1) with two instances of manual hand weeding. This may be attributed to the unaffordability for impoverished farmers, combined with the uncertain availability of labor during peak periods. The treatments including pre-plant inclusion of herbicides required comparatively reduced cultivation costs. The cost of cultivation significantly influences farmers' acceptance of any treatment. Consequently, it is evident that employing herbicides for weed management appears to be more cost-effective than manual weeding.

Gross monetary returns (GMRs)

The gross monetary returns (GMR) under a specific treatment were calculated by taking into account the value of economic produce (seed) and haulm based on the current market rate (Table 1 and Figure 1). The weedy check plot had the lowest GMR (Rs 39373 ha-1), but all of the plots getting weed management had a notable rise in GMR. Diclosulam 0.9% + Pendimethalin 35% SE plots applied together at 22.5 + 875 g ha-1 produced the highest GMR (Rs 75211 ha-1), closely followed by Diclosulam 0.9% + Pendimethalin 35% SE (Rs 67471 ha-1). However, when hand weeding was used, the GMR reached its maximum (Rs 84445 ha-1). The higher soybean seed and haulm yields under these treatments were the reason of the higher GMR values. Similar results were also reported Idapuganti *et al.* (2005).

Net monetary returns (NMRs)

The net monetary returns (NMR) for each treatment were calculated by deducting the cultivation cost from the treatment's GMR. The resulting treatment-wise values were displayed in Table 1 (Figure 1). The data showed that the NMR (Rs. 40120 ha-1) was subjected to hand weeding twice. Diclosulam 0.9% + Pendimethalin 35% SE at 22.5 + 875 g ha-1 (Rs. 37611 ha-1) suggesting that was more profitable than hand weeding twice which requires highest investment on weeding. The NMR with treatment Diclosulam 0.9% + Pendimethalin 35% SE at 22.5 + 875 g ha-1 closely followed by Diclosulam 0.9% + Pendimethalin 35% SE at 45 + 1750 g ha-1 (Rs. 25246ha-1). Both Kewat *et al.* (2000) and Idapuganti *et al.* (2005) found similar findings.

Benefit-cost ratio (B: C)

It represents the net economic return for each rupee invested under a specific treatment. Table 1 and Figure 2 present the benefit-cost ratio statistics as influenced by various interventions. The data clearly show that using Diclosulam 0.9% + Pendimethalin 35% SE at 22.5 + 875 g ha-1 resulted in a higher B: C ratio (2.00), closely followed by Diclosulam 84 % WG (1.74). Hand weeding gave the highest benefit-cost ratio (1.91). Weedy check, however, had the lowest B: C ratio (1.21). The benefit-cost ratio, which shows the overall economic gain under a specific treatment for every rupee of investment, indicates how profitable the therapies are. Idapuganti *et al*. (2005) and Kewat *et al.* (2000) both reported similar findings.

**Table 1. Economic analysis of different weed control treatments**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Treatments** | **Dose g ha-1** | **Cost of cultivation (Rsha-1)** | **Gross monetary returns (Rsha-1)** | **Net monetary returns (Rsha-1)** | **B:C Ratio** |
| T1 | Diclosulam 0.9% + Pendimethalin 35% SE | 18 + 700 | 36675 | 56998 | 20323 | 1.55 |
| T2 | Diclosulam 0.9% + Pendimethalin 35% SE | 20.25 + 787.5 | 37137 | 58917 | 21780 | 1.59 |
| T3 | Diclosulam 0.9% + Pendimethalin 35% SE | 22.5 + 875 | 37600 | 75211 | 37611 | 2.00 |
| T4 | Diclosulam 0.9% + Pendimethalin 35% SE | 45 + 1750 | 42225 | 67471 | 25246 | 1.60 |
| T5 | Diclosulam 84 % WG | 20.25 | 33023 | 56631 | 23608 | 1.71 |
| T6 | Diclosulam 84 % WG | 22.50 | 33027 | 57631 | 24604 | 1.74 |
| T7 | Pendimethalin 30 % EC | 787.5 | 34432 | 57574 | 23142 | 1.67 |
| T8 | Pendimethalin 30 % EC | 875 | 34579 | 57536 | 22957 | 1.66 |
| T9 | Pendimethalin30%EC +Imazethapyr 2 % EC | 900 + 60 | 35825 | 55723 | 19898 | 1.56 |
| T10 | Hand weeding | 20 & 40 DAS | 44325 | 84445 | 40120 | 1.91 |
| T11 | Weedy check | - | 32625 | 39373 | 6748 | 1.21 |

**Fig.1: Economic analysis of different weed control treatments in soybean**

**Fig.2: Influence of different weed control treatments on benefit- cost ratio**

**Conclusion:**

Based on the foregoing discussion it can be concluded that the application of Diclosulam 0.9% + Pendimethalin 35% SE at 22.5 + 875 g ha-1 was more profitable than other treatments in terms of net monetary return and B:C ratio (37611 Rs and 2.00, respectively), but the combined application of Diclosulam 0.9% + Pendimethalin 35% SE at 22.5 + 875 g ha-1 produced the highest GMR (Rs 75211 ha-1), closely followed by Diclosulam 0.9% + Pendimethalin 35% SE. The cultivation cost was highest (Rs. 44325 ha-1) when weeds were removed by hand twice.

Disclaimer (Artificial intelligence)

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

**References:**

Gulaiya S, Jain KK, Jamre PS, Ahirwal A, Sharma A, Kochale P, Prajapati R, Kumar A. Effect of Different Herbicides on Weed Management, Crop Growth and Yield of Soybean. International Journal of Plant & Soil Science. 2023 Nov 25;35(22):435-40.

Idapuganti RG, Rana DS and Pachauri DK. 2006. Integrated weed management in soybean (*Glycine max (L.) Merrill*) and its residual effect on succeeding wheat (*Triticum aestivum*). Indian Journal of Agriculture Science 76(2): 125-128

Kewat ML, Pandey J, Yaduraju NT and Kulshreshtha G. 2000. Economic and ecofriendly weed management in soybean. Indian Journal of Weed Science 32(3&4): 135-139.

SOPA 2018. The Soybean Processors Association of India e-mail: XXX@sopa.org, URL: [www.sopa.org](http://www.sopa.org)

Tiwari SP. 2006. Plant introduction in soybean- achievements and opportunities. Indian Journal of Plant Genetic Resources 19: 353–65.

USDA. 2018. World Agricultural Production. U.S. Department of Agriculture, International Production Assessment Division (IPAD), Washington. URL: http://www.fas.usda.gov