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Effect of pre-plant incorporation herbicide mixtures on crop productivity and quality of soybean under crop-weed interference

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Abstract
The BSP Unit, Department of Agronomy, JNKVV, Jabalpur (M.P.) performed a field experiment in *Kharif* 2019-20 in Randomised block design (RBD) with three replications was used to arrange the 11 herbicidal treatments that made up the study. The study revealed that highest seed yield (1811 kg ha^{-1}) and the greatest harvest index (36.1%) were found under Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha^{-1}, respectively, demonstrating a significant superiority over other herbicide mixtures when applied as a PPI. The control plot had the lowest protein value (40%). Whereas, applying Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha^{-1} (41.90%) and Diclosulam 0.9% + Pendimethalin 35% SE 45 + 1750 g ha^{-1} (41.70%) had the highest protein content, respectively. With the exception of hand weeding plots, no herbicide treatment outperforms hand weeding twice, making it noticeably better than all other treatments.

Keywords: Soybean, seed, weed, energy utilization, nutrient content, uptake, weeding, NPK, herbicidal mixture

1. Introduction
One of the most significant oil crops in the world, soybeans (*Glycine max* (L.) Merrill.) are also very valuable as food legumes. Belonging to the Leguminosae family and sub-family Papilionaceae, soybeans account for 53% of all oilseed crops produced globally. They play a significant role in the agricultural production systems of several major nations, including the United States, China, Brazil, Argentina, and India. Growing soybeans over 5.4 million hectares with a total yield of 5.9 million tonnes, Madhya Pradesh is one of India's top soybean-growing states. As a result, Madhya Pradesh is referred to as the nation's soybean state. However, soybean productivity is only 1094 kg ha^{-1}, significantly less than its 2500 kg ha^{-1} yield potential (SOPA, 2018) [7]. The crop's unique quality is its ability to increase soil fertility in cropping systems through biological nitrogen fixation. In tropical and subtropical climates, the crop thrives. The 21st-century "Miracle Crop," "Wonder Crop," or "Golden Bean" is thought to be soybean. It originated in China and was brought to India by Americans in 1968. In several nations, it has become a significant commercial crop. Generally speaking, weeds compete with crops in the early stages of growth for light, nutrients, and moisture, creating early-season competition (Shrestha *et al.* 2002) [9]. Depending on the kinds and severity of weed competition during the critical stage of crop growth, weeds can reduce soybean yield by 58 to 85% while significantly raising production costs (Tiwari *et al.* 1990) [8]. The primary issue limiting crop yields in soybeans, even in conventional agriculture with full use of tillage and herbicides, is losses from weed infestation.

2. Materials and Methods
The experiment was conducted during the *Kharif* season 2019-20 under climatic and edaphic conditions of Jabalpur (M.P.). The 11 treatments comprising of doses of Diclosulam 0.9% + Pendimethalin 35% SE from (18 + 700 to 45 + 1750 g ha^{-1}), Diclosulam 84% WG (20.25 &

22.50 g ha^{-1}), Pendimethalin 30% EC (787.5 & 875 g ha^{-1}) and Pendimethalin 30% EC + Imazethapyr 2% EC (900 + 60 g ha^{-1}), hand weeding and weedy check, were laid out in randomized block design with 3 replications. The Jabalpur region often has hot, dry summers and chilly, dry winters due to its sub-humid environment. Jabalpur is 411.78 metres above mean sea level and is located at latitude 230 09' North and longitude 790 58' East. The average yearly rainfall in Jabalpur is 1350 mm, with the most of the rain falling between mid-June and the end of September. The rest portions of the year see sporadic showers. In winter, the typical monthly temperature drops to about 4 °C, whereas in summer, the highest temperature ever recorded was 45 °C. In general, relative humidity is relatively low (15-30%) in the summer, moderate (60-75%) in the winter, and higher (80-95%) in the rainy season. The data makes it evident that the experimental field's soil had a sandy clay loam texture, was neutral in reaction (7.10), had a medium level of organic carbon (0.65%), and contained relatively high levels of nitrogen (360.30 kg/ha), phosphorus (15.83 kg/ha), and potassium (310.80 kg/ha).

3. Results and Discussion

3.1 Effect of herbicide on crop productivity

Table 1 shows statistics pertaining to the harvest index and soybean seed under different treatments. The data indicates there were significant differences in both the harvest index and seed yield as a result of the different weed management strategies. Out of all the treatments, the weedy check plot, which carried 907 kg ha^{-1} and had a harvest index of 28.4%, had the lowest seed yield and harvest index. But when weed management measures were put in place, the production significantly increased. When Diclosulam 0.9% + Pendimethalin 35% SE was applied at lower doses, 18 + 700 to 22.5 + 875 g ha^{-1}, the seed yield and harvest index rose, outperforming check herbicides. In contrast, the herbicidal treatments that produced the highest seed production and harvest index (1811 kg ha^{-1} and 36.1%, respectively) were Diclosulam 0.9% + Pendimethalin 35% SE, which was applied at 22.5 + 875 g ha^{-1}. Two manual weeding, on the other hand, produced the highest harvest index (38.2%) and seed production (2058 kg ha^{-1}), outperforming all herbicidal treatments by a significant margin. Hand weeding of soybean plants led to great growth and development of the plants, in contrast to other treatments that had severe crop weed competition beginning at early growth stages and ultimately provided the most poor yield qualities. Depending on the related weed species, their density, the length of crop weed competition, etc., and their cumulative effect of decreased crop production, weeds caused significant damage to the crop. These findings are consistent with the findings of Kamble *et al.* 2017 [2] and Khedkar *et al.* 2009 [3].

Table 1: Influence of herbicidal treatments on Seed yield (kg ha^{-1}) and Harvest index (%)

Treatments		Dose g ha^{-1}	Seed yield	Harvest index
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	1359	34.1
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	1400	33.4
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	1811	36.1
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	1611	34.4
T_5	Diclosulam 84% WG	20.25	1352	34.3
T_6	Diclosulam 84% WG	22.50	1361	32.3
T_7	Pendimethalin 30% EC	787.5	1365	33.0
T_8	Pendimethalin 30% EC	875	1369	33.6
T_9	Pendimethalin 30%EC + Imazethapyr 2% EC	900 + 60	1315	32.1
T_{10}	Hand weeding	20 & 40 DAS	2058	38.2
T_{11}	Weedy check	-	907	28.4
		SEm±	38.28	-
		CD (P= 0.05)	113.73	-

3.2 Effect of herbicide on crop quality parameter

3.2.1 Crude protein and oil content and yield in soybean seed

It is a known truth that the two main components influencing a crop's quality are protein and oil. Table 2 presents the results regarding the protein and oil content as well as the yield of soybean protein and oil affected by the application of various herbicidal treatments. Because there is less crop-weed competition, the data showed that hand weeded areas had the highest protein, protein yield and oil content and its yield (42.00% and 840.90 kg ha^{-1}, 22.00% and 452.76 kg ha^{-1}, respectively) throughout the treatment. The control plot had the lowest percentages of protein, oil content, and yield (40.00% and 375.56 kg ha^{-1}, 19.80% and 179.67 kg ha^{-1}, respectively). Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha^{-1} had the highest protein and oil content (41.90 and 21.90%, respectively), followed by Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 gha-1 (41.70 and 21.20%, respectively). Diclosulam 0.9% + Pendimethalin 35% SE 22.50 + 875 g ha^{-1} had the highest protein and oil yield (750.14 and 396.63 kg ha^{-1}). These results are in collaboration with the findings of Pahuja *et al.* (1985) [4] and Sankaran *et al.* (1988) [5].

Table 2: Effect of treatment on crude protein and oil content and their yield in soybean grain

Treatments		Dose g/ha	Crude Protein		Oil	
			Content (%)	Yield (kg/ha)	Content (%)	Yield (kg/ha)
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	41.10	560.16	20.20	274.57
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	41.30	640.02	20.30	284.20
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	41.90	750.14	21.90	396.63
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	41.70	680.85	21.20	341.56
T_5	Diclosulam 84% WG	20.25	40.03	530.20	20.01	270.51
T_6	Diclosulam 84% WG	22.50	40.20	556.40	20.20	274.94
T_7	Pendimethalin 30% EC	787.5	40.10	556.30	20.10	274.33

T_8	Pendimethalin 30% EC	875	40.25	558.20	20.15	275.76
T_9	Pendimethalin 30% EC + Imazethapyr 2% EC	900 + 60	40.01	500.23	20.08	264.01
T_{10}	Hand weeding	20 & 40 DAS	42.00	840.90	22.00	452.76
T_{11}	Weedy check	-	40.00	375.56	19.80	179.67

4. Conclusion

The one-year statistics could lead to the following conclusions, based on the foregoing discussion. With the exception of hand weeding plots, where no herbicide treatment has been found to outperform hand weeding twice, the application of PPI herbicide, specifically Diclosulam 0.9% + Pendimethalin 35% SE @ 22.5 + 875 g ha^{-1}, was found to be significantly superior among all herbicidal mixtures in terms of seed yield as well as harvest index, crude protein, and oil content and their yield.

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