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Effect of Different Herbicides on Weed Management, Crop Growth and Yield of Soybean

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To assess the performance of several PPI combination herbicides during the 2019 *Kharif* season, a field experiment was carried out at the Product Testing Unit, Department of Agronomy, JNKVV, Jabalpur (M.P.). Proper contact of herbicide with weeds is very difficult in case of post emergence application in soybean due to quick cover of ground and attaining the proper height. Post-emergence herbicides like chlorimuron, and phenoxaprop-p-ethyl are being used by the farmers from quite long time. Herbicides combinations are more effective weaponsin talkingweed menace and thereby nutrient depletion by them than a single herbicide approach. The use of herbicides, particularly as pre plant-incorporation may check the emergence of weeds in early stage and

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create weed free environment. Three replications of the field studies using the Randomized Block Design (RBD) with eleven treatments were conducted. The results showed that applying Diclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha^{-1} as PPI significantly surpassed other herbicide mixtures in terms of weed index (12%), WCE (77.69%), except for T_4 (81.00%), growth and yield attributes such as number of branches $plant^{-1}$ (4.07), root nodules $plant^{-1}$ (69.00), pods $plant^{-1}$(50.33), seeds pod^{-1} (2.67) as well as seed index (10.03). Whereas, highest seed as well stover yield was found superior underDiclosulam 0.9% + Pendimethalin 35% SE 22.5 + 875 g ha^{-1}.

Keywords: Diclosulam + Pendimethalin; hand weeding; Pre Plant Incorporation (PPI); root nodules soybean; seed yield; seed index.

1. INTRODUCTION

Soybean (*Glycine max* (L.) *merrill*) is a significant leguminous oilseed crop, accounting for more than 50% of oilseeds and around 30% of the supply of all vegetable oils in the nation [1]. The crop's unique property is its ability to increase soil fertility in a cropping system through biological nitrogen fixation. Tropical and subtropical climates are favorable for the crop's growth. Because of its exceptional resilience and ability to thrive in harsh water stress circumstances, soybeans may produce lucrative returns with the least amount of agricultural inputs and management techniques. Typically, it grows in a rainfed climate. In India, Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, and Karnataka account for the majority of the cultivation [2].The "Miracle Crop" or "Wonder Crop" or "Golden Bean" of the twenty-first century is soybean. It originated in China and was brought to India in 1968 by the USA. It has become a significant commercial crop in several nations.The top soybean-producing nations are China (4%), Brazil (30%), Argentina (18%), the United States (34%), and India, which contributes 3.95 percent to global production [3]. 11.48 million tones of soybeans are produced in India on an area of 10.84 million hectares. With 5.4 million hectares under cultivation and a total production of 5.9 million tones (SOPA 2018), Madhya Pradesh is one of the top states in India for soybean production. As a result, Madhya Pradesh is referred to as the soybean state in the nation. Nevertheless, soybean productivity is only 1094 kg ha^{-1}, which is far less than its yield potential of 2500 kg ha^{-1}[4]. Gidesa and Kebede (2018) recorded highest grain yield reduction (78.50%) in soybean due to weed competition [5].According to Kundu *et al.,* (2011) Since weeds contributed to a 43% decrease in soybean output, it is clear that weed control is essential to maximizing soybean yield potential [6]. Proper contact of herbicide with weeds is very difficult in case of post emergence application in soybean due to quick cover of ground and attaining the proper height. A considerable amount of study has been done on the management of weeds by pre-plant herbicide inclusion in soybean. Even there is a need to identify new molecules for selective management of weeds and to overcome the problem of resistance incertain weeds against recommended herbicides. The use of herbicides, particularly as pre plant-incorporation may check the emergence of weeds in early stage and create weed free environment. To effectively manage weeds in soybean, pre-emergence herbicide applications must be performed within a relatively small window of time, typically 2-3 DAS. If rain falls during this crucial application window during monsoon season, pre-emergence herbicide cannot be utilised to successfully control weeds in soybean. This circumstance has made looking for pre-plant herbicide integration necessary for the efficient and cost-effective management of weeds in soybeans. New molecules must be found in order to manage weeds selectively and to solve the issue.

2. MATERIALS AND METHOD

field experiment was carried out at the Product Testing Unit, Department of Agronomy, JNKVV, Jabalpur (M.P.) in 2019 *Kharif* season, Three replications of the field studies using the Randomized Block Design (RBD) with eleven treatments were conducted. The mixture Diclosulam 0.9% + Pendimethalin 35% SE (18 + 700, 20.25 + 787.5, 22.5 + 875, and 45 + 1750 g ha^{-1}), applications of Diclosulam 84% WG (20.25 + 22.50 g ha^{-1}), and Pendimethalin 30% EC (787.50 + 875 g ha^{-1}), combined the information shows that the soil in the experimental field had a sandy clay loam texture and was neutral in reaction (7.1), Medium levels of organic carbon (0.65%), nitrogen (360 kg/ha), phosphorus (16 kg/ha), and potassium (311 kg/ha) are present. Depending on the season, the growth of the crop, and the management techniques used

throughout the study, the soil of the experimental field can be infested with many kinds of weeds.

3. RESULTS AND DISCUSSION

3.1 Effect on Weed Control Efficiency and Weed Index (%)

Results of one year study revealed that the different herbicidal mixture had significant effect on WCE and WI. The data in relation to WCE and WI are presented in Table 1. , The maximum WCE (81.00%) was recordedcombined application of Diclosulam 0.9% + Pendimethalin 35% SE 45 + 1750 g ha^{-1} followed by Diclosulam 0.9% + Pendimethalin 35% SEat 22.5 + 875 g ha^{-1} (77.69%). However, the WCE was found highest (95.69%) under hand weeding twice at 20 and 40 DAS. The lowest weed index was recorded the application of Diclosulam 0.9% + Pendimethalin 35% SEat 22.5 + 875 g ha^{-1} (12.00%) under the herbicidal treatment and followed by Diclosulam 0.9% + Pendimethalin 35% SEat 45 + 1750 g ha^{-1} (21.72%). It is clear from the data that highest reduction in yield (55.91%) occurred in control plots.). But reduction in yield was found zero under hand weeding plots this might be due to the crop under hand weeded plots attained lush growth due to elimination of weeds from inter and intra row spaces which resulted better aeration owing to manipulation of surface soil and thus, more space, water, light and nutrients were available for the better growth and development resulting lower weed population [7-9].

3.2 Effect on Crop Growth Parameters

3.3 Branches and Root Nodules $plant^{-1}$

Results of one year study revealed that the different herbicidal mixture had significant effect on branches and root nodules. In Table 2, data on branches/plants at various growth stages under various weed management measures are shown. The number of branches per plant in soybeans was lowest at the 30day stage, produced with time to reach its peak at 90 DAS, and remained unchanged at harvest for all treatments. The statistics clearly show that applications of weed control have a noticeable impact on the plant's branches at 30, 60, and harvest. When the crop was harvested, it had reached its highest value under all of the treatments, and it grew as the crop grew This might be due to higher crop growth and lower weed crop comptetion at this stage would have facilitated better growth and development ultimately a greater number of branches per plant. At 60 DAS, weedy check plots (T_{11}) had the lowest number of branches per plant (2.07) while weed control treatment plots had significantly more branches per plant. The application of Diclosulam 0.9% + Pendimethalin 35% SE22.5 + 875 g ha^{-1} registered highest value of branches $plant^{-1}$ (3.87) followed by the effective nodules per plant for soybean at 30 and 45 DAS. It is evident from the above result shown in Table 3 that at 30 DAS, there

Table 1. Weed control efficiency and weed index as influenced by different weed control treatments

Treatment		Dose g/ha	Weed control efficiency (%)	Weed index (%)
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	71.85	33.95
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	74.79	31.97
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	77.69	12.00
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	81.00	21.72
T_5	Diclosulam 84 % WG	20.25	70.51	34.31
T_6	Diclosulam 84 % WG	22.50	69.87	33.86
T_7	Pendimethalin 30 % EC	787.5	69.33	33.68
T_8	Pendimethalin 30 % EC	875	70.26	33.50
T_9	Pendimethalin 30 % EC +Imazethapyr 2 % EC	900 + 60	68.48	36.11
T_{10}	Hand weeding	20 & 40 DAS	95.69	0.00
T_{11}	Control	-	0.00	55.91
	SEm±	-	-	0.74
	CD (p= 0.05)	-	-	2.21

Table 2. Influence of weed control treatments on branches and root nodules plant^{-1}

	Treatments	Dose g/ha	Branches plant^{-1}			Nodules plant^{-1}	
			30 DAS	60 DAS	At arvest	30 DAS	45 DAS
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	2.27	3.25	3.36	43.90	63.33
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	2.33	3.33	3.47	44.70	64.19
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	2.47	3.87	4.07	46.33	69.00
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	2.11	3.07	3.13	43.67	60.33
T_5	Diclosulam 84 % WG	20.25	2.20	3.17	3.23	44.10	62.90
T_6	Diclosulam 84 % WG	22.50	2.23	3.22	3.26	44.07	64.00
T_7	Pendimethalin 30 % EC	787.5	2.17	3.14	3.20	44.00	63.67
T_8	Pendimethalin 30 % EC	875	2.16	3.15	3.17	44.00	62.67
T_9	Pendimethalin 30 % EC +Imazethapyr % EC	900 + 60	2.13	3.11	3.18	44.03	63.00
T_{10}	Hand weeding	20 & 40 DAS	2.57	4.07	4.10	50.00	80.00
T_{11}	Control	-	1.10	2.07	2.00	31.07	50.00
		SEm±	0.06	0.06	0.07	0.87	1.91
		CD (p= 0.05)	0.18	0.19	0.21	2.57	5.67

were no appreciable differences in the number of nodules per Diclosulam 0.9% + Pendimethalin 35% SE% SE 20.25 + 787.5 g ha-1 of (3.33) and Diclosulam 0.9% + Pendimethalin 35% SE18 + 700 g ha-1 of (3.25).But none of the herbicidal methods outperformed hand weeding twice, which had the most branches per plant (4.00).These results are in collaboration with the findings [7,8]. On the other hand, Table 3 lists plant under various treatments. Under weedy check plots, the lowest number (31.07) of nodules per plant was observed among the various herbicidal treatments. When weed management strategies were implemented in soybean, the nodulation activity increased noticeably. The highest number of root nodules (46.33) per plant enhanced slightly with PPI application of Diclosulam 0.9% + Pendimethalin 35% SE@ 22.5 + 875 g ha^{-1}. Among the herbicidal treatment and highest dose of Diclosulam 0.9% + Pendimethalin 35% SE45 + 1750g ha^{-1}was recorded lower number (43.67) of nodules this might be due to some phytotoxic effect on plant. Diclosulam 0.9% + Pendimethalin 35% SE20.25 + 787.5 g ha^{-1}at par with the Diclosulam 0.9% + Pendimethalin 35% SE18 + 700.Similar results were also recorded at harvest. Themaximum root nodules (50.00 and 80.00) was observed under hand weeding at 30 and 45 DAS, respectively [10,11].

3.4 Effect on Yield Attributing Characters

Table 3 presents data on how various weed control methods affected the number of pods plant-1, seeds pod-1, and seed index. Data showed that number of pods plant^{-1}, seeds pod^{-1} and seed index varied vitally due to different weed control treatments. Under contro plot (T_{11}), the lowest numbers of pods plant^{-1}, seeds pod^{-1}, and seed index were observed across all treatments (27.08, 2.00, and 9.33, respectively), but these numbers dramatically rose when weed management techniques were implemented. Application of Diclosulam 0.9% + Pendimethalin 35% SE as pre plant incorporation at the rate of 18 + 700 and 20.25 + 787.5g ha^{-1} enhanced the number of pods plant^{-1}, seeds pod^{-1} and seed index in soybean plant. The maximum number of pods plant^{-1}, seeds pod^{-1} as well as seed index was noted under the application of Diclosulam 0.9% + Pendimethalin 35% SE applied at 22.5 + 875 g ha^{-1} (50.33), (2.67) and (10.03) respectively. This was followed by Diclosulam 0.9% + Pendimethalin 35% SE as pre plant incorporation at the rate of 20.25 + 787.5 g ha^{-1}. However, none of the herbicidal treatments were significantly better than manual weeding twice (20 and 40 DAS), which outperformed the other treatments (56.73), (2.80), and (10.23) in terms of number of pods plant^{-1}, seeds pod^{-1}as well as seed index respectively [12,13].

3.5 Effect on Yields of Soybean

The data presented in Table 4 relates to soybean seed and stover yield (kg ha^{-1}) under various treatments. The data shows that the various weed control methods resulted in considerable variations in seed and stover yield. The control plot (907.41 and 2283.33 kg ha^{-1}, respectively) found the lowest seed and stover yields among all the treatments owever, he seed and stover yield were increased when Diclosulam 0.9% + Pendimethalin 35% SE was applied at lower doses 18 + 700 to 22.5 + 875 g ha^{-1} which was superior over check herbicides. Incontrast, Diclosulam 0.9% + Pendimethalin 35% SE was applied at 22.5 + 875 g ha^{-1} found significantly highest seed as well as stover yield (1811.11 and 3207.41 kg ha^{-1} respectively) compared to other herbicidal treatments. However, manual weeding twice was shown to be significantly better than all the herbicidal treatments and the highest seed and stover yield was recorded (2058.02 and 3237.04 kg ha^{-1}, respectively. In contrast to other treatments that had severe crop weed competition starting at early growth stages and ultimately produced the most inferior yield attributes. , and weeding of soybean plants resulted in excellent growth and development of the plants. This may be due to the favorable environment during the critical period of crop growth [14,15].

Table 3. Influence of weed control treatments on pods plant^{-1}, seeds pod^{-1} and seed index

Treatments		Dose g ha^{-1}	pods $plant^{-1}$	seeds pod^{-1}	Seed index (g)
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	40.03	2.27	9.70
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	46.07	2.34	9.77
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	50.33	2.67	10.03
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	38.00	2.20	9.43
T_5	Diclosulam 84 % WG	20.25	39.07	2.23	9.70
T_6	Diclosulam 84 % WG	22.50	41.33	2.27	9.80
T_7	Pendimethalin 30 % EC	787.5	39.03	2.23	9.80
T_8	Pendimethalin 30 % EC	875	39.11	2.27	9.47
T_9	Pendimethalin 30%EC +Imazethapyr 2 % EC	900 + 60	38.03	2.17	9.44
T_{10}	Hand weeding	20 & 40 DAS	56.73	2.80	10.23
T_{11}	Control	-	27.08	2.00	9.33
		SEm±	0.86	0.08	0.16
		CD (P= 0.05)	2.57	0.23	0.48

Table 4. Influence of weed control treatments on seed and stover yield (kg ha^{-1}) ofsoybean

Treatment		Dose (g ha^{-1})	Seed yield	Stover yield
T_1	Diclosulam 0.9% + Pendimethalin 35% SE	18 + 700	1359.26	2627.78
T_2	Diclosulam 0.9% + Pendimethalin 35% SE	20.25 + 787.5	1400.00	2790.74
T_3	Diclosulam 0.9% + Pendimethalin 35% SE	22.5 + 875	1811.11	3207.41
T_4	Diclosulam 0.9% + Pendimethalin 35% SE	45 + 1750	1611.11	3079.63
T_5	Diclosulam 84 % WG	20.25	1351.85	2590.74
T_6	Diclosulam 84 % WG	22.50	1361.11	2853.70
T_7	Pendimethalin 30 % EC	787.5	1364.81	2775.93
T_8	Pendimethalin 30 % EC	875	1368.52	2705.56
T_9	Pendimethalin30%EC +Imazethapyr 2 % EC	900 + 60	1314.81	2777.78
T_{10}	Hand weeding	20 & 40 DAS	2058.00	3237.04
T_{11}	Control	-	907.41	2283.33
		SEm±	**38.28**	**71.09**
		CD (P= 0.05)	**113.73**	**211.20**

4. CONCLUSION

The results of the study showed that application of Diclosulam 0.9% + Pendimethalin 35% SE at 22.5 + 875 g ha^{-1} was found suitable for effective control of weeds in soybean which attained significantly higher values of growth parameters, yield attributing traits and yield without any phytotoxicity on soybean plant.

except hand weeding plots because there is no herbicides treatment beat hand weeding twice. The herbicides tested in present investigation must be evaluated alone or in combination at different doses in order to get cost effective weed control.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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