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Effect of Herbicidal Weed Management on Productivity and Profitability of Summer Cowpea

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ABSTRACT

Background: The presence of weeds in cowpea reduced the yield to the tune of 60-82% depending on the weed flora and density. The critical period of weed competition in cowpea was 20-25 DAS. Therefore it is essential to control weeds effectively to harness the maximum yield potential of the crop. To manage weeds in cowpea it is also important to determine the efficacy of pre and post-emergence herbicides. Sequential application of herbicides in a short duration crop not only increases the cost of production but also create cumbersome in its application. Therefore ready mix herbicides are now becoming popular among farming community. These new ready mix herbicides need to be tested for its bio-efficacy to manage weeds and its effect on crop productivity and symbiotic characters of cowpea. Therefore, a field experiment was carried out to evaluate the impact of herbicides on the productivity and profitability of summer cowpea (*Vigna unguiculata* L.) at Agronomy Main Research Farm, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha (India) during summer season.

Methods: The experiment was laid out at Agronomy Main Research Farm, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha (India) during the summer season of 2021 and 2022 in a randomized block design (RBD) comprised of eight treatment with three replications. Standard procedures were followed for the observations and statistical analysis of the data.

Result: The experimental results revealed that ready mix of pendimethalin+imazethapyr-750 g/ha significantly control the mixed flora of weeds which resulted significant increase in growth and yield. Ready mix application of pendimethalin + imazethapyr 750 g/ha registered the highest benefit to cost ratio.

Key words: Cowpea, Economics, Herbicides, Nodulation, Productivity, *Rhizobium*.

INTRODUCTION

Cowpea (*Vigna unguiculata* L.) is an annual leguminous crop that is grown mainly in semiarid regions. In the world, it is cultivated on an area of about 14.5.mha with productivity of about 427.kg/ha (FAO, 2016).

Whereas in India, it is cultivated on an area of about 3.9 m ha with productivity of about 683 kg/ha (Singh *et al*., 2012).

The low productivity of cowpea can be attributed to several limiting factors. However among all limiting factors, weed management are most important. Weeds impose competition for nutrients, solar radiation, water and it sets in at the early crop growth stages and their relative density plays significant role in reducing yield of crops. As regards the various weed control measures, manual eradication has proved its superiority over all the measures in managing weeds; however the adoption of this technique has not gained popularity as it is time consuming. Weed interference in cowpea not only reduced the final stand but also the grain yield up to 90% (Freitas *et al*., 2009). Timely weeding is most important to minimize the yield of losses and therefore under such circumstances the only effective tool left is to control weeds through the use of chemicals. Management of weeds through the use of chemicals has also been found as effective as realized under manual eradication in various crops including over and above benefits in saving extra costs involved in use of labour on manual eradication of weeds. For controlling weeds in cowpea it is also important to determine the efficacy of pre and post-emergence herbicides. The application of pendimethalin as a pre-emergence spray suppressed early emerging weeds (Gurjar *et al*., 2001 and Chauhan *et al*., 2002). Imazethapyr herbicide was used in leguminous crops to combat important annual and perennial grasses as well as broadleaved weeds (Dixit and Varshney, 2007 and Savu *et al*., 2006). Sequential application of herbicides in a short duration crop like cowpea, not only increases the cost of cultivation–but also create cumbersome in its application. Therefore ready mix herbicides of different groups are now becoming popular

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among farming community. Hence, keeping the above facts in view, the present investigation was undertaken to assess the performance of ready mix application of herbicides for providing effective weed control in cowpea.

MATERIALS AND METHODS

The field experiment was conducted in the Agronomy Main Research Farm, OUAT, Bhubaneswar during summer season of 2021 and 2022. The experimental soil was sandy loam in texture, moderately acidic in reaction (pH-6.35), low in organic carbon and available nitrogen, high in available phosphorus and medium in available potassium. The mean maximum and minimum atmospheric temperature during the cropping season were 33.51 and 24.79°C, respectively. Total rainfall of 134.3 mm was received during the crop growing season. Similarly the mean bright sunshine hour was 7.9 hr/day. All weather parameters were suitable for growth of cowpea. The experiment was laid out in a randomized block design (RBD) comprised of eight treatment combinations with three replications *viz*, T_1: (Pendimethalin 0.678 kg ha^{-1} at 2 DAS),T_2: Oxyfluorfen 50 kg ha^{-1} at 2 DAS), T_3: (Ready mix Pendimethalin + Imazethapyr 1.0 kg ha^{-1} at 2 DAS), T_4: (Ready mix Propaquizafop + imazethapyr 75 g ha^{-1} at 20 DAS), T_5: (Ready mix Fluazifop-p-butyl + fomesafen 125 g ha^{-1}at 20 DAS), T_6: Hand weeding at 20 DAS, T_7: Weedy check, T_8: Weed free. The soil samples were collected from the experimental plots at 40 and 60 DAS adopting the standard protocol by Jackson (1967). The collected samples were kept in the polythene container and put in a freezer to observe the beneficial (*Rhizobium*) bacteria by standard plate count method. The plates were incubated for 7 days at 28°C. The microflora (*Rhizobium*) population appeared on the specified media in form of colonies were expressed in terms of colony forming units (CFU) per gram of soil (Bunt and Rovira,1955). The (*Rhizobium*) population count were carried out by plate technique using Yeast extract mannitol agar (YEMA) medium with congo red. Further to estimate the ecotoxicological study of herbicides on nitrogen fixing bacteria, the number of root nodules per plant at 40 and 60 DAS were recorded by carefully uprooting five plants from each plot followed by careful washing. Then the number of nodules was counted from the randomly uprooted plants and the average numbers were expressed as nodule count. Data on weed density were recorded from an area enclosed in the quadrate of 0.5 m^2 randomly selected at two places in each plot. Weeds collected from 0.5 m^2 area at two places were first sun dried for 2-3 days and then oven dried at 70°C till the constant weight was recorded. The weed dry matter obtained at 60 DAS was expressed in gram per square meter (g/m^2). The data on weed density and weed dry weight thus obtained were subjected to square root transformation ($\sqrt{x+1}$) as wide variations existed among the treatments before statistical analysis.

The data obtained on various parameters - weed count, weed density, yield attributes and yield, were tabulated and subjected to analysis of variance techniques as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect on weed flora

The experimental field was infested mainly with *Cynodon dactylon* L., *Eleusine indica* L. and *Eragrostis minor* among grasses, *Cyperus rotundus* L. among sedge and *Vigna trilobata* L., *Euphorbia hirta* L., *Cassia tora* L., *Celosia argentea* L. and *Ageratum conyzoides* L. among broad leaved weeds.

Effect on weed density and dry weight

Critical observation on pooled data taken at 20 DAS indicates that ready mix application of Pendimethalin + Imazethapyr 750 g ha^{-1}, Pendimethalin 678 g ha^{-1} and hand weeding significantly reduced weed count and dry weight of weeds as compared to other treatments (Table 1). Hence pre-emergence herbicides showed their efficiency at earlier

Table 1: Effect of different weed control treatments on total weed density (Mean of 2 years).

Treatments	Weed density (Weed population m^{-2})		Weed dry weight	
	20 DAS	40 DAS	20 DAS	40 DAS
Pendimethalin 678 g ha^{-1} at 2 DAS	7.03 (49.42)	8.34 (69.49)	1.95 (3.80)	1.87 (3.48)
Oxyfluorfen 100 g ha^{-1}at 2 DAS	7.21 (52.08)	9.17 (84.15)	2.01 (4.04)	2.20 (4.83)
Pendimethalin + imazethapyr 750 g ha^{-1} at 2 DAS	6.37 (40.54)	7.88 (62.04)	1.39 (1.93)	1.96 (3.84)
Propaquizafop + imazethapyr 75 g ha^{-1} at 20 DAS	11.98 (143.43)	7.00 (48.99)	2.78 (7.72)	1.67 (2.78)
Fluazifop-p-butyl + fomesafen 125 g ha^{-1} at 20 DAS	12.32 (151.81)	7.50 (56.26)	3.51 (12.32)	2.07 (4.28)
Hand weeding at 20 DAS	6.83 (46.61)	12.61 (158.87)	1.60 (2.56)	3.28 (10.78)
Weedy check (Control)	13.42 (154.14)	15.02 (225.51)	4.29 (18.41)	5.07 (25.74)
Weed free (hand weeding at 15, 30 and 45 DAS)	6.10 (37.25)	6.43 (41.37)	1.33 (1.76)	1.63 (2.67)
SEm ±	0.35	0.37	0.10	0.11
CD (P≤0.05)	1.04*	1.09*	0.3*	0.3*

Data are square root transformation ($\sqrt{X}$) and figures in parenthesis are the original value.

*Significant at P≤0.05.

stage of crop growth but later as the crop progresses the effect also declines and thus resulting in increase in weed density and dry weight. At 40 DAS significantly lowest weed density and weed dry weight was recorded with ready mix application of Propaquizafop + Imazethapyr (7.0 m^{-2}) and (1.67 g m^{-2}) which was followed by Fluazifop-p-butyl + Fomesafen at 40 DAS (7.5 m^{-2}) and (2.07 g m^{-2}) along with weed free treatment (6.43 m^{-2}) and (1.63 g m^{-2}). Maximum number of weed density and dry weight was recorded from weedy check at both stages of crop growth. The results are in agreement with the findings of Kumar and Singh (2017) and Yadav *et al.* (2018).

Effect on nodules

Observations taken on nodule number of cowpea vary at 40 and 60 DAS of crop growth. Maximum-number of nodules was noticed in (hand weeding). At 40 DAS highest nodules were noticed in weed free treatment (24.28 $plant^{-1}$), whereas, lowest nodules per plant were observed in weedy check (12.75). Among herbicides, significantly higher number of nodules was observed with pendmethalin + imazethapyr 750 g/ha (16.95 $plant^{-1}$). Number of nodules $plant^{-1}$ recorded lowest at 60 DAS when compared to 40 DAS in all treatments (Table 2). Therefore it is possible that herbicide induces reduction in nodules formed per plant. This may be due to restriction of root growth and infection. Higher nodules in weed free treatment might be due to weed suppression for longer period, better soil aeration and soil structural manipulation. The results are also corroborated by Sah (2022) and Choudhary *et al*. (2013)

Effect on *Rhizobium* population

The effect of herbicides on *Rhizobium* population is tabulated in Table 2. At 40 DAS, Highest *Rhizobium* population of 6.54 × 10^4 CFU/g soil was noticed in weed free treatment. However, among herbicides, highest *Rhizobium* population observed with pendimethalin + imazethapyr treated plots (4.12 × 10^4 CFU/g soil) The lowest population of *Rhizobum* was observed in the oxyflourfen treated plots (3.11 × 10^4 CFU/g soil). Almost a similar trend was followed at 60 DAS. Similar findings were observed by Sah (2022) and Ahmad and Khan (2010).

Effect on yield

The seed yield, haulm yield (kg ha^{-1}) along with harvest index (%) are presented in (Table 3). The highest seed yield

Table 2: Effect of weed control treatments on nodules $plant^{-1}$, *Rhizobium* population and yield attributes (Mean of 2 years).

Treatment	Nodules (No of $plant^{-1}$)		*Rhizobium* population (Population × 10^4 CFU/g soil)	
	40 DAS	60 DAS	40 DAS	60 DAS
Pendimethalin 678 g ha^{-1}	16.78	10.90	3.96	1.46
Oxyfluorfen 100 g ha^{-1}	14.71	8.70	3.11	1.51
Pendimethalin + imazethapyr 750 g ha^{-1}	16.95	10.77	4.12	2.10
Propaquizafop + imazethapyr 75 g ha^{-1}	12.75	6.90	3.14	1.54
Fluazifop-p-butyl + fomesafen 125 g ha^{-1}	16.05	10.73	3.75	2.12
Hand weeding at 20 DAS	22.16	16.97	5.20	2.91
Weedy check (Control)	15.13	9.27	3.15	1.25
Weed free (Hand weeding at 15, 30 and 45 DAS)	24.28	18.40	6.54	3.33
SEm ±	0.49	0.51	0.48	0.16
CD (P≤0.05)	1.4*	1.5*	1.43*	0.47*

*Significant at P≤0.05.

Table 3: Effect of different weed control treatments on yield attributes, yield and harvest index of cowpea.

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)	B:C
Pendimethalin 678 g ha^{-1}	775.62	1995.98	28.00	2.18
Oxyfluorfen 140 g ha^{-1}	743.00	1885.03	28.27	2.19
Pendimethalin + imazethapyr 750 g ha^{-1}	961.13	2114.42	31.25	2.61
Propaquizafop + imazethapyr 75 g ha^{-1} at 20-25 DAS	824.55	1943.38	29.08	2.17
Fluazifop-p-butyl + fomesafen 125 g ha^{-1}	897.97	2015.42	30.82	2.34
Hand weeding at 20 DAS	692.99	1687.17	29.11	1.65
Weedy check (Control)	541.65	1433.20	27.48	1.69
Weed free (Hand weeding at 15, 30 and 45 DAS)	997.68	2218.00	31.04	1.98
SEm ±	46.06	118.28	-	-
CD (P≤0.05)	139.7*	358.71*	-	-

*Significant at P≤0.05.

was recorded in weed free treatment (997.68 kg ha^{-1}) which was statistically at par with ready mix application of pendimethalin + imazethapyr 750 g ha^{-1} treatment (961.13 kg ha^{-1}) and ready mix application of fluazifop-p-butyl + fomesafen 125 g ha^{-1} (897.97 kg ha^{-1}). These three treatments were found significantly superior to rest of the treatments. Next best treatments in registering higher seed yield was obtained with propaquizafop + imazethapyr 75 g ha^{-1} (824.55 kg ha^{-1}) followed by pendimethalin (775.62 kg ha^{-1}). The lowest seed yield was found in the untreated plot (541.65 kg ha^{-1}). The highest haulm yield (2114.42 kg ha^{-1}) was recorded in weed free treatment (2118 kg ha^{-1}), which remained at par with Pendimethalin + imazethapyr 750 g ha^{-1} (2114..42 kg ha^{-1} and Fluazifop-p-butyl + fomesafen 125 g ha^{-1} (2015.42 kg ha^{-1}). These three treatments were found significantly superior to rest of the treatments. In all the weed control treatments the harvest index was significantly higher than weedy check, highest being the Pendimethalin + imazethapyr 750 g ha^{-1} (31.25%). These results are in close conformity with Chinnusamy *et al*. (2010); Hanumanthappa *et al*. (2012).

Economics

The highest benefit to cost ratio was found in ready mix application of pendimethalin+ imazethapyr 750 g/ha is (2.61) followed by fluazifop-p-butyl + fomesafen 125 g/ha (2.34) (Table 3). Weedy check recorded the minimum value of 1.69. Weed free plot despite provide highest yield and gross return, the B:C Ratio is low. This is due to high cost of manpower involved. These findings are in conformity with Patil *et al*. (2014).

CONCLUSION

Based on two years study, it was concluded that ready mix application of pendimethalin + imazethapyr 750 g ha^{-1} was found effective in controlling mixed flora of weeds and realizing higher productivity of cowpea.

Conflict of interest

All authors declare that they have no conflict of interest.

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