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Efficient management of wild oat (*Avena fatua*) and canary grass (*Phalaris minor*) in chickpea (*Cicer arietinum*) for higher productivity and profitability under irrigated condition

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ABSTRACTS

A field study was conducted during 2015-16 to 2017-18 on instructional farm of KVK, Panna under JNKVV, Jabalpur to evaluate the efficacy of clodinofop-propargyl, pendimethalin, and mechanical weed management of dominated weed flora wild oats (*Avena fatua* L.) and canary grass (*Phalaris minor*) in chickpea (*Cicer arietinum* L.). Clodinofop-propargyl was responsible for the reduction in wild oat & canary grass population consistently which resulted in the improvement of chickpea yield as compared to control plot. Post-emergence application of weedicide clodinofop-propargyl @ 60 g a.i/ha at 25-30 DAS effectively weed killing efficiency of wild oat and canary grass (86.9 and 81.25%) respectively, weed control efficiency 85%, weed index 39.1%, weed control index 92.8% and weedicide control efficiency 5.42% and their dry matter accumulation reduce 92.7% and increase the grain yield of chickpea 49.3% as compared to control plot. Under this trial cost benefit ratio was found 2.9 under recommended practices followed by mechanical weed management 2.5 as compared to control plot 1.8.

Key words: B:C ratio, Nodulation, WCE, Weed dyanamic, WI,WKE, Yield

During the course of scientists-cum-farmers meet with farmers of KVK, Panna juridictional area, it was observed that wild oat (*Avena fatua* L.) and small canary grass (*Phalaris minor*) are the notorious weeds predominantly emerged in the chickpea crop due to adoption of continuous monotony cropping system (Blackgram/Sesame-Wheat/ Chickpea). These two weeds became the major grassy weeds in irrigated and rainfed chickpea in Bundelkhand region of Madhya Pradesh. Both weeds are becoming serious in winter pulses under predominated cropping system. Moreover, winter season favors wild oat (*Avena fatua*) and canary grass (*Phalaris minor*) which is poses negative impact on chickpea production (Kumar, 2013). Because these are one of the most competitive grassy weeds and they are near equal competitors of chickpea and became the major cause of low productivity of chickpea in the farmer's fields. Competition for nutrient, sunlight and space for growth with the chickpea crop initiated just after emergence and first 6 weeks are crucial period and are the important factor of yield losses varied between 40 to 94% in chickpea (Whish 2002). Therefore, the maximum yield benefits will be obtained by controlling these weeds as early as possible. They are the serious constraint in increasing production and productivity of chickpea and typical harvesting of crop. Due to its nature, chickpea is a poor competitor to weeds because of its slow growth rate and limited leaf area at early stages of crop growth. The early establishment of dominated weeds more specifically wild oat and canary grass. In such situation manual weeding became ineffective and more expensive for grassy weed as it needed more time and human labours. Therefore, synthetic chemical are the alternative and are more effective to manual weeding. It needs less human labour and often cost effective than other controls measures. In this situation effective weed management is essential for higher productivity per unit area. Keeping in view the losses caused due to the weed infestation and high cost of manual weeding, the present investigation was undertaken to test the efficacy of some selective weedicides for weed control in chickpea crop.

MATERIALS AND METHODS

Field experiment was conducted during 2015-16 to 2017-18 at KVK instructional farm to manage the predominant weed flora especially wild oat and canary grass. The seeds was sown in lines with recommonded dose of fertilizers (20:60:20 N,P,K kg/ha) and sowing was done with the help of seed-cum-fertidril (45× 22 cm, row × plant spacing) on II[nd] fortnight of October during 2015 to 2017. The experiments design consisted of four different

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treatments :(i) control*,* (ii) pendimethalin 1000 g a.i. /ha as pre-emergence*,* (iii) clodinofop-propargyl 60 g a.i./ha as post emergence at 25-30 days after sowing (DAS) and (iv) one hoeing at 30 DAS. Experiments were carried out in randomized block design and each treatment consisted of three replications.

Observations

The density and dry weight of weeds was recorded at 50 DAS and chickpea yield at physiological maturity. The control field (weedy check plots) was heavy infested with wild oat and canary grass. Sufficient soil moisture was maintained at the time of weedicide spray and spraying was done using volume spray at the rate of 500 litres/ha with the help of Knapsak sprayer fitted with flat fan nozzle. Weed count and weed dry biomass were recorded at 50 DAS by using a 1.0 m^2 sized quadrate randomly at 6 places in each plot. weed killing efficiency, weed index, weed control efficiency and Weed efficiency index calculated using the formulae given below:

$$WCE\ (\%) = \frac{(WDc - WDt)}{WDc} \times 100$$

where, *WDc* = Weed density in control plot, WDt = Weed density in treated plot.

$$WCI\ (\%) = \frac{(WDMc - WDMt)}{WDMc} \times 100$$

where, *WDMc* = Weed dry weight in control plot, WDMt = Weed dry weight in treated plot.

$$Weed\ Index\ (\%) = \frac{(Yt - Yc)}{Yt} \times 100$$

where, *Yt* = Seed yield in weed free plot, Yc =Seed yield in control plot.

$$\frac{(Yt - Yc)}{Yt} \times 100$$

$$\text{Weedicide efficiency Index, WEI (\%)} = \frac{(WDc - WDMt)}{WDMc} \times 100$$

where, *Yt* = Seed yield in weed free plot, Yc = Seed yield in control plot, *WDMc* = Weed dry weight in control plot, WDMt = Weed dry weight in treated plot.

However, the benefit-cost ratio was calculated by dividing net monetary returns by cost of cultivation. Data of number of pods per plant, no. of grains/pod, test weight and grain yield were arranged on personal contact basis.

RESULTS AND DISCUSSION

Effect of herbicide on weed spectrum

Highest weed population and dry weight (biomass) of weeds were recorded in weedy check plot as compared to the other treatments. The crop weed competition was significantly reduced by the selected weedicides used for control and it is evident from the significant decrease in weed population, dry matter accumulation (fresh and dry weight), and increase mortality percentage (9/m^2, 22.5 g/m^2 & 6.8 g/m^2) and 84% respectively by removing the weeds under the application of weedicide (Clodinofop-propargyl) followed by mechanical weed management (48/m^2, 120 g/m^2 and 36 g/m^2), and 20% respectively as compared to control plot (60 g/m^2, 312 g/m^2 and 93.6 g/m^2) (Table 1) which was significantly superior to control practices, similar results were reported by (Pandey *et al*. 2001). However, pool data analysis indicated that application of clodinofop-propargyl @ 60g a.i./ha was found to most effective weedicide for controlling of wild oat and canary grass weed throughout the growing season. It is absorbed by the leaves rapidly and translocated to the growing points of leaves and stems. It interferes with the cell division and elongation resulting stunted growth of the treated plants. It interferes with the production of fatty acids needed for plant growth in susceptible grassy weeds. They inhibit the enzyme, acetyl coenzyme A carboxylase, and disrupt fatty acid biosynthesis in susceptible grasses and growth was stoped within 48 hr of application (Baghestani *et al.* 2008).

Performance of effective weedicide on WCE, WI and WEI.

Results revealed that maximum weed control efficiency(85), weed index (39.1), weed control index (92.8) and weedicide efficiency index (5.42%) were found under post emergence application of clodinafop propargyl 60 g a.i./ha (Table 1) followed by mechanical weed management (20, 29.4, 20 and 0.76), respectively but they significantly higher than the untreated control treatment. All the weed indexes indicated that pre-emergence application of pendimethalin (1.0 kg a.i/ha) might reduce the germination of weed seeds (Pedde *et al.* 2013). Post–emergence application of clodinafop propargyl (60 g a.i./ha) proved superior over rest of the treatments with respect of above mentioned parameter. It is absorbed by the plants adequately, move to the site of action without being deactivated. Their systemic mode of action provides great opportunity to accomplish effective weed control and their efficiency at much lower cost than mechanical method or other treatment. This is in accordance with (Singh *et al* 2013, Narendra *et al* 2016).

Effect of weedicide on growth attributes of chickpea

Growth parameter

The analysis of variance of the data revealed that minimum plant height and number of branches/plant (48.50 cm and 4.5/plant) was recorded under the application of pendimethalin 1000 g a.i./ha treated fields. While maximum plant height and number of branches/plant (55.6 cm and 5.8) was noted in weed free field to increase the interception of sunlight and maximum utilization of available resource as compared to other treatments. The phytotoxic effect of weedicide on chickpea plant height and their branches demonstrated that pre-emergence weedicide had restricted the plant height and number of branches/plant reduce as

Table 1 Effect of herbicide on weed spectrum

Treatment	25 DAS					50 DAS					50 DAS	50 DAS				
	No. of wild oat/ m^2	No.of *Phalaris minor*/m^2	Total weeds/ m^2	Total Fresh weed weight/m^2	Total dry weed weight/ m^2	No.of wild oat/ m^2	No.of *Phalaris minor*/m^2	Total no. of weeds/ m^2	Total Fresh weed weight/m^2	Total dry weed weight/ m^2	Mortality % of wild oat	Mortality % of Canary grass	WI	WCE (%)	WCI (%)	Weedicide efficiency Index (%)
T_0 Control	45	15	60	192	53.8	45	16	60	312	93.6	-	-	-	-	-	
T_1 Pendimethalin	44	16	60	186	52.1	35	14	49	171.5	51.5	12.5	12.5	26.3	18.3	45.0	0.48
T_2 Clodinofop-propargyl	46	16	62	198.4	55.6	6	3	9	22.5	6.8	86.9	81.25	39.1	85.0	92.8	5.42
T_3 Hand hoeing	45	15	60	192	53.8	36	12	48	120	36.0	20	20	29.4	20.0	61.5	0.76
SEM±	1.1	1.3	1.9	13.2	2.7	2.1	1.0	0.7	2.7	0.5						
CV	4.4	14.8	5.6	13.6	8.8	12.1	16.8	3.1	3.0	2.1						
CD at 5%	3.9	4.6	6.7	45.6	9.6	7.3	3.7	2.5	9.4	1.9						

compared to the post-emergence application of weedicide (clodinafop-propargyl). The remarkable reduction in the growth parameter of plant might be due to reduction in photosynthates production or slower the translocation of photosynthates to the tops similar depressive effect was also being reported earlier by Kumar and Singh (2010). While appropriate post-emergence application of weedicide increases the crop canopy by increasing the translocation of photosynthates which is greatly reduced due to weed infestation and resulted enhanced the efficient utilization of available resources by crop than weeds. These findings indicated that the positive impact of weedicide on plant growth parameters because in recent times availability of appropriate dose, high potency and broad spectrum weedicides has provided great opportunity to accomplish effective weed control at much lower cost than mechanical weed management methods (Narendra *et al*. 2016).

Number of nodules and their diameter

Under the current investigation all the tested treatment, i.e. pre and post-emergence application of weedicides and mechanical weed management depicted variable results in term of nodule number and their diameter. Results revealed that the maximum number of nodules/plant and nodule diameter (21 and 27 and 5.5 and 6.5 mm) respectively were recorded in the plants under the treated with clodinafop-propargyl followed by mechanical weed management (8 and 20 and 4.8 and 5.3 mm) respectively at 25 and 50 DAS, whereas the lowest number of nodules/plant and their diameter was recorded (15 and 17 and 3.5 and 4.0 mm) respectively were noted under the application of pendimethalin treated plot (Table 2).While drastically reduced trend in the nodule number/plant and their diameter was recorded at 75 DAS in the all of treatments. The better weed management practices provide weed free condition which favours professed root development and improve mobility of *Rhizobia* in rhizosphere of root zone. They are responsible for nitrogen fixation which ultimately resulted in more nodulation and increase their diameter by increased the nitrogenase activity that can be directly related to the improved photosynthetic process under weed free field. However, several researchers reported that when legumes are exposed to several inappropriate weedicides reduced the nodulation and nitrogen fixation ability in the crop plants by decreasing the nitrogenase activity that can be related to the damage caused in the photosynthetic process under weed infested field (Drew and Ballard 2010).

Nodule fresh and dry weight/plant

The nitrogen fixing capability in legume can judge by the accumulation of fresh and dry matter in the nodule. The analysis of the data showed that the highest fresh and dry nodule weight was recorded under the application of clodinafop-propargyl at both stages 25 DAS and 50 DAS (98 and 145, and 21.6 and 31.9 mg/plant) respectively followed by mechanical weed management (87 and 105 and 17.4 and 22.1 mg/plant) respectively, whereas the lowest

Tabel 2 Effect of herbicide on root nodulation

Treatment	Number of root/ plant	Nodule no./ plant			Nodule diameter (mm)			Fresh nodule weight (mg/plant)			Dry nodule weight (mg/plant)		
		25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS	25 DAS	50 DAS	75 DAS
T_0 Control	11	15	17	11	3.5	4.0	2.3	60	80	44.3	12.0	16.8	9
T_1 Pendimethalin	13.5	17	21	12	4.4	4.6	2.5	80	104	54.5	16.8	23.1	10.5
T_2 Clodinofop-propargyl	18.4	21	27	15	5.5	6.5	3.2	98	145	67.5	21.6	31.9	17.5
T_3 Hand hoeing	15	18	20	12	4.8	5.3	2.9	87	105	54.7	17.4	22.1	11.5
SEM±	0.5	0.33	0.29	1.3	0.2	0.06	0.08	1.2	2.8	5.7	1.3	0.9	0.4
CV	5.5	3.2	2.3	18.4	8.6	1.8	5.1	2.5	4.4	16.4	12.9	6.7	7.0
CD at 5%	1.5	1.2	0.99	4.6	0.8	0.2	0.3	4.1	9.7	19.9	4.8	3.1	1.7

nodule fresh and dry weight (60 and 80 and 12 and 16.8 mg/plant) respectively was recorded under control plot (Table 2). While the linear decrease trend in the nodule fresh and dry weight was observed at 75 DAS in all of the treatments. The lower nodules fresh and dry weight in the pre-emergence weedicide treated field might be due to the inhibition of symbiotic process between legume crop root and with the *Rhizobia* responsible for nitrogen fixation. However, the reduction in the nodulation could possibly due to deceasing in nitrogenase activity that can be correlated with the photosynthetic process disturbance with the nodule alteration which resulted reduce in the nodule fresh and dry weight at all three stages (Khan *et al.* 2004). While appropriate application of weedicide improve nodulation. It might be due to weedicide promote symbiotic process between legume crop root and with the bacteria responsible for nitrogen fixation. However, the increase in the nodulation could possibly be due to increase in the nitrogenase activity that can be correlated with the photosynthetic process for smooth nodulation process (Zaidi *et al.* 2005). It has provided great opportunity to accomplish effective weed control at much lower cost than indiscriminate use of weedicides which could cause adverse changes on soil micro flora, poor quality crop production. So, the appropriate weed management is an only alternative for improving the pulse production (Narendra *et al.* 2016). Almost similar trend was recorded at 25 and 50 days stage. In case of 75 days stages, declined the number of nodules, nodule fresh and dry weight/plant due to cessation of nodulation and started drying of nodules. The results are in agreement with the finding by Choudhary *et al.* (2012).

Crop phenology and growth

Chickpea plants attained early average flowering and physiological maturity date of 5 and 13 days from experimental sites under the application of post-emergence weedicide as compared pre-emergence use of weedicide pendimethalin (Table 3). In weedy check, the shading of crop plants by weeds might have reduced sunlight interception thus prolonged the vegetative growth resulting 5 days delayed in flowering and 13 days delayed in maturity similar results was reported in cowpea (Sunday and Udensi 2013).While remove the shading effect of weed by appropriate weed management to provide proper sunlight to promote vegetative and reproductive growth resulting in earlier flowering and maturity. Similarly, some phonological changes in plants was observed by Kumar and Singh (2010).

Yield and yield attributes

The present study also showed the non-significant effect on number of seeds/pod in all the treatments (Table 3). While significantly higher number of pods/plant, test weight and yield was noted under the treatments of clodinafop-propargyl (30, 180 g and 13.8 q/ha) respectively followed by mechanical weed management (28, 178 g and 11.9 q/ha)

Table 3 Effect of herbicide on yield attributes chickpea

Treatment	Plant height (cm)	Number of branches/ plant	Average flowering date (DAS)	Days to maturity (DAS)	Number of pod/ plant	Number of grains/ pod	Test weight (g)	Yield (q/ha)	Straw yield (q/ha)	Increas yield (%)	G:S ratio	Harvest Index
T_0 Control	48.5	3.8	47	140	22	2	165	8.4	13.9	-	1.7	108.4
T_1 Pendimethalin	50.5	4.5	45	137	27	2	179	11.4	18.5	34.1	1.6	111.4
T_2 Clodinofop	55.6	5.8	42	127	30	2	180	13.8	20.6	49.3	1.5	113.8
T_3 Hand hoeing	51.5	5.4	45	135	28	2	178	11.9	18.7	35.4	1.6	111.9
SEM±	0.9	0.09	0.8	0.8	0.8	0.3	3.2	0.15	0.09			
CV	3.1	3.5	3.1	1.1	5.6	28	3.1	2.3	0.9			
CD at 5%	3.3	0.34	2.8	2.9	2.9	1.1	11.1	0.52	0.34			

Table 4 Effect of weed control measures on economics of different treatments

Treatment	Cost of cultivation (₹/ha)	Gross return (₹/ha)	Net return (₹/ha)	B:C ratio
T_0 Control	33600	18500	15100	1.8
T_1 Pendimethalin	45600	19000	26600	2.4
T_2 Clodinofop	55200	19000	36200	2.9
T_3 Hand hoeing	47600	19000	28600	2.5

as compared to control plot (22, 165 g and 8.4 q/ha). The treatments, in which weed control was effective, ultimately provided better environment and reduced competition to crop for their growth, resulted better grain yields as well as biomass (20.6 q/ha) followed by mechanical weed management (18.7 q/ha) respectively as compared to control plot. Young wild oat plants had higher net assimilation rates by efficient utilization of water and nutrients than the cultivated crops due to their adaptability to excess heat and waterless conditions and soon caught up and passed them. The difference in net assimilation rate did not persist, and in the later stages of growth. These results corroborate the work of Narender *et al.* (2014). The development of more and healthy plants under low weed infestation might have also helped to improve the photosynthetic efficiency of the crop which resulted increased yield. While pre-emergence weedicides when applied to the soil that make the upper soil layer toxic that not only affect the weed seed germination but also inhibit the crop growth as well to a certain extent. In other studies Khan *et al.* (2004) found considerable decline in chickpea yield when they applied pre-emergence weedicide fluchloraline.

Effect of weed control measures on economics of different treatments

Maximum net monetary returns and B:C ratio (₹ 36200/ ha and 2.9) were recorded in post-emergence application of clodinafop-propargyl (60 g/ha) at 25 DAS followed by mechanical weed management (₹ 28600/ha and 2.5) as compared to control plot (₹ 15100/ ha and 1.8).These results are in the conformity with the work of (Pedde *et al.* 2013).

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