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Effect of Herbicidal Weed Management Practices on Weed Dynamics and Productivity of Chickpea (*Cicer arietinum* L.)

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ABSTRACT

Background: This study was conducted in 2017-2018 and 2018-2019 to determine the effects of pre and post herbicides and different doses of applications on the weed dynamics, yield components and yield of chickpea under irrigated condition of Central Punjab region. The main objective of this experiment was to find out the suitable herbicide options to control the weeds along with high profitability.

Methods: The experiment was carried out at Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, during the *rabi* season of two consecutive years. The experiment was conducted in randomized block design comprised of ten treatments with three replications.

Result: The experiment result revealed significantly lowest weed density was found with application of pendimethalin @ 1 kg ha^{-1} as pre-emergence + quizalofop @ 60 g ha^{-1} as post emergence and it remained at par with pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1} and oxyfluorfen @ 125 g ha^{-1} + quizalofop @ 60 g ha^{-1}. The highest yield attributes *viz*. number of pods plant^{-1}, seed pod^{-1} and seed index and grain yield were recorded under these treatments. The effective control of first flush of weeds by pendimethalin and subsequent flushes by post-emergence application of quizalofop and imazethapyr.

Key words: Chickpea, Herbicide, Weed control efficiency, Weed index, Yield.

INTRODUCTION

The total world acreage under pulses is about 85.40 million hectares with production of 87.40 million tones and average productivity of 1023 kg ha^{-1}. India is the major chickpea growing country in the world with an annual production of 119.11 lakh tonnes with average productivity of 1192 kg ha^{-1} (Anonymous 2020). Among various barriers of low productivity in chickpea, the problem of weed management is one of the most important which directly affects the yield of chickpea. Weed is a biotic factor which competes with crops for nutrients, water, space and carbon dioxide which ultimately affects crop growth and development that limits the crop yield (Chandrakar *et al*., 2015 and Das, 2015). Chickpea, being slow in its early growth and short stature plant, is highly susceptible to weed competition (Dubey *et al*., 2018).

Herbicides play a significant role in controlling the weeds and thereby increasing production. Most of the pre-emergence and post-emergence herbicides were applied in large quantities for weed management in chickpea. Pendimethalin inhibits the growth of weed by reduced cell division and it prevents weed from emerging. Pre-emergence herbicides control weeds only for a short period and thereafter late-emerging weeds start competing with crops. Therefore, post emergent herbicidal option is best alternative to mitigate crop-weed competition right from the early stages of the crop. Quizalofop and imazethapyr have been found effective to control broadleaf weed and sedges of different leguminous crops. Application of pendimethalin @ 1 kg ha^{-1} *fb* Clodinafop @ 60 g ha^{-1} effectively controlled grassy as well as the broadleaf weeds (Dubey *et al*., 2018). The higher seed yield of chickpea was found in weed free and it was statistically at par with imazethapyr 55 g/ha and pendimethalin 0.75 kg/ha (Kashyap *et al*., 2022). Therefore, judicious selection of pre and post emergence herbicides helps to increase productivity of chickpea. Nepali

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MATERIALS AND METHODS

The experiment was carried out at Experimental Farm, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, during the *rabi* season of two consecutive years (2017-18 and 2018-19). The experimental farm is geographically situated at 30.5°N latitude and 76.4°E longitude, at an altitude of 271 m above mean sea level. The soil of the experimental site was clay loam in texture with low organic carbon (0.79%) and medium in nitrogen (340 kg ha^{-1}), phosphorus (16.75 kg ha^{-1}) and potassium (174 kg ha^{-1}). The experiment consisted of ten treatments

viz., weedy check (T_1), weed free (T_2), pendimethalin @ 1 kg ha^{-1} as Pre-emergence (T_3), oxyfluorfen @ 125 g ha^{-1} as PE (T_4), pendimethalin @ 1 kg ha as Pre-emergence + quizalofop @ 60 g ha^{-1} as PoE (T_5), oxyfluorfen @ 125 g ha^{-1} as Pre-emergence + quizalofop @ 60 g ha^{-1} as post-emergence (T_6), pendimethalin @ 1 kg ha^{-1} as Pre-emergence + imazethapyr @ 40 g ha^{-1} as post-emergence (T_7), oxyfluorfen @ 125 g ha^{-1} as Pre-emergence + imazethapyr @ 40 g ha^{-1} as post-emergence (T_8), quizalofop @ 60 g ha^{-1} as post-emergence (T_9), imazethapyr @ 40 g ha^{-1} as post-emergence (T_{10}). The experiment was laid out in randomized block design and replicated thrice. The chickpea variety PBG-7 was sown using a seed rate of 50 kg ha^{-1}. Recommended doses of N, P_2O_5 and K_2O were applied at 30, 60 and 40 kg/ha respectively. Full doses of nitrogen, phosphorus and potassium were applied to the crop basal dose before sowing. The chickpea was sown on 20th October 2018 and 10th November 2019 at a row spacing of 30 cm. Herbicides were applied as per treatments with hand sprayer fitted with a flat fan nozzle and the spray volume was 500 litres ha^{-1}. Pre-emergence herbicide was applied just after sowing of the crop, while the application of post-emergence herbicide was done at 25 DAS (days after sowing) as per treatments. Weedy check plots remained infested with native population of weeds till harvest. Data on weed density was 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 65°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 ($\sqrt{x+0.5}$) as wide variations existed among the treatments before statistical analysis. Weed control efficiency and weed index were worked out to assess the efficiency of different herbicide treatments. 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 Das (2015) and Cox (1963).

RESULTS AND DISCUSSION

Weed flora

The experimental field was severely infested with *Echinochloa crusgalli, Melilotus alba*, *Chenopodium album*, *Cynodon dactylon*, *Phalaris minor, Phyllanthus niruri, Portulaca oleracea, Digera arvensis* and *Anagallis arvensis, Chenopodium murale*, *Rumex dentatus*, *Asphodelus tenuifolius*, *Cyperus rotundus* and *Parthenium spp*. during both the years of study. Pooled data results revealed that application of various herbicides did not affect significantly on individual weed species during both the years. The most dominant weed flora was *Chenopodium murale*., *Chenopodium album* and *Rumex dentatus* during both years. The result conformity was found with Yadav *et al*. (2019) and Rathod *et al*. (2017).

Weed density, weed dry matter and WCE and WI

Application of herbicides had significant effect on the weed population of monocot weeds, total density and weed dry accumulation as compared to weedy check at different stage of crop growth. The results are given in Table 1. The density of monocot weeds was recorded with application of pendimethalin @ 1 kg ha^{-1} + quizalofop @ 60 g ha^{-1} which was at par with pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1} and pendimethalin @ 1 kg ha^{-1} at 30 DAS. Similar trend was observed with respect to dicot and total density of weeds at 30DAS. However, the minimum weed density of monocot, dicot weeds and total weed density were recorded with application of pendimethalin @ 1 kg ha^{-1} + quizalofop @ 60 g ha^{-1} which was at par with application of pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1} and oxyfluorfen @ 125 g ha^{-1} + quizalofop @ 60 g ha^{-1} and significantly inferior over rest of treatments at 60, 90 DAS and at harvest. This might be due to effective control of first flush of weeds by pendimethalin and subsequent flushes by post-emergence application of quizalofop and imazethapyr, which was found effective against broadleaf weeds and sedges resulted in reduced density and dry matter of weeds (Singh *et al*., 2017 and Kashyap *et al*., 2022). Oxyfluorfen inhibit protoporphyrinogen oxidase in plants leads to an accumulation of phototoxic chlorophyll precursors which, in the presence of light, produce activated oxygen species which rapidly disrupt cell membrane integrity. Similar findings have been reported by Yadav *et al*. (2019) and Nepali *et al*. (2022). Further, two years of pooled data of weed dry matter revealed that among the various treatments, the significant variation in treatments was due to application of different herbicides. The results are given in Table 2. The application of pendimethalin @ 1 kg ha^{-1} + quizalofop @ 60 g ha^{-1} efficiently reduces the total weed dry matter and it was found at par with pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1} and oxyfluorfen @ 125 g ha^{-1} + quizalofop @ 60 g ha^{-1} and significantly inferior over the rest of treatments at different stages of crop except 30 DAS. However, at 30 DAS, the minimum weed dry matter was recorded with application of pendimethalin @ 1 kg ha^{-1} + quizalofop @ 60 g ha^{-1} which was found at par with pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1} and pendimethalin @ 1 kg ha^{-1} and significantly inferior over rest of treatments. It might be due to favorable microclimate in the field such as adequate availability of soil moisture and congenial temperature for higher weed biomass production, resulting in greater dry matter accumulation by weeds. The gradual increase in dry matter of weed till harvest in chickpea has also been reported by Singh and Jain (2017). Weed biomass directly influenced the value of weed control efficiency. The results are given in Table 3. A close observation of the data revealed that the maximum weed control efficiency was recorded with pendimethalin @ 1 kg ha^{-1} + quizalofop @ 60 g ha^{-1} followed by pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1}. However, the minimum weed control efficiency was observed in weedy check. This might

Table 1: Efficacy of herbicides on total density of mono and dicot weeds (m^{-2}) (pooled data of two years).

Treatment	Density of monocot weeds (m^{-2})				Density of dicot weeds (m^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1 - Weedy check	3.27(10.21)	5.03(24.87)	5.67(31.71)	6.13 (37.17)	3.43(11.32)	5.27(27.35)	5.98(35.34)	6.46 (41.32)
T_2 - Weed free	0.71(0.00)	0.71 (0.00)	0.71 (0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71(0.00)	0.71 (0.00)
T_3 - Pendimethalin @ 1 kg ha^{-1}	2.17(4.25)	4.23 (14.47)	5.06(25.09)	5.60 (30.93)	2.70(6.80)	3.91 (14.81)	5.33(28.05)	5.37 (28.46)
T_4 - Oxyfluorfen @ 125 g ha^{-1}	2.95(8.19)	4.91 (23.68)	5.17(26.23)	5.73 (32.34)	3.13(9.35)	4.28 (17.86)	5.42(28.99)	5.85 (33.79)
T_5 - Pendimethalin @ 1 kg ha^{-1} fb Quizalofop @ 60 g ha^{-1}	1.91(2.77)	2.67 (6.69)	4.18(17.00)	4.59 (20.60)	2.44(5.46)	2.76(7.14)	4.54(20.12)	4.22 (17.37)
T_6 - Oxyfluorfen @ 125 g ha^{-1} fb Quizalofop @ 60 g ha^{-1}	2.37(5.15)	2.92 (8.06)	4.44(19.22)	4.99 (24.59)	2.94(8.14)	3.13(9.30)	4.77(22.32)	4.44 (19.35)
T_7 - Pendimethalin @ 1 kg ha^{-1} fb Imazethapyr @ 40 g ha^{-1}	2.12 (4.01)	2.82 (7.49)	4.34 (18.37)	4.86 (23.18)	2.56(6.06)	2.94(8.16)	4.76(22.20)	4.36 (18.64)
T_8 - Oxyfluorfen @ 125 g ha^{-1} fb Imazethapyr @ 40 g ha^{-1}	2.65 (6.51)	3.13 (9.39)	4.67 (21.31)	5.18(26.41)	3.10(9.13)	3.34 (10.66)	5.17(26.26)	4.96(24.24)
T_9 - Quizalofop @ 60 g ha^{-1}	3.11 (9.18)	3.61(12.55)	4.75 (22.07)	5.22 (26.84)	3.15(9.50)	3.46(11.47)	5.24(26.97)	5.09 (25.45)
T_{10} - Imazethapyr @ 40 g ha^{-1}	3.19 (9.69)	3.90 (14.73)	4.90 (23.51)	5.34 (28.14)	3.25 (10.11)	3.55(12.20)	5.29(27.51)	5.15(26.11)
CD (5%)	0.27	0.40	0.28	0.50	0.36	0.34	0.45	0.60

Data were subjected to $\sqrt{x + 0.5}$. Figures in parthensis are original values.

Table 2: Efficacy of different herbicides on total density of weeds (m^{-2}) total dry matter of weed (gm^{-2}) (pooled data of two years).

Treatment	Total density of weeds (m^{-2})				Total dry matter of weed (gm^{-2})			
	30 DAS	60 DAS	90 DAS	At harvest	30 DAS	60 DAS	90 DAS	At harvest
T_1 - Weedy check	4.69 (21.53)	7.26 (52.22)	8.22 (67.05)	8.89 (78.49)	4.45 (19.30)	9.47 (89.39)	10.92 (119.23)	12.83 (164.09)
T_2 - Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_3 - Pendimethalin @ 1 kg ha^{-1}	3.31 (11.05)	5.72 (32.28)	7.31 (53.14)	7.73 (59.38)	2.37 (5.14)	6.70 (44.53)	8.74 (76.04)	10.76 (115.54)
T_4 - Oxyfluorfen @ 125 g ha^{-1}	4.25 (17.53)	6.48 (41.54)	7.46 (55.22)	8.16 (66.12)	3.15 (9.41)	7.52 (56.45)	9.07 (81.79)	11.26 (126.47)
T_5 - Pendimethalin @ 1 kg ha^{-1} fb Quizalofop @ 60 g ha^{-1}	2.96 (8.23)	3.78 (13.83)	6.13 (37.12)	6.20 (37.97)	2.02 (3.60)	3.36 (10.81)	4.25 (17.64)	5.86 (33.88)
T_6 - Oxyfluorfen @ 125 g ha^{-1} fb Quizalofop @ 60 g ha^{-1}	3.71 (13.29)	4.22 (17.36)	6.48 (41.54)	6.65 (43.84)	2.76 (7.10)	4.15 (16.82)	4.81 (22.71)	6.77 (45.44)
T_7 - Pendimethalin @ 1 kg ha^{-1} fb Imazethapyr @ 40 g ha^{-1}	3.25 (10.07)	4.02 (15.66)	6.41 (40.57)	6.49 (41.82)	2.31 (4.87)	3.85 (14.33)	4.45 (19.41)	6.29 (39.12)
T_8 - Oxyfluorfen @ 125 g ha^{-1} fb Imazethapyr @ 40 g ha^{-1}	4.01 (15.64)	4.53 (20.05)	6.93 (47.56)	7.14 (50.65)	3.13 (9.32)	5.36 (28.39)	7.11 (50.17)	8.53 (72.76)
T_9 - Quizalofop @ 60 g ha^{-1}	4.37 (18.67)	4.95 (24.01)	7.04 (49.05)	7.26 (52.29)	4.00 (15.47)	6.26 (38.88)	7.73 (59.38)	9.53 (90.58)
T_{10} - Imazethapyr @ 40 g ha^{-1}	4.50 (19.79)	5.23 (26.92)	7.18 (51.02)	7.39 (54.25)	4.26 (17.61)	6.34 (39.73)	8.22 (67.13)	9.98 (99.47)
CD (5%)	0.37	0.36	0.48	0.65	0.23	0.80	0.75	0.94

Data were subjected to $\sqrt{x + 0.5}$. Figures in parthensis are original values.

have happened due to lowest weed biomass recorded under these treatments. Pendimethalin controlled weed by inhibiting cell division and elongation, thereafter, coinciding with quizalofop which acted as inhibitor of aryloxy phenoxy-propionates group. It acts as an Acetyl CoA Carboxylase inhibitor. and thus, resulted in the lowest weed counts and ultimately produced lower weed dry weight. Imazethapyr inhibits the plastid enzyme acetolactate synthase (ALS) in plants which catalyses the first step in the biosynthesis of essential branched chain amino acids (valine, leucine, isoleucine). The ALS inhibitors thus stop cell division and reduce carbohydrate translocation in the susceptible plants. It reduces both density and dry matter accumulation in weeds (Kashyap *et al*., 2022). Further, data showed that the minimum weed index was recorded with pendimethalin @ 1 kg ha^{-1} + quizalofop @ 60 g ha^{-1} followed by pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1}. This might be due to minimum weed competition coupled with herbicidal combined action of pre–and post-emergence that resulted in comparatively higher yield attributes and yield of chickpea. Weedy check recorded maximum weed index due to heavy flushes of weeds over the entire crop growth period, thereby causing severe weed competition by uncontrolled weed growth. These results are in agreement with the findings of Dubey *et al*. (2018) and Nepali *et al*. (2022).

Yield attributing and yield of crop

Herbicidal weed management options resulted insignificant influence on yield except number of seeds/ pod and yield of chickpea crop. The results are given in Table 4. The maximum yield attributing parameters and yields were observed with pendimethalin @ 1 kg ha^{-1} + quizalofop @ 60 g ha^{-1} which was at par with pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1} and oxyfluorfen @ 125 g ha^{-1} + quizalofop @ 60 g ha^{-1} and significantly inferior over the rest of treatments during experimentation except the seeds/pod.Further data showed that the highest seeds/ pod was recorded with application of pendimethalin @ 1 kg ha^{-1} + quizalofop @ 60 g ha^{-1} followed pendimethalin @ 1 kg ha^{-1} + imazethapyr @ 40 g ha^{-1}. Improved yield was owing to minimum weed infestation and crop-weed competition during critical growth period and improved yield attributes which in turn increased yield contributing characters and resulted in high crop yield. Kashyap *et al*. (2022) also reported highest growth and yield attributing parameters of chickpea with the application of imazethapyr. Similar result reported by Yadav *et al*. (2019) and Sethi *et al*. (2021).

Table 3: Efficacy of different herbicides on WCE (%) and WI (%) (Pooled data of two years).

Treatments	WCE (%)				WI (%)
	30 DAS	60 DAS	90 DAS	Harvest	
T_1- Weedy check	0.00	0.00	0.00	0.00	53.12
T_2- Weed free	100.00	100.00	100.00	100.00	0.00
T_3- Pendimethalin @ 1 kg ha^{-1}	73.38	50.19	36.22	29.59	36.19
T_4- Oxyfluorfen @ 125 g ha^{-1}	51.25	36.85	31.40	22.93	38.14
T_5- Pendimethalin @ 1 kg ha^{-1} fb Quizalofop @ 60 g ha^{-1}	81.34	87.90	85.21	79.36	3.77
T_6- Oxyfluorfen @ 125 g ha^{-1} fb Quizalofop @ 60 g ha^{-1}	63.23	81.18	80.95	72.31	11.65
T_7- Pendimethalin @ 1 kg ha^{-1} fb Imazethapyr @ 40 g ha^{-1}	74.75	83.96	83.72	76.16	9.48
T_8- Oxyfluorfen @ 125 g ha^{-1} fb Imazethapyr @ 40 g ha^{-1}	51.72	68.24	57.92	55.66	29.13
T_9- Quizalofop @ 60 g ha^{-1}	19.84	56.51	50.20	44.80	30.78
T_{10}- Imazethapyr @ 40 g ha^{-1}	8.75	55.56	43.69	39.38	33.85

Table 4: Efficacy of different herbicides on yield attributing characters, WCE (%) and WI (%) (Pooled data of wo years).

Treatment	No of pods plant^{-1}	Seed pod^{-1}	Seed %	Seed yield (q ha^{-1})	Stover yield (qha^{-1})
T_1- Weedy check	38.42	1.49	11.02	10.83	16.75
T_2- Weed free	51.98	1.82	14.29	23.10	28.96
T_3- Pendimethalin @ 1 kg ha^{-1}	40.38	1.57	11.69	14.74	19.98
T_4- Oxyfluorfen @ 125 g ha^{-1}	40.03	1.56	11.35	14.29	19.68
T_5- Pendimethalin @ 1 kg ha^{-1} fb Quizalofop @ 60 g ha^{-1}	50.27	1.78	14.08	22.23	26.76
T_6- Oxyfluorfen @ 125 g ha^{-1} fb Quizalofop @ 60 g ha^{-1}	46.70	1.66	13.05	20.41	25.14
T_7- Pendimethalin @ 1 kg ha^{-1} fb Imazethapyr @ 40 g ha^{-1}	48.73	1.75	13.72	20.91	25.55
T_8- Oxyfluorfen @ 125 g ha^{-1} fb Imazethapyr @ 40 g ha^{-1}	43.04	1.62	12.24	16.37	22.45
T_9- Quizalofop @ 60 g ha^{-1}	42.27	1.61	12.03	15.99	21.67
T_{10}- Imazethapyr @ 40 g ha^{-1}	41.04	1.60	11.89	15.28	21.07
CD (5%)	4.28	NS	1.79	2.87	2.57

CONCLUSION

On the basis of two years of data it was concluded that weed management have profound effects on controlling weeds as well as enhancing the yield of chickpea. The study clearly indicated that sequential application of pendimethalin 1 kg/ha followed by quizalofop 60 g/ha was found effective in controlling weeds and realizing higher seed yield of chickpea.

Conflict of interest

All authors declared that there is no conflict of interest.

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