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Research Communication

Efficacy of various herbicides for weed management in irrigated chickpea (*Cicer arietinum*)

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ABSTRACT

Chickpea is a short-stature crop with slow initial growth and limited leaf area development due to which it is heavily infested with a wide spectrum of weeds. The menace of weeds has increased to such an extent that an effective weed management schedule has become a necessity. A research study was conducted during the *rabi* season of 2021–22 at the Agronomy Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar, Haryana. Thirteen weed control treatments *viz*., pre-plant incorporation (PPI) and pre-emergence (PRE) pendimethalin at 1,000 g/ha, PPI imazethapyr at 75 g/ha and 100 g/ha, PRE imazethapyr at 75 g/ha and 100 g/ha, post-emergence (PoE) imazethapyr at 75 g/ha and 100 g/ha, PPI and PRE pendimethalin + imazethapyr Ready mix (RM) at 1,000 g/h and two hand hoeings at 30 and 50 DAS were compared with weedy check and weed free in a randomized block design and replicated thrice. Among the herbicides, lowest weed dry weight was observed under PPI and PRE pendimethalin + imazethapyr (RM) at 1,000 g/ha respectively. PoE application of imazethapyr displayed phytotoxicity symptoms like stunting, leaf crinkling, and chlorosis as indicated by phytotoxicity scale ranging from 1-5. Significantly higher seed yield was obtained by pendimethalin + imazethapyr (1,827 kg/ha) over other combinations. Therefore, the PRE-application of pendimethalin + imazethapyr (RM) at 1,000 g/ha was the most suitable herbicide for efficient weed management in chickpea as it not only controlled the diverse weed flora but also improved seed yield.

Key words: Chickpea, Imazethapyr, Pendimethalin, Phytotoxicity, Weed control efficiency

Chickpea (*Cicer arietinum* L.) is a self-pollinating legume crop classified under the family Leguminosae. The average chickpea yield in India stands at around 11.9 million tons, grown over 8.8 million hectares with a national productivity rate of 1.11 tons/hectare (Anonymous, 2022). India holds the distinction of being both the lead producer and consumer of chickpea globally. Despite the cultivation of high-yielding varieties and the adoption of improved agronomic practices, chickpea productivity remains low. One contributing factor is the prevalence of weeds in chickpea fields. Chickpea exhibits slow growth and limited leaf area development in the early stages, making it a weak competitor against weeds. During the *rabi* season, broadleaf weeds are particularly detrimental to yield compared to grassy weeds (Baghel, 2018). The major weeds in chickpea are *Chenopodium album*, *Fumaria parviflora* and *Phalaris minor* and other minor weed species are *Convolvulus arvensis*, *Anagallis arvensis*, *Melilotus alba*, *Coronopus didymus* and *Spergula arvensis* (Khope *et al*., 2011). Hand weeding and mechanical weed control methods traditionally followed in developing countries like India are becoming expensive due to increased labour wages. The pre-emergence herbicides effectively control weeds at the early stage of seedling growth, but weeds germinating after crop emergence become dominant in the field and cause substantial yield losses. Gupta *et al*. (2017) reported that among the chemical herbicides, PRE application of pendimethalin 30% EC + imazethapyr 2% EC (RM) recorded the highest net monetary returns (₹20,208 /ha) and B:C ratio (2.0). Kumar and Sharma (2022) reported weed control efficiency of 76.2% under application of pendimethalin @ 1 kg/ha which proves that pendimethalin had a pronounced effect on weed density. In view of this, the present study was planned to study the effect of pendimethalin, imazethapyr, and its RM formulation at various doses and time of application to find out the best

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dose of herbicide for getting higher weed control efficiency and yield of irrigated chickpea.

The experiment was conducted at the Agronomy Research Farm, Chaudhary Charan Singh Haryana Agricultural University, Hisar, during the *rabi* season of 2021–22. Meteorological data for this season was consistently recorded at the CCSHAU Research Farm's meteorological observatory. The experimental site, situated at 29º 10′ N latitude and 75º 46′ E longitude in Haryana State, India, has an elevation of 215.2 m above mean sea level. Hisar experiences a semi-arid, sub-tropical climate with hot, dry summers and intense cold winters. The range of maximum and minimum temperature varied between 14.0–41.1 °C and 3.3–21.2 °C, respectively. The total rainfall received during the crop growing period was 72.9 mm. The mean weekly values for morning and evening relative humidity ranged between 68 to 99 and 17 to 79%, respectively. The bright sunshine during crop growth period ranged between 0.7 and 8.8 hours. Availability of favourable temperature and solar radiation proved conducive for growth and yield attributing characters and eventually to the higher yield. The total pan evaporation was 67.8 mm during 2021–22.

The soil in the experimental area is sandy loam, with organic carbon content of 0.5%, available nitrogen at 113 kg/ha, available phosphorus at 11.7 kg/ha, available potassium at 252 kg/ha, and a pH of 8.1. The experiment was laid out in a randomized block design with 13 treatments replicated thrice. The allocation of treatments in the field was random, with the chickpea variety HC-6 planted in plots measuring 5 m in length and 4.5 m in width. The treatments involved various herbicides and weed control measures. The details of treatments are as follows: T_1 (pendimethalin 30EC @ 1,000 g/ha applied as pre-plant incorporation), T_2 (imazethapyr 10EC @ 75 g/ha applied as pre-plant incorporation), T_3 (imazethapyr 10EC @ 100 g/ha applied as pre-plant incorporation), T_4 (pendimethalin 30EC + imazethapyr 2% EC (ready mix RM) @ 1,000 g/ha applied as pre-plant incorporation), T_5 (pendimethalin 30EC @ 1,000 g/ha applied as pre-emergence), T_6 (imazethapyr 10EC @ 75 g/ha applied as pre-emergence), T_7 (imazethapyr 10EC @100 g/ha applied as pre-emergence), T_8 (pendimethalin 30EC + imazethapyr 2EC (RM) @ 1,000 g/ha applied as pre-emergence), T_9 (imazethapyr 10EC @ 75 g/ha applied as post-emergence), T_{10} (imazethapyr 10EC @ 100 g/ha applied as post-emergence), T_{11} (two hand hoeing at 30 & 50 DAS), T_{12} (weed-free), and T_{13} (weedy check). The field was prepared with the help of a tractor-drawn cultivator to break up clods and residues from the previous crop were cleared. Cross harrowing and two additional cultivator passes were followed by planking, creating finely tilled soil for sowing. As part of field preparation, a standardized basal dose of fertilizers (20 kg/ha nitrogen and 40 kg/ha phosphorous through DAP) was applied. Following the planned layout, the crop was sown using the *pora* method on October 30, 2021. Herbicides were applied with a knapsack sprayer, ensuring sufficient soil moisture during application. The treatment plot (T_{12}) was kept weed-free through manual hand weeding throughout the crop growing period. Two hoeing at 30 and 50 days after sowing (DAS) in T_{11} were performed using a hand hoe, maintaining recommended spacing and a weed-free environment. The experimental area experienced no severe instances of insect pests or diseases, and the plant stand remained satisfactory, eliminating the need for additional plant protection measures. At full physiological maturity, the chickpea crop was harvested using a sickle, cutting close to the ground in each plot separately. The harvested produce was sun-dried in the respective plot until a constant weight was achieved. After drying, bundles of produce were formed for each plot, and their weights were recorded. Subsequently, the crop was hand-threshed, and the seed weight of each plot was measured in kg/plot and later calculated to kg/ha. The dry mass accumulation of weeds was documented at 60, 90, 120 DAS and at harvest. Weeds within a 0.25 m^2 quadrat were removed, and their roots were separated, air-dried, and subsequently oven-dried at 60°C for 48 hours and the dry weight was recorded. Phytotoxicity of herbicides was recorded at all crop growth stages. Phytotoxicity was graded in the scale of 1-5 (Punia *et al*., 2015). The weed control efficiency (WCE) was determined at 60, 90, 120 DAS and at harvest by assessing the decrease in weed dry matter production in treated plots relative to the weedy check as per the given formula (Patil and Patil, 1983).

$$\text{WCE (\%)} = \frac{\text{Weed dry matter in weedy check} - \text{Weed dry matter treated plot}}{\text{Weed dry matter in weedy check}} \times 100$$

The data exhibited significant variability in both weed count and weed dry weight. To attain the assumption of the analysis of variance, the data for weed count and weed dry weight underwent square root transformation using the formula $\sqrt{x} + 0.5$, as recommended by Chandel and Yadava (1984). The data collected on various weed parameters were statistically analysed with ANOVA using standard Randomised Block Design and post-hoc test for grain yield (Gomez and Gomez, 1984).

The experimental field was mainly dominated by dicot weeds (*Chenopodium album*, *Fumaria parviflora*, *Anagallis arvensis*). The other weeds infesting the crop comprised of *Convolvulus arvensis*, *Melilotus alba*, *Coronopus didymus*, *Spergula arvensis* and *Phalaris minor*. Among the different herbicides, imazethapyr showed phytotoxicity when applied as PoE @ 75 g/ha and 100 g/ha, respectively. The phytotoxicity was in the form of

Table 1. Effect of weed control treatments on WCE (%), dry weight of weeds (g/m^2) and phytotoxicity

Treatment	WCE (%)				Dry weight of weeds (g/m^2)				Phytotoxicity scale (1–5 scale)			
	60 DAS	90 DAS	120 DAS	Maturity	60 DAS	90 DAS	120 DAS	Maturity	60 DAS	90 DAS	120 DAS	Maturity
T_1	61.40	53.56	55.75	51.42	3.05 (8.30)	3.56 (11.69)	4.10 (15.78)	4.45 (18.78)	1	1	1	1
T_2	37.88	27.68	40.04	37.53	3.79 (13.36)	4.38 (18.20)	4.73 (21.39)	5.02 (24.16)	1	1	1	1
T_3	46.22	32.72	45.21	42.10	3.54 (11.56)	4.24 (16.93)	4.53 (19.54)	4.84 (22.39)	1	1	1	1
T_4	69.75	66.08	61.61	56.83	2.74 (6.50)	3.09 (8.54)	3.83 (13.69)	4.21 (16.69)	1	1	1	1
T_5	61.12	52.58	56.38	52.01	3.06 (8.36)	3.60 (11.93)	4.07 (15.56)	4.42 (18.56)	1	1	1	1
T_6	39.85	27.81	39.53	36.39	3.73 (12.93)	4.38 (18.17)	4.75 (21.57)	5.06 (24.60)	1	1	1	1
T_7	45.73	33.89	44.92	43.05	3.56 (11.67)	4.20 (16.64)	4.54 (19.64	4.80 (22.02)	1	1	1	1
T_8	70.31	64.77	61.68	56.90	2.71 (6.38)	3.14 (8.87)	3.83 (13.67)	4.20 (16.67)	1	1	1	1
T_9	52.09	36.86	49.82	46.53	3.35 (10.30)	4.11 (15.89)	4.35 (17.90)	4.66 (20.68)	2	4	4	3
T_{10}	53.18	38.15	51.53	47.43	3.33 (10.07)	4.07 (15.57)	4.28 (17.29)	4.62 (20.33)	2	4	4	3
T_{11}	90.85	86.36	80.28	76.81	1.72 (1.97)	2.10 (3.43)	2.83 (7.03)	3.16 (8.97)	1	1	1	1
T_{12}	100.00	100.00	100.00	100.00	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1	1	1	1
T_{13}	0.00	0.00	0.00	0.00	4.74 (21.50)	5.12 (25.17)	6.05 (35.67)	6.30 (38.67)	1	1	1	1
SEm±					0.05	0.04	0.04	0.03				
CD (P=0.05)					0.13	0.12	0.13	0.10				

*T_1, (pendimethalin 30 EC @ 1,000 g/ha applied as pre-plant incorporation), T_2, (imazethapyr 10 EC @ 75 g/ha applied as pre-plant incorporation), T_3, (imazethapyr 10 EC @ 100 g/ha applied as pre-plant incorporation); T_4, (pendimethalin 30 EC + imazethapyr 2% EC (ready mix RM) @ 1,000 g/ha applied as pre-plant incorporation); T_5, (pendimethalin 30 EC @ 1,000 g/ha applied as pre-emergence); T_6, (imazethapyr 10 EC @ 75 g/ha applied as pre-emergence); T_7, (imazethapyr 10 EC @ 100 g/ha applied as pre-emergence); T_8, (pendimethalin 30 EC + imazethapyr 2 EC (RM) @ 1,000 g/ha applied as pre-emergence); T_9, (imazethapyr 10 EC @ 75 g/ha applied as post-emergence); T_{10}, (imazethapyr 10 EC @ 100 g/ha applied as post-emergence), T_{11}, (2 hand hoeing at 30 and 50 DAS); T_{12}, (weed-free), and T_{13}, (weedy check)

#Phytotoxicity scale: 1, 0-20%; 2, 21–40%; 3, 41–60%; 4, 61–80%; 5, 81–100% phytotoxicity.

Figures in the parenthesis indicate mean of original values.

stunted growth, bushy plant, chlorosis, necrosis, and reduced leaf size of chickpea plants. As the crop growth advanced and approached maturity, the plants recovered but to a very little extent. Total weed dry weight at 60 DAS, 90 DAS, 120 DAS and at maturity is presented in Table 1. Amongst the herbicidal treatments, the total weed dry weight was the lowest under PPI and PRE application of pendimethalin + imazethapyr (RM) @ 1,000 g/ha and statistically at par with each other (Table 1). WCE was significantly affected by weed control treatments in chickpea. WCE of a treatment has strong negative correlation with weed biomass. Maximum weed control efficiency (%) at 60, 90, 120 DAS, and at maturity was recorded with two hoeing performed at 30 and 50 DAS (86.76, 90.85, 86.36, 80.28 and 76.81%, respectively). Among the herbicidal treatments, highest weed control efficiency was recorded at 60, 90, 120 DAS and at maturity with PRE application of pendimethalin + imazethapyr (RM) @ 1,000 g/ha 70.31, 64.77, 61.68 and 56.90%, respectively. Two hand hoeing at 30 and 50 DAS produced significantly lower dry matter as compared to different herbicide treatments and weedy check. This might be due to the reduced weed intensity of one or the other weeds in different weed control treatment. Unchecked growth of weeds in weedy check resulted in 55.2% reduction in seed yield, compared to weed free plots (Figure 1). Maximum seed yield (1,968 kg/ha) and higher value of yield attributes of chickpea were recorded with weed free treatment which were statistically at par with two hand hoeing performed at 30 and 50 DAS (1,940 kg/ha) and among herbicidal treatments, maximum seed yield was recorded with PRE application of pendimethalin + imazethapyr (RM) @ 1,000 g/ha (1,827 kg/ha) which was significantly higher over pendimethalin 30EC @ 1,000 g/ha applied as pre-emergence, imazethapyr 10EC @100 g/ha applied as pre-emergence, imazethapyr 10EC @ 75 g/ha applied as pre-emergence by 2.35, 19.27, and 27.59 %, respectively. Sahu *et al*. (2023) also reported hand weeding at 30 DAS led to lowest number of weeds with lesser weed biomass resulting in higher weed control efficiency (WCE).

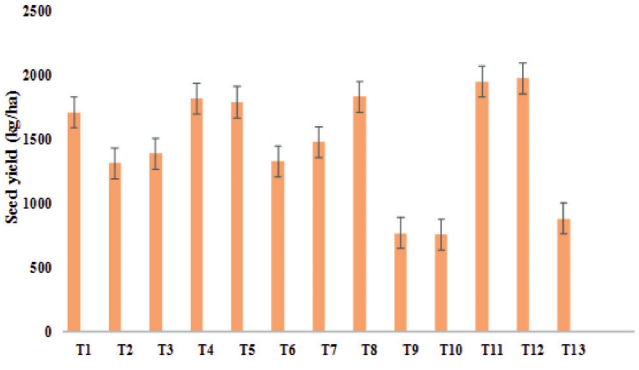

Fig. 1. Effect of weed control treatments on chickpea seed yield

From this study, this can conclude that PPI or PRE application of pendimethalin + imazethapyr (RM) @ 1,000 g/ha is the best option to control dicot weeds in chickpea followed by PRE application of pendimethalin @ 1,000 g ha^{-1}. Post emergence application of imazethapyr at a high dose (75 and 100 g/ha) should be completely avoided to reduce the phytotoxicity to a minimum. Ready mix is highly desirable as its PRE application not only controlled the weed flora but also recorded seed yield of 1,827 kg/ha.

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