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RESEARCH NOTE

Evaluation of dose and application time of topramezone for weed management in chickpea

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ABSTRACT

Application of a broad-spectrum post-emergence herbicide is a promising weed management option for chickpea (*Cicer arietinum* L.). So, the goal of this experiment was to find out how much and when to use topramezone to control weeds in chickpea. The experiment was designed in RBD of ten treatments, *viz.* two different doses of topramezone 20.6 and 25.7 g/ha were applied at 14, 21, and 28 days after sowing (DAS) and quizalofop-p-ethyl 100 g/ha at 25 DAS applied as post-emergence (PoE). The ready-mix of pendimethalin 30% + imazethapyr 2% 1000 g/ha applied as pre-emergence (PE) *fb* one HW at 30 DAS, weed free check, (WFC) and weedy check (WC). Among different application times of topramezone sprayed, early-PoE application (14 DAS) caused some phytotoxicity on crop (rating 4), and late-PoE application (28 DAS) was less effective on weeds, but the application of topramezone at 21 DAS controlled all broad and narrow leaf weeds without crop injury. In all the topramezone sprayed plots, topramezone 25.7 g/ha (21 DAS) had the lowest narrow and broad-leaf weeds density, and total weed dry weight than other doses and application times. Among all PoE herbicide treatments, topramezone 25.7 g/ha (21 DAS) yielded the highest seed yield (1.31 t/ha), while quizalofop-p-ethyl 100 g/ha (25 DAS) yielded the lowest (0.79 t/ha). It produced 7-65% higher seed yield as compared to other doses and time of application of all PoE applied herbicides. It gave 81% and 116% higher net return than topramezone 25.7 and 20.6 g/ha sprayed at 28 DAS (late-PoE), and 159% and 259% higher than topramezone 25.7 and 20.6 g/ha sprayed at 14 DAS (early-PoE), respectively. Hence, topramezone application of 25.7 g/ha (21 DAS) can be safely used for proper weed management in the chickpea crop.

Keywords: Chickpea, Chemical control, Early-PoE and Late-PoE, Imazethapyr, Phytotoxicity, Topramezone, Weed management

Chickpea is the major pulse crop in India. The cultivated area of chickpea in India has been constantly increasing though, the productivity has not substantially increased during this period (Samriti *et al.* 2020). It is a well-known fact that productivity of chickpea is affected by various biotic and abiotic factors. Poor weed management is one of the factors of the reduction in chickpea productivity (Rathod *et al*. 2017) and affects its productivity adversely. Chickpea is a poor weed competitor due to its slow initial growth rate, on the contrary, weeds grow fast and compete with crop for nutrients, space, and water (Chaudhary *et al.* 2005, Rao, 2000), hence, reduced chickpea yield up to 70–80%. The initial 30-60 days of the crop growth period are very important for crop weed competition in chickpea (Kumar and Singh 2010). Farmers generally manage weeds in chickpea by pre-emergence herbicides and/or hand weeding (Kumar *et al.* 2015), but due to scarcity and the higher cost of labour, manual weeding is difficult and less economic. Application of pre-emergence (PE) herbicides does not control the second flushes and many weeds. Post-emergence (PoE) herbicide like quizalofop-p-ethyl at 100 g/ha is recommended for narrow-leaf weeds, but dominated broad-leaf weeds caused crop yield loss (Nath *et al.* 2018). Therefore, weed control by herbicides is inevitable, and farmers need a broad-spectrum herbicide for effective weed management in chickpea. Topramezone is a new highly selective pyrazole-structured herbicide known to control broad-spectrum weeds in maize but their selectivity and efficacy not well established in chickpea. Topramezone treatment results in strong photo-bleaching symptoms on the shoots, followed by (*fb*) sensitive weed plant death. 4-HPPD activities are strongly inhibited by topramezone and targeted plant bleach after exposure to sunshine, and perish as a result. So, it requires studying the proper dose and time of application of topramezone in chickpea. If this herbicide found selective, it would be helpful for controlling all broad- and narrow-leaf weeds in chickpea. Taking all these things into consideration, the current experiment was done to find the best dose and time to apply topramezone to control weeds in chickpea.

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A field experiment was carried out at an agronomical research farm, TCA, Dholi, Muzaffarpur (Bihar) during *Rabi* (winter) season of 2020-21. It is situated in the mid Indo-Gangetic area and lies at 25° 99' North latitude, 85° 60'East longitude, and an altitude of 52.18 m above mean sea level. The soil in the field was sandy-loam with organic carbon (0.45%), available nitrogen (239 kg/ha), phosphorus (17.6 kg/ha), potassium (128 kg/ha), EC 1.13 dS/m, and pH 7.84. The experiment was designed in randomized block consisted of 10 treatments, *viz*. topramezone 20.6 g/ha at 14 days after sowing (DAS) (as early-PoE), 21 DAS (as PoE) and 28 DAS (late-PoE), topramezone 25.7 g/ha at 14 DAS (early-PoE), 21 DAS (PoE) and 28 DAS (late-PoE), and quizalofop-p-ethyl 100 g/ha at 25 DAS applied as post-emergence (PoE). The ready-mix pendimethalin 30% + imazethapyr 2% at 1000 g/ha was applied as pre-emergence (PE) *fb* one HW at 30 DAS, weed free check (two hand weeding at 30 and 50 DAS), (WFC) and weedy check (WC). The variety of chickpea was *GNG-2299* (*Awadh*)**.** At the time of field preparation, the entire recommended dose of N, P, K and Zn (20, 40, 20 and 25 kg/ha, respectively) was applied as a basal dose. Before sowing, seeds were treated with *Rhizobium* culture, phosphate solubilizing bacteria (PSB) culture (200 g/10 kg seed) and thiram (2.5 g/kg seed). The crop was sown on November 10th, 2020 at 30 × 10 cm spacing (R × P) and harvested on April 3rd, 2021. The calculated dose of herbicides, as per treatment, was mixed with water and sprayed over the plot by a knapsack sprayer. One day after sowing, PE herbicide ready-mix of pendimethalin 30% + imazethapyr 2% was sprayed, PoE herbicides were applied as per schedule, and two-hand weeding (HW) were done at 30 and 50 DAS. The only pod borer major pest was seen in field, which was kept in check by the spraying chlorpyrifos insecticide. Weeds were counted using a quadrate of 0.25 square meter (0.5 × 0.5 m), and data obtained were expressed as density (no./m^2) at 60 and 90 DAS. These weeds species were identified and divided in groups of sedges, narrow leaf weeds and broad leaf weeds. To record weed biomass, weeds within each square was trimmed close to the ground, washed with tap water, and after sun drying, the samples were placed in an oven at 70 °C until a constant weight was achieved. Subsequently, the dried samples were measured in grams (g) and the dry weight was converted to grams per square meter (g/m²). The grain yield was taken from each plot and expressed in kg/ha at 12% moisture content. Economic analysis was done as per the prevailing cost of inputs and selling price of output as per the concerning year. Visual scoring for phytotoxicity (*like*-chlorosis, burning, and death) was undertaken of PoE applied herbicides up to 15 days after application on a 0-10 scale for crop. For chickpea, 0 meant no phytotoxicity and 10 meant complete death of the plant, and a score of <3 was considered acceptable. For the statistical analysis weed density and biomass were converted to 1 m^2 and imposed square root transformation by using formula ($\sqrt{x+0.5}$) before analysis. The grain yield was taken by 1 m^2 area from the centre of each plot and expressed in kg/ha. Economic analysis was done as per the prevailing cost of inputs and selling price of output as per the concerning year. Statistical analysis was done by adopting appropriate method of Analysis of Variance (Gomez and Gomez 1984). For each species and category, weed density and dry weight necessitate square-root transformation. Treatment means were compared using a protected least significant difference test at p=0.05.

Effect on weeds

Narrow-leaf or grassy weeds (*Cynodon dactylon, Echinochloa colona,* and *Avena fatua*), broad-leaf weeds (*Cannabis sativa*, *Chenopodium album, Melilotus albus,* and *Anagallis arvensis*), and sedges (*Cyprus rotundus*) were the most common in the experimental field. All weed management practices reduced the total weed density and weed dry weight over the weedy check. The application of ready mix of pendimethalin 30% + imazethapyr 2% + single HW had the lowest total weed density and dry matter (**Table 1** and **2**), which was significantly lower than all herbicide treatments except topramezone 25.7 g/ha applied at 21 DAS. It is due to the ready-mix of pendimethalin 30% + imazethapyr 2% herbicide persist in the soil, suppressed germination of weeds, and at 30 DAS, weeds are removed manually, leading to the lowest weed density. Topramezone 25.7 g/ha (21 DAS) suppressed all narrow-leaf weeds (NLWs) and broad- leaf weeds (BLWs), and had lowest total weed density and weed dry matter than other topramezone applied treatments. It reduced total weed density and weed dry weight by 77-83% and by 78-81%, respectively as compared to weedy control treatment. It also recorded significantly lower weed dry weight than other doses and time of applications of topramezone. Similarly, Mahto *et al.* (2020) reported, 25.2 g/ha dose of topramezone recorded lowest weed density and weed dry weight as compared to other doses.

Species wise weed density and dry weight

With a relative density (RD) of 69%, the BLWs were the most common plants in the experimental research control plot. The narrow-leaf weeds (NLW) and sedges came in second and third, with RDs of 10% and 21%, respectively. Among all PoE applied herbicides, either dose or time of application did not affect the sedges The lowest NLW density recorded under quizalofop-p-ethyl treatment and it was significantly over by other PoE applied herbicides but at par with topramezone 21 DAS treatment. Topramezone 25.7 g/ha (21 DAS) had lowest NLW density than other topramezone treatments. It decreased NLWs density by 39-52% and 44-57% as compared to early and early-PoE applications of topramezone (14 and 28 DAS) at 60 to 90 DAS. respectively.

Effect on BLW weeds

All practices of weed management significantly reduced BLW density as compared to unweeded treatment except quizalofop-p-ethyl 100 g/ha sprayed at 25 DAS. Among different doses and time of applications of topramezone, 25.7 g/ha at 21 DAS reduced BLWs density by 59-66% and 60-69% at 60 and 90 DAS, respectively than other doses and application times.

Weed control efficiency and weed index

Application of ready-mix of pendimethalin 30% + imazethapyr 2% 1000 g/ha as PE + HW at 30 DAS significantly reduced the weeds growth and resulted in the highest WCE (89.6%) and the lowest value of weed index (4.3%). Topramezone 25.7 g/ha (21 DAS) recorded the highest WCE, both at 60 and 90 DAS (81.0 and 77.7%, respectively), lowest WI (17.3%) compared with other PoE applied herbicides (**Table 2**).

Herbicide phytotoxicity

Herbicide phytotoxicity observations were recorded at 1, 3, 5, 8, 11 and 15 days after herbicide spraying, chlorosis and necrosis like symptoms were observed on crop plants in early-PoE application (**Table 3**). Topramezone acts by inhibiting 4-hydroxy-phenyl-pyruvate dioxygenase (HPPD) enzyme and preventing carotenoid biosynthesis, which lead to photo-oxidation of chlorophyll molecules (Wang *et al*., 2018). Crop phytotoxicity of topramezone after herbicide application varied with dose and time of application. Spray of topramezone 25.7 g/ha at 14 and 21 DAS, both controlled weed properly but early-PoE (14 DAS) dose caused some phytotoxic effects on the crop (rating 3-4), as well as weeds also emerged at later stage, due to slow early growth of crop. When topramezone applied as late-PoE (28 DAS), it was unable to control weeds due to weeds at later stage becomes hardy in nature and topramezone not effective against weeds at this stage. So, topramezone 25.7 g/ha PoE (21 DAS) application was safe for crop and also controlled all narrow and broad-leaf weeds.

Yield and economics

The highest seed yield (kg/ha) was observed in two hand weeded treatment, which yielded 221% more, than the weedy check treatment, despite the weedy check decreased crop yield by 56%. Similarly, Yadav *et al.* (2019) reported weeds infestation reduced 69% chickpea yield. Among all herbicidal treatments, pre-emergence spray of ready mix of pendimethalin 30% + imazethapyr 2% 1000 g/ha + single hand weeding produced the highest seed yield (1504 kg/ha), which was significantly higher than other herbicidal treatments and recorded 209% more seed yield, also generated 4.95 times more net return, than the weedy check. Among PoE herbicide applications, highest seed yield was obtained from topramezone 25.7 g/ha (21 DAS) treatment, it produced 82% higher seed yield over weedy check

Table 1. Effect of herbicide application on weed density (no./m^2)

Treatment	Sedge		NLW		BLW		Total weed density	
	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS	60 DAS	90 DAS
Topramezone 20.6 g/ha at 14 DAS (early-PoE)	4.11(16.6)	2.95(8.2)	3.93(15.0)	3.73(13.5)	7.38(54.2)	6.81(46.1)	9.27(85.8)	8.25(67.8)
Topramezone 20.6 g/ha at 21 DAS (PoE)	3.88(14.6)	2.96(8.3)	3.35(10.8)	3.21(9.8)	5.36(28.3)	4.68(21.5)	7.36(53.7)	6.32(39.6)
Topramezone 20.6 g/ha at 28 DAS (late-PoE)	3.81(14.1)	2.75(7.1)	3.64(12.9)	3.49(11.8)	7.39(54.3)	6.73(45.0)	9.02(81.2)	8.01(63.9)
Topramezone 25.7 g/ha at 14 DAS (early-PoE)	4.15(16.9)	3.14(9.4)	4.10(16.3)	3.95(15.2)	8.03(64.1)	7.29(52.9)	9.88(97.3)	8.81(77.5)
Topramezone 25.7 g/ha at 21 DAS (PoE)	3.68(13.2)	3.01(8.6)	3.08(9.1)	2.64(6.5)	4.69(21.6)	4.09(16.3)	6.65(44.0)	5.65(31.4)
Topramezone 25.7 g/ha at 28 DAS (late-PoE)	3.96(15.3)	2.77(7.2)	3.53(12.0)	3.37(10.9)	7.25(52.4)	6.44(41.2)	8.95(79.7)	7.72(59.3)
Quizalofop-p-ethyl 100 g/ha at 25 DAS (PoE)	3.59(12.5)	3.31(10.5)	2.98(8.4)	2.94(8.2)	11.2(125.7)	10.2(103.3)	12.12(146.5)	11.0(122.0)
Ready mix of pendimethalin 30% + imazethapyr 2% 1000 g/ha (PE) + HW at 30 DAS	2.86(7.8)	1.90(3.1)	2.73(7.0)	2.12(4.0)	4.31(18.2)	3.46(11.5)	5.76(33.0)	4.36(18.6)
Two HW at 30 DAS and 50 DAS (WFC)	1.68(2.3)	1.38(1.4)	2.04(3.7)	2.00(3.5)	3.13(9.3)	2.98(8.4)	3.98(15.3)	3.71(13.3)
Weedy check (WC)	4.54(20.2)	3.92(14.9)	6.42(41.0)	5.72(32.4)	11.5(132.7)	10.7(114.8)	13.9(193.9)	12.7(162.1)
LSD (p=0.05)	0.68	0.22	0.61	0.48	0.89	0.86	0.93	1.01

DAS = Days after sowing, NLW = Narrow-leaved weed, BLW = Broad-leaf weed; Transformed value = $\sqrt{(x+0.5)}$). Original values are given in the parentheses

Table 2. Effect of herbicide application on total weed density, total weed dry weight, WCE and WI

Treatment	Total weed dry weight (g/m^2)		WCE (%)		WI (%)	Seed yield (kg/ha)	Net return (₹/ha)	BCR
	60 DAS	90 DAS	60 DAS	90 DAS				
Topramezone 20.6 g/ha at 14 DAS (early-PoE)	6.97$^{\#}$ (48.1)	16.7 (280)	54.7	42.5	44.0	886	12769	1.40
Topramezone 20.6 g/ha at 21 DAS (PoE)	5.17 (26.3)	11.8 (139)	75.3	71.4	22.8	1222	29573	1.93
Topramezone 20.6 g/ha at 28 DAS (late-PoE)	6.60 (43.1)	15.5 (239)	59.4	50.7	40.7	938	15322	1.48
Topramezone 25.7 g/ha at 14 DAS (early-PoE)	7.05 (49.2)	17.9 (321)	53.6	33.9	47.4	832	9219	1.28
Topramezone 25.7 g/ha at 21 DAS (PoE)	4.55 (20.2)	10.4 (108)	81.0	77.7	17.3	1308	33085	2.01
Topramezone 25.7 g/ha at 28 DAS (late-PoE)	6.23 (38.4)	13.8 (190)	64.0	60.9	36.0	1012	18282	1.56
Quizalofop-p-ethyl 100 g/ha at 25 DAS (PoE)	7.37 (53.8)	20.6 (423)	49.5	13.2	49.8	794	10461	1.35
Ready mix of pendimethalin 30% + imazethapyr 2% 1000 g/ha (PE) + HW at 30 DAS	3.40 (11.1)	8.1 (65)	89.6	86.7	4.3	1504	40670	2.17
Two HW at 30 DAS and 50 DAS (WFC)	1.54 (1.9)	5.2 (27)	98.2	94.5	0.0	1582	39204	1.98
Weedy check (WC)	10.35 (106.8)	22.1 (488)	0.0	0.0	54.7	717	8216	1.29
LSD (p=0.05)	0.36	0.71	-	-	-	287.19	14363.33	0.43

Transformed value = $\sqrt{(x+0.5)}$). Original values are given in the parentheses

Table 3. Effect of herbicides applications on crop phytotoxicity

Treatment	Phytotoxicity rating
Topramezone 20.6 g/ha at 14 DAS	3
Topramezone 20.6 g/ha at 21 DAS	2
Topramezone 20.6 g/ha at 28 DAS	1
Topramezone 25.7 g/ha at 14 DAS	4
Topramezone 25.7 g/ha at 21 DAS	3
Topramezone 25.7 g/ha at 28 DAS	2

treatment and also giving 7-57% higher seed yield as compared to other doses and time of application of topramezone treatments. It gave maximum net return than topramezone 20.6 and 25.7 g/ha early- late-PoE application (14 and 28 DAS). It was recorded the highest B: C ratio than all other PoE herbicidal treatments (**Table 2**). It could be due to higher uptake of plant nutrients and soil moisture in comparison to other plots, resulting in more photosynthates translocated from source to sink. Tiwari *et al.* (2018) reported in maize, higher dose of topramezone (25.2 g/ha) was found significantly superior over lower dose of topramezone (13.4 g/ha). Whereas, topramezone 20.6 and 25.7 g/ha (early-PoE) controlled weeds effectively but new weeds emerged at later stage due to slow initial growth of chickpea. However, other two doses of topramezone 25.7 and 20.6 g/ha (late-PoE) gave lower weed control efficiency, because at later stage weeds becomes hardy in nature and then tolerant to herbicide, and finally decreased crop yield.

Conclusion

Topramezone 25.7 g/ha (21 DAS) was best option for controlling all narrow- and broad-leaved weeds in chickpea as compared to other early and late post-emergence herbicdes applications. It recorded the highest WCE, lowest total weed density and weed dry matter, maximum seed yield than other topramezone treatments. Hence, it can be effectively utilized in future for its selectivity, and future research should conduct for its doses and application time optimization.

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