The Pharma Innovation Journal 2023; 12(9): 317-320

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(9): 317-320

www.thepharmajournal.com
Received: 23-06-2023
Accepted: 29-07-2023

Bio-efficacy of different POE herbicides for broad spectrum weed management in chickpea under rainfed conditions

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Abstract
The experiment was undertaken at Research Farm, Andro (Imphal), Central Agricultural University, Imphal (Manipur),India for two consecutive years (2018-19 and 2019-2020) comprising six herbicides *viz*. Topramezone 20.6 g ai/ha at 14 DAS, Topramezone 20.6 g ai/ha at 21 DAS , Topramezone 25.7 g ai/ha at 14 DAS , Topramezone 25.7 g ai/ha at 21 DAS , Quizalof- p- ethyl 100 g ai/ha at 21 DAS and Imazethapyr at 70 g a.i/ha at 21 DAS besides unweeded control (UWC) and weed-free check (WFC). When compared to the other herbicides, Topramezone 20.6 g ai/ha at 14 DAS or 21 DAS significantly controlled the predominant broad-leaved weeds. In comparison to UWC, topramezone decreased total weed density by 76-91% and 48-65% at 45 and 105 DAS, respectively. So, compared to other treatments, this herbicide showed a better weed control efficacy of 82.71. Compared to the recommended herbicide Imazethapyr, Topramezone enhanced chickpea seed yield by 24.6–51.7% at 25.7 g a.i/ha at 21 DAS. In comparison to the WFC, the UWC caused a 66.9% yield reduction in chickpea. Significantly, topramezone provided yield comparable to WFC. Therefore, topramezone can be used in chickpea without risk to control broad-leaved weeds and achieve higher yield.

Keywords: Crop, weed, herbicides, weed control efficiency, chickpea

Introduction

The chickpea (*Cicer arietinum* L.), one of the most significant pulse crops in the world, is grown on 14.6 million hectares and yields 14.8 million tonnes annually (Merga and Haji, 2019) [7]. Chickpeas are grown on 10.6 Mha in India and have an annual production of 11.2 Mt (Nath *et al*., 2018) [11]. As a valuable source of proteins and minerals for vegetarians, chickpeas are prized for their nutritional qualities. In agriculture diversification and intensification, pulse crops are also encouraged to assure long-term yield and reduce soil erosion. Due to its ability to conserve resources and its capacity for biological nitrogen fixation, chickpeas in particular are crucial to conservation agriculture systems. Despite having a larger yield potential, chickpea yields have stayed constant over the past few decades. (Nair *et al*. 2014) [9]. Therefore, research on chickpeas will significantly affect soil fertility, sustainable crop intensification, and nutritional security. One of the key issues preventing better chickpea output is infestations of weeds severely. (Nath *et al*. 2018) [11]. Due to its initial slow development and foliage cover, chickpea is in fact a poor weed competitor and can cause yield losses of up to 80% when weeds are present during the entire growing season. In chickpea, an average yield drop of 24-63% has been documented (Muhammad *et al*. 2011) [8]. The current suggested method for controlling chickpea weeds is to apply the PE herbicide pendimethalin 1000 g a.i./ha followed by hand weeding (Kumar *et al*. 2015) [6]. But, hand weeding is a laborious procedure due to lack of labour during a crutial time and rising cost. Sowing of the crop after one month, pre-emergence application of herbicide(pendimethalin) doesn't control the second weed flush (Singh *et al*. 2014) [13]. Because of this reason, POE herbicide application are crucial. It is crucial to investigate the selective ability of different post-emergence herbicides for their broad range of actions in chickpea in order to decrease yield loss and improve weed control effectiveness. Some POST herbicides, including topramezone and tembotrione for maize (*Zea mays* L.), clodinafop-propargyl in addition sodium-acifluorfen for soybean (*Glycine max* (L.) Merr.), and oxyfluorfen for sunflower (*Helianthus annuus* L.), are advised, but their effectiveness and the selectivity for chickpea are not widely recognized. Topramezone suppresses the production of carotenoid pigment by the hydroxylphenyl pyruvate dioxygenase enzyme. It is typically used to control broad- and narrow-leaved weeds and is selective to maize by quickly digesting the herbicide into inactive chemicals (Arslan *et al*., 2016) [1]. The information and data offered are useful for figuring out the herbicides' efficiency, site of action, and bio-efficacy as well as for guiding the prudent administration of herbicides in agriculture. Herbicide selectivity can actually be changed because it is influenced by dose, timing, stage, and crop (Susha *et al*., 2018) [14]. The current experiment was done to test the crop selectivity and chickpea seed yield in response to several post-emergence herbicides.

Materials and methods

The field trial was carried out at the Central Agricultural University's Research Farm (Andro), Imphal, India. A subtropical humid environment prevails in the study location. The soil in the experiment field is clayey loam. According to a chemical examination of the top 15 cm of soil, it had a pH of 5.4, was high in organic carbon, medium in available nitrogen, low in available phosphorus and high in available potassium. The experiment was conducted in randomized block design with three replications in winter season (November-mid April) for two consecutive years of 2018-19 and 2019-20. Treatments consisted of six different herbicides, T_1-Topramezone 20.6 g ai/ha at 14 DAS, T_2-Topramezone 20.6 g ai/ha at 21 DAS , T_3-Topramezone 25.7 g ai/ha at 14 DAS, T_4- Topramezone 25.7 g ai/ha at 21 DAS , T_5-Quizalof- p- ethyl 100 g ai/ha at 21 DAS and T_6-Imazethapyr at 70 g a.i/ha at 21 DAS along with T_7-weed-free check (WFC) and T_8-unweeded control (UWC). Each experimental plot had a size of 5 m x 3.6 m (18 m^2) in total. The crop was raised using standard tillage techniques, including planking after the first disc harrowing and two cultivator ploughings. On November 12, 2018 and November 18, 2019, chickpea cultivar GJG 0809 was sown at 30cm x 10 cm spacing with a seed rate of 80 kg/ha. A uniform fertilizer dose of 20 kg N, 40 kg P_2O_5 and K_2O kg/ha was applied at sowing. Crop received three irrigations as needed. At the flowering stage, one spray of chlorpyriphos was applied to manage pod borer infestation.

The data gathered for the experiment's various components were computed using the analysis of variance methods described by Gomez and Gomez (1984) [2]. The comparison of the treatment critical difference at a five percent probability level was worked out if the treatment differences were substantial. While NS was used to denote the non-significant.

Results and discussion

Weed density and the effectiveness of weed control treatments

Regarding the weed density, the treatment T_8 (Unweeded control) recorded the highest monocot and dicot weed count per m^2 at 45, 65, 105 DAS and harvest stage and the treatment T_6 (Weed free check (Manual + I/c) recorded the lowest (Table 1). At 45 DAS, highest monocot weed count per m^2 was found under T_7 which was on par with the treatment T_8, T_5, T_4, T_2 and T_3 in descending order, lowest under the treatment T_6 which was on par with T_1, for dicot weed count per m^2, highest was observed under unweeded control, followed by T_5 and T_8. However, lowest was observed under weed free check which was closely followed by treatment T_3 and T_1. At 65 DAS for the monocot and dicot weed count per m^2 highest was found under unweeded control followed by T_4 and T_8 and lowest under weed free check which was then followed by T_1 and T_3. And the trend follows the same at 105 DAS and harvest stage. Herbicide tropamezone showed prolonged and higher weed control action, that automatically results in lowering the weed density and it thus, results in reduction of emerging the later weed flush. Similar results were obtained by Nath *et al.* (2021) [12].

Weed dry matter accumulation

Data on weed dry matter accumulation are shown in Table 2, and it was discovered that at 45 DAS, the maximum weed dry matter accumulation was found under unweeded control, followed by T_8 and T_5, and the lowest weed dry matter accumulation was found under weed free check, which was comparable to T_1 and T_3 for the monocot weed dry matter accumulation. For the dicot weed dry matter accumulation highest was observed under T_7 followed by T_5 and T_8 and lowest under T_6 which was on par with T_2, T_3 and T_1. At 65 DAS for monocot weed dry matter accumulation highest under T_7 followed by T_8, T_2 and T_5 and lowest under T_6 followed by T_3 and T_1, for dicot weed dry matter accumulation highest under T_7 followed by T_8 and T_5 and lowest under T_6 followed by T_3 and T_1. The trend follows the same at 105 DAS and harvest stage. Lowest weed dry matter accumulation values were attained as a result of fewer weeds emerging during the growing season of the crop. Nath *et al.* (2021) [12] also achieved comparable outcomes.

Weed indices in chickpea

Data regarding weed control treatments on various weed indices *viz*., weed control efficiency, weed control index, weed index, weed persistence index, crop persistence index and herbicide efficiency index in chickpea have represented in the Table 3. From the data, the highest WCE are found under T_6 followed by T_1 and T_2 and lowest under T_8 followed by T_5. The trend follows the same for the weed control index. Regarding weed index highest was found under T_1 followed by T_2 and lowest under T_7 followed by T_8. For weed persistence index, highest was recorded under, T_8 followed by T_3 and lowest under T_5 followed by T_4. For crop resistance index highest was recorded under T_1 followed by T_5 and T_4 and lowest under T_8 and followed by T_3. For herbicide efficiency index highest was observed under T_1 followed by T_3 and lowest was observed under T_8 and followed by T_5. Herbicide tropamezone showed prolonged and higher weed control action, that automatically results in lowering the weed density and it thus, results in reduction of emerging the later weed flush. Similar results were obtained by Nath *et al.* (2021) [12].

Growth and yield components of chickpea

Data regarding growth and yield components *viz*., plant height (cm), No. of branches per plant, dry matter production (g/plant), No. of pods per plant, No. of seeds per pod and 100 seeds weight (g) have been presented in the Table 4 and found out that highest plant height was recorded under T_6 followed by T_7 and T_5 and lowest under T_8 followed by T_3 and T_2. The trend follows the same for the No. of branches per plant. For dry matter production (g/plant) highest was observed under T_6 which was followed by T_1 and T_2 and lowest under T_7 and T_8. Highest No. of pods per plant was recorded under T_6 followed by T_1 and T_2 and lowest under T_7 followed by T_8 and T_4.

Maximum No. of seeds per pod were observed under T_1 and followed by T_2 and T_3 and minimum was recorded under T_8 and followed by T_6 and T_7. Regarding 100 seed weight T_4 recorded the highest followed by T_6 and T_5 and lowest was recorded under T_8 followed by T_2 and T_1. Emerging of less weed during the period of the crop growth makes the crop to grow vigorously and compared to crops infested with weed plots. Similar results were obtained by Khope *et al.* (2011) [5].

Table 1: Effect of weed control treatments on weed density of chickpea (pooled mean)

Treatments	Weed count/m^2 at 45 DAS		Weed count/m^2 at 65 DAS		Weed count/m^2 at 105 DAS		Weed count/m^2 at harvest	
	Monocot	Dicot	Monocot	Dicot	Monocot	Dicot	Monocot	Dicot
T_1: Topramezone 20.6 g a.i./ha at 14 DAS	3.14	1.55	4.12	2.62	2.36	2.36	3.18	3.00
T_2: Topramezone 20.6 g a.i./ha at 21 DAS	5.34	0.98	5.01	3.52	3.24	3.24	3.15	3.43
T_3: Topramezone 25.7 g a.i./ha at 14 DAS	4.17	1.22	4.20	1.69	3.38	3.38	2.84	2.96
T_4: Topramezone 25.7 g a.i./ha at 21 DAS	5.99	2.75	6.19	3.68	3.48	3.48	3.69	3.97
T_5: Quizalof- p- Ethyl 100 g a.i./ha at 21 DAS	6.34	7.87	5.14	5.83	3.85	3.85	5.49	5.32
T_6: Weed free check (Manual + I/c)	0.71	0.71	0.71	0.71	0.71	0.71	0.71	0.71
T_7: Unweeded control	6.87	11.66	6.87	11.74	6.76	6.76	7.09	6.58
T_8: Imazethapyr at 70 g a.i/ha at 21 DAS	6.52	5.68	5.81	6.62	6.51	6.51	5.65	5.23
S. Em±	1.00	1.48	0.50	1.38	0.23	0.23	0.68	0.74
CD at 5%	2.92	4.34	1.47	4.04	0.68	0.68	1.99	2.16

(Figures in parentheses are original values)

Table 2: Effect of weed control treatments on weed dry matter accumulation of chickpea(pooled mean)

Treatments	Weed dry matter accumulation/m^2 at 45 DAS		Weed dry matter accumulation /m^2 at 65 DAS		Weed dry matter accumulation /m^2 at 105 DAS		Weed dry matter accumulation /m^2 at harvest	
	Monocot	Dicot	Monocot	Dicot	Monocot	Dicot	Monocot	Dicot
T_1: Topramezone 20.6 g ai/ha at 14 DAS	0.92(0.60)	0.74(0.30)	1.18(1.14)	0.95(0.65)	1.12(1.00)	1.33(1.52)	1.30(1.44)	1.44(1.82)
T_2: Topramezone 20.6 g ai/ha at 21 DAS	1.38(1.65)	0.71(0.00)	1.42(1.77)	1.09(0.94)	1.01(0.77)	1.40(1.71)	1.57(2.21)	1.41(1.74)
T_3: Topramezone 25.7 g ai/ha at 14 DAS	0.92(0.60)	0.71(0.00)	1.28(1.39)	0.87(0.51)	1.39(1.68)	1.47(1.91)	1.57(2.21)	1.45(1.85)
T_4: Topramezone 25.7 g ai/ha at 21 DAS	1.84(3.14)	1.11(0.98)	1.30(1.44)	1.08(0.92)	1.13(1.03)	1.33(1.52)	1.28(1.39)	1.84(3.14)
T_5: Quizalof- p- Ethyl 100 g ai/ha at 21 DAS	2.36(5.32)	1.94(3.51)	1.33(1.52)	1.51(2.03)	1.35(1.57)	1.42(1.77)	1.55(2.15)	2.19(4.55)
T_6: Weed free check (Manual + I/c)	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_7: Unweeded control	2.59(6.46)	3.07(9.17)	1.95(3.55)	2.54(6.20)	1.97(3.63)	2.77(7.42)	2.00(3.75)	3.65(13.07)
T_8: Imazethapyr at 70 g a.i/ha at 21 DAS	2.40(5.51)	1.84(3.14)	1.77(2.88)	1.85(3.17)	1.95(3.55)	2.80(7.59)	1.74(2.78)	3.56(12.42)
S. Em±	0.38	0.31	0.18	0.26	0.14	0.15	0.10	0.26
CD at 5%	1.11	0.92	0.54	0.76	0.40	0.44	0.29	0.76

(Figures in parentheses are original values)

Table 3: Effect of weed control treatments on various weed indices in chickpea

Treatments	Weed Control Efficiency	Weed Control Index	Weed Index	Weed Persistence Index	Crop Resistance Index	Herbicide Efficiency Index
T_1: Topramezone 20.6 g ai/ha at 14 DAS	82.71	82.5	4.45	0.93	4.57	12.17
T_2: Topramezone 20.6 g ai/ha at 21 DAS	78.92	78.1	9.05	1.28	3.79	9.21
T_3: Topramezone 25.7 g ai/ha at 14 DAS	77.20	75.0	10.69	1.40	3.90	9.39
T_4: Topramezone 25.7 g ai/ha at 21 DAS	72.60	71.50	38.70	0.94	4.55	6.92
T_5: Quizalof- p- Ethyl 100 g ai/ha at 21 DAS	59.65	59.0	36.95	0.71	2.85	2.89
T_6: Weed free check (Manual + I/c)	100.00	100.0	0.00	-	-	-
T_7: Unweeded control	0.00	0.00	66.78	-	1.00	-
T_8: Imazethapyr at 70 g a.i/ha at 21 DAS	9.56	9.90	54.03	1.98	0.93	0.51

Yield, harvest index and economics of chickpea

The data regarding yield, harvest index and economics of chickpea have been presented in the Table 5 and observed that for the seed yield and biological yield highest was observed under T_6 and followed by T_1 and T_2 and lowest under T_7 and followed by T_8 and T_4. For the HI highest values were observed under T_3 followed by T_2 and T_5 and lowest under T_6 followed by T_8 and T_4. For the cost of cultivation highest was recorded under T_3 and T_4, however lowest under T_7 and followed by T_8. Gross and net returns, highest was recorded under T_6 with the values Rs. 94945.0/ha and Rs. 50264.5/ha respectively and lowest under T_7 Rs. 31398.6/ha and Rs. 6381.8/ha respectively. For the B:C ratio T_1 (2.37) recorded the highest followed by T_6 (2.34) and T_2 (2.26) and lowest were observed under T_7 (0.93) followed by T_8 (1.25) and T_4 (1.48). Similar results were found by Nath *et al.* (2015) [10].

Table 4: Effect of weed control treatments on growth and yield components of chickpea

Treatments	Plant height (cm)	No. of branches / plant	TDM (g/plant)	No. of pods / plant	No. of Seeds/pod	100 seed wt (g)
T_1: Topramezone 20.6 g ai/ha at 14 DAS	34.30	5.90	9.16	20.35	1.42	19.05
T_2: Topramezone 20.6 g ai/ha at 21 DAS	33.20	5.25	7.97	18.05	1.33	19.03
T_3: Topramezone 25.7 g ai/ha at 14 DAS	31.70	4.30	7.43	18.00	1.31	19.75
T_4: Topramezone 25.7 g ai/ha at 21 DAS	33.70	4.45	5.92	13.35	1.27	22.27
T_5: Quizalof- p- Ethyl 100 g ai/ha at 21 DAS	35.45	4.65	5.80	14.20	1.23	21.11
T_6: Weed free check (Manual + I/c)	38.00	7.07	10.66	21.67	1.22	21.21
T_7: Unweeded control	35.85	3.70	4.05	7.25	1.24	19.50
T_8: Imazethapyr at 70 g a.i/ha at 21 DAS	30.50	3.70	4.84	9.95	1.20	18.60
S. Em±	1.43	0.31	0.52	1.03	0.06	1.24
CV (%)	8.40	12.75	14.91	13.39	9.28	12.35

Table 5: Effect of weed control treatments on yield, harvest index and economics of chickpea

Treatments	Seed yield (kg/ha)	Biological yield (kg/ha)	HI (%)	Cost of cultivation (Rs/ha)	Gross Returns (Rs/ha)	Net returns (Rs/ha)	B:C
T_1: Topramezone 20.6 g ai/ha at 14 DAS	1509.49	3049.28	49.63	38173.55	90569.3	50034.0	2.37
T_2: Topramezone 20.6 g ai/ha at 21 DAS	1438.89	2654.18	54.40	38173.55	86333.6	41752.3	2.26
T_3: Topramezone 25.7 g ai/ha at 14 DAS	1409.09	2474.02	57.03	39097.42	84545.4	43088.6	2.16
T_4: Topramezone 25.7 g ai/ha at 21 DAS	965.53	1969.86	48.88	39097.42	57932.0	28942.8	1.48
T_5: Quizalof- p- Ethyl 100 g ai/ha at 21 DAS	999.17	1932.40	52.87	38581.84	59950.0	25534.2	1.55
T_6: Weed free check (Manual + I/c)	1582.42	3548.28	44.87	40489.84	94945.0	50264.5	2.34
T_7: Unweeded control	523.31	1348.32	39.95	33769.84	31398.6	6381.8	0.93
T_8: Imazethapyr at 70 g a.i/ha at 21 DAS	727.61	1610.72	45.02	34959.84	43656.3	13439.1	1.25
S. Em±	84.75	173.17	3.93		5085.2	10765.5	0.13
CD at 5%	248.70	508.14	11.54		14921.8	31589.5	0.39
CV (%)	14.81	14.91	16.03		14.8	66.4	14.91

Conclusion

The results showed that both applications of 20.6 g of topramezone per hectare at 14 and 21 DAS resulted in higher weed control indices (82.5% and 78.1%), lower weed indices (4.45% and 9.05%), and lower weed persistence indices (0.9 and 1.28) but higher indices for crop resistance indices (4.57 and 3.79) and herbicide efficiency indices (HEI) (12.17 and 9.21). The highest benefit-cost ratios (2.37 and 2.26) were achieved with both of these treatments, which increased grain yield by 188.1 and 97.7 percent, respectively, above the unweeded control.

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