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Research Paper

Effect of post–emergence herbicides on growth and yield of chickpea (*Cicer arietinum* L.)

AM Deka[1]*, NJ Bhuyan[1], Narendra Kumar[2], B Borah[1], JR Hazarika[1] and HK Bora[1]

[1]*Assam Agricultural University-Zonal Research Station, Shillongani, Nagaon-782 002, Assam, India*
[2]*ICAR-Indian Institute of Pulses Research, Kanpur -208 024, Uttar Pradesh, India*

***Corresponding author e-mail:** anju.m.deka@aau.ac.in*

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ABSTRACT

In the present study, the effect of post-emergence (POE) herbicides was studied on growth and yield and for managing broad-spectrum weeds in chickpea. The lowest weed density (3.78 & 4.84/m^2 at 40 & 60 DAS, respectively) and weed dry weight (3.16 & 3.86 g/m^2 at 40 & 60 DAS, respectively), highest values of weed control efficiency (72.49% & 70.17% at 40 & 60 DAS, respectively), seed yield (1245 kg/ha), harvest index (36.27%), gross return (₹ 63,494/ha) and net return (₹ 36,495/ha) were observed in weed free check (control). However, among the herbicidal treatments, the lowest values of weed density (5.29& 6.23/m^2 at 40 & 60 DAS, respectively) and weed dry weight (4.77 & 5.42 g/m^2 at 40 & 60 DAS, respectively) were observed with the application of Topramezone @ 20.6 g a.i./ha at 21 DAS followed by Topramezone @ 25.7 g a.i/ha at 21 DAS and Topramezone @ 20.6 g a.i/ha at 14 DAS. Among the herbicides, the lowest weed index (4.99%), highest seed yield (1175 kg/ha) and B:C ratio (2.52) were also found with Topramezone @ 20.6 g ai/ha at 21 DAS followed by Topramezone @ 20.6 g ai/ha at 14 DAS and Imazethypr 75g a.i/ha at 14 DAS + HW at 40 days of crop.

***Key words*:** Chickpea, Yield, Herbicides, Economics, Weed index, Weed control efficiency, Yield attributes

INTRODUCTION

Chickpea (*Cicer arientinum* L.) is one of the most important *Rabi* pulse crops of India and occupies the first position among the pulses grown in Indian. India is the largest producer of chickpea, contributing about 65% of the world's chickpea production (Hedayetullah and Kumar 2023). It is cultivated in an area of 10.91 mha with production of 13.75 mt and productivity of 12.60 t/ha (Anonymous 2023). Among the different limiting factors of low yield of chickpea, the infestation of weeds is a very important and major one. Weed infestation at the early stages of the chickpea crop poses a considerable threat to achieving the desired grain yield. The extent of yield reduction due to weed infestation varies from 30-85% depending upon the duration, the type of weeds, intensity of weed growth, time of weed competition, season, soil type and rainfall (Malik *et al.* 2000). Weeds cause significant yield loss of up to 75% in chickpea if weeds are not controlled within the critical period of cropgrowth (Chaudhary *et al.* 2005, Bankoti *et al.* 2021, Hedayetullah and Kumar 2023). Apart from direct losses, weeds also remove a substantial quantity of nutrients and may serve as an alternative host for diseases, insectpests and nematodes.

Chickpea is a poor competitor with weeds due to slow initial growth rate, short stature plant and limited leaf area development, and coverage at early stages of crop growth and establishment. Weeds affect the growth, yield and quality of crop plants adversely and reduce soil fertility, compete with the crop plants for soil moisture, nutrients, space and sunlight. Therefore, one of the biggest challenges for growing chickpea is control of weeds at the critical period of crop-weed competition. Unlike cereals and oilseeds, legumes are generally not competitive with weeds and are highly susceptible to yield loss due to competition. Tremendous weed competition may adversely affect the flowering and fruiting, resulting in small-sized seeds and fewer pods/plant. Among the crop management practices, weed management is of key importance. The conventional methods of weed control, such as hoeing and hand weeding are labour-intensive and expensive. Manual weeding and hoeing are more effective in respect of reducing weed population and increasing chickpea yield than herbicide application (Kayan and Adak 2005).

But effective and economical weed management on a large scale in chickpea is not possible through manual operations and the use of mechanical means due to increasing labour costs, and also scarcity of labour at the proper time of weed control. Under such situations, the use of herbicides in chickpea is the best substitute and can be a viable, effective and economic method of weed control (Yadav *et al.* 2019). The available post-emergence herbicides can check the emergence and growth of weeds at the initial growth of the chickpea crop and can eliminate the early weed competition and prevent yield losses. Keeping these facts in view, the present experiment was planned to find out the effective weed management practice for chickpea.

MATERIALS AND METHODS

The experiment was conducted during *Rabi* 2019-20, 2020-21 and 2021-22 under irrigated condition to study the effect of different post emergence herbicide and their time of application to control weeds in chickpea at ZRS, Shillongani, Nagaon, Assam which is situated at a latitude of 26^0 N, longitude of $90^0 45^/$ E and at an altitude of 50.2 m above from the mean sea level. The climate of this region is sub-tropical with a hot, humid summer and a relatively dry and cold winter. The crop experienced favourable weather conditions in all three years. During the crop growth period, the total rainfall received was 336.70 mm, 395.8 mm, and 381.60 mm with rainy days of 34, 30 and 36 during 2018-19, 2019-20 and 2020-21, respectively. The mean maximum and minimum temperatures experienced were in the range of 31.70 to 23.20 °C and 20.17 to 9.87°C, respectively (means of three years). The weather variables during the crop season of 2018-19, 2019-20 and 2020-21 are presented in Figure 1. Eight treatments *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, Quizalofop P Ethyl 100 g ai/ha at 21 DAS, Unweeded control, Weed free check (Manual + I/c) and Imazethapyr 75g ai/ha at 14 DAS + HW at 40 days were evaluated in RBD with 4 replications. The plot size was 6m x 5m. The chickpea variety used was JG 14, and sowing was done in line with a spacing of 30 cm apart on15th November, 10th December, and 13th November during 2019-20, 2020-21, and 2021-22, respectively. The soil of the experimental field was sandy loam, having a pH of 5.6, organic carbon of 0.89%, EC 0.5-0.7 ds/m, available N 299.42 kg/ha, available P_2O_5 20.60 kg/ha, and available K_2O 175.76 kg/ha. The recommended dose of fertilizer, viz. 20 kg N, 40 kg P_2O_5, 15 kg K_2O per ha, was applied through urea, SSP, and MOP, respectively, as basal before sowing of seeds. Herbicides were applied as per treatments with a manually operated knapsack sprayer fitted with a flat-fan nozzle using 500 l water/ha.

There was no toxicity effect of herbicides on chickpea. The observation on weed density and weed dry weight was recorded at 40 DAS and 60 DAS using a quadrate of 1m× 1m size randomly in two places of each plot. Weed samples were being sun-dried for a day, followed by oven-drying at 65°C till a constant weight was achieved. The final dry weight was recorded and expressed in g/m². These data were statistically analyzed after being subjected to a square root transformation for uniformity. Economics of the treatments were computed on the average of three years' yield data. Cost of cultivation and gross return were calculated based on prevailing prices of inputs and outputs. The total monetary return was calculated using minimum support prices declared by the Government of India for the respective years.

Weed index (WI) and weed control efficiency (WEC) were calculated as suggested by Gill and Kumar (1969) and Mani *et al*. (1973), respectively, as given below:

$$\text{WCE (\%)} = \frac{\text{Weed count in unweeded plot} - \text{Weed count in treated plot}}{\text{Weed count in unweeded plot}} \times 100$$

$$\text{Weed index} = \frac{\text{Yield from weed free plot} - \text{yield from treated plot}}{\text{Yield from weed free plot}} \times 100$$

The experimental data of each character were tabulated and finally statistically analysed by using the online statistical program OPSTAT. The significance or non-significance of the variances due to treatment effects was tested by F-test. Comparisons of treatment mean values were performed using least significant difference (LSD, p=0.05).

RESULTS AND DISCUSSION

Weed flora

The experimental field was infested by a number of weed species. Monocot weeds viz. *Cynodon dactylon*, *Echinochloa colona*, *E. crusgalli*, *Setaria pumila*, *Elusine indica, Digitaria setigera* and

Digitaria sanguinalis; dicot weeds viz. *Amaranthus viridis*, *Ageratum conyzoides*, *Convolvulus arvensis*, *Chenopodium album*, *Physalis minima*, *Ceratopteris spp*, *Euphorbia hirta*, *Solanum nigram*, *Scoparia dulcis*, *Leucas aspera*, *Spilanthes acmella*, *Sesbania bispinosa*, *Parthenium hysterophorus*, *Alternanthera sessili* and *Vicia hirsuta* and sedges *viz*. *Cyperus rotundus* and *C. esculantus* were the predominant weed flora in the experimental field.

Effect on weed density and weed dry weight

Among all the weed control treatments, at 40 and 60 DAS of chickpea, significantly higher number of weeds [52.35/m^2 (7.21) & 79.15/m^2 (8.89), respectively] and weed dry weight [44.87g/m^2 (6.65)& 63.32 g/m^2 (7.89), respectively] were recorded by unweeded control (Table 1). However, the weed-free check recorded significantly lower numbers of weeds [14.85/m^2 (3.78) & 23.64/m^2 (4.84)] and weed dry weight [10.96 g/m^2 (3.16) & 15.09 g/m2 (3.86)] at 40 and 60 DAS, respectively. Lower weed density in the weed-free check might be due to the suppression of weeds by manual weeding and interculture operations, resulting in better soil aeration and soil structural manipulation. Similar results were also reported by Lhungdim *et al.* (2013). Among the herbicide treatments, Topramezone @ 20.6 g a.i./ha at 21 DAS recorded significantly lower number of weeds [28.21/m^2 (5.29)] and weed dry weight [23.36 g/m^2 (4.77)] at 40 DAS and it was followed byall other Topramezone treatments and Imazethypr @ 75g a.i./ha at 14 DAS + HW at 40 days. While at 60 DAS, among the herbicides applied, Imazethypr @ 75g a.i./ha at 14 DAS + hand weeding at 40 days recorded the lowest number of weeds and weed dry weight,and it was statistically at par with Topramezone 20.6 g ai/ha and Topramezone 25.7 g a.i./ha at 21 DAS (Table1). Similar results were reported by Khope *et al*. (2011) and Hedayetullah and Kumar (2023). This might be due to control and suppression of weeds to some extent in the plots of respective herbicidal treatments and thereby resulting in lower weed population.

Effect on weed control efficiency (WCE) and weed index (WI)

Weed control efficiency (WCE) and weed index (WI) (Table 1) were significantly affected by different weed control treatments (Table 2).Weed control efficiency (WCE) was found significantly higher (72.49% and 70.17%) in the weed-free check at both 40 and 60 DAS, respectively, as compared to others (Table 2). Among the herbicide treatments, at 40 DAS, POE application of Topramezone @ 20.6 g a.i/ha at 21 DAS recorded the highest WCE (46.29%), which was at par with all other Topramezone treatments and Imazethypr @ 75g a.i./ha at 14 DAS + HW at 40 days of crop. While at 60 DAS, the WCE was found to be highest (53.52%) in Imazethypr @ 75g a.i./ha at 14 DAS + HW at 40 days of crop, and it was at par with all other Topramezone treatments at both 14 and 21 DAS. Similar results were also observed by Hedayetullah and Kumar (2023).

In case of weed index or yield loss, among the herbicide treatments, the lower weed index (4.99%) was found in Topramezone @ 20.6 g a.i./ha at 21 DAS, followed by Topramezone @ 20.6 g a.i/ha at 14 DAS (6.33%) and Imazethypr @ 75g a.i./ha at 14 DAS + HW at 40 days compared to Quizalofop P-Ethyl 100 g a.i./ha at 21 DAS (Table 2). The highest weed index (29.10%) was recorded in the unweeded control.The highest value of the weed index under unweeded control was due to heavy infestation of weeds, resulting in a reduction of yield as compared to the application of post-emergence herbicides. These results conform with Singh *et al.* (2014), Chandrakar *et al.* (2015), and Yadav *et al.* (2019). The weed-free environment up to 40 DAS caused maximum reduction of weed dry matter because of the prolonged effect of manual hoeing on controlling the weeds, and was further aggravated by the shading effect of the crop. Similar findings were also reported by Hedayetullah and Kumar (2023), Chaudhari *et al.* (2016), and Manasa *et al.* (2022).

Effect on growth attributes

Different growth attributes, viz. plant height, primary and secondary branches per plant, were affected significantly under different weed control treatments (Table 3). Weed-free check recorded the highest values of growth attributes, while the unweeded control recorded the lowest value of the same. Among the herbicide treatments, the highest plant height was found under Topramezone @ 20.6 g a.i/ha at 21 DAS, followed by Imazethypr @ 75 g ai/ha at 14 DAS + HW at 40 days and Topramezone @ 20.6 g a.i/ha at 14 DAS. The primary branches per plant were found more in Topramezone@ 20.6 g ai/ha at 14 DAS, followed by Topramezone @ 20.6 g a.i/ha at 21 DAS and Imazethypr @ 75g ai/ha at 14 DAS + HW at 40 days. In case of secondary branches per plant, Imazethypr @ 75g ai/ha at 14 DAS + HW at 40 days recorded the highest secondary branches per plant, and it was at par with Topramezone @

Table 1. Effect of post -emergence herbicides on weed density and weed dry weight (Pooled of 3 years)

Treatments	Weed density (no/m²)		Weed dry weight (g/m²)	
	40 DAS	60 DAS	40 DAS	60 DAS
Topramezone 20.6 g ai/ha at 14 DAS	5.43 (29.87) *	6.44 (41.76) *	4.85 (24.27)	5.47 (30.06)
Topramezone 20.6 g ai/ha at 21 DAS	5.29 (28.21)	6.23 (39.10)	4.77 (23.36)	5.42 (29.47)
Topramezone 25.7 g ai/ha at 14 DAS	5.46 (30.11)	6.45 (41.93)	4.89 (24.58)	5.50 (30.43)
Topramezone 25.7 g ai/ha at 21 DAS	5.39 (29.28)	6.26 (39.39)	4.83 (24.02)	5.49 (30.29)
Quizalofop P Ethyl 100 g ai/ha at 21 DAS	5.79 (33.95)	6.93 (48.71)	5.14 (27.31)	5.75 (33.20)
Unweeded control	7.21 (52.35)	8.89 (79.15)	6.65 (44.87)	7.89 (63.32)
Weed free check (Manual + I/c)	3.78 (14.85)	4.84 (23.64)	3.16 (10.96)	3.86 (15.09)
Imazethapyr 75g ai/ha at 14 DAS + HW at 40 days	5.58 (31.51)	5.98 (36.52)	4.95 (25.30)	5.42 (29.41)
S. Em (±)	0.12	0.14	0.15	0.28
C.D. at 5%	0.36	0.44	0.43	0.82

Note: Data on weeds are subjected to square root transformation. Values within parentheses are original

Table 2. Effect of post -emergence herbicides on weed control efficiency (WCE) and weed index (Pooled of 3 years)

Treatments	WCE (%)		Weed index (WI)
	40 DAS	60 DAS	
Topramezone 20.6 g ai/ha at 14 DAS	43.06	47.39	6.33
Topramezone 20.6 g ai/ha at 21 DAS	46.29	50.64	4.99
Topramezone 25.7 g ai/ha at 14 DAS	42.99	47.10	9.30
Topramezone 25.7 g ai/ha at 21 DAS	44.28	50.29	8.34
Quizalofop P Ethyl 100 g ai/ha at 21 DAS	35.66	38.67	18.24
Unweeded control	0	0	29.10
Weed free check (Manual + I/c)	72.49	70.17	0
Imazethapyr 75g ai/ha at 14 DAS + HW at 40 days	39.96	53.52	7.92
SEm±	2.19	2.15	0.99
CD (p=0.05)	6.48	6.43	3.01

Table 3. Growth and yield parameters of chickpea as influenced by different weed control treatments (pooled of 3 years)

Treatments	Plant height (cm)	Primary branches / plant	Secondarybranches / plant	Pods / plant
Topramezone 20.6 g ai/ha at 14 DAS	62.11	3.25	17.50	38.68
Topramezone 20.6 g ai/ha at 21 DAS	63.70	3.20	18.25	40.75
Topramezone 25.7 g ai/ha at 14 DAS	60.68	2.98	15.00	35.60
Topramezone 25.7 g ai/ha at 21 DAS	61.53	3.00	15.75	37.27
Quizalofop P Ethyl 100 g ai/ha at 21 DAS	58.33	2.85	15.00	32.68
Unweeded control	54.89	2.60	14.25	26.57
Weed free check (Manual + I/c)	66.47	3.56	19.00	44.17
Imazethapyr 75g ai/ha at 14 DAS + HW at 40 days	63.62	3.15	18.50	40.83
SEm±	3.35	0.25	0.96	2.33
CD (p=0.05)	9.87	0.69	2.85	6.86

20.6 g a.i/ha at 21 DAS and Topramezone @ 20.6 g a.i/ha at 14 DAS. The better growth attributes with the application of herbicides might be attributed to the lower weed density and weed dry weight at the initial stage of crop growth.The result is supported by the findings of Singh *et al.* (2014) and Bankoti *et al.* (2021).

Effect on yield attributes

The different yield attributes were significantly influenced by the different weed control treatments, either sole or in an integrated manner (Table 4).The highest values of different yield attributes *viz.* pods/plant Total Dry Matter (TDM), pod weight/plant, seed weight/plant, and 100 seed weight, were found in the weed-free check, and the lowest values of the same were found in the unweeded control. However, among the herbicide treatments, pods/plant (40.83) and pod weight/plant (17.71g) were found to be highest under Imazethypr @ 75 g a.i/ha at 14 DAS + HW at 40 days, followed by Topramezone @ 20.6 g a.i/ha at 21 DAS and Topramezone @ 20.6 g a.i/ha at 14 DAS. While the higher values of TDM (23.12 g) and 100 seed weight (24.56 g) were observed under Topramezone @ 20.6 g a.i/ha at 21 DAS, followed by Topramezone @ 20.6 g a.i/ha at 14 DAS and Imazethypr @ 75g a.i./ha at 14 DAS + HW at 40 days. In case of seed weight/plant, the highest seed weight/plant (14.72 g) was noted in Topramezone @ 20.6 g a.i/ha at 21 DAS, followed by Imazethypr @ 75g a.i/ha at 14 DAS + HW at 40 DAS and Topramezone @ 20.6 g a.i/ha at 14 DAS. The higher yield attributes associated with post-emergence application of herbicides were mainly due to reduced weed density and weed dry matter accumulation and minimum crop-weed competition during the crop growth period. The minimum weed biomass and maximum weed control efficiency enabled the crop to better utilize essential nutrients, soil moisture, sunlight and space. The results are in agreement with Kaur *et al.* (2009), Singh *et al.* (2014), Chandrakar *et al.* (2015), Singh and Jain (2017) and Hedayetullah and Kumar (2023).

Effect on seed and stover yield

Unweeded control registered significantly lower seed yield (866 kg/ha) compared to all other weed control treatments. However, seed yield was found significantly higher with weed free check (1245 kg/ha) and it was statistically at par with application of Topramezone @ 20.6 g ai/ha at 21 DAS (1175 kg/ha) and Topramezone 20.6 g a.i/ha at 14 DAS (1161 kg/ha) as compared to all other treatments (Table 5). The higher seed yield with these treatments was associated with a reduction in weed infestation that enhanced translocation of photosynthates from source to sink, better weed control, decreased weed dynamics, as well as improved yield contributing characters.The same result was also reported by Khope *et al.* (2011). In case of harvest index, the weed-free check recorded significantly higher value (36.27%) followed by Topramezone @ 20.6 g ai/ha at 21 DAS (35.08%) and Topramezone @ 20.6 g a.i/ha at 14 DAS (34.91%) compared to all other weed control treatments. Similar results have also been reported by Goud *et al.* (2013) and Dubey *et al.* (2018a).

Effect on economics

Weed-freecheck recorded significantly higher gross returns (₹63495/ha) and net return (₹36,495/ha), followed by Topramezone 20.6 g ai/ha at 21 DAS and Topramezone 20.6 g a.i/ha at 14 DAS as compared to other weed control treatments (Table 6). However, the B:C was found significantly higher with Topramezone 20.6 g ai/ha at 21 DAS (2.42), followed by Topramezone 20.6 g a.i/ha at 14 DAS (2.39) and Imazethypr @ 75g a.i./ha at 14 DAS + HW at 40 days (2.35) compared to the rest of the treatments (Table 6). It was mainly due to the lower cost of cultivation, particularly in weed management, and the higher economic yield of chickpea associated with these treatments. Unweeded control was not economically viable with the best treatment. The B:C ratio of the unweeded control treatment was significantly lower than the best treatment,Topramezone 20.6 g ai. /ha at 14-21 DAS due to significantly lower seed yield.Similar results have also been reported by Rathod *et al.*

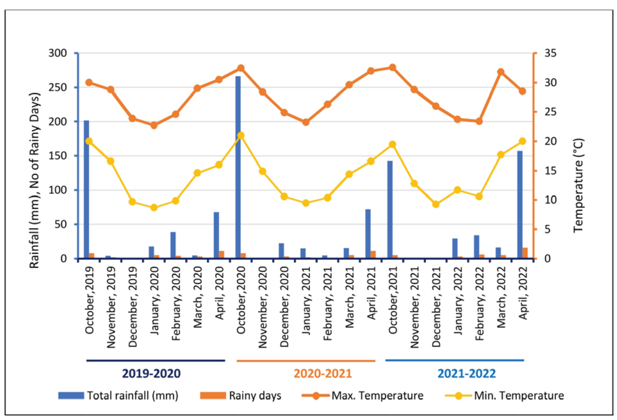

Fig. 1. Monthly weather parameters during crop season of 2019-20, 2020-21 and 2021-22

Table 4. Yield parameters of chickpea as influenced by different weed control treatments (pooled of 3 years)

Treatments	**Total Dry Matter** (g/plant)	Pod weight (g /plant)	Seed weight (g /plant)	100 seed wt. (g)
Topramezone 20.6 g ai/ha at 14 DAS	23.01	17.38	14.25	24.18
Topramezone 20.6 g ai/ha at 21 DAS	23.12	17.69	14.72	24.56
Topramezone 25.7 g ai/ha at 14 DAS	22.47	16.9	13.99	23.57
Topramezone 25.7 g ai/ha at 21 DAS	22.68	17.17	14.01	23.80
Quizalofop P Ethyl 100 g ai/ha at 21 DAS	21.96	16.17	13.19	23.16
Unweeded control	21.03	15.15	12.58	22.31
Weed free check (Manual + I/c)	23.85	18.73	15.52	24.68
Imazethapyr 75g ai/ha at 14 DAS + HW at 40 days	23	17.71	14.65	24.13
SEm±	0.5	0.80	0.75	0.48
CD (p=0.05)	1.47	2.37	2.16	1.41

Table 5. Yield of chickpea as influenced by different weed control treatments (pooled of 3 years)

Treatments	**Seed yield (kg/ha)**				**Stover yield (kg/ha)**	**HI (%)**
	2019-20	**2020-21**	**2021-22**	**Pooled**		
Topramezone 20.6 g ai/ha at 14 DAS	1130	1084	1238	1161	2164	34.91
Topramezone 20.6 g ai/ha at 21 DAS	1170	1105	1245	1175	2174	35.08
Topramezone 25.7 g ai/ha at 14 DAS	1070	1051	1185	1099	2166	33.66
Topramezone 25.7 g ai/ha at 21 DAS	1092	1063	1200	1119	2158	34.15
Quizalofop P Ethyl 100 g ai/ha at 21 DAS	1031	968	1030	999	2141	31.82
Unweeded control	965	850	883	866	2086	29.34
Weed free check (Manual + I/c)	1248	1160	1325	1245	2187	36.27
Imazethapyr 75g ai/ha at 14 DAS + HW at 40 days	1045	1045	1253	1149	2140	34.93
SEm±	27.81	27.11	31.65	26.08	40.85	0.48
CD (p=0.05)	81.79	79.73	92.09	77.24	NS	1.43

Table 6. Economics of chickpea as influenced by different weed control treatments (Pooled of 3 years)

Treatments	**Seed yield (kg/ha)**	**Gross Returns (Rs/ha)**	**Net returns (Rs/ha)**	**B:C**
Topramezone 20.6 g ai/ha at 14 DAS	1161	59211	34453	2.39
Topramezone 20.6 g ai/ha at 21 DAS	1175	59925	35167	2.42
Topramezone 25.7 g ai/ha at 14 DAS	1099	56049	30606	2.20
Topramezone 25.7 g ai/ha at 21 DAS	1119	57069	31626	2.24
Quizalofop P Ethyl 100 g ai/ha at 21 DAS	999	50949	26749	2.11
Unweeded control	866	44166	24166	2.21
Weed free check (Manual + I/c)	1245	63495	36495	2.35
Imazethapyr 75g ai/ha at 14 DAS + HW at 40 days	1149	58599	33059	2.29
SEm±	26.08	1501	1038	0.04
CD (p=0.05)	77.24	4425	3073	0.12

(2017), Dubey *et al.* (2018b) and Sethi *et al.* (2021), Jain LK and Parewa HP (2022), Hedayetullah and Kumar (2023).

CONCLUSION

From the study, it can be concluded that application of post-emergence herbicide Topramezone @ 20.6 g a.i./ha at 14-21 DAS was more effective in controlling weeds at initial growth stages of chickpea, along with higher seed yield and B:C ratio compared to other herbicides.

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