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Effect of post emergence herbicides on yield & economics in chickpea (*Cicer arietinum* L.)

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Abstract
At the Agricultural Research Station in Badnapur, an agronomic investigation was carried out to determine the economics of weed control and the effects of several post-emergence herbicides on crop development and yield in chickpea. The gross and net plot sizes of the experimental unit were 4.5 m × 5.0 m and 3.6 m x 4.8 m, respectively. The sowing process was completed on October 19, 2020, using the dibbling technique, which uses 45 cm x 10 cm spacing. Irrigation, fertilizer management, pest control, and seed treatment were implemented for every treatment in accordance with the guidelines. In the field investigation, nine treatments were used, including randomized block design (RBD) and post-emergence herbicides. Treatment comprised of (T_1) Topramezone 20.6 g a.i./ha at 14 DAS, (T_2) Topramezone 20.6 g a.i./ha at 21 DAS, (T_3) Topramezone 25.7 g a.i./ha at 14 DAS, (T_4) Topramezone 25.7g a.i./ha at 21 DAS, (T_5) Quizalofop-p-ethyl 100 g a.i./ha 25 DAS, (T_6) Unweeded control, (T_7) Weed free check (Manual weed control/ Recommended practice), (T_8) Pendimethalin @ 0.75 kg a.i./ha (PE), (T_9) Fluazifop-p-butyl @ 1.0 kg a.i./ha 30 DAS. The results specified that, height of the plant, number of branches plant^{-1}, number of pods plant^{-1}, pod yield plant^{-1}(g), seed yield plant^{-1} (g), seed index, seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), biological yield (kg ha^{-1}), harvest index, gross monetary returns (Rs ha^{-1}), net monetary returns (Rs ha^{-1}) and benefit: cost ratio was found highest in (T_7) weed free check (Manual weed control/ Recommended practice) followed by (T_5) Quizalofop-p-ethyl 100 g a.i./ha 25 DAS.

Keywords: chickpea, topramezone, post emergence, herbicide, weed

Introduction

Around the world, chickpeas are a significant pulse crop that are mostly farmed and consumed in Afro-Asian nations. One member of the Fabaceae family of legumes is the chickpea (Cicer arietinum L.). It is grown in both irrigated and conserved soil moisture environments. It is utilized as animal feed as well as for human use. Uses: Vegetable made from fresh green leaves. It is rich in essential vitamins, including thiamine, folate, riboflavin, niacin, and the precursor vitamin A, β-carotene. Chickpeas have the ability to fix nitrogen, which makes them essential for boosting soil fertility. Chickpeas can replenish up to 140 kg N ha during their growing phase (Poonia and Pithia, 2013) [12]. After pigeon pea, chickpeas are the second most widely used pulse crop worldwide for human food and other purposes. With an average output of 967.6 kg ha and a total production of 13.10 tons, this is grown on an area of 13.45 million ha. (Anonymous, 2017) [1]. With 9.93 million hectares of cultivation, 9.53 million tons of output, with an average yield of 960 kg ha-1, it is the most productive crop in India. The states that produce the most chickpeas, sharing over 95% of their total area, are Madhya Pradesh, Uttar Pradesh, Maharashtra, Gujrat, Andhra Pradesh, and Karnataka. On 10.59 lakh hectares in Marathwada, chickpea was grown, yielding 7.96 lakh tons and 707.56 kg/ha of productivity (Sontakke *et al*., 2020) [10]. Weed infestation is one of the main obstacles to chickpea production. Due to their competition for space, water, and nutrients with crop plants, weeds significantly reduce agricultural yields. Therefore, if weeds are not thoroughly and promptly removed, one of the main obstacles to achieving a high grain yield of enhanced crop varieties is their presence. Due to their slow growth rate and restricted leaf development in the early stages of crop growth and establishment, chickpeas are poor competitors with weeds; if weed management is ignored in these circumstances, production loss can range from 40 to 87% (Ratnam *et al*., 2011) [8]. There aren't many options for applying post-emergence herbicides to suppress weeds because chickpeas are known to be sensitive to a lot of herbicides.

Materials and Methods

During the 2020–21 Rabi season, the experiment was conducted at the Research Farm, Agricultural Research Station, Badnapur, Dist. Jalna. With a kharif cropping pattern and an average annual precipitation of 650 mm spread over 46 rainy days, primarily from June to September, Badnapur is categorized as a guaranteed rainfall zone. Light, erratic showers often fall throughout the winter. Most of the rainy season occurs during the monsoon season in the southwest. The topography of the experimental plot was level, and the soil had a medium black color, was clayey, reasonably deep, and had good drainage. Prior to setting up the experiment, a random soil sample from 10 places ranging in depth from 0 to 30 cm was taken. A composite sample was then made and examined to evaluate a number of physio-chemical parameters. The experimental plot's soil was found to have a clayey texture, low levels of organic carbon (0.68%), poor levels of nitrogen (155 kg ha^{-1}), medium levels of available phosphorus (14 kg ha-1), high levels of potash (641 kg ha^{-1}), and slightly alkaline (pH 7.4) in reaction, according to mechanical analysis of the soil conducted using the international pipette method (Piper, 1996) [6]; available potassium by flame emission method (Jackson, 1967) [4]; available phosphorus by Olsen method (Jackson, 1967) [4]; available potassium by flame emission method (Piper, 1996) [6]; and pH by electrode pH meter. The seeds were sown by dibbling, with one or two per hill, at a distance of 45 cm by 10 cm and a depth of roughly 4.0 cm. Gap filling was done ten days after sowing. First, at 30-35 and 60-35 DAS, two-hand weeding; for weed-free treatment, hoeing at 20-25 DAS. Just prior to sowing, all treatments received an equal application of the full dose of 25 kg N ha^{-1} in the form of urea and 50 kg P_2O_5 ha^{-1} in the form of single super phosphate and K_2O in MOP. The field experiment was laid out in randomized block design with three replications and nine treatments *viz*., (T_1) Topramezone 20.6 g a.i/ha at 14 DAS, (T_2) Topramezone 20.6 g a.i/ha at 21 DAS, (T_3) Topramezone 25.7 g a.i/ha at 14 DAS, (T_4) Topramezone 25.7 g a.i/ha at 21 DAS, (T_5) Quizalofop-p-ethyl 100 g a.i/ha 25 DAS, (T_6) Unweeded control, (T_7) Weed free check (Manual weed control/Recommended practice), (T_8) Pendimethalin @ 0.75 kg a.i/ha (PE), (T_9) Fluazifop-p-butyl @ 1.0 kg a.i/ ha 30 DAS. Periodic biometric observations were recorded at 30 DAS on these labelled plants. These plants were separately harvested at maturity for assessing their yield and yield attributes. Prior to harvest, the final plant stand from every net plot was measured and the emergence count was conducted on day twenty-seven. In order to calculate the average height of plant-1 and count the number of branches that emerge from the main shoot on specific plants, the height of each plant was measured from the base of the stem to the tip of the main shoot of the sampling plants. The findings were noted at harvest as well as at 30, 60, and 90 DAS. From day 75 onward, the number of pods per plant was counted, with a 15-day interval till harvest. At harvest, the first pod yield $plant^{-1}$ was measured from each of the five chosen plants in each net plot. Five observation plants had their pods threshed, and the mean seed yield $plant^{-1}$ was computed. From each net plot-1, 100 grains were randomly selected, and their weights were noted. Each net plot's plants were gathered and threshed, and the seeds were cleaned by winnowing before the yield of seed net plot-1 was calculated in kilograms. The difference between the weight of all the products and the grain weight net $plot^{-1}$ was used to compute the straw yield net $plot^{-1}$ on a hectare basis. The following formula was used to record the biological yield in kilograms. Biological yield = Grain yield + Straw yield Harvest index was calculated by using following formula.

$$\text{H.I (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

The gross monetary returns (₹ ha^{-1}) recorded due to different treatments in the present study, was worked out by considering market prices of economic product, by product and crop residues during the experimental year. The net monetary returns (₹ ha^{-1}) of each treatment were worked out by deducting the mean cost of cultivation (₹ ha^{-1}) of each treatment from the gross monetary returns (₹ ha^{-1}) gained from the respective treatments. The cost of cultivation (₹ ha^{-1}) of each treatment was worked out by considering the price of inputs, charges of cultivation, labour and other charges The B:C ratio of each treatment was calculated and analyzed by analysis of variance method. Based on error variance, the treatment's standard errors were computed. Critical differences (CD at P=0.05) for the comparison of treatment means were also computed whenever the results were deemed significant.

Results and Discussion

Plant height

The difference in plant height among the treatments were statistically significant at all growth stages of the crop. At harvest, the significantly higher plant height was observed in the treatment of weed free check (T_7) (39 cm) but it was found at par with treatment Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (36.13cm). Significantly the lowest plant height was observed in unweeded control (T_6) (27.56 cm). Similar trend was observed at harvest. Similar results were also reported by Kour *et al*. (2014) [5], Rathod *et al*. (2017) [7].

Number of branches $plant^{-1}$

The difference in number of branches per plant among the treatments were statistically significant at all growth stages of the crop. At harvest, the significantly higher number of branches were observed in the treatment of weed free check (T_7) (7.00) and which was at par with treatment Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (6.82). Significantly the lowest number of branches were observed in unweeded control (T_6) (5.81). Bhutada and Bhale (2013) [2] also reported the similar results.

Table 1: Effect of broad spectrum weed management practices on growth and yield of chickpea

Treatments	Plant height (cm)	Branches plant^{-1}	Pods Plant^{-1}	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1: Topramezone 20.6 g a.i/ha at 14 DAS	32.03	6.30	28.13	1391	2617	4008	35.42
T_2: Topramezone 20.6 g a.i/ha at 21 DAS	33.70	6.40	30.00	1505	2777	4283	34.24
T_3: Topramezone 25.7 g a.i/ha at 14 DAS	34.56	6.41	32.66	1525	2778	4303	35.81
T_4: Topramezone 25.7 g a.i/ha at 21 DAS	35.33	6.50	33.40	1574	2872	4446	35.73
T_5: Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS	36.13	6.82	36.36	1632	2946	4491	36.07
T_6: Unweeded control	27.56	5.81	27.20	911	2025	2936	32.36
T_7: Weed free	39.00	7.00	37.86	1788	3128	4916	36.67
T_8: Pendimethalin @0.75 kg a.i/ha (PE)	31.76	6.03	27.80	1252	2427	3680	34.60
T_9: Fluazifop-p-butyl @1.0 kg a.i/ha at 30 DAS	35.01	6.20	28.33	1471	2732	4203	35.06
S.Em ±	1.50	0.21	2.12	98.07	95.73	182.62	0.65
C.D at 5%	4.53	0.65	6.39	295.23	288.17	258.26	1.97
GM	33.90	6.4	31.08	1420	2700	4159	35.22

Mean number of pods plant^{-1}

At harvest, maximum mean number of pods were observed in treatment weed free check (T_7) (37.86). Whereas, it was at par with treatment Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (36.36), Significantly lowest mean number of pods were observed in unweeded control (T_6) (27.20).

Seed yield plant^{-1}(g)

The mean seed yield per hectare was 1420 kg ha^{-1}. Highest seed yield (1788 kg ha^{-1}) was recorded in weed free check treatment (T_7) which was at par with Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (1632 kg ha^{-1}) followed by Topramezone 25.7 g a.i/ha at 21 DAS (T_4) (1574kg ha^{-1}). Significantly lowest seed yield (911 kg ha^{-1}) was recorded in (T_6) *i.e*., unweeded control. The results are in accordance with the finding of Nandan *et al*. (2011) [5].

Straw yield (kg ha^{-1})

The mean straw yield per hectare was 2700 kg ha^{-1}. Highest straw yield (3128 kg ha^{-1}) was recorded in weed free check treatment (T_7) which was at par with Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (2946 kg ha^{-1}) followed by Topramezone 25.7 g a.i/ha at 21 DAS (T_4) (2872 kg ha^{-1}). Significantly lowest straw yield (2025 kg ha^{-1}) was recorded in (T_6) *i.e*., unweeded control. These conclusions are parallel with Poonia and Pithia (2013) [12] and Singh *et al*. (2014) [9].

Biological yield (kg ha^{-1})

The mean biological yield per hectare was 4159 kg ha^{-1}. Highest biological yield (4916 kg ha^{-1}) was recorded in weed free check treatment (T_7) which was at par with Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (4491kg ha^{-1}) followed by Topramezone 25.7 g a.i/ha at 21 DAS (T_4) (4446 kg ha^{-1}). Significantly lowest biological yield (2936 kg ha^{-1}) was recorded in (T_6) *i.e*., unweeded control.

Harvest index (HI)

Highest harvest index (36.67%) was recorded in weed free check (T_7) which was at par with Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (36.07%) followed by Topramezone 25.7 g a.i/ha at 21 DAS (T_4) (35.73%) While the lowest harvest index (32.36%) was recorded in (T_6) unweeded control. Such results are consistent with Chaudhary *et al*. (2005) [13] findings.

Gross monetary returns (Rs ha^{-1})

Maximum Gross Monetary Returns (GMR) were obtained under the weed free check (T_7) (88952 Rs ha^{-1}) which was significantly more over unweeded control (T_6) (45753 Rs ha^{-1}), followed by treatments Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (81332 Rs ha^{-1}). Dubey *et al*. (2018) [14] was reported similar results.

Net monetary returns (Rs ha^{-1})

Maximum net monetary returns (NMR) were obtained under the weed free check (T_7) (60490 ₹ ha^{-1}) was significantly superior over unweeded control (T_6) (20406 ₹ ha^{-1}), followed by treatments Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS(T_5) (54887 ₹ ha^{-1}), Topramezone 25.7 g a.i/ha at 21 DAS (T_4) (48879 ₹ ha^{-1}. The lowest net monetary returns recorded in unweeded control (T_6) (17475 ₹ ha^{-1}).

Table 2: Effect of weed management practices on economics

Treatments	Cost of Cultivation (Rs ha^{-1})			Gross Monetary Return (₹ ha-^{1})	Net Monetary Return (₹ ha-^{1})	Benefit cost ratio
	Fixed cost (₹ ha^{-1})	Variable cost (₹ ha^{-1})	Total cost (₹ ha^{-1})			
T_1: Topramezone 20.6 g a.i/ha at 14 DAS	25345	4062	29407	69385	39984	2.35
T_2: Topramezone 20.6 g a.i/ha at 21 DAS	25345	4062	29407	75017	45616	2.55
T_3: Topramezone 25.7 g a.i/ha at 14 DAS	25345	4200	29545	75978	46433	2.57
T_4: Topramezone 25.7 g a.i/ha at 21 DAS	25345	4200	29545	78424	48879	2.65
T_5: Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS	25345	1100	26445	81332	54887	3.07
T_6: Unweeded control	25345	0	25345	45753	20406	2.23
T_7: Weed free check	25345	3120	28462	88952	60490	3.12
T_8: Pendimethalin @0.75 kg a.i/ha (PE)	25345	1375	26720	73340	35001	2.74
T_9: Fluazifop-p-butyl @1.0 kg a.i/ha at 30 DAS	25345	2250	27592	62593	46620	2.26

Benefit: Cost ratio

The B:C ratio was significantly higher in treatment weed free check (T_7) (3.12), Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS(T_5) (3.07), Topramezone 25.7 g a.i/ha at 21 DAS (T_4) (2.65), Topramezone 25.7 g a.i/ha at 14 DAS (T_3) (2.57) and significantly lower B:C ratio unweeded control was recorded in (T_6) (2.23) plot, respectively. The similar results were also reported. Maximum gross return, net profit and benefit: cost ratio was obtained under weed free check (T_7). The higher B:C ratio may be attributed due to higher seed yields in combination with lower chemical treatment cost.

Conclusion

An agronomic investigation was carried out to study the effect of post emergence herbicides on weeds in chickpea which included weed index, weed count and counting weed control efficiency. Based on the results of experimentation, some of the important findings emerging from this investigation are summarized below.

1. Highest weed index recorded in unweeded control(T_6) (49.04%) while lowest recorded in Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) (13.64%), followed by treatments receiving post emergence application of Topramezone 25.7 g a.i/ha at 21 DAS (T_4) (13.69%), Topramezone 25.7 g a.i/ha at 14 DAS (T_3) (14.70).
2. Weed free check (T_7) recorded lowest number of weeds per m^2 (0.00) and dry matter of weed per m^2 (0.00) whereas highest number of weeds per m^2 (25.66) and dry matter of weed per m^2 (24.66) was observed by unweeded control treatment (T_6) respectively.
3. Highest weed control efficiency (79.72%) was recorded in weed Quizalofop-p-ethyl 100 g a.i/ha at 25 DAS (T_5) at 35 DAS and lowest (35.28%) was observed in treatment Fluazifop-p-butyl @1.0 kg a.i/ ha 30DAS (T_9). Then, treatment (T_4) and (T_6) also recorded lowest and highest weed index respectively.

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