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RESEARCH ARTICLE

Effect of herbicides on weeds, yield and economics of chickpea

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ABSTRACT

A filed experiment was conducted at Mahatma Gandhi Chitrakoot Gramodaya Vishwavidyalaya, Chitrakoot, Satna, Madhya Pradesh during winter (*Rabi*) season of 2019-20 and 2020-21 to assess the efficacy of herbicides on production and profitability of chickpea (*Cicer arietinum* L.). The experiment was laid out in a randomized block design with ten treatments and three replications. The crop was sown as per the package of practices recommended for zone Kymore Plateau of Madhya Pradesh. The major monocot weed was *Cynodon dactylon* and dominant dicot weed was *Chenopodium album* at 30 days after sowing (DAS). At 30 DAS, significantly lower weed density (7.75/m^2) and biomass (2.70 g/m^2) were recorded with post-emergence application (PoE) of fomesafen (11.1% W/W) 220 g + fluazifop-p-butyl (11.1% W/W) 220 g/ha PoE at 20 DAS, followed by imazethapyr (35%) + imazamox (35%) 100 g/ha PoE at 20 DAS. The lowest weed index was noted with imazethapyr 55 g/ha PoE followed by pre-emergence application (PE) of pendimethalin 0.75 kg/ha and fomesafen 220 g + fluazifop-p-butyl 220 g/ha PoE at 30 DAS. Higher weed control efficiency (WCE) at 30 DAS was recorded with fomesafen 220 g + fluazifop-p-butyl 220 g/ha (70.6%) followed by hand weeding at 20 and 40 DAS (57.1%). However, fomesafen 220 g + fluazifop-p-butyl 220 g/ha PoE at 20 DAS and imazethapyr + imazamox 100 g/ha PoE at 20 DAS caused severe injury to chickpea plants and even mortality of a few plants. Significantly higher 1000 seed weight (183.0 g) and grain yield (1.79 t/ha) were observed with imazethapyr 55 g/ha PoE which was statistically at par with weed free check. Significantly higher net returns (₹ 70746/ha) and B:C ratio (3.97) were recorded with imazethapyr 55 g/ha PoE (₹ 70746/ha), followed by pendimethalin 0.75 kg/ha PE. The monetary efficiency (₹ 589.5/ha/day) of imazethapyr 55 g/ha PoE was statistically at par with weed free (₹ 541.3/ha/day) and was significantly higher than all other treatments.

Keywords: Chickpea, Economics, Fomesafen + fluazifop-p-butyl, Herbicides, Imazethapyr, Imazethapyr + imazamox, Weed control efficiency

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the third most important pulse crop in the world after French bean and field peas (FAO 2019). Chickpea occupies about 38% of area under pulses and contributes about 50% of the total pulse production of India. In India, it was grown in an area of 10.17 million ha and producing 11.35 million tons with productivity of 1116 kg/ha (Anonymous 2021). Madhya Pradesh is ranked first amongst chickpea growing states of the India covering an area of about 1.93 million ha with production of 2.48 million tons and productivity 1288 kg/ha (Anonymous 2021).

The poor productivity of chickpea is due to biological and physical constraints of which weed menace is a prominent one. Early and heavy flushes of weeds are recognized as a major bottleneck in realizing the full yield potential of chickpea (Dubey *et al.* 2018) as chickpea is a short statured crop with slow initial growth and heavily infested with wide spectrum of weeds. The early emergence and fast-growing weeds cause severe crop – weed competition for light, moisture, nutrients and space, which culminates in heavy reduction in growth and 40-75% yield of chickpea and lessens the profitability (Chopra *et al.* 2003, Chaudhary *et al.* 2005, Ratnam *et al.* 2011). Hence, weed management is one of the critical input essential for improving the chickpea productivity which necessitates the development of an effective weed management program in chickpea. Thus, the present study was conducted to identify suitable herbicides for effective weed management while assessing their influence on weed flora, yield and economics of chickpea under Kymore Plateau of Madhya Pradesh.

MATERIALS AND METHODS

The field experiment was conducted during winter (*Rabi*) seasons of 2019-20 and 2020-21 at Agriculture Farm of Mahatma Gandhi Chitrakoot

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Gramodaya Vishwavidyalaya, Chitrakoot, Satna Madhya Pradesh (M.P.). The soil of the experimental field was sandy loam in texture having soil in neutral pH (6.5 and 6.8), low in organic carbon (0.49% and 0.43%), available nitrogen (235.6 kg/ha and 228.3 kg/ha), high in available phosphorus (42.76 kg/ha and 26.5 kg/ha) and medium in available potassium (245.2 kg/ha and 247.1 kg/ha) during two consecutive years.

The mean annual rainfall of Chitrakoot is 950 mm while, the crop received 264 mm and 38 mm rainfall during crop season *i.e.* October to March in two respective years. Ten treatments were tested, *viz.* weedy check, weed free, hand weeding twice at 20 and 40 days after seeding (DAS), pre-emergence application (PE) of pendimethalin 0.75 kg/ha, post-emergence application (PoE) of imazethapyr 55 g/ha at 20 DAS, fluazifop-p-butyl 250g/ha PoE, propaquizafop 2.5% 33.3 g/ha + imazethapyr 3.7% 50 g/ha PoE, acifluorfen-sodium 16.5% 140 g + clodinafop-propargyl 8% 70 g/ha PoE, fomesafen 11.1% W/W 220g + fluazifop-p-butyl 11.1% W/W 220 g/ha PoE and imazethapyr 35 % + imazamox 35% 100 g/ha PoE. A randomized block design was used with three replications.

Chickpea seeds were treated with carrier-based *Rhizobium* 20 g/kg and PSB 40 g/kg seed and mixed well to ensure the inoculums to stick on to the surface of the seeds. The chickpea (*RVG-203*) was sown on 20th October 2019 and 10th November 2020 at a row spacing of 30 cm using 100 kg seed/ha and was harvested on 10th March 2020 and 14th March 2021. The crop was fertilized 20 kg N, 40 kg P and 20 kg K/ ha through DAP and MOP as basal. The PoE herbicides alone or in combination were applied at 20 DAS with knapsack sprayer fitted with flat-fan nozzle using 600-litter water/ha. Crop was irrigated at pre-flowering and pod development stage.

The data on density (no./m^2) and biomass (g/m^2) of weeds was recorded at 30 DAS with the help of quadrat of one meter square. Yield attributes and grain and straw yields were recorded as per standard procedures and economics was computed using the prevailing market price for inputs and outputs (grain and straw). The data on total weed density and biomass were subjected to square root transformation ($\sqrt{x+1}$) before subjecting to statistically analysis. Monetary efficiency was calculated by dividing the total net returns with the duration of the crop as follows:

$$\text{Monetary efficiency (₹/ha/day)} = \frac{\text{Net returns (₹/ha)}}{\text{Duration of the crop (days)}}$$

The Experimental data related to each character was then statistically analysed as per procedure of analysis of variance and significance tested by "F" test (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Weed flora

The weeds species (weed flora) recorded in weedy check plots were *Cynodon dactylon, Cyperus rotundus, Chenopodium album, Anagallis arvensis, Convolvulus arvensis, Medicago hispida, Argemone mexicana* and *Parthenium hysterophorus.* The major monocot/sedge weed was *Cynodon dactylon* (7.33/ m^2) while, dominant dicot weed was *Chenopodium album* (134.33/m^2) at 30 DAS. However, relative density of monocot/sedge was higher for *Cynodon dactylon* (4.05 %) and it was 74.36 % for *Chenopodium album* (**Table 1**). Similar weeds in winter season chickpea were also reported earlier (Goud *et al.* 2013 and Kumar *et al.* 2014).

Weed density and biomass

At 30 DAS, significantly lower weed density was recorded in fomesafen 220 g + fluazifop-p-butyl 220 g/ha (7.75/m^2) and imazethapyr + imazamox 100g /ha (9.20/m^2). Similar observations were made by Singh and Jain (2017) and Ashu and Menon (2021). The weed biomass at 30 DAS was also significantly lower in fomesafen 220 g + fluazifop-p-butyl 220g/ha (2.70 g/m^2). Hand weeding twice at 20 and 40 DAS, pendimethalin 0.75 kg/ha PE, imazethapyr 55 g/ha PoE, fluazifop-p-butyl 250 g/ha PoE, propaquizafop 33.3 g + imazethapyr 50 g/ha PoE, acifluorfen-sodium 140 g + clodinafop

Table 1. Weed density and relative density (%) in weedy check at 30 days after seeding (DAS)

Weed species	Weed density (no./m^2)	Relative density (%)
Monocot / Sedge		
Cynodon dactylon	7.33	4.05
Cyperus rotundus	3.6	1.99
Total	10.99	6.08
Dicot		
Chenopodium album	134.33	74.36
Anagallis arvensis	6	3.32
Convolvulus arvensis	5.33	2.95
Medicago hispida	12	6.64
Argemone Mexicana	9.66	5.34
Parthenium hysterophorus	2.33	1.28
Total	169.65	93.91
Grand total	180.64	100

propargyl 70 g/ha, fomesafen 220 g + fluazifop-p-butyl 220 g/ha and imazethapyr + imazamox 100 g/ha reduced the weed biomass by 44.9, 40.2, 34.7, 33.0, 27.6, 34.7, 50.3 and 41.7%, respectively (**Table 2**). The post-emergence application of the efficacy of imazethapyr PoE in effectively controlling weeds was also reported earlier in soybean (Ram and Singh 2011) and blackgram (Singh *et al.* 2013, Nirala *et al.* 2012).

Weed index and weed control efficiency at 30 DAS

Weed index (WI) at 30 DAS was highest under weedy check and the lowest in imazethapyr 55 g/ha PoE (5.57) followed by pendimethalin 0.75 kg/ha PE (15.38) and fomesafen 220 g + fluazifop-p-butyl 220 g/ha (15.90) treated plots. Fomesafen 220 g + fluazifop-p-butyl 220 g/ha recorded highest weed control efficiency (70.6%) followed by hand weeding (57.1%) and imazethapyr 55 g/ha (55%), while, it was the lowest in propaquizafop 33.3 g/ha + imazethapyr 50 g/ha (14.4%). However, imazethapyr 35% + imazamox 35% 100 g/ha was observed to cause higher toxicity to chickpea crop. These results are in conformity with those of Ratnam *et.al* (2011), Singh *et al*. (2014), Kumar and Chinnamuthu (2014).

Effect on crop

Nodulation: The number of nodules at chickpea flower initiation stage were significantly higher under hand weeding (4.22) followed by pendimethalin 0.75 kg/ha PE (4.10), imazethapyr 55 g/ha PoE (3.98). However, dry weight of nodules per plant at flower initiation stage was significantly superior in pendimethalin 0.75 kg/ha PE (0.11 g) followed by weed free (0.10 g) and hand weeding twice at 20 and 40 DAS (0.10 g) (**Table 3**). This might be due to more space availed by roots of crop which could have resulted into greater number of nodules per plant in those treatments

Table 2. Effect of treatments tested on weed density and biomass, weed index and weed control efficiency in chickpea at 30 days after seeding

Treatment	Weed density (no./m^2)	Weed biomass (g/m^2)	Weed index	Weed control efficiency (%)
Pendimethalin 0.75 kg/ha (PE)	9.54(73)	3.26(5.15)	15.38	48.08
Imazethapyr 10 % SL 55g/ha at 20-25 DAS	11.24(105)	3.52(6.40)	5.57	55
Fluazifop-p-butyl 13.4 % W/W 250 g/ha at 20-25 DAS	11.72(115)	3.63(6.93)	28.99	30.14
Propaquizafop 2.5% 33.3 g + imazethapyr 3.7% 50 g/ha at 20-25 DAS	11.26(105.33)	3.91(8.50)	20.61	14.43
Acifluorfen-sodium 16.5% 140 g + clodinafop propargyl 8% 70g/ha at 20-25 DAS	9.66(75)	3.52(6.37)	39.14	35.78
Fomesafen 11.1%W/W 220g + fluazifop-p-butyl 11.1%W/W 220 g/ha at 20-25 DAS	7.75(45.66)	2.70(2.92)	15.90	70.56
Imazethapyr 35% + imazamox 35% 100 g/ha at 20–25 DAS	9.20(67.33)	3.14(4.60)	47.19	53.62
HW at 20 and 40 DAS	10.30(86.66)	3.72(7.40)	31.98	57.15
Weed free	1.00(0.00)	1.00(0.00)	-	100
Weedy check	14.49(182) *	4.14(9.92)*	48.25	-
LSD (p=0.05)	2.79	0.63	-	-

*Original data given in parentheses were subjected to square root transformation $\sqrt{X+1}$ before statistically analysis

Table 3. Effect of treatments tested on nodulation, yield attributes and yield of chickpea

Treatment	No of nodules/plant at 60 DAS	Nodules dry weight/plant (g) at 60 DAS	Pods/ plant	Seeds/ pod	Grain weight / plant (g)	1000 seed weight (g)	Yield (t/ha)	
							Grain	Stover
Pendimethalin 0.75 kg/ha (PE)	4.10	0.11	26.60	1.53	18.93	178.4	1.61	1.96
Imazethapyr 10 % SL 55g/ha at 20-25 DAS	3.98	0.09	24.27	1.55	19.33	183.0	1.79	2.33
Fluazifop-p-butyl 13.4 % W/W 250 g/ha at 20-25 DAS	3.75	0.08	27.00	1.38	17.40	175.6	1.35	2.05
Propaquizafop 2.5% 33.3 g + imazethapyr 3.7% 50 g/ha at 20-25 DAS	3.97	0.09	27.13	1.52	18.00	174.7	1.51	1.97
Acifluorfen-sodium 16.5% 140 g + clodinafop propargyl 8% 70 g/ha at 20-25 DAS	3.55	0.07	27.47	1.50	19.07	164.8	1.15	1.72
Fomesafen 11.1%W/W 220g + fluazifop-p-butyl 11.1%W/W 220 g/ha at 20-25 DAS	3.22	0.07	26.73	1.47	20.53	177.4	1.60	1.90
Imazethapyr 35% + imazamox 35% 100 g/ha at 20–25 DAS	2.63	0.05	18.00	1.58	15.07	162.4	1.00	0.91
HW at 20 and 40 DAS	4.22	0.10	26.27	1.48	20.07	179.6	1.29	1.90
Weed free	3.53	0.10	41.93	1.52	22.93	185.2	1.90	2.78
Weedy check	3.11	0.08	26.27	1.46	20.87	171.0	0.98	1.35
LSD (p=0.05)	0.93	0.04	4.81	NS	3.93	12.3	189	616

Table 4. Effect of treatments tested on returns and monetary efficiency of chickpea

Treatment	Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit: cost ratio	Monetary efficiency (₹/ha/day)
Pendimethalin 0.75 kg/ha (PE)	24735	84509	59773	3.42	498.10
Imazethapyr 10 % SL 55g/ha at 20-25 DAS	23856	94602	70746	3.97	589.55
Fluazifop-p-butyl 13.4 % W/W 250 g/ha at 20-25 DAS	26499	71725	45225	2.71	376.87
Propaquizafop 2.5% 33.3 g + imazethapyr 3.7% 50 g/ha at 20-25 DAS	24243	79560	55316	3.28	460.72
Acifluorfen-sodium 16.5% 140 g + clodinafop propargyl 8% 70 g/ha at 20-25 DAS	24824	61392	36567	2.47	304.72
Fomesafen 11.1%W/W 220g + fluazifop-p-butyl 11.1%W/W 220 g/ha at 20-25 DAS	26930	83901	56970	3.12	474.75
Imazethapyr 35% + imazamox 35% 100 g/ha at 20–25 DAS	23699	52124	28424	2.20	236.86
HW at 20 and 40 DAS	27308	68582	41274	2.51	343.95
Weed free	35848	100805	64957	2.81	541.30
Weedy check	23038	51996	28958	2.25	241.31
LSD (p=0.05)	-	9631	9631	0.38	-

Yield attributes

Higher number of pods/plant (27.47) were recorded under acifluorfen-sodium 140 g/ha + clodinafop-propargyl 70 g/ha PoE and it was statically at par with rest of weed control treatments except imazethapyr + imazamox 100 g/ha PoE. Number of seeds/pod was numerically higher under imazethapyr + imazamox 100 g/ha PoE (1.58) followed by propaquizafop 33.3 g/ha + imazethapyr 50 g/ha PoE (1.52) and acifluorfen-sodium 140 g + clodinafop-propargyl 70g/ha PoE (1.50). Seed weight/plant (20.53 g) was found significantly greater under fomesafen 220 g + fluazifop-p-butyl 220g/ha PoE and it was statistically at par with all weed control treatments except imazethapyr + imazamox 100 g/ha PoE. The 1000-seed weight was higher with imazethapyr 55 g/ha (183 g), and it was statistically at par with HW twice at 20 and 40 DAS, pendimethalin 0.75 kg/ha PE, fluazifop-p-butyl 250 g/ha PoE, propaquizafop 33.3 g + imazethapyr 50 g/ha PoE, fomesafen 220 g + fluazifop-p-butyl 220 g/ha PoE and weedy check. Goud *et al.* (2013) also reported highest growth and yield attributing parameters of chickpea with the application of imazethapyr 75 g/ha PoE. Weed free treatment producing higher values of yield attributes in chickpea was reported earlier by Khope *et al.* (2011), Singh *et al.* (2014) and Rupareliya *et al.* (2018).

Yield

Seed yield was higher with weed free check (1.90 t/ha) and was statistically at par with imazethapyr 55 g/ha PoE (1.79 t/ha) and pendimethalin 0.75 kg/ha PE (1.61 t/ha). Stover yield also followed the similar trend (**Table 3**). Khope *et al.* (2011) also reported higher chickpea yield with imazethapyr. Similar results have also been reported by Goud *et al.* (2013).

Economics

The maximum cost of production was incurred in weed free treatment (₹ 35848 /ha) followed by hand weeding twice wat 20 and 40 DAS (₹ 27308/ha) due to greater number of labor involved. Gross return was maximum under weed free (₹ 100805 /ha) but statistically at par to imazethapyr 55g/ha PoE (₹ 94602/ha). The higher gross returns were mainly due to higher seed yield, obtained due to higher weed control efficiency. While, net return was significantly higher in imazethapyr 55 g/ha PoE (₹ 70746 /ha) and weed free (₹ 64957/ha), which were statistically at par. Higher B:C ratio was with imazethapyr 55 g/ha PoE (3.97) followed by pendimethalin 0.75 kg/ha PE (3.42) due to higher gross returns along with lesser cost of cultivation, particularly less weed management cost as observed by Rathod *et al.* (2017), Dubey *et al.* (2018) and Sethi *et al.* (2021).

Monetary efficiency

The monetary efficiency of imazethapyr 55 g/ha PoE (₹ 589.55/ha/day) was statistically at par with weed free (₹ 541.30/ha/day) and was significantly higher than rest of the treatments (**Table 4**). Thus, it was concluded that imazethapyr 55 g/ha applied at 20 DAS could be used for attaining satisfactory weed control in chickpea along with higher productivity and farm income in Kymore Plateau region of Madhya Pradesh.

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