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Effect of Pre and Post Emergent Herbicides on Weed Management, Yield and Economics in Irrigated Chickpea (*Cicer arietinum* L.)

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ABSTRACT

A field experiment was conducted to study the effect of pre and post emergence herbicides on growth and yield of chickpea at College of Agriculture, Vijayapura, during *rabi*, 2021-22. The experiment was laid out in RCBD with three replications. The experiment consisted of 11 treatments involving two pre-emergence herbicides (Pendimethalin, Pendimethalin + Imazethapyr) and five post-emergence herbicides (Imazethapyr + Imazamox, Propaquizafop + Imazethapyr, Imazethapyr, Quizalofop ethyl and Aciflor + Clodinafop), intercultivation at 20 and 40 DAS, weed free check and weedy check. Among the herbicidal treatments, significantly lower weed population per m^2 (2.40), lower total dry weight of weeds (3.18 g), higher weed control efficiency (84.98%), lower weed index (11.06 %), higher grain yield (2197 kg/ha), haulm yield (2766 kg/ha), net returns (₹ 80621/ha) and B:C ratio (3.01) was recorded with sequential application of Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ (125 g a.i./ha) as PoE at 25 DAS compared to all other treatments. Among herbicidal treatments lowest grain yield (923 kg/ha) and haulm yield (2098 kg/ha) were recorded with Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS due to phytotoxicity and the results were almost near to weedy check which recorded 38.18 pods/plant, 100 seed weight of 22.36 g, 16.96 g of seed yield / plant, grain yield (896 kg/ha) and haulm yield (2056 kg/ha).

Keywords Chickpea, Herbicides, Weeds, Yield, Economics.

INTRODUCTION

One of the most frequently cultivated pulse crops in India and the rest of the globe, after beans and peas, is chickpea (*Cicer arietinum* L.). It is also known by other names such as gram or bengal gram, and is commonly referred to as chana in various parts of the nation. Chickpea is a cool-season quantitative long-day legume crop that belongs to the fabaceae family and the faboideae subfamily. It is prized for its nutritious seed, which has a large amount of protein (21.1%), carbohydrates (61.5%) and lipids (4.5%), and is being used as a meat substitute. Green leaves include malic and oxalic acids, which have medicinal value in individuals suffering from digestive disorders. It has therapeutic significance in the treatment

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of gastrointestinal disorders. The dry sections of the chickpea are called as "Bhoosa," and they have a high protein content, making them an ideal cattle fodder.

Chickpea accounts for more than 20% of global pulse production, also, India supplies the majority of the world's chickpea supply (80-90%). With a productivity of 1192 kg/ha, India leads the globe in chickpea area (9.99 million ha) and production (11.91 million tonnes). With an area of 7.13 lakh hectares and an annual production of 4.45 lakh tonnes, Karnataka is India's fourth largest producer of chickpeas, with an average productivity of 625 kg/ha (Indiastat 2021).

Out of several factors weed infestation has been found to cause yield reductions of up to 75% (Chaudhary *et al.* 2005). In chickpeas, grain yield was reduced by 17.1% within the first 30 days of sowing due to weed competition, which escalated to roughly 50% when weeds battled with the crop throughout the entire crop season. The first 60 days are thought to be the most important (Singh and Singh 1992). Different weed control practices such as crop architecture, use of appropriate cultivars and use of herbicides were followed for better management. An appropriate herbicide for the efficient management of mixed weed flora is required for farmers to adopt this crop more readily. Herbicides have made it feasible to efficiently and affordably control a wide range of weeds in pulses.

Application of herbicide at critical growth stages followed by one or two hand weeding at proper time or manipulation of row spacing to improve the weed suppressing effect of crops gives disputable improvement in crop yield. One strategy for broad-spectrum weed management could be the use of post-emergence herbicides in conjunction with pre-emergence herbicides. In chickpea, weed control is an important part of plant protection, which increases the crop's output capacity.

MATERIALS AND METHODS

Field experiment was conducted during *rabi* 2021 at College of Agriculture, Vijayapura, Karnataka on Vertisol having pH 8.11 and EC 0.24 dS/m. The soil was Low in organic carbon content (0.53%) and available N (175 kg/ha), P_2O_5 (26.3 kg/ha), and K_2O (398 kg/ha). The experimental site was located at 16°45′ North latitude, 75°44′ East longitude and at an altitude of 593.8 m above the mean sea level in Northern Dry Zone of Karnataka (Zone 3).

The variety JG-11 was used in this experiment. There were 11 treatments. The experiment was laid out in Randomized Complete Block Design and replicated thrice. Nitrogen, phosphorus and potassium were applied at the rate of 10:20:0 kg/ha and in the form of urea and di-ammonium phosphate. Crop was sown on 13th October 2021 with spacing of 45×10 cm. During the experimental year (2021-22), a total rainfall of 632.8 mm was recorded in 52 rainy days and which was more than the average rainfall of (594.4 mm) 40 years (1981-2020) by 38.4 mm. The weather conditions prevailed during the cropping season encouraged the growth of both crop and the weeds. Spraying of pre-emergent herbicides was taken up after 2 DAS and post-emergent herbicides was after 20 DAS. Observations on weed density, weed dry matter and weed control efficiency were recorded at 30 and 45 days after sowing (DAS). Yield was also recorded. The weed index and economics were worked out.

Statistical analysis

The data collected from the experiment at different growth stages and at harvest were subjected to statistical analysis as described by Gomez and Gomez (1984). The level of significance used for 'F' and 't' tests was p=0.05. Critical Difference (CD) values were calculated at 5% probability level if the F test will found to be significant.

RESULTS AND DISCUSSION

Weed flora in experimental area

The major common weed species observed in the experimental site were, *Chloris radiata, Bracheria reptans, Eleucina indica, Panicum repens* and *Dinebra retroflexa* among monocot weeds and *Abitulon indicum, Achyranthus aspera, Cassia tora, Convolvulus arvensis, Desmodium diffusum, Digeria muricata, Euphorbia hirta, Euphorbia geniculate, Lactuca*

Table 1. Effect of different weed management practices on weeds density and weed dry weight at 30 and 45 days after sowing of irrigated chickpea. * Square root (√+0.5) transformed values and the figures in parenthesis indicate the original values.

Treatments		Weed density		Weed dry weight	
		30 DAS	45 DAS	30 DAS	45 DAS
T_1	Pendimethalin 38.7% CS @ 1.0 kg a.i. /ha as PE	2.91*(8.00)	3.34*(10.67)	4.02*(15.67)	5.54*(30.25)
T_2	Pendimethalin 30% EC + Imazethapyr 2% EC (RM) @ (1000 g a.i./ha) or 3 L/ha as PE	3.02 (8.67)	3.53 (12.00)	4.13 (16.67)	5.60 (31.06)
T_3	Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS	3.47 (11.67)	2.85 (7.67)	4.83 (23.46)	4.31 (18.10)
T_4	Imazethapyr 10 % SL @ 70 g a.i./ha as PoE at 25 DAS	3.36 (11.00)	2.80 (7.33)	4.79 (22.62)	4.13 (16.58)
T_5	Quizalofop ethyl 5 % EC @ 50 g a.i./ha PoE	3.56 (12.33)	3.72 (13.33)	5.26 (27.52)	5.33 (27.96)
T_6	Aciflor 16.5% + Clodinafop 8% EC (RM) @ 245 g a.i./ha as PoE at 25 DAS	3.49 (11.67)	2.68 (6.67)	4.74 (22.05)	3.99 (15.55)
T_7	Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ (125 g a.i./ha) as PoE at 25 DAS	3.28 (10.33)	2.40 (5.33)	4.31 (18.16)	3.18 (9.71)
T_8	Pendimethalin 38.7 % CS @ 800 g a.i./ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS	3.44 (11.33)	2.46 (5.67)	4.61 (20.96)	3.71 (13.64)
T_9	Intercultivation at 20 and 40 DAS (Farmers practice)	3.19 (9.67)	2.18 (4.33)	3.12 (9.39)	4.08 (16.20)
T_{10}	Weed free check	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
T_{11}	Weedy check	4.65 (21.33)	5.83 (33.67)	6.61 (43.33)	8.12 (65.54)
SEm±		0.17	0.16	0.22	0.18
CD (p=0.05)		0.50	0.46	0.66	0.53

serriola, Parthenium hysterophorus, Phyllanthus maderaspatensis, Sida acuta, Tridax procumbens and *Trichodesma zylenicum* among dicot weeds.

Effect of different weed management practices on weed density and dry weight

Experimental results revealed that weed management practices evinced significant influence on weed density and weed dry weight of weeds (Table 1).

Weed density

Among all the weed management treatments, weed free check (T_{10}) recorded significantly lower number of weeds (0.71) per m^2 at all the stages of growth and weedy check (T_{11}) recorded significantly the highest number of weeds per m^2.

At 30 DAS, weedy check recorded significantly higher number of weeds (4.65) per m^2 as compared to other treatments. The lowest number of total weed population per m^2 was observed in weed free check (0.71). Among the herbicidal treatments T_1: Pendimethalin 38.7% CS @ 1.0 kg a.i. / ha as Pre emergence application recorded lowest number of weeds (2.91) and it was followed by T_2: Pendimethalin 30% EC + Imazethapyr 2% EC (RM) @ (1000 g a.i./ha) (3.02).

At 45 DAS, T_9 : Intercultivation at 20 and 40 DAS (Farmers practice) recorded significantly lower number of weeds per m^2 (2.18) and was found to be on par with T_7: Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ 125 g a.i./ha as PoE at 25 DAS and T_8: Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS with a weed population of 2.40 and 2.46 per m^2, respectively. Weedy check showed significantly higher weed population per m^2 (5.83) among all the treatments.

Weed dry weight

Significantly higher total weed weight was recorded in weedy check (T_{11}) at 30, 45 DAS (6.61, and 8.12 g per m^2 respectively,), while significantly lower weed dry weight of weeds was recorded in weed free check (0.71 g) compared to other treatments (Table 1).

Table 2. Effect of different weed management practices on weed control efficiency and weed index in irrigated chickpea. RM = Ready mix, DAS = Days after sowing, PoE = Post emergent, PE = Pre emergent.

	Treatments	WCE (%) 30 DAS	WCE (%) 45 DAS	Weed index (%)
T_1	Pendimethalin 38.7% CS @ 1.0 kg a.i./ha as PE	64.81	53.50	29.41
T_2	Pendimethalin 30% EC + Imazethapyr 2% EC (RM) @ (1000 g a.i./ha) or 3 L/ha as PE	61.52	52.68	30.37
T_3	Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g a.i./ha as PoE at 25 DAS	47.06	72.41	60.18
T_4	Imazethapyr 10% SL @ 70 g a.i./ha as PoE at 25 DAS	46.76	74.55	20.83
T_5	Quizalofop ethyl 5% EC @ 50 g a.i./ha PoE	37.25	56.76	26.69
T_6	Aciflor 16.5% + Clodinafop 8% EC (RM) @ 245 g a.i./ha as PoE at 25 DAS	48.74	76.02	14.33
T_7	Pendimethalin 38.7 % CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ (125 g a.i./ha) as PoE at 25 DAS	57.73	84.98	11.06
T_8	Pendimethalin 38.7 % CS @ 800 g a.i./ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS	51.68	79.18	58.97
T_9	Intercultivation at 20 and 40 DAS (Farmers practice)	78.54	75.05	14.71
T_{10}	Weed free check	100.00	100.00	0.00
T_{11}	Weedy check	0.00	0.00	61.16
	SEm±	4.80	2.40	4.98
	CD (p=0.05)	14.08	7.05	14.61

At 30 DAS, T_9 : Intercultivation at 20 and 40 DAS (Farmers practice) recorded significantly lower total weed dry weight (3.12 g) per m^2 and among the herbicidal treatments T_1: Pendimethalin 38.7% CS @ 1.0 kg a.i. /ha as pre-emergence application recorded significantly lower total weed weight (4.02 g) per m^2 and was followed by T_2 : Pendimethalin 30% EC + Imazethapyr 2% EC (RM) @ (1000 g a.i./ha) as PE (4.13 g), T_7 : Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ 125 g a.i./ha as PoE at 25 DAS (4.31 g) and T_8: Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS (4.61 g).

At 45 DAS T_7: Pendimethalin 38.7 % CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) 125 g a.i./ha as PoE at 25 DAS recorded significantly lower total weed dry weight (3.18 g) per m^2 and it was found to be on par with T_8: Pendimethalin 38.7% CS @ 800 g a.i./ha as PE fb Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS (3.71 g).

Effect of different weed management practices on weed control efficiency and weed index

The data on weed control efficiency and weed index as influenced by different weed management treatments in chickpea are presented in Table 2.

Weed control efficiency (%)

At all the growth stages of chickpea, compared to other treatments, weed free check recorded significantly higher (100%) weed control efficiency and weedy check recorded the lowest (0.00%) weed control efficiency.

At 30 DAS, total weed control efficiency ranged from 37.25 to 78.54% across the treatments. Within the treatments, T_9: Intercultivation @ 20 and 40 DAS (Farmers practice) recorded significantly higher (78.54%) weed control efficiency compared to all other treatments. It was on par with T_1: Pendimethalin 38.7% CS @ 1.0 kg a.i./ha as Pre emergence (64.81%). However the lowest weed control efficiency was recorded in T_5: Quizalofop ethyl 5% EC @ 50 g a.i./ha PoE (37.25 %).

At 45 DAS, total weed control efficiency ranged from 52.68 to 84.98% within the treatments, while T_7: Pendimethalin 38.7 % CS @ 800 g a.i./ha as

Table 3. Yield and economics of chickpea (*Cicer arietinum* L.) as influenced by different weed management treatments.

	Treatments	Grain yield (kg/ha)	Cost of cultivation (₹/ha)	Gross returns (₹ /ha)	Net returns (₹/ha)	BC ratio
T_1	Pendimethalin 38.7% CS @ 1.0 kg a.i. /ha as PE	1638	36757	90103	53346	2.45
T_2	Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (1000 g a.i./ha) or 3 L/ha as PE	1611	37750	88587	50838	2.35
T_3	Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS	923	36631	50765	14134	1.39
T_4	Imazethapyr 10 % SL @ 70 g a.i./ha as PoE at 25 DAS	1839	37637	101150	63512	2.69
T_5	Quizalofop ethyl 5% EC @ 50 g a.i./ha PoE	1696	37476	93257	55780	2.49
T_6	Aciflor 16.5% + Clodinafop 8% EC (RM) @ 245 g a.i./ha as PoE at 25 DAS	2001	37275	110055	72780	2.95
T_7	Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ (125 g a.i./ha) as PoE at 25 DAS	2197	40207	120828	80621	3.01
T_8	Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS	945	39707	51957	12249	1.31
T_9	Intercultivation at 20 and 40 DAS (Farmers practice)	1976	39776	108672	68896	2.73
T_{10}	Weed free check	2315	45066	127310	82244	2.82
T_{11}	Weedy check	896	32876	49298	16422	1.50
	SEm±	116.44	-	6404	6404	0.17
	CD (p=0.05)	341.53	-	18784	18784	0.50

PE fb Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g a.i./ha as PoE at 25 DAS recorded significantly higher (84.98 %) weed control efficiency compared to all other treatments and was found to be on par with T_8 : Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS (79.18%). However the lowest weed control efficiency was recorded in T_2: Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (1000 g a.i./ha) as PE (52.68%). These results were justified with the findings of Panda *et al.* (2017), Suryavanshi *et al.* (2018) and Nagre *et al.* (2017).

Weed index (%)

Among all the treatments, the lower weed index was noticed in T_{10} : weed free check (0.00%). Among rest of the treatments lower weed index was observed in T_7: Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ 125 g a.i./ha as PoE at 25 DAS (11.06%) and it was followed by T_6: Aciflor 16.5% + Clodinafop 8% EC (RM) @ 245 g a.i./ha as PoE at 25 DAS (14.33 %), T_9: Intercultivation at 20 and 40 DAS (Farmers practice) (14.71%) and T_4: Imazethapyr 10% SL @ 70 g a.i./ha as PoE at 25 DAS (20.83). The highest weed index was observed in T_{11}: Weedy check (61.16%) and it was comparable with T_8: Pendimethalin 38.7 % CS @ 800 g a.i./ha as PE *fb* Imazethapyr 35%+ Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS (58.97%) and T_3: Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS (60.18%). This was in conformity with the results of Nath *et al.* (2017).

Effect of different weed management practices on yield and economics

The data on yield and economics as influenced by different weed management treatments in chickpea are presented in Table 3.

Yield

Among the treatments, significantly higher grain yield was obtained in the treatment T_{10}: Weedy free check (2315 kg/ha) when compared to other treatments.

Among the different chemical weed management practices, sequential application of Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ 125 g a.i./ha as PoE at 25 DAS recorded highest grain yield (2197 kg/ha). This might be due to lower weed population during maturity stage leads to efficient resource use by crop which leads to more number of pods per plant and better pod filling. Similar results were obtained by Sandil *et al.* (2015).

Significantly lower seed yield was recorded wherever Imazethapyr 35% + Imazamox 35% WG (RM) was applied in the treatments viz.,T_8: Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS (945 kg/ha) and T_3: Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g a.i./ha as PoE at 25 DAS (923 kg/ha) and which were comparable with treatment that recorded lowest seed yield i.e. T_{11}: Weedy check (896 kg/ha). It might be due to phytotoxic effect of Imazethapyr 35% + Imazamox 35 % WG (RM) herbicide on the crop plants resulted in lowest dry matter accumulation in reproductive parts. These results are in accordance with the findings of Nath *et al.* (2017), these results were also backed up by Rana *et al.* (2019).

Economics

The economics in terms of net returns has a greater impact on the practical utility and acceptance of the technology. Gross returns, net returns and BC ratio were differed significantly due to different weed management practices (Table 3).

Higher cost of cultivation (₹ 45,066 /ha), Gross returns (₹ 1,27,310/ha), Net returns (₹ 82,244 /ha) was recorded with T_{10}: Weed free check followed by T_7: Pendimethalin 38.7 % CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ 125 g a.i./ha as PoE at 25 DAS with cost of cultivation (₹ 40,207 /ha), Gross returns (₹ 1,20,828 /ha) and Net returns (₹ 80,621 /ha). Higher labor cost due to repeated hand weeding to maintain weed free condition in weed free plot (T_{10}) and higher cost of herbicides and their combinations resulted in higher cost of production compared to other weed management treatments. However minimum crop-weed competition throughout the crop growth period, thus enabling the crop for maximum utilization of nutrients, moisture, light and space which had favorable influence on growth and yield components which in turn increased the Gross and net returns.

Among the treatments, significantly higher BC ratio was recorded with T_7: Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ 125 g a.i./ha as PoE at 25 DAS (3.01) over other treatments. Although higher gross return was obtained with weed free check, it was incurred with high cost of cultivation and hence it recorded lesser benefit cost ratio compared to T_7.

CONCLUSION

It is concluded that among the herbicide treatments, Pendimethalin 38.7% CS @ 800 g a.i./ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ (125 g a.i./ha) as PoE at 25 DAS was found to be the most effective weed management practice for controlling complex weeds in term of weed density, weed dry weight, weed control efficiency, weed index, grain yield, net return and BC ratio.

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