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EFFICACY OF PRE- AND POST-EMERGENCE HERBICIDES IN CHICKPEA (*Cicer arietinum L.)*

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ABSTRACT---
A field study was performed to examine the effectiveness of pre-, post-emergence and sequential application of herbicides in weed management in chickpea. The experimental work was carried out following the randomized block design comprising twelve treatments and three replications. Pre-emergence application of oxyfluorfen at two rates, post emergence application of quizalofop-p-ethyl, propaquizafop and topramezone at varying times and rates, three sequential application comprising of one pre- and two post-emergence, weed-free treatment and weedy treatment were included among the treatments used. The field was predominantly occupied by Chenopodium album, Convolvulus arvensis, Taraxacum officinale and Parthenium hysterophorus. The weed management treatments were found to reduce the weed population, weed dry biomass and yield loss compared to the weedy treatment. Weed-free condition resulted in the maximum grain yield (2280.9 kg ha-1) and maximum income from crop production. Amongst herbicide treatments, topramezone 25.7 g ai ha-1 at 21 DAS post emergence resulted in the lowest weed index (8.7%), highest weed control efficiency at harvest (55.63%), lowest weed biomass at harvest (1.92 g m-2), highest grain yield (2083.3 kg ha-1) and maximum benefits: costs ratio (4.9).
KEYWORDS: *Chickpea, Herbicide, Topramezone, Oxyfluorfen, Weed Control Efficiency, Grain Yield, Economics*--

1. INTRODUCTION

Chickpea (Cicer arietinum L.) is a popular rabi pulse crop in India, being economically valuable owing to high-protein seeds, biological nitrogen fixation capacity, and suitability under moisture-stress conditions and limited irrigation. However, the actual production of the crop falls short of its potentials due to moisture stress, disease and insect attack, nutrient deficiencies and weeds. Amongst them, weed invasion constitutes one of the persistent limitations, especially during early growth phases of the crop.

Chickpea is relatively slow-growing in its early stages, and canopy closure occurs much later compared to that in cereals. Consequently, low early competitiveness facilitates weed emergence in a short time period and creates competition among plants for moisture, nutrients, light, and space. Weed invasion leads to decreased crop establishment, branching, dry matter production, podding, and ultimately yield of grains. It is well-established that weed competition is maximum during early periods following planting, making weed management a crucial activity to maintain crop vigor and protect its yield.

The critical period of competition in chickpea commonly occurs during the first few weeks after sowing; therefore, timely weed management is essential for maintaining crop vigour and protecting yield.

Traditional hand weeding and hoeing can control weeds effectively when performed at the correct time, but these operations are becoming less reliable because of labour scarcity, high wage rates and difficulty in carrying out timely field operations. Chemical weed management offers a practical alternative, especially where labour availability is uncertain. Pre-emergence herbicides can suppress early weed flushes, whereas post-emergence herbicides provide flexibility after the weed flora has emerged. Sequential programs may broaden the spectrum of control by targeting weeds at more than one stage.

The present paper evaluates the efficacy of selected pre- and post-emergence herbicides in chickpea with emphasis on weed dynamics, crop growth, yield attributes, yield and profitability. The specific objectives were to compare different herbicidal treatments for weed control, assess their effect on yield attributes and work out the economics of weed-management options in chickpea.

2. MATERIALS AND METHODS

2.1 Experimental site, crop and soil

The rabi field trial was conducted on the Research Farm of the Faculty of Agriculture Science, SAM Global University, Raisen, Madhya Pradesh. Chickpea variety RGV-202 was selected for test crop. The study area was characterized by moderate black clay loam soil with moderate topography and well-drained soil. The initial soil analysis results revealed low available nitrogen content, medium availability of phosphorus and sulphur, high availability of potassium with pH and electrical conductivity within the normal range.

The crop was planted in rows with spacings of 30 cm between rows and 10 cm between plants, using seed rates of 80 kg ha-1. The optimal rate of fertilizer application was 20:50:20:20 kg N:P2O5:K2O:S ha-1. Crop planting was carried out in suitable soil moisture conditions, and standard agricultural management practices were adopted across all treatments except for weed control measures.

2.2 Experimental design and treatments

The experiment was laid out in a randomized block design with twelve treatments and three replications. Gross plot size was 5.0 m x 3.0 m, and net plot size was 4.5 m x 2.4 m. Treatment details are given in Table 1.

Table 1. Herbicidal treatments evaluated in chickpea.

Code	Treatment
T1	Oxyfluorfen 150 g a.i. ha-1 (PE)
T2	Oxyfluorfen 250 g a.i. ha-1 (PE)
T3	Quizalofop-p-ethyl 100 g a.i. ha-1 at 15-20 DAS (PoE)
T4	Propaquizafop 100 g a.i. ha-1 at 15-20 DAS (PoE)
T5	Topramezone 20.6 g a.i. ha-1 at 14 DAS (PoE)
T6	Topramezone 20.6 g a.i. ha-1 at 21 DAS (PoE)
T7	Topramezone 25.7 g a.i. ha-1 at 21 DAS (PoE)
T8	Oxyfluorfen 150 g a.i. ha-1 + Quizalofop-p-ethyl 100 g a.i. ha-1 at 15-20 DAS (PE + PoE)
T9	Oxyfluorfen 150 g a.i. ha-1 + Propaquizafop 100 g a.i. ha-1 at 15-20 DAS (PE + PoE)
T10	Oxyfluorfen 150 g a.i. ha-1 + Topramezone 20.6 g a.i. ha-1 at 14-21 DAS (PE + PoE)
T11	Weed-free check
T12	Weedy check

2.3 Herbicide application and observations

The pre-emergence herbicides were applied immediately after seed sowing, whereas post-emergence herbicides were applied at designated growth stages of the crop during the treatments. The knapsack sprayer with a flat-fan nozzle was employed for even application of the sprays and reduction of drift into neighboring plots.

Various parameters related to weeds such as weed population, weed dry matter, weed index, efficiency of weed control, plant population, plant height, plant dry matter, nodulation, yield characters, grain yield, straw yield, biological yield and economics were measured. The data pertaining to weed dry matter were collected at 30 days after sowing (DAS), 50 DAS and harvest time. Economic analysis comprised of gross income, cost of cultivation, net income and benefit:cost ratio.

3. RESULTS AND DISCUSSION

3.1 Weed flora and weed population

The field used in this experiment had a weed community that was dominated by species such as C. album, C. arvensis, T. officinale, and P. hysterophorus. The weed management techniques resulted in the reduction of weed population when compared with the uncontrolled checks. The weed-free check had no weed population at all because of regular removal of weeds.

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Amongst the different chemical herbicides used, topramezone 25.7 g ai ha-1 at 21 DAS (T7) had the lowest weed population at the time of harvest for all dominant weeds. It lowered the number of C. album to 1.84m-2, C. arvensis to 1.90 m-2, T. officinale to 1.34 m-2, and P. hysterophorus to 2.76m-2. T7 is effective in suppressing weeds due to its post-emergence activity on broad-leaved plants. Sequential applications with oxyfluorfen and post-emergence herbicide gave reasonable weed control although they were not as effective as T7.

Table 2. Population of major weed species at harvest (m-2) in chickpea.

Treatment	C. album	C. arvensis	T. officinale	P. hysterophorus
T1	2.37	3.07	2.02	4.26
T2	2.40	3.07	1.96	4.23
T3	2.39	2.96	1.94	4.15
T4	2.34	2.81	1.84	3.87
T5	2.34	2.82	1.84	3.97
T6	1.99	2.48	1.83	3.74
T7	1.84	1.90	1.34	2.76
T8	2.28	2.67	1.81	3.23
T9	2.16	2.85	1.83	3.73
T10	2.13	2.50	1.83	3.81
T11	0.00	0.00	0.00	0.00
T12	2.15	4.64	2.92	6.47

3.2 Weed dry matter, weed index and weed control efficiency

The weed dry matter proves to be a better measure of competitiveness between crops and weeds than the weed count since the former includes both density and biomass of the weed populations. Weed dry matter of all treatments was lower than the weed dry matter of the weed checks. The minimum weed dry matter was observed in the weed-free check treatment while among the herbicides, T7 showed the lowest weed dry matter (1.92 g m-2).

The maximum weed index was found in the weedy check since this represents the most yield loss caused by weeds. The lowest weed index was recorded with the herbicide T7 (8.7%) while the maximum weed control efficiency was observed in the same herbicide at the time of harvest (55.63%). This means that weed control efficiency was high due to less weed biomass in the treatment.

Table 3. Weed dry matter, weed index and weed control efficiency in chickpea.

Treatment	WDW 30 DAS (g m-2)	WDW 50 DAS (g m-2)	WDW harvest (g m-2)	Weed index (%)	WCE harvest (%)
T1	3.12	3.10	2.86	16.9	33.92
T2	2.98	3.02	2.83	16.8	34.75
T3	2.94	2.99	2.79	17.5	35.69
T4	2.87	2.88	2.65	18.5	38.79
T5	2.87	2.90	2.67	11.9	38.43
T6	2.81	2.90	2.50	9.1	42.52
T7	2.25	2.26	1.92	8.7	55.63
T8	2.62	2.64	2.49	20.3	42.37
T9	2.73	2.74	2.50	16.6	42.31
T10	2.67	2.62	2.51	13.7	42.10
T11	1.79	1.72	1.43	0.0	66.88
T12	4.50	4.72	4.33	39.1	0.00
SEm±	0.026	0.079	0.058	3.49	1.23
CD (5%)	0.017	0.050	0.036	2.183	0.767

Figure 1. Weed control efficiency and weed index under different weed-management treatments.

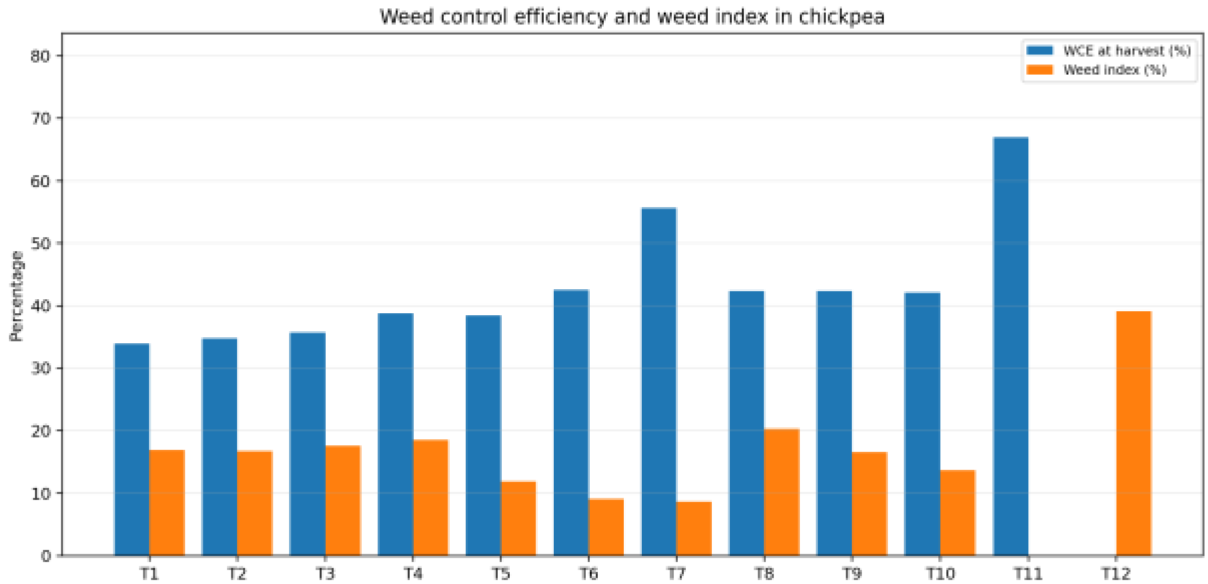

Figure 1 shows that weed-free conditions gave the highest WCE, while T7 was the best herbicidal option with high WCE and low weed index. The weedy check showed no WCE and the greatest yield loss due to weed competition.

3.3 Growth and yield attributes

There was considerable enhancement in crop growth under weed management. The plot with weeds removed had the greatest number of plants per meter square (31.84 plants m-2), height (48.51 cm) and dry weight of the plant (39.54 g plant-1). In relation to herbicide application, treatments T6 and T7 showed higher plant population and treatment T7 had greater height and plant dry weight. This could have been due to less competition for resources like moisture, nutrients, and light during the early growth stage of the chickpeas.

The yield attributes also showed a similar pattern. There was higher numbers of pods per plant (52.48) and seeds per pod (1.37) in the absence of weeds. Among the herbicide treatments, treatment T7 had higher pods per plant (49.28) and seeds per pod (1.35). This was followed by treatments T6 and T5, implying that topramezone-based treatments facilitated better reproductive growth of the chickpeas. Higher pod number and seed setting could be as a result of good branching and effective resource use.

Table 4. Growth and yield-attributing characters of chickpea at harvest.

Treatment	Plant pop. (m-2)	Plant height (cm)	Plant DW (g plant-1)	Pods plant-1	Seeds pod-1	Seed index (g)	Harvest index (%)
T1	26.14	33.15	14.05	24.54	1.21	21.35	35.57
T2	24.45	32.83	14.86	25.95	1.12	21.66	33.33
T3	26.24	36.20	19.43	34.74	1.25	22.65	36.26
T4	30.33	38.17	21.15	40.60	1.29	23.14	36.07
T5	30.95	40.20	29.74	48.67	1.32	24.34	36.51
T6	31.71	46.51	29.14	48.73	1.33	23.66	41.07
T7	30.99	45.81	34.55	49.28	1.35	24.34	40.24
T8	24.29	38.81	20.86	26.58	1.25	22.05	34.67
T9	27.56	36.58	21.16	27.41	1.25	22.37	33.37
T10	27.86	37.17	25.55	37.34	1.25	22.86	34.67
T11	31.84	48.51	39.54	52.48	1.37	25.30	41.33
T12	24.49	31.24	10.46	22.69	0.93	20.35	24.18
SEm±	8.01	0.073	0.012	0.252	0.006	0.199	0.268
CD (5%)	19.48	0.178	0.028	0.612	0.016	0.483	0.651

3.4 Grain, straw and biological yield

The yield of grains was affected by the weed management technique used. The weed-free treatment resulted in the highest yield of grains amounting to 2280.9 kg/ha-1, since there was no weed interference during the crop season. In terms of herbicides, T7 had the highest yield of grains (2083.3 kg ha-1), followed by T6 (2074.1 kg ha-1), and T5 (2009.3 kg ha-1). On the other hand, the weedy treatment had the lowest yield of grains (1388.9 kg ha-1).

The sequential treatment, T10, had the highest yield of straw and biological yield. Despite having a higher biological yield, T10 yielded lesser grain yield compared to T7. The significance of this observation lies in the fact that the success of weed control should translate into high economic yield.

Table 5. Grain yield, straw yield and biological yield of chickpea.

Treatment	Grain yield (kg ha-1)	Straw yield (kg ha-1)	Biological yield (kg ha-1)
T1	1895.1	3432.1	5327.2
T2	1898.1	3796.3	5694.4
T3	1882.7	3308.6	5191.4
T4	1858.0	3293.2	5151.2
T5	2009.3	3493.8	5503.1
T6	2074.1	2842.6	4916.7
T7	2083.3	2851.8	4935.2
T8	1817.9	3425.9	5243.8
T9	1901.2	3796.3	5697.5
T10	1969.1	4006.2	5975.3
T11	2280.9	3237.7	5518.5
T12	1388.9	4351.8	5740.7
SEm±	16.38	17.84	27.80
CD (5%)	39.84	43.38	67.61

3.5 Economics

Based on the economic point of view, yield difference alone was not sufficient for making the treatments profitable as there were differences among the treatments in terms of their cost of cultivation. The weed-free check required the highest cost of cultivation since weeds were removed by manual weeding. However, it provided the highest gross and net incomes along with the benefit:cost ratio of 4.9, the highest one among all. Treatment T7 performed best economically with gross income of Rs 111,145.7 ha-1, net income of Rs 88,295.7 ha-1.

The high B:C ratio (4.9) of T7 implies an advantageous relationship among yield improvement, weed suppression and cost of the treatment. The weedy check had the lowest benefit:cost ratio (3.3) showing that not spending money on weed control is not economical where yield reduction is high.

Table 6. Economics of different weed-management treatments in chickpea.

Treatment	Gross income (Rs ha-1)	Cost of cultivation (Rs ha-1)	Net income (Rs ha-1)	B:C ratio
T1	101,101.4	22,348	78,753.1	4.5
T2	101,266.1	22,450	78,816.1	4.5
T3	100,442.8	22,350	78,092.8	4.5
T4	99,125.5	22,350	76,775.5	4.4
T5	107,193.9	23,000	84,193.9	4.7
T6	110,651.7	23,500	87,151.7	4.7
T7	111,145.7	22,850	88,295.7	4.9
T8	96,984.9	23,300	73,684.9	4.2
T9	101,430.8	23,300	78,130.8	4.4
T10	105,053.3	23,472	81,581.6	4.5
T11	121,684.0	25,500	96,184.0	4.8
T12	74,097.1	22,150	51,947.1	3.3

Figure 2. Grain yield, net return and B:C ratio of chickpea under different treatments.

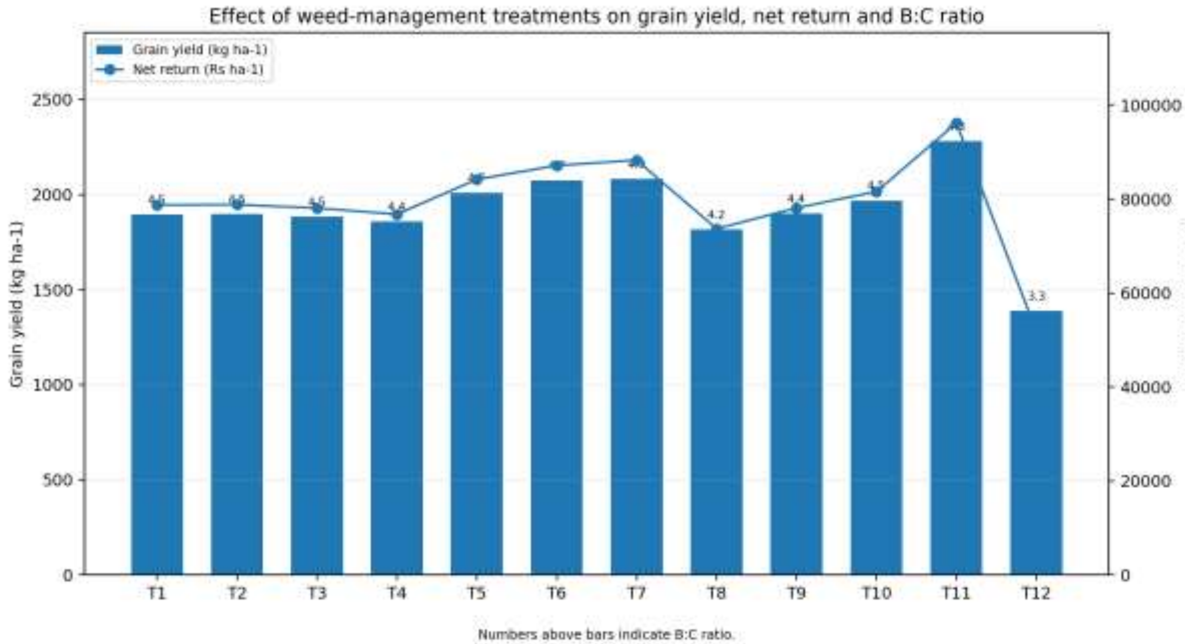

Figure 2 indicates that the weed-free check produced the highest grain yield and net return, while T7 was the most efficient herbicidal treatment because it combined high grain yield, strong net return and the highest B:C ratio.

4. CONCLUSION

It was very clear from the research results that weed infestation greatly affected chickpea growth and yield attributes, grain yield and profitability. Weedy check was inferior to other weed management treatments in terms of weed population and crop growth. However, the performance of weed management practices varied depending on herbicide type, dose and timing of spray. Weed-free plots had the greatest grain yield; nevertheless, when considering the effects of herbicides on crop yields, topamzone 25.7 g ai ha-1 at 21 days after seeding (DAS) was the most effective herbicide treatment for weed population and weed dry biomass reduction.

Tooramzone 25.7 g ai ha-1 at 21 DAS had the lowest weed index value among herbicides, highest grain yield among all herbicidal treatments and benefit:cost ratio. This treatment is therefore regarded as a potential economically feasible weed management practice under such field conditions. Since it was a one season trial experiment, more seasons and locations are advised to recommend this practice extensively.

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