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Effect of herbicides on performance of chickpea (*Cicer arietinum* L.) and weed dynamics for Chhattisgarh

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Abstract

The experiment titled "Effect of herbicides on performance of chickpea (*Cicer arietinum* L.) and weed dynamics for Chhattisgarh " was performed at the Instructional cum Research Farm, IGKV, Raipur (C.G.) during the 2020-21 *rabi* season. The experimental field featured neutral soil pH, characterized by low N, medium P, and high K levels. The research followed a randomized block design (RBD) with 3 replications, incorporating a total of 15 distinct herbicidal treatments. On November 15, 2020, the chickpea variety 'Indira Chana 1' was sown, utilizing a seed rate of 80 kg per hectare and spaced at 30 cm intervals, and the crop was successfully harvested on March 5, 2021.

The results demonstrated that Treatment 8: Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 2-3 Leaf stage of weed significantly outperformed other treatments in terms of plant population (per square meter), plant height (centimeter), number of branches per plant, dry matter accumulation (gram per plant), number of nodules per plant, dry weight of nodules per plant, yield attributes, seed yield (kilogram per hectare), stover yield (kilogram per hectare), and harvest index (percent). However, it was par with Treatment 14: hand weeding twice at 20 and 40 Days After Sowing and Treatment 9: Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 5-6 Leaf stage of weed. The lowest values for the mentioned characteristics were observed in the unweeded control plot (Treatment 15).

In the experimental field, the dominant weed species observed were *Medicago denticulata* L., *Cichorium intybus* L., and *Chenopodium album* L. Additionally, *Echinochloa colona* L. and *Cynodon dactylon* L. were also present.

Keywords: Herbicides, chickpea, yield

Introduction

Chickpea (*Cicer arietinum* L.) holds a significant position as a crucial *rabi* season pulse crop. Chickpea is highly valued for its nutritious seeds, which boast a rich protein content ranging from 18% to 22%, as well as moderate levels of fat (4% to 10%), essential minerals like Ca, P, and Fe, and various vitamins. Its cultivation spans approximately 139.81 lakh hectares, resulting in a total production of 137.31 lakh tonnes, with an average yield of 982 kg per hectare (FAO, 2017) [6]. This highlights its critical role in meeting dietary and nutritional needs worldwide.

Absolutely, chickpeas are valuable for their ability to enhance soil fertility through nitrogen fixation. During its growth cycle, chickpea plants can fix as much as 140 kilograms of nitrogen per hectare (Poonia and Pithia, 2013) [11]. This nitrogen fixation not only provides a direct source of nitrogen for the chickpea crop itself but also leaves a significant amount of residual nitrogen in the soil for use by subsequent crops. Furthermore, chickpea plants contribute ample organic matter to the soil as they decompose, which helps to sustain and enhance overall soil health and fertility. This dual benefit of nitrogen fixation and organic matter addition makes chickpea cultivation an important component of sustainable agricultural practices.

Chickpea takes the lead in terms of cultivated area in India, covering approximately 96.26 lakh hectares. This extensive cultivation results in a production of 9.62 lakh tonnes and an average yield of 974 kg per hectare (Anonymous, 2016) [1]. The major chickpea-producing states in India, which collectively account for over 95% of the total area under cultivation, include Madhya Pradesh (MP), Uttar Pradesh (UP), Rajasthan, Maharashtra, Gujarat, Andhra Pradesh (AP), and Karnataka. Additionally, Chhattisgarh boasts favorable agro-ecological conditions for chickpea production, where it is cultivated over an area of 3.07 lakh hectares.

This leads to an annual production of 3.59 lakh tonnes and an impressive average productivity of 1171 kg per hectare (Anonymous, 2017) [3]. Chickpea's prominence in Indian agriculture underscores its significance as a staple crop for both sustenance and economic development in the region.

In chickpea production, one of the significant challenges is weed infestation. Chickpea faces particular difficulties in competing with weeds due to its slow growth rate and limited leaf development during the early stages of crop growth. When proper weed management is lacking, this vulnerability to weed competition can lead to substantial yield losses, ranging from 40% to as high as 87% (Chaudhary *et al.*, 2005) [5]. Addressing weed infestation is therefore a critical aspect of successful chickpea cultivation, as it directly impacts crop productivity and overall agricultural sustainability.

The inefficiency and unavailability of labor during critical periods of crop-weed competition, coupled with the rising costs of manual weeding, have made herbicides an increasingly attractive option for weed control in chickpea production. Pre-emergence herbicides, in particular, provide effective weed control during the initial 25 to 30 days after sowing (DAS). However, to address weed flushes that emerge later in the growing season, the application of post-emergence herbicides becomes necessary. Utilizing herbicides for weed management not only proves to be cost-effective but also supports the adoption of zero tillage or minimum tillage methods, which are integral to the practice of conservation agriculture.

Weed management through herbicides offers several advantages, including speed, effectiveness, and cost-efficiency, as noted by Shah *et al.* (1989) [16]. Selective herbicides are particularly effective in controlling weeds while preserving the crop. When used correctly, pre-emergence (PE) herbicides can achieve efficient and cost-effective weed control, resulting in chickpea seed yields that are similar to or only slightly lower than those obtained in weed-free treatments. However, it's worth noting that the availability of post-emergence (PoE) herbicides, especially for broadleaf weeds, can be limited. As mentioned by Wright *et al.* (1995) [15], the absence of registered PoE herbicides for broadleaf weeds narrows down the options for effective weed management in chickpea cultivation.

Materials and Methods

The experiment titled “Effect of herbicides on performance of chickpea (*Cicer arietinum* L.) and weed dynamics for Chhattisgarh"was performed at the Instructional cum Research Farm of IGKV during the *rabi* season of 2020-21. The climate in the region spans from sub-humid to semi-arid. The soil in the experimental field was classified as *Vertisol*, with varying levels of NPK content, specifically low nitrogen, medium phosphorus, and high potassium. These soils also displayed a neutral pH. The study focused on the JL-3 chickpea variety, and the research was carried out using a Randomized Block Design (RBD). The experiment consisted of three replications and a total of fifteen distinct treatments *viz.* (Treatment 1 - Oxadiargyl 80 gram per hectare 0-3 Days After Sowing), (Treatment 2 - Metribuzin 350 gram per hectare 0-3 Days After Sowing), (Treatment 3 - Topramezone 19.35 gram per hectare 2-3 Leaf stage of weed), (Treatment 4 -Topramezone 25.8 gram per hectare 2-3 Leaf stage of weed), (Treatment 5 - Topramezone 32.25 gram per hectare 2-3 Leaf stage of weed), (Treatment 6 - Topramezone 25.8 gram per hectare 5-6 Leaf stage of weed), (Treatment 7- Topramezone 32.25 gram per hectare 5-6 Leaf stage of weed), (Treatment 8 - Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 2-3 Leaf stage of weed), (Treatment 9 - Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 5-6 Leaf stage of weed), (Treatment 10 - Fluzifop-p-butyl 13.4 percent + Fomesafen 11.1 percent 250 gram per hectare 5-6 Leaf stage of weed), (Treatment 11 - Sodium acifluorfen 16.5 percent + coldinafop-proparzyl 8 percent (directed application) 187.5 gram per hectare 2 to 3 leaf stage of weed), (Treatment 12 - Mertibuzin (directed application) 350 gram per hectare 2 to 3 leaf stage of weed), (Treatment 13 - Metsulfuron (directed application) 4 gram per hectare 2 to 3 leaf stage of weed), (Treatment 14 - Hand weeding twice 20 and 40 Days After Sowing) and (Treatment 15- Unweeded control). The chickpea cultivar "Indira Chana 1" was sown on 15-11-2020, and it was subsequently harvested on 05-03-2021, signifying the duration of its growth cycle for that particular season. Throughout the crop growth period, various yield-related characteristics, including the number of pods per plant, the number of seeds per pod, seed size (seed index), seed yield, and stover yield, were meticulously recorded in accordance with the predetermined schedule and the specific research objectives of the investigation.

Results and Discussion

Number of pods plant^{-1}

A significantly higher number of pods per plant was observed in Treatment 8 (38.58), over other weed management practices, however it was found at par with Treatment 14 (38.29), followed by Treatment 9 (38.28), while treatment 15 was found to have lowest number of pods per plant (19.46).

This may be due to better growth of crop resulting in less crop weed competition under herbicidal Treatment 8 and Treatment 9 that subsequently increased nutrient and moisture availability to the chickpea crop over rest of all treatments which ultimately resulted in increased number of pods per plant, while least number of pods per plant were recorded in weedy condition because of higher crop weed competition. This results was in conformity to Aslam *et al.* (2007).

Number of seeds pod^{-1}

Highest number of seeds pod^{-1} had been recorded in Treatment 8 (2.15) over other treatments. On the other hand, lowest number of seeds pod^{-1} was found in Treatment 15 (1.1). This was due to better suppression of weeds which resulted in better growth of crop and translocation of photosynthates in $T_{8,}$ T_{14} and T_9. Singh and Jain (2017) reported similar results.

Seed weight (g)

Higher number of 100 seed weight had been recorded in Treatment 8 (28.86 g), over other treatments, while lowest number of seeds pod^{-1} was found in Treatment 15 (24.38 g).

Seed yield (kg ha^{-1})

The findings revealed that treatments exhibited significant differences among them and the Treatment 8 (1956.27 kg/ha) recorded notably highest pod yield over other weed management treatments, however it was statistically at par with the treatments Treatment 14 (1903.56 kg ha^{-1}) and Treatment 9 (1880.93 kg ha^{-1}). Significantly lowest seed yield was observed under treatment Treatment 15 (782.40 kg ha^{-1}). The findings are in accordance with those of Singh *et al.* (2008) [14] and Nandan *et al*. (2011) [9].

Stover yield (kg ha^{-1})

The significantly higher stover yield was obtained under Treatment 8 (2545.01 kg ha^{-1}), over other treatments and was at par with Treatment 14 (2524.44 kg ha^{-1}) followed by Treatment 9 (2516.62 kg ha^{-1}).On the other hand significantly lowest "stover yield" was recorded with Treatment 15 (1923.33 kg ha^{-1}). Similar finding were reported by Patel *et al*, (2006) [10], Singh *et al*, (2017) [13] and Poonia *et al*, (2013) [11].

Harvest index (%)

The findings revealed that weed management practices had a major impact on harvest index (percent). The data revealed that all the weed management practices resulted in significantly higher harvest indices when compared to the control. This suggests that effective weed management strategies had a positive impact on the overall productivity of the crops, leading to higher harvest indices.

The highest harvest index was recorded in Treatment 8 (43.46%) followed by Treatment 14 (42.99%) then Treatment 9 (42.77%) among the chemical weed management practices. On the other hand significantly lowest harvest index was found by Treatment 15 (28.91%).

The higher harvest index observed in the weed management practices could be attributed to the efficient translocation of photosynthates during the reproductive stage, ensuring that a larger proportion of the plant's resources were directed towards seed production within the total yield. This outcome aligns with the findings of Chaudhary *et al.* (2005) [5] and Pooniya *et al.* (2009) [12], indicating that effective weed management strategies can enhance the allocation of resources towards seed production and ultimately lead to a higher harvest index.

Table 1: Yield attributes of chickpea as influenced by various herbicide treatments

S. N.	Treatments	Number of pods plant^{-1}	Number of seeds pod^{-1}	100 seed Weight (g)
T_1	Oxadiargyl 80 g ha^{-1} at 0-3 DAS	33.87	1.25	24.91
T_2	Metribuzin 350 g ha^{-1} at 0-3 DAS	34.68	1.27	25.04
T_3	Topramezone 19.35 g ha^{-1} at 2-3 Leaf stage of weed	36.71	1.45	26.58
T_4	Topramezone 25.8 g ha^{-1} at 2-3 Leaf stage of weed	36.98	1.50	26.83
T_5	Topramezone 32.25 g ha^{-1} at 2-3 Leaf stage of weed	37.54	1.65	27.85
T_6	Topramezone 25.8 g ha^{-1} at 5-6 Leaf stage of weed	36.70	1.40	26.58
T_7	Topramezone 32.25 g ha^{-1} at 5-6 Leaf stage of weed	37.32	1.60	27.62
T_8	Metribuzin 350 g ha^{-1} *fb* Topramezone 25.8 g ha^{-1} at 0-3 DAS & 2-3 Leaf stage of weed	38.58	2.15	28.86
T_9	Metribuzin 350 g ha^{-1} *fb* Topramazone 25.8 g ha^{-1} at 0-3 DAS & 5-6 Leaf stage of weed	38.28	1.75	28.25
T_{10}	Fluzifop-p-butyl 13.4% + fomesafen11.1% 250 g ha^{-1} at 2-3 Leaf stage of weed	33.23	1.20	24.73
T_{11}	Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) 187.5 g ha^{-1} at 2-3 leaf stage of weed	35.83	1.40	25.68
T_{12}	Mertibuzin (directed application) 350 g ha^{-1} at 2-3 leaf stage of weed	35.12	1.30	25.26
T_{13}	Metsulfuron (directed application) 4 g ha^{-1} at 2-3 leaf stage of weed	35.39	1.35	25.52
T_{14}	Hand weeding twice at 20 & 40 DAS	38.29	1.9	28.29
T_{15}	Unweeded control	19.46	1.1	24.38
	SEm±	1.28	0.65	0.08
	CD (at 5% level)	3.54	NS	NS

Table 2: Seed yield, Stover yield and harvest index of chickpea as influenced by various herbicide treatments

S. N.	Treatments	Seed yield (kg/ha)	Stover yield (Kg/ha)	Harvest index (%)
T_1	Oxadiargyl 80 g ha^{-1} at 0-3 DAS	1045.77	2420.15	30.17
T_2	Metribuzin 350 g ha^{-1} at 0-3 DAS	1283.49	2422.95	34.63
T_3	Topramezone 19.35 g ha^{-1} at 2-3 Leaf stage of weed	1586.71	2468.49	39.13
T_4	Topramezone 25.8 g ha^{-1} at 2-3 Leaf stage of weed	1620.90	2486.83	39.46
T_5	Topramezone 32.25 g ha^{-1} at 2-3 Leaf stage of weed	1820.57	2503.64	42.10
T_6	Topramezone 25.8 g ha^{-1} at 5-6 Leaf stage of weed	1482.59	2463.36	37.57
T_7	Topramezone 32.25 g ha^{-1} at 5-6 Leaf stage of weed	1748.12	2492.32	41.22
T_8	Metribuzin 350 g/ha *fb* Topramezone 25.8 g ha^{-1}at 0-3 DAS & 2-3 Leaf stage of weed	1956.27	2545.01	43.46
T_9	Metribuzin 350 g/ha *fb* Topramezone 25.8 g ha^{-1} at 0-3 DAS & 5-6 Leaf stage of weed	1880.93	2516.62	42.77
T_{10}	Fluzifop-p-butyl 13.4% + fomesafen11.1% 250 g ha^{-1} at 2-3 Leaf stage of weed	1113.04	2405.00	31.64
T_{11}	Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) 187.5 g ha^{-1} at 2-3 leaf stage of weed	1358.03	2455.86	35.61
T_{12}	Mertibuzin (directed application) 350 g ha^{-1}at 2-3 leaf stage of weed	1304.98	2441.56	34.83
T_{13}	Metsulfuron (directed application) 4 g ha^{-1} at 2-3 leaf stage of weed	1320.35	2452.14	35.00
T_{14}	Hand weeding twice at 20 & 40 DAS	1903.56	2524.44	42.99
T_{15}	Unweeded control	782.40	1923.83	28.91
	SEm±	32.62	26.31	-
	CD (at 5% level)	94.49	76.21	-

Conclusion

Treatment 8, achieved superior results in terms of various yield-contributing factors, including the number of pods per plant, the number of seeds per pod, 100-seed weight, and harvest index. This treatment was closely followed by Treatment 14 and Treatment 9.

Furthermore, Treatment 8 was found to be economically advantageous compared to the other treatments. It yielded the highest gross return of Rs 93901 per ha^{-1}, net return of Rs 56615 per ha^{-1}, and a favorable benefit-to-cost ratio (B:C ratio) of 2.52. These findings highlight the economic viability and productivity of treatment T_8 in the context of chickpea cultivation.

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