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To workout the economics of chickpea (*Cicer arietinum* L.) under effect of different herbicides

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Abstract
The study titled "To workout the economics of chickpea (*Cicer arietinum* L.) under effect of different herbicides" was conducted at the Research Farm of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the 2020-21 *rabi* season. The experimental field featured neutral soil pH, characterized by low nitrogen, medium phosphorus, and high potassium levels. The research followed a randomized block design with three replications, incorporating a total of 15 distinct herbicidal 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). 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.
In terms of economic returns, both gross returns and net returns were highest under Treatment 8: metribuzin 350 gram per hectare followed by topramazone 25.8 gram per hectare (at 0-3 Days After Sowing and 2-3 Leaf stage of weed). Following closely behind were Treatment 14: hand weeding twice at 20 and 40 Days After Sowing, and Treatment 9: metribuzin 350 gram per hectare followed by topramazone 25.8 gram hectare (at 0-3 Days After Sowing and 5-6 Leaf stage of weed).
However, when considering net returns and the benefit-to-cost (B:C) ratio, Treatment 8: metribuzin 350 gram per hectare followed by topramazone 25.8 gram per hectare (at 0-3 Days After Sowing and 2-3 Leaf stage of weed) stood out as the most economically favorable option. This difference in economic performance may be attributed to the higher cultivation costs associated with the frequent weeding required in Treatment 14: hand weeding twice at 20 and 40 Days after Sowing.

Keywords: Herbicides, chickpea, economics

Introduction
Chickpea (*Cicer arietinum* L.) holds a significant position as a crucial winter season pulse crop. It serves as a vital source of protein and plays a pivotal role in the nutritional well-being of large populations in developing countries. 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 maintain and improve 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 cultivation, 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) [2]. Chickpea's prominence in Indian agriculture underscores its significance as a staple crop for both sustenance and economic development in the region.

Weed infestation is a significant challenge in chickpea production. 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). 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), 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 conducted at the Research cum Instructional 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 nitrogen (N), phosphorus (P), and potassium (K) content, specifically low nitrogen, medium phosphorus, and high potassium. These soils also displayed a neutral pH. The study focused on the JL-3 chickpea test variety, and the research was carried out using a Randomized Block Design. 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 variety "Indira Chana 1" was sown on November 15, 2020, and it was subsequently harvested on March 5, 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

Cost of cultivation (Rs ha^{-1})

Highest cost of cultivation was associated with treatment Treatment 14 - Hand weeding twice 20 and 40 Days After Sowing (42990 Rs ha^{-1}) followed by Treatment 5 - Topramezone 32.25 gram per hectare 2-3 Leaf stage of weed (37660 Rs ha^{-1}) and Treatment 7- Topramezone 32.25 gram per hectare 5-6 Leaf stage of weed (37660 Rs ha^{-1}). It's noteworthy that the lowest cost of cultivation was observed in Treatment 15 - Unweeded control (30350 Rs ha^{-1}).

This is likely attributed to the substantial labor needed for continuous manual weeding in Hand weeding twice at 20 & 40 DAS treatment. Lhungdim *et al.* (2013) [8], Kalyani (2011) [7].

Gross return (Rs ha^{-1})

Treatment 8 - Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 2-3 Leaf stage of weed (93901 Rs ha^{-1}) recorded highest gross return followed by Treatment 14 - Hand weeding twice 20 and 40 Days After

Sowing (91371 Rs ha^{-1}) and lowest gross return was obtained in Treatment 15 - Unweeded control (37555 Rs ha^{-1}). Lhungdim *et al*. (2013) [8], Kalyani (2011) [7].

Net return (Rs ha^{-1})

Treatment 8 - Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 2-3 Leaf stage of weed (56615 Rs ha^{-1}) recorded highest net return followed by Treatment 9 - Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 5-6 Leaf stage of weed (52999 Rs ha^{-1}). It's noteworthy that the lowest net return was obtained in Treatment 15 - Unweeded control (7205 Rs ha^{-1}).

The higher net return observed in Treatment 8 - Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 2-3 Leaf stage of weed can likely be attributed to the effective control of weeds throughout the entire crop period. This effective weed management strategy in Treatment 8 - Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 2-3 Leaf stage of weed led to higher yields while keeping cultivation expenses relatively lower, thus resulting in a more profitable outcome. and higher weed competition resulted in very low yield in T_{15}: Unweeded control. Lhungdim *et al*. (2013) [8] and Kalyani (2011) [7].

B:C ratio

Treatment 8 - Metribuzin followed by Topramezone 350-25.8 gram per hectare 0-3 Days After Sowing and 2-3 Leaf stage of weed (2.52) resulted in highest B: C ratio and lowest B: C ratio was recorded in treatment 15: Unweeded control (1.24). The observation that Treatment 8 had higher seed and straw yields with relatively lower cultivation costs suggests that this treatment was particularly efficient in terms of resource utilization and productivity Lhungdim *et al*. (2013) [8] and Kalyan (2011) [7].

Table 1: Economics of different weed management practices in chickpea.

	Treatments	Cost of cultivation (Rs ha^{-1})	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
T_1	Oxadiargyl 80 g ha^{-1} at 0-3 DAS	32238	50197	17919	1.56
T_2	Metribuzin 350 g ha^{-1} at 0-3 DAS	32400	61608	29208	1.90
T_3	Topramezone 19.35 g ha^{-1} at 2-3 Leaf stage of weed	35000	76162	41162	2.18
T_4	Topramezone 25.8 g ha^{-1} at 2-3 Leaf stage of weed	36184	77803	41619	2.15
T_5	Topramezone 32.25 g ha^{-1} at 2-3 Leaf stage of weed	37660	87387	49727	2.32
T_6	Topramezone 25.8 g ha^{-1} at 5-6 Leaf stage of weed	36184	71164	34980	1.97
T_7	Topramezone 32.25 g ha^{-1} at 5-6 Leaf stage of weed	37660	83910	46250	2.23
T_8	Metribuzin 350 g ha^{-1} *fb* Topramezone 25.8 g ha^{-1} at 0-3 DAS & 2-3 Leaf stage of weed	37286	93901	56615	2.52
T_9	Metribuzin 350 g ha^{-1} *fb* Topramezone 25.8 g ha^{-1} at 5-6 DAS & 2-3 Leaf stage of weed	37286	90285	52999	2.42
T_{10}	Fluzifop-p-butyl 13.4% + fomesafen11.1% 250 g ha^{-1} at 2-3 Leaf stage of weed	33186	53426	20240	1.61
T_{11}	Sodium acifluorfen16.5%+ clodinafop proparzyl 8% (directed application) 187.5 g ha^{-1} at 2-3 leaf stage of weed	32780	65185	32405	1.99
T_{12}	Mertibuzin (directed application) 350 g ha^{-1} at 2-3 leaf stage of weed	32400	62639	30239	1.93
T_{13}	Metsulfuron (directed application) 4 g ha^{-1} at 2-3 leaf stage of weed	31748	63377	31629	2.00
T_{14}	Hand weeding twice at 20 & 40 DAS	42990	91371	48381	2.13
T_{15}	Unweeded control	30350	37555	7205	1.24

Conclusion

- Cost of cultivation was obtained highest in Treatment 14 - hand weeding twice at 20 and 40 Days After Sowing followed by Treatment 5 - topramezone 32.25 gram per hectare at 2-3 leaf stage of weed and Treatment 7 - topramezone 32.25 gram per hectare (at 5-6 leaf stage of weed). Highest gross return was observed in Treatment 8 - metribuzin 350 gram per hectare *followed by* topramezone 25.8 gram per hectare (at 0-3 Days After Sowing and 2-3 leaf stage of weed) followed by Treatment 14 - hand weeding twice at 20 and 40 Days After Sowing respectively.
- Net monetary return and B:C ratio was recorded highest in Treatment 8 - metribuzin 350 gram per hectare followed by topramezone 25.8 gram per hectare (at 0-3 Days After Sowing and 2-3 leaf stage of weed).

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