The Pharma Innovation Journal 2023; 12(8): 2461-2464

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(8): 2461-2464

www.thepharmajournal.com
Received: xx-05-2023
Accepted: xx-06-2023

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Studies on economics of various herbicides for controlling weeds in chickpea (*Cicer arietinum* L.)

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Abstract
The current study, titled "Studies on Bioefficacy of Different Herbicides for Weed Management in Chickpea [*Cicer arietinum* L.]". Ten treatments were applied in the field experiment, which the setup using a randomised block design. Among herbicides, oxyfluorfen had the tallest plant height values (41.67), number of leaves (122), and number of branches (8.67) at harvest. In terms of plant height, it was comparable to quizalofop-p-ethyl (T_6) (40.33). The highest seed yield (1788 kg/ha) was recorded by the weed-free treatment (T_9), which was comparable to hand weeding at 30 DAS and hoeing at 45 DAS (T_8) (1632 kg/ha), Oxyflourfen (T_3), and quizalofop-p-ethyl (T_6). The herbicide oxyfluorfen (T_3) yielded the highest seed production (1574 kg/ha), that was comparable to quizalofop-p-ethyl (T_6) (1525 kg/ha). The weed-free treatment (T_9) outperformed all other treatments in terms of seed yield (1788 kg ha^{-1}). During the experimental period, the chickpea was found to be associated with *Parthenium hysterophorus, Medicago denticulate, Chenopodium album, Cynodon dactylon, and Echinochloa colonum*. Oxyflourfen a type of herbicide, recorded a (5) weed count and (5) dry matter of weed at harvest. In the weedy check, there were 37 weeds counted and 54 weeds with dry matter. At harvest, oxyfluorfen (T_3) recorded the highest weed control efficiency (90.74), proceeded by (T_8) hand weeding at 30 DAS and hoeing at 45 DAS (79.62), and (T_7) imazethapyr (58.64%). Next, the oxyfluorfen treatment (T_3) (11.96%) and the weedy check (T_{10}) (49.04%) recorded the lowest and highest weed indices, respectively.

Keywords: Chickpea, herbicide, weed, weed management, pre emergence, post emergence

Introduction
A staple of the cooler months is the legume with wide geographic distribution is the chickpea (*Cicer arietinum* L.). The name Cicero, which refers to a well-known Roman family, is a translation of the Greek word "Kiros." From the Latin word for arietinum "aries," which means "ram" and alludes to the kabuli chickpea's ram-like shape. In different countries, the chickpea is referred to as gramme, garbanzo, chana, Bengalgram, pois, hoos, hommos, and hoos de beco. (From Dr. Rajendra Prasad's Textbook of Field Crop Production, Vol. 1) [6].

Leguminoceae is the family that includes chickpeas (*Cicer arietinum* L.). It is regarded as the supreme pulse. India's primary pulse crop is chickpea. The important pulse crop in India is the chickpea. Chickpea is also referred to as Bengal Gramme or Gramme. Chickpeas are used to purify blood and are thought to have medicinal properties. Scurvy is a disease that is treated with chickpea seeds that have germinated. Malic acid and oxalic acid are responsible for the specific sour taste of Gramme leaves.

Due to its ability to fix nitrogen, chickpea also contributes significantly to raising soil fertility. Chickpeas can replenish up to 140 kg of N per hectare during a growing season (Poonia and Pithia, 2013) [1]. These leaves provide a lot of organic matter to support and enhance the quality and fertility of soils as well as significant amounts of residual nitrogen for upcoming crops. India leads the world in both area and production on a global scale. In terms of area, Pakistan, Iran, and Australia come after India, while Australia and Myanmar come after it in terms of production. The total area planted with pulses was 89405 ha, and there were 749190 tonnes produced overall, with a global average productivity of 4631 kg ha^{-1}. (Economics & Statistics Directorate 2021).

In India, the chickpea is the most widely grown pulse crop. During 2020-2021, India will produce 9.85 million/ha, 11.99 MT and 1217 kg ha^{-1} on average of chickpeas. (Economics & Statistics Directorate 2021).

Rajasthan follows Madhya Pradesh in terms of acreage and production in India. 2.10 million Ha and 3.13 million tonnes of chickpea are produced in Madhya Pradesh (Directorate of Economics & Statistics Report 2020-2021).

In Maharashtra Amravati district leads in chickpea production, with a share of 8%, followed by Ahmadnagar (7%), Akola (7%), Hingoli (6%), Washim (5%), Buldhana (5%), Latur (5%), Osmanabad (5%), Nagpur (5%), Jalgaon (5%), Nanded (5%) and other district in the state by 38%. (Mafwda 2021).

Chickpea production (7.96 lakh tonnes), productivity (707 kg/ha), and area (9.89 lakh/ha) in the Marathwada region were all noted in the years 2020-21. The region's contribution to the state area is 36.53%, and its average production share over the past ten years is 35.38%. (Chief Statistician Commisionarate of Agriculture Report, Pune 2020-2021) [7].

There are many reasons why the average yield of chickpeas is so low because weed which competes with the crop for moisture, nutrients, space, and light, is one of the major factors contributing to this low productivity in chickpea. In the winter, irrigated and rainfed pulses (*Asphodelus tenuifolius* L.) are home to lamb's quarters (*Chenopodium album* L.), scarlet pimpernel (*Anagallis arvensis* L.), and (*Fumaria parviflora* L.). In northern and central India on light soils, it appears in various flushes and causes problems for rainfed lentil and chickpea crops (Kumar, 2010) [9]. The growth of weeds makes it difficult to increase chickpea yield and facilitate harvesting. Chickpea is a weed competitor because it grows slowly and only develops a small amount of leaf area at the beginning of the crop's growth and establishment. The amount of yield loss brought on by weed competition varies significantly. Despite this, almost all values accurately reflect how serious the weed problem is.

Weeds are a major issue for the chickpea crop because, at the moment, fewer herbicides are advised for chickpea than for other commercial crops, and because hand weeding is impractical because of the high wages of farm labourers. Weeds compete fiercely with this crop for all growth factors because of its short height and slow initial growth. The losses caused by weeds may range from 40 to 80 percent, according to the severity of the weed vegetation and the length of the infestation (Vaishya *et al*., 1996) [8]. By using an efficient herbicide in conjunction with better crop management that can effectively control these weeds, the per unit yield of this crop can be increased.

Older herbicides like pendimethalin, alachlor, and oxyfluorfen are still used frequently to control weeds in chickpea. The brand-new herbicide that targets post-emergence Topramezone needs to be tested on chickpeas. It has wide-ranging weed control. At 45 and 95 DAS, respectively, topramezone reduces 68-70% and 48-51% reductions in total weed density less than the unweeded control (research gate net). Accordingly, the effectiveness of Imazethapyr and Quizalofop in chickpea needs to be compared to that of ethyl and topramezone.

Weeds affect crop plant development, yield and quality as well as soil fertility, accessible soil moisture and crop plants and nutrients compete for space and sunlight. Weeds are a serious threat to chickpea crops in both rainfed and irrigated environments. According to Vaishya *et al*. (1996) [8], weeds can reduce seed yield by 40-87 percent.

Material and Methods

The current study, titled "Studies on the bioefficacy of different herbicides for weed management in chickpea [*Cicer arietinum* L.]," was completed at the Badnapur College of Agriculture. Soil properties included a clay-like texture, a medium nitrogen availability, a low phosphorus availability, a high potassium availability, and a slightly alkaline reaction. The environment that prevailed during the experimental period was favourable for the normal growth and maturity of the chickpea crop.

The randomised block design field experiment included ten treatments. treatments comprised of treatment comprised of pendimethalin (30% EC) @ 0.50 kg a. i/ ha (PE) (T_1), alachlor (50% EC) @ 0.30 kg a. i /ha (PE) (T_2), oxyfluorfen (23.5% EC) @ 0.17 Kg a. i / ha (PE) (T_3), topramezone 25.7 g a.i / ha at 14 DAS (PoE) (T_4), topramezone 25.7 g a.i / ha at 21 DAS (PoE) (T_5), quizalofop ethyl (5% EC) @0.80 kg a. i/ ha at 21 DAS (PoE) (T_6), imazethapyr (10% S. L) @ 0.75 Kg a. i / ha at 21 DAS (PoE) (T_7), hand Weeding at 30 DAS & hoeing at 45 DAS (T_8), weed free (hand weeding as and when Required) (T_9), weedy check (T_{10}). For each experimental unit, gross plot and net plot sizes were, respectively, 4.5 m x 5.0 m and 3.6 x 4.8 m^2 Sowing was completed on October 19, 2021, using the dibbling method with 45 cm x 10 cm spacing. All treatments received the recommended seed treatment, pest management, irrigation, and fertiliser management. The fertiliser dose for chickpea crop was 25: 50: 00: kg NPK ha^{-1}.

Results and Discussion

Mean number of weeds m^2

Table 1.1 lists the average number of weeds at various harvesting stages growth as affected by various management of weeds strategies.

At 30 days, significantly lowest weed count was observed in treatment of Oxyfluorfen (T_3) which was at par with Hand weeding at 30 DAS & Hoeing at 45 DAS (T_8) (5.63), Pendimethalin (T_1) (6.33), Topramezone (T_4), Topramezone (T_5) (7.20) respectively. Weedy check treatment (T_{10}) was associated with the highest mean number of weeds per m^2 (24). Compared to the weedy check (T_{10}), all treatments successfully reduced the weed infestation. Reduced weed infestation due to Pendimethalin application @ 0.75 kg a.i. per ha was reported by Rao *et al*. (2015) [10], quizalofop-ethyl @ 60 g ha^{-1} was reported by kumar *et al*. (2015) [9], imazethapyr @ 37.5 g ha^{-1} was reported by Singh *et al*. (2014), oxyflourfen was reported by Yousefi *et al*. (2007) [10] was observed due to timely control of weeds.

At 60 days, weed count was much lower than noticed in treatment of (T_3) which was at par with Hand weeding at 30 DAS & Hoeing at 45 DAS (T_8) (6.93), Pendimethalin (T_1) (7.33), Topramezone (T_4) (8), Topramezone (T_5) (8.20), respectively. Weedy check treatment (T_{10}) resulted in the highest average number of weeds per square metre (36). Compared to the weedy check (T_{10}), all treatments successfully reduced the weed infestation. Similar trend was also observed at at harvest.

Economics of chickpea cultivation

Gross financial returns (Rs ha^{-1})

Under the weed-free treatment (T_9), the highest gross monetary returns (GMR) were attained (89400 ₹ ha^{-1}) which was at par with hand weeding at 30 DAS & hoeing at 45 DAS (T_8) (81600 ₹ ha^{-1}), oxyfluorfen (T_3) (78700 ₹ ha^{-1}), respectively, and was significantly more than treatments quizalofop-p-ethyl (T_5) (76250 ₹ ha^{-1}), pendimethalin (T_1) (75250 ₹ ha^{-1}), alachlor (T_2) (73550 ₹ ha^{-1}), imazethapyr (T_7) (69550 ₹ ha^{-1}), topramezone (T_5) (65000 ₹ ha^{-1}), topramezone (T_4) (62600 ₹ ha^{-1}). The lowest gross monetary returns

recorded in weedy check (T_{10}) (45550 ₹ ha^{-1}) high seed yield due to weed free treatment and herbicides are weedy check contributed to more gross monetary returns. Higher economical yield and grain yield due to application of herbicides ultimately resulted into improved gross monetary returns over weedy check. Dubey *et al.*, (2001) [4] was also reported higher gross monetary return (67932 ₹ ha^{-1}) under the treatment imazethapyr and pendimethalin.

Net financial returns (Rs ha^{-1})

The highest Net Monetary Returns (NMR) were obtained through the Oxyfluorfen (T_3) (49155 ₹ ha^{-1}), weed free treatment (T_9) (47750 ₹ ha^{-1}) which was at par with Hand weeding at 30 DAS & Hoeing at 45 DAS (T_8) (45280 ₹ ha^{-1}), respectively, and was Significantly more than treatments Quizalofop-p-ethyl (T_5) (46705 ₹ ha^{-1}), Pendimethalin (T_1) (45843 ₹ ha^{-1}), Alachlor (T_2) (45830 ₹ ha^{-1}), Imazethapyr (40153 ₹ ha^{-1}), Topramezone (T_5) (35408 ₹ ha^{-1}), Topramezone (T_4) (33008 ₹ ha^{-1}). The lowest Net monetary returns recorded in weedy check (T_{10}) (20205 ₹ ha^{-1}). Increases cost under weed free treatment reduced net monetary returns cost. Dubey *et al.*, (2001) [4] was also reported higher net monetary return (44835 ₹ ha^{-1}) under the treatment of pendimethalin @ 1.0 kg ha^{-1} and imazethapyr (@ 75 g ha^{-1}). Higher net monetary returns due to application of herbicides over weedy check indicated improved yield as well as lower cost involved in application of herbicides. increased cost of cultivation for weed free regulated into compare net monetary returns with hand weeding at 30 DAS & hoeing at 45 DAS (T_8) (52280 ₹ ha^{-1}), oxyfluorfen (T_3) (49155 ₹ ha^{-1}), quizalofop-p-ethyl (T_5) (46705 ₹ ha^{-1}), pendimethalin (T_1) (45843 ₹ ha^{-1}), alachlor (T_2) (45830 ₹ ha^{-1}), imazethapyr (T_3) (40153 ₹ ha^{-1}), topramezone (T_5) (35408 ₹ ha^{-1}), topramezone (T_4) (33008 ₹ ha^{-1})

Benefit: Cost Ratio

The B:C ratio was considerably more Oxyfluorfen (T_3) (2.66), Alachlor (T_2) (2.65), Quizalofop-p-ethyl (T_5) (2.58), Pendimethalin (T_1) (2.55), Imazethapyr (2.36), Hand weeding at 30 DAS & Hoeing at 45 DAS (T_8) (2.24), Topramezone (T_5) (2.19), weed free (T_9) (2.14), Topramezone (T_4) (2.11) and significantly lower B:C ratio weedy check was recorded in (T_{10}) (1.79) plot, respectively. Gore *et al*, (2015) [11] was also reported higher benefit cost ratio (3.23 and 2.86) quizalofop @ 40 g ha^{-1} and imazethapyr @ 0.75 kg ha^{-1} showed their superiority over weedy check.

Maximum net profit, maximum gross return, and benefit: cost ratio was obtained under weed free treatment (T_9). The higher B:C ratio may be attributed due to higher seed yields in combination with lower chemical treatment cost.

Yield attributes

Different treatments had a substantial impact on chickpea yield attributing characters such as pod yield plant^{-1} (g), seed yield plant^{-1} (g), seed index (g), seed yield (kg ha^{-1}), straw yield (kg ha^{-1}), and biological yield (kg ha^{-1}). Maximum number of Pod yield plant^{-1} (19.97 g), seed yield plant^{-1} (16.67 g), Seed index (19.67 g), Seed Yield (1788 kg ha^{-1}), Straw Yield (3128 kg ha^{-1}) Biological Yield (4916 kg ha^{-1}) was recorded with the weed free treatment (T9) which was at par with hand weeding at 30 DAS & hoeing at 45 DAS (T_8), oxyfluorfen (T_3), pendimethalin (T_1), alachlor (T_2), quizalofop ethyl (T_6), respectively and was significantly more than imazethapyr (T_7), topramezone (T_5), topramezone (T_4). Total pod yield plant^{-1} found in weedy check (T_{10}) (9.33g) was lower than the rest of all treatments. The more pod yield due to application of oxyfluorfen (17.33) and pendimethalin (17.63) over weedy check (T_4) (9.33) was also reported by Poonia and Pithia (2013) [1], respectively. Goud *et al.* (2013) [4] found that using imazethapyr at lower doses (@ 0.75g ha^{-1}) conclude that High pod yeild. Comparable branches of herbicide application with weed free treatment may be associated with higher pod yield due to timely weed control. The higher pod yield in the weed-free treatment could be attributed to less competition from weeds for space, nutrients, and water. The lower number of pod yield in the weedy check treatment could be attributed to weeds competing with chickpea for space, nutrients, and water. Kachhadiya *et al.* (2009) [3] and Pooniya *et al.* (2009) [2] found similar results.

Table 1: Number of weeds per m^2 as influenced by various treatment at different crop growth stages.

Treatment details	30 DAS	60 DAS	At harvest
T_1: Pendimethalin (30% EC) @ 0.50 kg a. i/ ha	6.33	7.33	8.33
T_2: Alachlor (50% EC) @ 0.30 kg a. i /ha	8	9.5	10.5
T_3: Oxyfluorfen (23.5% EC) @ 0.17 Kg a. i / ha	4	4	5
T_4: Topramezone 25.7 g a.i / ha at 14 DAS	7	8	9
T_5: Topramezone 25.7 g a.i / ha at 21 DAS	7.20	8.20	9.20
T_6: Quizalofop ethyl (5% EC) @0.80 kg a. i/ ha at 21 DAS	7.93	9.26	10.26
T_7: Imazethapyr (10% S. L) @ 0.75 Kg a. i / ha at 21 DAS	8.66	11	12
T_8: Hand weeding at 30 DAS & Hoeing at 45 DAS	5.63	6.93	7.93
T_9: Weed free (Hand Weeding as and when Required)	0.00	0.00	0.00
T_{10}: Weedy check	24	36	37
SE (m) ±	1.20	1.38	1.54
CD at 5%	3.56	4.09	4.57
GM	7.88	10.02	10.92

Table 2: Economics of chickpea cultivation as affected by different treatments.

Treatments	Seed Yield (kg per ha)	Pod yield per plant (g)	Seed yield per plant (g)	Cost of cultivation (₹ per ha)	Gross Monetary Return (₹ per ha)	Net Monetary Return (₹ per ha)	Benefit Cost ratio
T_1: Pendimethalin (30% EC) @ 0.50 kg a. i/ ha	1505	17.63	14.3	29407	75250	45843	2.55
T_2: Alachlor (50% EC) @ 0.30 kg a. i /ha	1471	17.06	14	27720	73550	45830	2.65
T_3: Oxyfluorfen (23.5% EC) @ 0.17 Kg a. i / ha	1574	17.33	14.67	29545	78700	49155	2.66
T_4: Topramezone 25.7 g a.i / ha at 14 DAS	1252	11.33	10.00	29592	62600	33008	2.11
T : Topramezone 25.7 g a.i / ha at 21 DAS	1300	11.67	10.67	29592	65000	35408	2.19
T_6: Quizalofop ethyl (5% EC) @0.80 kg a. i/ ha at 21 DAS	1525	17.03	13.66	29545	76250	46705	2.58
T_7: Imazethapyr (10% S. L) @ 0.75 Kg a. i / ha at 21 DAS	1391	14.33	11.66	29407	69550	40153	2.36
T_8: Hand weeding at 30 DAS & Hoeing at 45 DAS	1632	18.67	15.07	36320	81600	45280	2.24
T_9: Weed free (Hand Weeding as and when Required)	1788	19.97	16.67	41650	89400	47750	2.14
T_{10}: Weedy check	911	9.33	8	25345	45550	20205	1.79
SE(m)+	138	1.12	1.08	-	395.58	426.01	-
CD at 5%	410	3.32	3.20	-	1175.36	1265.78	-
General mean	1434	15.44	12.87	28506	71745	43240	2.51

Conclusion

The findings of this investigation demonstrate that the use of oxyfluorfen (T_3) has a significant impact on yield parameters such as number of filled seeds, test weight, weight of seed per plant, bio-yield and harvest index, and seed yield, as well as characteristics of Growth like Height of the plant, total area of leaf, number of leaves etc.

In terms of weed control, the most successful herbicide application was oxyfluorfen (T_3), while imazethapyr (T_7) had the least effective method (58.64%).

Weed index (49.04%), the reduction yield, was higher for the weedy check. The herbicide treatment with the lowest weed index (11.96) was oxyfluorfen (T_3) treatment.

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