

# Original Research Article

## Effect of combined application of herbicides on weed flora, Yield attributes Yield, and Profitability of chickpea (*Cicerarietinum L.*)

### Abstract

A field experiment was conducted during the *rabi* seasons of 2021-22 at the Agronomy Research Farm of the Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (UP). ~~The field experiment was laid out in a randomized block design~~ ~~X~~ ~~assigning~~ ~~Replicated~~ ~~thrice~~ ~~set of~~ eleven treatments ~~viz.,~~ (1=Pendimethalin 30 EC @ 1.0 kg a.i./ha PE, 2=Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE, 3=Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE, 4=Propaquizafop 10 EC @ 0.075 kg a.i./ha PoE, 5=Quizalfop ethyl 5 EC @ 40 g a.i./ha PoE, 6=Pendimethalin 30 EC @ 1.0 kg a.i./ha PE Fb by Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE, 7=Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Propaquizafop 10 EC @ 0.075 kg a.i./ha PoE, 8=Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE, 9=Pendimethalin 30 EC @ 1.0 kg a.i./ha pEfb by Quizalfop ethyl 5 EC @ 40 g a.i./ha PoE, 10=Weed free and 11=Weedy check) ~~was laid out in randomized block design,~~ ~~replicated~~ ~~thrice~~. Weed management was done as per treatment. Other crop management practices were followed as per the recommendation of the area. Pendimethalin @1.0 kg a.i./ha PE fb Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha as PoE during the experiment recorded significantly less weed density, weed dry matter, and higher weed control efficiency, yield attributes (number of pods/plant, number of seeds/pod and test weight), yield (grain yield, stover yield, biological yield, and harvest yield). Economically it recorded higher gross returns, the net return, and B:C ratio was noted and proved to be more remunerative as compared to other herbicide applications used in chickpea crop.

**Keywords:** Herbicide combination, Chickpea, Weed management, Clodinafoppropargyl

### 1. INTRODUCTION

Pulses are an integral part of Indian agriculture. Chickpea (*Cicerarietinum L.*) commonly known as gram or Bengal gram belongs to the family Leguminaceae (Fabaceae). It's one of the most important *rabi* season pulse crops grown in India for economic importance and to improve soil fertility. In Indian pulses, chickpea is the second most important component of the diet after cereals. The net availability of food grains per capita increased day by day from 144.1 kg/year in 1951 to 179.6 kg/year in 2019 despite population growth however the net obtainability of pulses has reduced from 25 kg/year in 1961 to 17.5 kg/year in 2019 [1] (Anonymous, 2020). Chickpea is a major pulse crop in India which contributed about 71% of the world's area (13.57 million hectares) and 67% of the world's production. India ranked first in the area with 9.93 million hectares (34%) and first in production with 9.53 million tones (26%) in the world, followed by Pakistan, Australia, and Iran. In India, during 2019-20, pulses were cultivated over

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**Comment [AF9]:** Follow the journal Guidelines, References must be listed at the end of the manuscript and numbered in the order that they appear in the text. Every reference referred in the text must also present in the reference list and vice versa. In the text, citations should be indicated by the reference number in brackets [3].

more than 29 million hectares of area and registered the highest ever production of 25.90 mt with a productivity level of 908 kg/hectares. The exponential growth rate in pulse production over the past year has been more than 9 percent. (Anonymous, 2020) The highest **productivity production** of 6120 kg/ha is observed in Israel followed by Yemen, Canada, and Egypt. India's productivity was 920 kg/ha yields, (Anonymous, 2020). Today, 80% of total pulses production, in India, is realized in six states namely, Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, and Uttar Pradesh. The productivity of chickpea is low despite **of having** high-yielding varieties and new agronomic practices. One of the causes of poor productivity is the infestation of weeds in the field of chickpea. It is a poor competitor to weeds because of its slow growth rate and limited leaf area development at early stages. Crop yield losses due to non-adoption of weed management practices particularly in **assured**-irrigated conditions. Poonia and Pithia (2013) reported a 54.7% loss in grain yield due to weed competition in chickpea under rainfed conditions. Major weeds associated with chickpea vary with crops and locations. The Directorate of Weed Research (DWR), Jabalpur, has developed a Weed Atlas for major weeds in major crops in 435 districts spread across 19 states of the country and published a handbook on weed identification (Naidu 2012). Its findings concluded that weeds have economic significance in specific crops (Rao-*et al.* 2014). Weeds for Chickpea are; *Chenopodium album*-L., *Avena fatua*-L., *Medicago denticulata*, *Chicorium intybus*, *Convolvulus arvensis*-L., *Lathyrus aphaca*-L. *Lathyrus sativus*-L., *Vicia sativa*, *Cyperus rotundus*-L., *Phalaris minor*, *Avena ludoviciana*, *Euphorbia geniculata*, and *Melelotus spp.* etc. In the total annual loss of agricultural produce from various pests in India, weeds roughly account for 37%, insects for 29%, diseases for 22%, and other pests for 12% (Yaduraju, 2006). Weed emergence with the *rabi*-sown chickpea crop creates competition unless controlled timely and effectively. **There is,** Therefore, **it is need of hour an urgent need** to move from the **costly expensive** manual and mechanical weed control **practices** to chemical weed control (Marwat-*et al.*, 2003). The predominant method of weed control by mechanical hoeing and manual weeding over an extensive scale is **found to decline declining** because **availability of labor due to of a shift ed from of** agricultural **laborers fields** to industries for better and assured wages. **Weed control methods such as eradication of weeds through** manual weeding. **However, and** hoeing is expensive, tedious, and time-consuming, **and On the other hand use of single herbicides used individually** cannot achieve complete weed control due to their selective destruction. **Their** Therefore use **of herbicide can will be made** more effective if supplemented by manual weeding and hoeing. **It is a** well-known fact that relying on a single weed control method is ineffective, and an integrated approach may be required. Among several herbicides in the market *viz.* Pendimethalin, Clodinafoppropargyl, Quizalofop-ethyl, Propaquizafop, and Imazethapyr are currently being used for controlling both grassy and broad-leaved weeds but their effects under various climatic conditions are not well defined. It was recently found that the herbicide Clodinafoppropargyl is very effective in controlling weeds in chickpea. This herbicide is active against broadleaf weeds and grasses but their effects may differ in different locations depending on soil type, intensity, and weed flora type, among other factors. As a result, it is important to compare the effectiveness of various promising herbicides in terms of chickpea productivity and weed competition in weed-free environments. Vaishya-*et al.*, (1996) reported that integrated weed management (pre-emergence application of Pendimethalin @ 1.0kg/ha-*fb*-one hand weeding) was found to be the most economical. Among the chemical weed control treatment, application of Pendimethalin @ 1.0 kg a.i./ha produced a higher yield and gave the highest net monetary returns and B: C ratio and was found most effective and

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economical in controlling weeds and increasing the yield of chickpea. A suitable herbicide for effective control of mixed weed flora is required for better adoption in this crop by farmers. The introduction of herbicides has made it possible to control a broad spectrum of weeds in pulses effectively at a reasonable cost. Weed management in chickpea is a crucial component of plant protection thus improving the production potential of the crop.

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## 2. MATERIALS AND METHODS

A field experiment was conducted during *rabi*-season 2021-22 at Agronomy Research Farm of the Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (UP) India, which falls in a subtropical climate and situated at 26° 47' North latitude, 82° 12' East longitudes with an altitude of 113 meters above mean sea level. During the crop growing season of the year 2021-22, the weekly maximum and minimum temperatures, relative humidity, sunshine hours, wind velocity, evaporation ranged between 32.0 °C and 5.7 °C, 87.40 and 74.70 %, 9.0 and 4.7 hours, 5.5 and 2.0 kmph, 6.4 and 2.1 mm respectively. The soil of the experimental site was homogeneous in fertility with uniform textural makeup. The alluvial soils of Indo-Gangetic plains in general are deep, flat, and well drained with low available nitrogen and medium in available phosphorus and potassium. Chickpea variety RVG 202 was used with a seed rate was used 80 kg/ha. Weed observations were recorded at 30, 60, and 90 DAS. The quadrat of 1 sq. m was randomly placed at three places in each plot and then species-wise and total weed counts were recorded. In weed biomass, all the associated weeds were collected, randomly from 0.25 m<sup>2</sup> quadrat at four places in each plot. The weeds were kept in paper bags and dried in the oven at 60°C for 24-25 hours (up to constant weight) and dry weight was recorded at 30, 60, and 90 DAS into g/m<sup>2</sup>. For weeds, the original values were transformed using the square root of X+0.5 transformations and analyzed statistically. Weed control efficiency (%) of treatment expressed in percentage for controlling weeds in comparison to weedy check and worked out based on the given formula. Weed control efficiency (%) was computed based on the following formula: In Crop yield and yield attributing characters were recorded as the number of pods/plant on five randomly selected plants per plot were counted and their averages were calculated.

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2.1. Treatments and design  
2.2. Crop husbandry  
2.3. Observation and measurements  
2.4. Statistical analysis

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$$WCE = \frac{\text{Dryweightofweedsincontrolplot} - \text{Dryweightofweedsintreatedplot}}{\text{Dryweightofweedsincontrolplot}} \times 100$$

The total number of pods from each five sample plants was threshed and the average number of seeds/pod<sup>-1</sup> was recorded. From a lot of threshed clean seeds of each plot, a random seed sample was taken and one hundred seeds were counted from the samples of each plot, and the weight of seeds was recorded on an electronic balance. Seed yield and straw yield obtained from each plot were added to obtain biological yield in kilogram from each plot and converted to quintal per-hectare<sup>-1</sup>. The weight of clean seeds obtained from each plot was recorded on a double pan balance. Finally, the seed yield/plot<sup>-1</sup> was converted into yield/ha<sup>-1</sup> by multiplying with the appropriate conversion factor. Stover yield was determined by subtracting the seed yield from the biological yield of each net plot under a particular treatment. Then, the values were converted into stover yields/ha<sup>-1</sup> by using the same conversion factor, which will be used in the case of conversion of seed yields. Harvest Index (%) refers to the ratio of economic yield (seed yield) to

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the biological (seed + stover) yield under a particular treatment and it was expressed in percentage.

$$\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Biological Yield}} \times 100$$

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Regarding economic analysis of study of the crop, the cost of cultivation of crops was calculated treatment-wise, based on prevailing local market prices of different inputs used in the cultivation. Gross returns of grain yield and straw yield were computed in Rs/ha<sup>-1</sup> by using the minimum support prices for grains and prevailing local market price for straw. The gross return was obtained by adding the monetary value of grain and straw yield in Rs/ha<sup>-1</sup>, treatment-wise. The net return for each treatment was calculated by deducting the cost of cultivation from the respective gross returns. Benefit:Cost ratio in terms of net return per rupee investment was calculated by using the following formula.

$$\text{B: C ratio} = \frac{\text{Net return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

The data obtained were subjected to statistical analysis as outlined by Gomez & Gomez (1984). The treatment differences were tested by the least significant difference at a 5% level of significance.

$$\text{WCE} = \frac{\text{Dryweightofweedsincontrolplot} - \text{Dryweightofweedsintreatedplot}}{\text{Dryweightofweedsincontrolplot}} \times 100$$

$$\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Biological Yield}} \times 100$$

$$\text{B: C ratio} = \frac{\text{Net return (Rs/ha)}}{\text{Cost of cultivation (Rs/ha)}}$$

### 3. RESULTS AND DISCUSSION

#### 3.1. Weed Studies indices/attributes

Data of Total total weed density (m<sup>-2</sup>) given in Table 1 indicate that the effect of various weed management practices was significant on the density of weeds at 30, 60, and 90 DAS. Weed management practices exerted a significant effect on the density of total weeds. Weedy check recorded a significantly higher density of total weeds (8.96, 11.62, and 12.42) over the rest of the treatments at all stages of crop growth while weed-free treatments noted the least density of total weeds (0.71, 0.71, and 0.71). Among the herbicidal treatments at 30, 60, and 90 DAS the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Clodinafoppropargyl 15 WP @ 0.060 kg a.i./ha PoE recorded minimum density (5.23, 3.83, and 3.97) of weeds which were statistically at par with Pendimethalin EC @ 1.0 kg a.i./ha PE fb Imazethapyr 10 % SL @ 0.06 kg a.i./ha PoE. These two treatments significantly has lesser reduced the weed density significantly than the rest of the weed management practices treatments. This might be due to effective weed control by both herbicides at all stages of crop growth whereas weedy check

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treatment recorded significantly highest density of weeds (80.00, 135.00, and 154.00 m<sup>-2</sup>) at 30, 60, and 90 DAS respectively. This might be due to no weed control measures being carried out in these treatments. These results were in agreement with the results of **Yadav et al. (2017)** and **Jaswal and Menon (2020)**. Data on dry matter of total weeds recorded at 30, 60, and 90, DAS has been given in Table 1 indicate that the weed management treatments at various crop growth stages. Weedy check recorded maximum weed dry matter of total weeds (4.05g, 9.38g and 10.09g) at 30, 60 and 90, DAS respectively. While weed-free recorded the lowest dry matter of total weeds at 30, 60, and 90, DAS due to better weed management practices. Among the herbicidal treatments, at 30 DAS application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Clodinafoppropargyl 15 WP @ 0.060 kg a.i./ha as PoE recorded significantly minimum dry matter (2.45, 3.12 and 3.26 g·m<sup>-2</sup>) which was statistically at par with Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Imazethapyr 10 % SL @ 0.060 kg a.i./ha PoE, while which were significantly lesser than the rest of the treatments. A similar trend was observed at the 60 and 90 DAS stages during the experiment. This might be due to effective weed control of weeds reducing the dry weight. In the weedy check treatment, the dry matter of weeds was significantly maximum because of the highest weed population and higher capacity of utilizing the sunlight, nutrients, moisture, CO<sub>2</sub>, space, etc., over the rest of the treatments. In treatment, weed-free treatment, for up to 90 days and application of pre-emergence herbicides in combination with PoE application of herbicides reported the less weed population at a critical stage of crop growth resulting in lower weed dry matter. These results were also reported by the finding of **Singh et al. (2006)**, **Bhutada and Bhale (2014)**, **Kumar et al. (2015)**, and **Kumar et al. (2020)**. The data regarding weed control efficiency as influenced by various weed control treatments are given in Table 1. In weed management treatments at harvest, weed control efficiency was highest in the treatment of weed-free treatment (100%) which was significantly superior to all other treatments, while weedy check treatment recorded the lowest weed control efficiency (0.00%). Among herbicidal treatments the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Clodinafoppropargyl 15 WP @ 0.060 kg a.i./ha noted significantly greater-higher value (90.00%) of weed control efficiency which was found at par with treatment Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Imazethapyr 10 % SL @ 0.060 kg a.i./ha (POE) (89.61) while significantly higher than the rest of the herbicidal treatments. The application of herbicides Pendimethalin and oxyfluorfen before emergence reduces the density of the weeds and results in high efficiency in weed control, this could be attributed to the herbicide's maximum uptake and more assimilation occurring immediately after weed emergence after the PoE application of Clodinafoppropargyl and Imazethapyr reduce the weed intensity and dry weight than weedy check, which could be one of the reasons for their superior weed control efficiency. These findings were parallel to the conclusions of **Singh and Jain (2017)**, **Rathod et al. (2017)**, and **Singh et al. (2020)**.

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### 3.1. Yield attributes

Data about yield contributing characters viz. numbers of pods/plant<sup>-1</sup>, the number of seeds/pod<sup>-1</sup>, and the weight of 1000 seeds (g) are presented in Table 2. It is obvious from the results that the number of pods/plants was affected significantly due to different weed management practices.

In weed management practices the maximum number of pods/plant<sup>-1</sup> (57.00) was recorded with weed-free treatments and the minimum (33.00) with the weedy check. Herbicidal treatments also significantly influenced the number of pods/plant<sup>-1</sup>. The maximum number of pods/plant<sup>-1</sup> (54.60) was recorded with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE which was at par with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE and significantly higher number of pods than the rest of the treatments except weed free. It is clear from the data that the number of seeds/pod<sup>-1</sup> was affected significantly due to different weed management practices of the chickpea crop. In weed management practices the maximum number of seeds/pod<sup>-1</sup> (1.96) was recorded with weed-free treatments and the minimum (1.32) with the weedy check. Among the herbicidal treatments, the maximum number of seeds/pod<sup>-1</sup> (1.88) was recorded with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE being at par with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE. While which were significantly higher than the rest of the treatments. Maximum test weight (200.40g) was recorded with weed-free treatments and minimum (178.80g) with the weedy check. Among the herbicidal treatments, the maximum test weight (197.70g) was recorded with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE. Almost all parameters related to yield viz. number of pods/plant, number of seeds/pod (Table 2) were significantly influenced by weed management practices and test weight failed to reach the level of significance. Significantly higher values for yield attributes (Table 2) were observed with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE. This might be due to effective control of weeds reducing the weed competition and resulting in leads to the formation of a higher number of yield attributes. Almost similar findings were reported by Kachhadiya *et al.* (2009), Khope *et al.* (2011), and Singh *et al.* (2019).

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### 3.2. Yields

Grain yield is a function of the source and sinks relationship, source is the various growth parameters and sink are yield attributes parameters like dry matter accumulation, number of nodules/plant, number of pods/plant, number of seeds/pod, and test weight. It is the most important parameter to compare the effectiveness of different treatments. Different weed management treatments influenced significantly seed yield, and stover yield of chickpea embodied in Table 2. In weed-free treatment recorded maximum grain yield (20.60 q/ha<sup>-1</sup>) and minimum grain yield (13.80 q/ha<sup>-1</sup>) were noted with in weedy check treatment. The lowest yield in weedy check treatment resulting due could be attributed to severe crop weed competition as weeds utilize a large amount of moisture and nutrients than crop which was due to no weed management practice. Among the herbicidal treatments the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE recorded a

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significantly higher seed yield ( $19.80 \text{ qha}^{-1}\text{q/ha}$ ) being at par with Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Imazethapyr 10 % SL @ 0.06 kg a.i./ha PoE, while significantly higher than the rest of the herbicidal treatments. This might be due to effective control of weeds resulting in higher yield. Similar findings were reported by **Punia et al. (2011)** and **Singh et al. (2014)**. Among weed management practices showed a significant variation in stover yield of chickpea. Weed-free treatment recorded maximum stover yield ( $37.43 \text{ kg/ha}^{-1}$ ) and minimum with the weedy check ( $26.50 \text{ kg/ha}^{-1}\text{kg/ha}$ ). Data further reveals that among herbicidal treatments the maximum stover yield ( $36.27 \text{ q/ha}^{-1}$ ) was recorded with Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE which was statistically at par with an application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Imazethapyr 10 % SL 0.06 kg a.i./ha PoE while significantly higher than the rest of the herbicidal treatments. These results were in the agreement with those of **Poonia et al. (2013)**, **Chavada et al. (2018)**, and **Singh et al. (2020)**. Among weed management practices significantly higher biological yield ( $58.03 \text{ qha}^{-1}\text{q/ha}$ ) was observed with weed-free treatments and least biological yield ( $39.85 \text{ qha}^{-1}$ ) with weedy check treatments. In the case of herbicidal treatments with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Clodinafoppropargyl 15 WP @ 0.060 kg a.i./ha PoE which was statistically at par with an application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Imazethapyr 10 % SL @ 0.06 kg a.i./ha PoE while significantly higher than the rest of the herbicidal treatments. This might be due to effective control of weeds by above weed competition resulting in higher biomass production. Similar results were reported by **Kumar et al. (2014)** and **Singh et al. (2020)**. Among the weed management treatments, the maximum harvest index was recorded with weed-free (35.49 %) and minimum with the weedy check (34.62 %). Among herbicidal treatments the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb Clodinafoppropargyl 15 WP @ 0.060 kg a.i./ha PoE recorded a maximum harvest index (35.38 %). The similar result obtained by **Chavada et al. (2018)**.

### **3.3. Economic analysis**

The **Economic analysis** of the weed control treatments was worked out based on input-output analysis. Various components of economics are described here. The details have been given in Table 3. The cost of cultivation ( $\text{Rs/ha}^{-1}$ ) incurred on weed control treatments was added to the **common-fixed** cost of different treatments which gave the total cost of cultivation. The highest cost of cultivation ( $39024 \text{ Rsha}^{-1}\text{Rs/ha}$ ) was recorded under the treatment weed free and the lowest with the weedy check ( $36024 \text{ Rsha}^{-1}\text{Rs/ha}$ ). Among herbicide treatments, the higher cost ( $38564 \text{ Rsha}^{-1}\text{Rs/ha}$ ) was recorded with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE. In Table 3 data on gross return computed under different treatments showed that the highest gross return ( $108803 \text{ Rsha}^{-1}\text{Rs/ha}$ ) was achieved with weed-free treatments and the lowest with the weedy check ( $72985 \text{ Rsha}^{-1}\text{Rs/ha}$ ). Among herbicidal treatments, the highest gross return ( $104595 \text{ Rsha}^{-1}\text{Rs/ha}$ ) was recorded with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE. Data on net return computed under different treatments showed that the highest net return ( $66031 \text{ Rsha}^{-1}\text{Rs/ha}$ ) was obtained with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE fb by Clodinafoppropargyl 15 WP @

0.06 kg a.i./ha PoE. In Table 3 data on B:C ratio computed under different treatments showed that the highest B:C ratio(1.71 Rs/Rupees investment) was recorded with the application of Pendimethalin 30 EC @ 1.0 kg a.i./ha PE *fb* by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE and lowest with the weedy check (1.02 Rs/Rupees investment). A similar finding conforms with the finding of **Dungarwal *et al.* (2002)**, **Ratnam *et al.* (2011)**, **Meena *et al.* (2011)**, and **Dubey *et al.* (2018)**.

**Table:1**Effect of herbicide combination on Weed density, Weed dry weight (g) at 30, 60, 90 DAS, and Weed control efficiency (%) of Chickpea

Treatments	Weed density (DAS)			Weed dry weight (g) (DAS)			Weed control efficiency (%)
	30	60	90	30	60	90	
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE	5.54 (30.30)	6.35 (40.00)	6.67 (44.00)	2.55 (6.06)	5.14 (26.00)	5.43 (29.04)	71.43
Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE	7.46 (55.40)	5.95 (35.20)	6.20 (38.00)	3.40 (11.08)	4.82 (22.88)	5.05 (25.08)	75.32
Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE	7.83 (61.20)	5.83 (33.60)	6.12 (37.00)	3.56 (12.24)	4.72 (21.84)	4.97 (24.42)	75.97
Propaquizafop 10 EC @ 0.075 kg a.i./ha PoE	8.51 (72.00)	7.12 (50.40)	7.43 (55.00)	3.85 (14.40)	5.76 (32.76)	6.06 (36.30)	64.29
Quizalofop ethyl 5 EC @ 40 g a.i./ha PoE	7.66 (58.40)	6.39 (40.40)	6.63 (43.80)	3.48 (11.68)	5.17 (26.26)	5.41 (28.91)	71.56
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE	5.29 (27.60)	3.93 (15.00)	4.06 (16.00)	2.36 (5.10)	3.19 (9.75)	3.31 (10.56)	89.61
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Propaquizafop 10 EC @ 0.075 kg a.i./ha PoE	5.42 (29.00)	4.45 (19.31)	4.67 (21.40)	2.51 (5.80)	3.62 (12.63)	3.69 (13.95)	75.13
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE	5.23 (27.00)	3.83 (14.20)	3.97 (15.40)	2.34 (5.02)	3.12 (9.23)	3.26 (10.16)	90.00
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Quizalofop ethyl 5 EC @ 40 g a.i./ha PoE	5.47 (29.40)	4.51 (20.00)	4.73 (22.00)	2.52 (5.88)	3.67 (13.00)	3.87 (14.52)	76.34
Weed free	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	100.00
Weedy check	8.96	11.62	12.42	4.05	9.38	10.09	0.00

**Comment [AF36]:** Statistical analysis lettering is missing. How someone will differentiate the treatment means?

	(80.00)	(135.0)	(154.00)	(16.00)	(87.75)	(101.64)	
<b>SEm±</b>	<b>0.29</b>	<b>1.00</b>	<b>0.51</b>	<b>0.17</b>	<b>0.61</b>	<b>0.76</b>	<b>0.89</b>
<b>CD (p = 0.05)</b>	<b>0.88</b>	<b>2.89</b>	<b>1.53</b>	<b>0.53</b>	<b>1.83</b>	<b>2.26</b>	<b>2.52</b>

Comment [AF37]: Explain in table foot note

**Table:2Effect of herbicide combination on Yield attribute, Yields, and Harvest Index (%) of Chickpea**

Treatments	Yield attribute			Yields			Harvest Index (%)
	Pods/plant	Seeds/pod	Test Weight (g)	Grain Yield	Straw Yield	Biological yield	
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE	45.03	1.42	180.00	16.50	30.78	47.28	34.89
Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE	46.80	1.40	180.60	17.00	31.63	48.63	34.95
Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE	47.00	1.38	181.80	17.20	31.44	49.15	34.99
Propaquizafop 10 EC @ 0.075 kg a.i./ha PoE	43.60	1.46	179.20	16.00	30.05	46.02	34.82
Quizalfop ethyl 5 EC @ 40 g a.i./ha PoE	44.00	1.44	179.80	16.30	30.47	46.77	34.85
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE	53.40	1.85	196.00	19.60	35.83	55.43	35.35
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Propaquizafop 10 EC @ 0.075 kga.i./ha PoE	47.90	1.45	192.00	16.78	31.07	48.19	35.30
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Clodinafoppropargyl 15 WP @ 0.06 kg a.i. /ha PoE	54.60	1.88	197.70	19.80	36.27	55.95	35.38
Pendimethalin 30 EC @ 1.0 kg a.i. /ha PE <i>fb</i> by Quizalfop ethyl 5 EC @ 40 g a.i./ha PoE	48.00	1.47	190.70	16.83	30.66	47.79	35.19
Weed free	57.00	1.96	200.40	20.60	37.43	58.03	35.49

Comment [AF38]: Use same word for trait as used in text

Weedy check	33.00	1.32	178.80	13.80	26.05	39.85	34.62
<b>SEm±</b>	<b>0.65</b>	<b>0.12</b>	<b>9.41</b>	<b>0.87</b>	<b>1.49</b>	<b>1.34</b>	<b>1.25</b>
<b>CD(p = 0.05)</b>	<b>1.95</b>	<b>0.38</b>	<b>NS</b>	<b>2.58</b>	<b>4.41</b>	<b>4.00</b>	<b>NS</b>

**Table:3 Effect of herbicide combination on Cost of cultivation, Gross return, Net return, and B: C ratio of Chickpea**

Treatments	Cost of cultivation (Rs ha <sup>-1</sup> )	Gross return (Rs ha <sup>-1</sup> )	Net return (Rs ha <sup>-1</sup> )	B: C ratio
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE	38004	87228	49224	1.29
Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE	36905	89863	52958	1.43
Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE	36584	90915	54331	1.48
Propaquizafop 10 EC @ 0.075 kg a.i./ha PoE	36976	84595	47619	1.28
Quizalofop ethyl 5 EC @ 40 g a.i./ha PoE	36944	86177	49233	1.33
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Imazethapyr 10% SL @ 0.06 kg a.i./ha PoE	38885	103543	64658	1.66
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Propaquizafop 10 EC @ 0.075 kg a.i./ha PoE	38956	100382	61426	1.57
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha PoE	38564	104595	66031	1.71
Pendimethalin 30 EC @ 1.0 kg a.i./ha PE <i>fb</i> by Quizalofop ethyl 5 EC @ 40 g a.i./ha PoE	38924	99342	60418	1.55
Weed free	46024	108803	69779	1.51
Weedy check	36024	72985	36961	1.02
<b>SEm±</b>	----	----	----	----
<b>CD(p = 0.05)</b>	----	----	----	----

## Conclusion

~~As per the discussed problem higher weed infestation in chickpea~~ In crux, application of pre-emergence (pendimethalin @1.0 kg a.i./ha) followed by post-emergence PE fb (Clodinafoppropargyl 15 WP @ 0.06 kg a.i./ha) as PoE may could be the best way to control weed in Chickpea crop. ~~i.e.~~ A combine package of pre and post-emergence herbicide resulted in S significantly less weed density, weed dry matter, and higher weed control efficiency, yield attributes (number of pods/plant<sup>-1</sup>, number of seeds/pod<sup>-1</sup>

**Comment [AF39]:** In conclusion never use abbreviation it will make easier for reader to understand the conclusive remarks.

and test weight), and yield (grain yield, stover yield, biological yield, and harvest yield). Moreover, ~~in term of economic use of pre and post-emergence herbicide package it also recorded gave higher gross returns, the net return, and B:Benefit cost ratio proved to be more remunerative as compared to other herbicide applications used in chickpea crop.~~

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Comment [AF40]: Follow the Journal Author guideline for references setting and style.

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