Impact weed control efficiency of herbicides on Yield and economic returns of Chickpea

Commented [KML1]: Scientific name

ABSTRACT

The field experiment was carried out at College of Agriculture, Vijayapura, during *rabi*, 2021–22, to investigate the impact of pre- and post-emergence herbicides on chickpea growth and yield. Three replications were set up in RCBD with eleven treatments including: Intercultivation at 20 and 40 DAS, weed free check and weedy check along with two pre-emergence herbicides (Pendimethalin, Pendimethalin + Imazethapyr) and five post-emergence herbicides (Imazethapyr + Imazamox, Propaquizafop + Imazethapyr, Imazethapyr, Quizalofop ethyl and Aciflor + Clodinafop]. Among the herbicidal treatments, application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS recorded significantly higher weed control efficiency (84.98%), higher yield attributes *viz.*, higher number of pods per plant (49.09), higher weight of 100 seeds (24.86 g), higher seed yield per plant (21.37 g) and also recorded higher grain yield (2197 kg/ha), haulm yield (2766 kg/ha), net returns (₹ 80621/ha) and B:C ratio (3.01) compared to the other herbicidal treatments and was on par with the weed free check which was recorded higher results in all the above parameters but encountered with higher cost of cultivation. However, weedy check recorded lowest number of pods per plant (38.18), lower weight of 100 seeds (22.36 g) and lower Seed yield per plant (16.96 g) due to higher weed competition and resulted in lower yield and less returns.

Commented [KML2]:

Commented [KML3R2]: To delete, either give a brief context or state the purpose of the study.

Commented [KML4]: The sentence is too long and therefore difficult for the reader to understand.

Commented [KML5]: This word needs to be revised, however.
You can say with weeds .....

Keywords: Chickpea, Herbicides, WCE, Yield, Economics

1. Introduction

In Indian agriculture, pulses are crucial for long-term yield, better soil health, and environmental preservation. In terms of production and consumption, pulses—also referred to as food legumes are a less expensive option than grains in India. In terms of area, productivity, and economic value, pulses are second only to cereals and oilseeds in the Indian agriculture sector (Choudhary, 2009). After beans and peas, chickpeas (*Cicer arietinum* L.) are among the most widely grown pulse crops in India and around the world. It is also referred to as Chana in several regions of the country, and it is also known by other names like gram or Bengal gram. It is highly valued for its nutrient-dense seed, which can be used in place of meat and contains significant amounts of protein (21.1%), carbs (61.5%), and lipids (4.5%). India leads the world with a production of 11.91 million tons, with an area of 9.99 million hectares and a productivity of 1192 kg ha-1 (Anonymous, 2021).

The average yield of this crop is very low due to many biotic and abiotic factors but among these, infestation of weeds is very important. Weeds compete with crops for carbon dioxide, space, water, and nutrients. Crop production is ultimately limited by this competition, which impacts crop growth and development (Chandrakar *et al*., 2014 and Das, 2015). Weed infestation has been found to cause yield reductions of up to 75%. (Chaudhary *et al*., 2005). The presence of weeds throughout the crop season reduces the grain yield of chickpea by up to 68% (Kumar *et al*., 2014). The most common weeds in chickpea fields were *Avena ludoviciana, Chenopodium album, Cynodon dactylon, Phalaris minor, Medicago hispida,*

Anagali s arvensis, Melilotus indica, Melilotus alba, Cyperus rotundus, Argemone maxicana, Solanum nigrum, Vicia hirsute, and Vicia sativa (Gupta *et al*., 2012).

However, one of the barriers for expanding chickpea production is weed control. It has been shown that the widespread use of mechanical hoeing and human weeding to control weeds is declining as farm labourers move into enterprises in search of better and more stable wages. Based on current trends and anticipated advancements, chemicals have the potential to be utilized as a viable weed management strategy and to supplant conventional weed control techniques in intensive agriculture. An appropriate herbicide for the efficient management of mixed weed flora is required for farmers to adopt this crop more readily.

One strategy for broad-spectrum weed management could be the use of post-emergence herbicides or combinations like, Imazethapyr + Imazamox (Odyssey), Propaquizafop + Imazethapyr (Shaked), Imazethapyr, Quizalofop ethyl and Aciflor + Clodinafop (Iris) in conjunction with pre-emergence herbicides like Pendimethalin or Pendimethalin + Imazethapyr (Valor).

2. Materials and Methods

A field experiment was conducted at College of Agriculture, Vijayapura, Karnataka, in Vertisol soil with a p^H of 8.11 and an EC of 0.24 dSm^{-1} and was carried out during *rabi* (October–December, 2021). The soil's accessible nitrogen concentration was 175 kg ha^{-1}, P_2O_5 was 26.3 kg ha^{-1}, and K_2O was 398 kg ha^{-1}. Its organic carbon content was low at 0.49%. The experimental site was situated in the Northern Dry Zone (Zone 3) of Karnataka at a latitude of 16°45′ North and a longitude of 75°44′ East. It was elevated at an elevation of 593.8 meters above mean sea level.

In this experiment, the variety JG-11 was utilized. The experiment was conducted using eleven treatments replicated thrice in a randomized complete block design. Urea and di-ammonium phosphate were used to apply NPK at a rate of 10:20:0 kg ha^{-1}. On October 13, 2021, the crop was sowed with 45 x 10 cm spacing. 52 rainy days during the study year (2021–2022) yielded a total rainfall of 632.8 mm, which was 38.4 mm more than the average rainfall of 594.4 mm over the past 40 years (1981–2020). The cropping season's prevailing weather conditions favoured the growth of weeds as well as crops.

Pre-emergent herbicides *viz.*, Pendimethalin 38.7% CS @800 g a.i. ha^{-1} (Stomp Xtra) and Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (1000 g *a.i.*/ha) or 3 L/ha (Valor) were sprayed after 2 DAS, and post-emergent herbicides *viz.*, Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha (Odyssey), Imazethapyr 10 % SL @ 70 g *a.i.*/ha (Emoji), Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha (Hakama), Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha (Iris) and Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha (Shaked) were sprayed after 20 DAS. Intercultivation at 20 and 40 DAS, weed free check and weedy check were also followed and At 30 and 45 days after sowing (DAS), observations on weed density, weed dry matter, and weed control efficiency were carried out. Additionally, yield attributes, yield and economics were recorded.

3. Results and Discussion

3.1 Weed flora in experimental field

Commented [KML6]:

Commented [KML7R6]: adds authors to each species cited

Commented [KML8]: The objectives of the study are not defined.

Commented [KML9]: the method of data analysis is not mentioned in this manuscript. i think he needs to review the methodology.

Commented [KML10]: what does vertisol stand for? what is the temperature and rainfall in this area?

Commented [KML11]: These are the facts, not the method of working on the subject in question.

Commented [KML12]: you don't explain the working method. the two herbicides can't be applied at the same time. the experimental plots must be set up differently.

Chloris radiata, Bracheria reptans, Eleucina indica, Panicum repens, and *Dinebra retroflexa* were the most common monocot weed species found in the experimental site. The dicot weed species included *Abitulon indicum, Achyranthus aspera, Cassia tora, Convolvulus arvensis, Desmodium diffusum, Digeria muricata, Euphorbia hirta, Euphorbia geniculate, Lactuca serriola, Parthenium hysterophorus, Phyllanthus maderaspatensis, Sida acuta, Tridax procumbens,* and *Trichodesma zylenicum.*

Commented [KML13]: such as saying that is not a result. a result is obtained after carrying out an activity. but come the list

3.2 Weed control efficiency (%)

Weed free check recorded a much greater (100%) weed control effectiveness than other treatments at all chickpea growth stages, whereas weedy check recorded the lowest (0.00%) weed control efficiency (Table 1 & Fig. 1).

Commented [KML14]: I don't understand the point of this part.

3.2.1 Monocot weeds control efficiency (%)

At 30 DAS, monocot weeds control efficiency ranged from 45.11 to 79.07 per cent in different treatments. Among the treatments, Intercultivation at 20 and 40 DAS (Farmers practice) recorded significantly higher (79.07 %) weed control efficiency compared to all other treatments and it was found to be on par with application of Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE (68.81 %).

At 45 DAS, monocot weeds control efficiency ranged from 51.65 to 96.90 per cent in different treatments. Among the treatments, application of Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE recorded significantly higher (96.90 %) weed control efficiency compared to all other treatments and it was comparable with sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha) as PoE at 25 DAS (88.66 %).

Commented [KML15]: Call of table

3.2.2 Dicot weeds control efficiency (%)

At 30 DAS, dicot weeds control efficiency ranged from 1.09 to 76.29 per cent among different treatments. Intercultivation @ 20 and 40 DAS (Farmers practice) recorded significantly higher (76.29%) weed control efficiency compared to all other treatments. It was on par with application of Pendimethalin 38.7% CS @ 1.0 kg *a.i.* /ha as Pre emergence (60.62 %), Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (1000 g *a.i.*/ha) or 3 L/ha as PE (57.84 %) and Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (54.95 %). However application of Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE recorded lower (1.09 %) weed control efficiency compared to all other treatments.

At 45 DAS, dicot weeds control efficiency ranged from 0.65 to 82.09 per cent in different treatments. Among the various treatments, application of Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS recorded significantly higher (82.09 %) weed control efficiency compared to all other treatments and it was on par with sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (80.38 %), sequential application of Pendimethalin 38.7

% CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS (79.78 %) and Intercultivation at 20 and 40 DAS (Farmers practice) (75.49 %). However they were comparable with application of Imazethapyr 10 % SL @ 70 g *a.i.*/ha as PoE at 25 DAS with a weed control efficiency of 71.62 %. Whereas the lowest weed control efficiency (0.65 %) was observed with Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE.

3.2.3 Total weed control efficiency (%)

At 30 DAS, Intercultivation @ 20 and 40 DAS (Farmers practice) recorded significantly higher (78.54 %) weed control efficiency compared to all other treatments. Whereas at 45 DAS, In comparison to all other treatments, sequential application of Pendimethalin 38.7% CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS recorded a significantly higher (84.98 %) weed control efficiency. It was also found to be comparable to sequential application of Pendimethalin 38.7% CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g a.i./ha as PoE at 25 DAS (79.18 %). However the lower weed control efficiency (52.68 %) was recorded with application of Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (1000 g a.i./ha) as PE. These results were supported by the findings of Panda *et al*. (2017) and Suryavanshi *et al*. (2018).

3.3 Effect of different weed management practices on Yield and Yield attributes of chickpea

3.3.1 No. of pods per plant

The data on No. of pods per plant in chickpea due to various weed management treatments are presented in Table 21 & Fig. 2.

Number of pods per plant of chickpea differed significantly due to various weed management treatments. Among all the treatments, weed free check recorded significantly higher (53.37) number of pods per plant. However, among the Herbicidal treatments, sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS recorded significantly higher (49.09) number of pods per plant, which was followed by application of Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS (48.62) and Intercultivation at 20 and 40 DAS (Farmers practice) (48.43). However among the herbicidal treatments lower number of pods per plant was recorded with sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (39.91) and Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (38.28) which are comparable with Weedy check (38.18). Almost similar results were obtained by Sandil *et al*. (2015) in soybean.

3.3.2 100 seed weight (g)

Commented [KML16]: these sentences are long and the results table must be announced.

Commented [KML17]: these results are not discussed

Commented [KML18]: I only see comparisons between treatments and other studies. The reason for your results does not stand out.

Commented [KML19]: the table quoted does not correspond. the results are not always discussed.

Commented [KML20R19]: No

Formatted: Highlight

The data on 100 seed weight in chickpea due to different weed management treatments are presented in Table 2~~1~~ & Fig. 2.

Weight of 100 seeds of chickpea differed non-significantly due to various weed management treatments. Among all the treatments, weed free check recorded higher weight of 100 seeds (25.02 g) and lower weight of 100 seeds was recorded in Weedy check (22.36 g). However, Among the herbicidal treatments, sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS recorded comparably higher (24.86) 100 seed weight.

3.3.3 Seed yield per plant (g)

Seed yield per plant of chickpea differed significantly due to various weed management treatments. Among the combination of treatments, T_{10}: weed free check recorded significantly higher (22.14 g) Seed yield per plant. However, among the herbicidal treatments, sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS recorded highest (21.37 g) seed yield per plant, and was found to be on par with application of Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS (20.85 g) and Intercultivation at 20 and 40 DAS (Farmers practice) (19.79). These results were in conformity with Sandil *et al*. (2015) in soybean. However among the herbicidal treatments lower Seed yield per plant was recorded with sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS(17.25 g) and Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (17.06 g) which are comparable with Weedy check (16.96 g). Similar results were obtained by Nath *et al.* (2017) and Rana *et al.* (2019).

3.3.4 Grain yield (kg/ha) (Table 3)

Seed yield of chickpea differed significantly due to various weed management treatments. When compared to other treatments, the weed free check produced a significantly higher grain yield (2315 kg/ha) out of all the treatments. However, the highest grain yield was achieved among the herbicidal treatments by sequential application of Pendimethalin 38.7% CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5% + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS (2197 kg/ha) in sequence and was followed by Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS (2001 kg/ha) and Intercultivation at 20 and 40 DAS (Farmers practice) (1976 kg/ha). Wherever Imazethapyr 35% + Imazamox 35% WG (RM) was treated in the treatments, a significantly reduced grain production was observed due to Phytotoxicity. The treatments that produced the lowest grain yield were sequential application of Pendimethalin 38.7% CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (945 kg/ha) and Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (923 kg/ha) which were almost comparable with Weedy check (896 kg/ha). Almost similar results were recorded by Suryavanshi *et al*. (2018) in black gram.

Formatted: Highlight

Commented [KML21]: Rephrase the sentences, they are too long

Formatted: Highlight

4.3.5 Haulm yield (kg/ha)

Haulm yield of chickpea differed significantly due to various weed management treatments. Significantly higher haulm yield was obtained in the treatment with weedy free check (2910 kg/ha) as compared to other treatments. However, among the herbicidal treatments, higher haulm yield was recorded with sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS (2766 kg/ha), followed by application of Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS (2685 kg/ha) and Intercultivation at 20 and 40 DAS (Farmers practice) (2604 kg/ha). Significantly lower haulm yield was recorded wherever Imazethapyr 35 % + Imazamox 35 % WG (RM) was applied in the treatments like sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (2115 kg/ha) and Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (2098 kg/ha) and which were comparable with treatment that recorded lower haulm yield *i.e.* with Weedy check (2056 kg/ha).

Formatted: Highlight

4.3.6 Total biological yield (kg/ha) of chickpea

The experimental data on total biological yield of chickpea is the sum of seed and haulm yields. The variation in the total biological yield as influenced by different weed management practices is presented in Table 3.

Commented [KML22]: You don't belong here, you need to go back to data analysis methods.

The total biological yield of chickpea differed significantly due to the effect of different weed management treatments. Among all the treatments, significantly higher biological yield was obtained with weedy free check (5224 kg/ha) as compared to rest of treatments. However, it was found to be at par with sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS (4962 kg/ha) and application of Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS (4686 kg/ha). Among the herbicidal treatments significantly lower biological yield was noticed wherever Imazethapyr 35 % + Imazamox 35 % WG (RM) was applied *viz.*, sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (3060 kg/ha) and Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS (3021 kg/ha) which are almost equal with treatment that recorded lower biological yield *i.e.* Weedy check (2953 kg/ha).

3.4 Effect of different weed management practices on Economic returns of chickpea

The acceptability and practical usability of the technology is greatly affected by the economics in terms of net returns. Different weed control strategies led to significant variations in net returns and the BC ratio. (Table 3).

Commented [KML23]: not necessary here

3.4.1 Net returns (₹/ha)

Net returns differed significantly due to various weed management practices (Table 3). Significantly higher net returns were recorded with Weed free check (₹ 82,244 /ha) as compared to other treatments and among the herbicidal treatments, sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS recorded higher net returns (₹ 80,621 /ha) and was followed by application of Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS (₹ 72,780/ha) and Intercultivation at 20 and 40 DAS (Farmers practice) (₹ 68,896 /ha) and Among the other treatments, application of Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS and sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS recorded the lowest net returns (₹ 14,134 and ₹ 12,249 /ha, respectively).

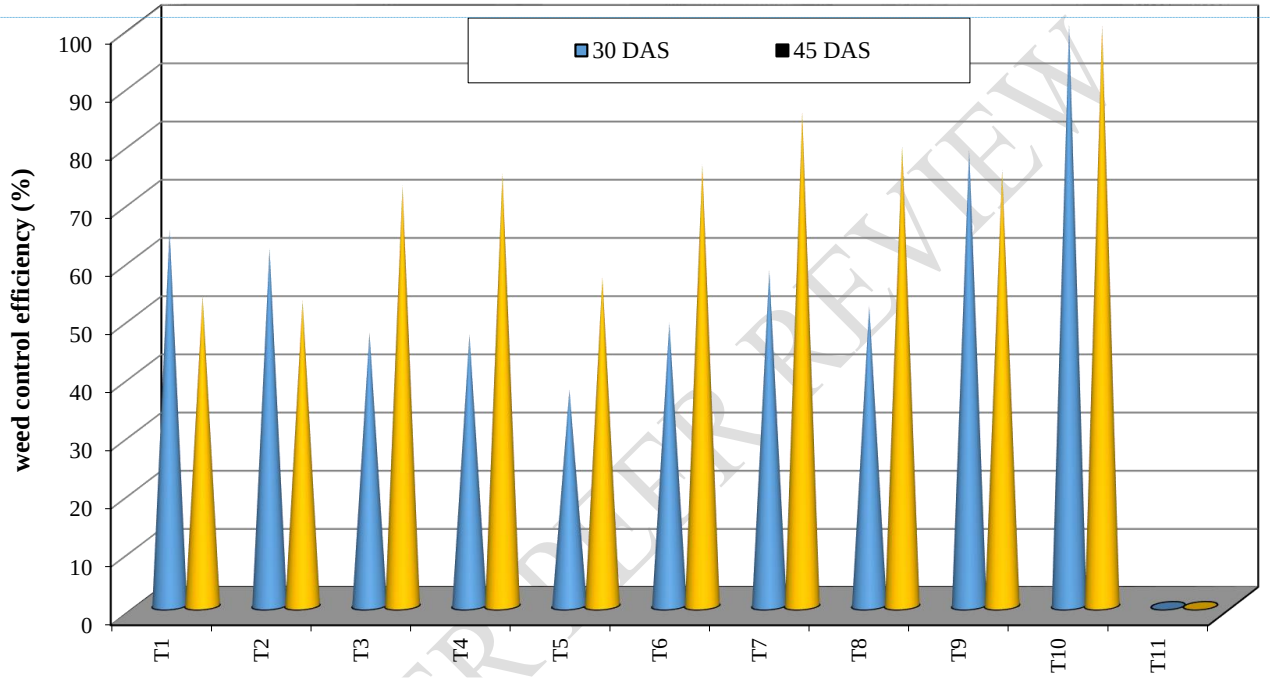
Formatted: Highlight

3.4.2 Benefit Cost ratio

Benefit cost ratio differed significantly due to various weed management treatments. Among all the treatments, significantly higher BC ratio was recorded in treatment sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS (3.01) over other treatments, however, it was on par with application of Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS (2.95), Weed free check (2.82) and Intercultivation at 20 and 40 DAS (Farmers practice) (2.73). While, application of Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS and sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS recorded significantly lower BC ratio (1.39 and 1.31, respectively) compared to rest of the treatments due to stand loss occur due to Phytotoxicity of Imazethapyr + Imazamox product on chickpea crop.

Commented [KML24]: call Table 3 in this text

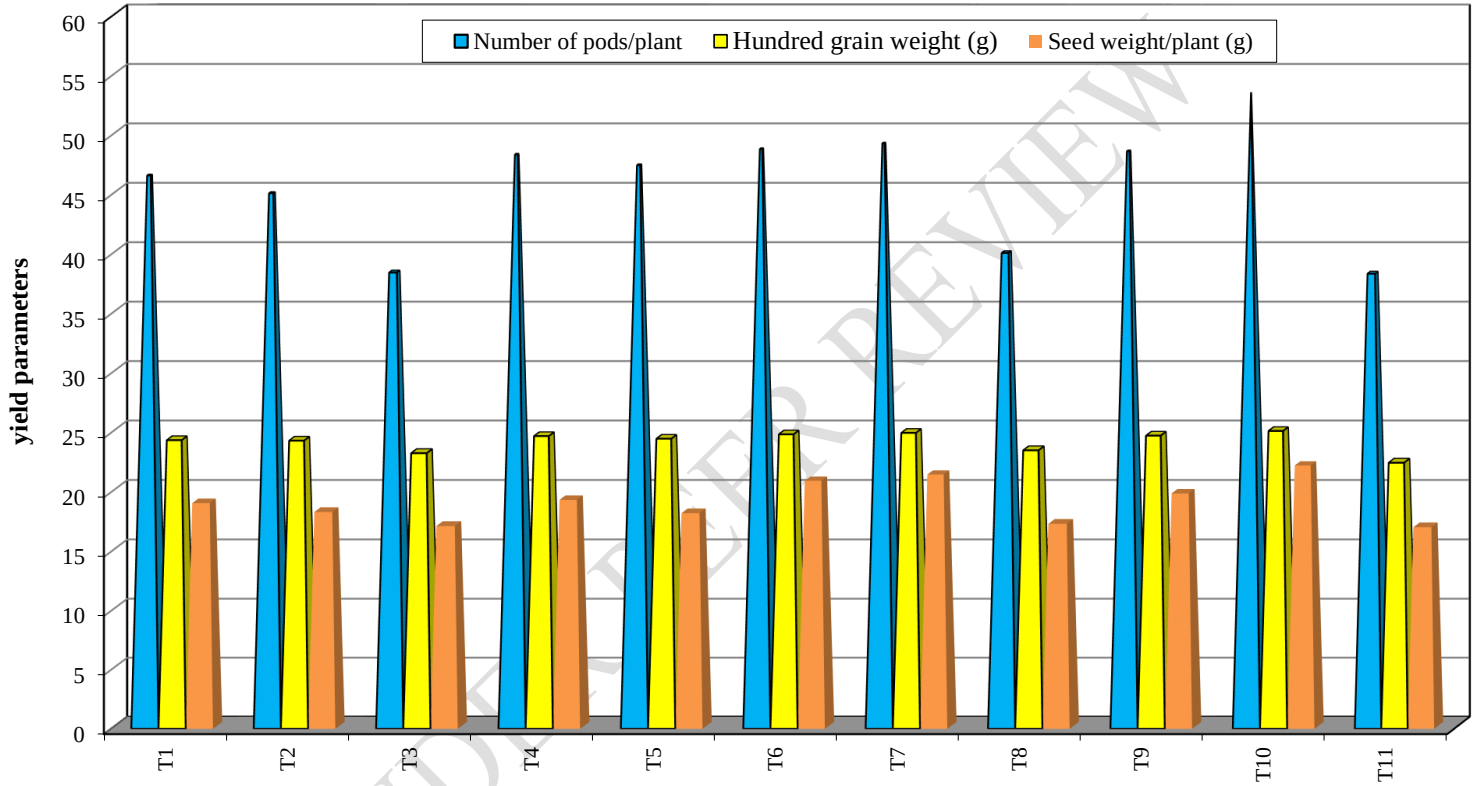
Formatted: Highlight



T_1: Pendimethalin 38.7 % CS @ 1.0 kg *a.i.* /ha as Pre emergence
T_2: Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (900 + 600 g *a.i.*/ha) or 3 L/ha as PE
T_3: Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS
T_4: Imazethapyr 10 % SL @ 70 g *a.i.*/ha as PoE at 25 DAS
T_5: Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE
T_6: Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 1 L *a.i.*/ha as PoE at 25 DAS
T_7: Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE fb Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ (50+75 g *a.i.*/ha) 2000 g/ha as PoE at 25 DAS
T_8: Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE fb Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25DAS
T_9: Intercultivation @ 20 and 40 DAS (Farmers practice)
T_{10}: Weed free check
T_{11}: Weedy check

Fig. 1: Total weed control efficiency (%) as influenced by different weed management treatments

Commented [KML25]: legend and figure have different colors



T_1: Pendimethalin 38.7 % CS @ 1.0 kg *a.i.* /ha as Pre emergence
T_2: Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (900 + 600 g *a.i.*/ha) or 3 L/ha as PE
T_3: Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS
T_4: Imazethapyr 10 % SL @ 70 g *a.i.*/ha as PoE at 25 DAS
T_5: Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE
T_6: Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 1 L *a.i.*/ha as PoE at 25 DAS
T_7: Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE fb Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ (50+75 g *a.i.*/ha) 2000 g/ha as PoE at 25 DAS
T_8: Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE fb Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS
T_9: Intercultivation @ 20 and 40 DAS (Farmers practice)
T_{10}: Weed free check
T_{11}: Weedy check

Fig. 2: No. of pods/plant, 100 seed weight (g), Seed yield / plant of chickpea as influenced by different weed management treatments

Table 1. Weed control efficiency (%) in chickpea (*Cicer arietinum* L.) as influenced by different weed management treatments

Treatment		Monocot WCE (%)		Dicot WCE (%)		Total WCE (%)	
		30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS
T_1	Pendimethalin 38.7% CS @ 1.0 kg *a.i.* /ha as PE	64.26	52.26	60.62	54.71	64.81	53.50
T_2	Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (1000 g *a.i.*/ha) or 3 L/ha as PE	61.00	51.65	57.84	52.73	61.52	52.68
T_3	Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS	45.11	73.74	48.74	70.31	47.06	72.41
T_4	Imazethapyr 10 % SL @ 70 g *a.i.*/ha as PoE at 25 DAS	45.79	76.58	42.63	71.62	46.76	74.55
T_5	Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE	68.81	96.90	1.09	0.65	37.25	56.76
T_6	Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS	48.58	71.24	49.27	82.09	48.74	76.02
T_7	Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ (125 g *a.i.*/ha) as PoE at 25 DAS	61.62	88.66	51.43	79.78	57.73	84.98
T_8	Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS	49.66	77.69	54.95	80.38	51.68	79.18
T_9	Intercultivation at 20 and 40 DAS (Farmers practice)	79.07	74.86	76.29	75.49	78.54	75.05
T_{10}	Weed free check	100.00	100.00	100.00	100.00	100.00	100.00
T_{11}	Weedy check	0.00	0.00	0.00	0.00	0.00	0.00
S.Em±		5.59	3.34	8.03	3.82	4.80	2.40
C.D. (P=0.05)		13.45	9.79	23.54	11.20	14.08	7.05

Formatted: Spanish (Guatemala)

Commented [KML26]: the method of analysis is not explained. difficult to judge the value of the tables

Table 2. No. of pods/plant, 100 seed weight (g), Seed yield/plant of chickpea (*Cicer arietinum* L.) as influenced by different weed management treatments

Treatment		No. of pods/plant	100 seed weight(g)	Seed yield / plant
T_1	Pendimethalin 38.7% CS @ 1.0 kg *a.i.* /ha as PE	46.39	24.25	18.98
T_2	Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (1000 g *a.i.*/ha) or 3 L/ha as PE	44.91	24.21	18.24
T_3	Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS	38.28	23.16	17.06
T_4	Imazethapyr 10 % SL @ 70 g *a.i.*/ha as PoE at 25 DAS	48.15	24.59	19.25
T_5	Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE	47.26	24.37	18.14
T_6	Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS	48.62	24.74	20.85
T_7	Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ (125 g *a.i.*/ha) as PoE at 25 DAS	49.09	24.86	21.37
T_8	Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS	39.91	23.40	17.25
T_9	Intercultivation at 20 and 40 DAS (Farmers practice)	48.43	24.63	19.79
T_{10}	Weed free check	53.37	25.02	22.14
T_{11}	Weedy check	38.18	22.36	16.96
S.Em±		1.69	1.10	0.89
C.D. (P=0.05)		4.96	NS	2.60

Formatted: Spanish (Guatemala)

Table 3: Seed yield (kg/ha), haulm yield (kg/ha), biological yield (kg/ha) Net returns (₹/ha) and BC ratio of chickpea (*Cicer arietinum* L.) as influenced by different weed management treatments.

Treatment		Seed yield (Kg/ha)	Haulm Yield (Kg/ha)	Biological yield (Kg/ha)	Net returns (₹/ha)	BC ratio
T_1	Pendimethalin 38.7% CS @ 1.0 kg *a.i.* /ha as PE	1638	2476	4114	53346	2.45
T_2	Pendimethalin 30 % EC + Imazethapyr 2% EC (RM) @ (1000 g *a.i.*/ha) or 3 L/ha as PE	1611	2487	4097	50838	2.35
T_3	Imazethapyr 35 % + Imazamox 35 % WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS	923	2098	3021	14134	1.39
T_4	Imazethapyr 10 % SL @ 70 g *a.i.*/ha as PoE at 25 DAS	1839	2556	4395	63512	2.69
T_5	Quizalofop ethyl 5 % EC @ 50 g *a.i.*/ha PoE	1696	2523	4218	55780	2.49
T_6	Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 245 g *a.i.*/ha as PoE at 25 DAS	2001	2685	4686	72780	2.95
T_7	Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ (125 g *a.i.*/ha) as PoE at 25 DAS	2197	2766	4962	80621	3.01
T_8	Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Imazethapyr 35% + Imazamox 35% WG (RM) @ 70 g *a.i.*/ha as PoE at 25 DAS	945	2115	3060	12249	1.31
T_9	Intercultivation at 20 and 40 DAS (Farmers practice)	1976	2604	4580	68896	2.73
T_{10}	Weed free check	2315	2910	5224	82244	2.82
T_{11}	Weedy check	896	2056	2953	16422	1.50
S.Em±		116.44	118.13	143.42	6404	0.17
C.D. (P=0.05)		341.53	346.47	420.66	18784	0.50

Formatted: Spanish (Guatemala)

Conclusion:

Apart from weed free check, sequential application of Pendimethalin 38.7 % CS @ 800 g *a.i.*/ha as PE *fb* Propaquizafop 2.5 % + Imazethapyr 3.75% W/W ME (RM) @ 125 g *a.i.*/ha as PoE at 25 DAS resulted in better weed control, higher yield (2,197 kg/ha), net returns (Rs 80,621/ha) and benefit cost ratio (3.01) compared to other herbicidal treatments which was followed by post emergence application of Aciflor 16.5 % + Clodinafop 8 % EC (RM) @ 1 L *a.i.*/ha as PoE at 25 DAS and Intercultivation @ 20 and 40 DAS (Farmers practice).

References:

Anonymous, 2021. Selected state-wise area, production and productivity of gram in India, Ministry of Agriculture and Farmers welfare, Govt. of India. Available from https://www.indiastat.com/table/agriculture-data-productionproductivityg/1409248. Accessed on 19th September 2021.

Chandrakar, D.K., Nagre, S.K., Chandrakar, K., Singh, A.P., Nair, S.K., 2014. Chemical weed management in black gram. P 242. In: Extended Summary of Biennial Conference of Indian Society of Weed Science, DSWR, Jabalpur (M.P.).

Chaudhary B M, Patel J J and Delvadia D R, 2005, Effect of weed management practices and seed rates on weeds and yield of chickpea. *Indian Journal of Weed Science*, 37: 271-272.

Choudhary, A.K., 2009. Role of phosphorus in pulses and its management. Indian Farmers' Digest 42(9), 32–34

Das, T.K., 2015. Weed Science: Basic and Applications. Jain Brothers, New Delhi, India.

Gupta, V., Singh, B.N., Kumar, J., Singh, M., Jamwal, B.S., 2012. Effect of imazethapyr on weed control and yield in chickpea under kandi belt of low altitude sub-tropical zone of Jammu. Madras Agricultural Journal 99, 81–86. https://doi.org/10.29321/MAJ.10.100020

Kumar, N., Nandal, D.P., Punia, S.S., 2014. Weed management in chickpea under irrigated conditions. Indian Journal of Weed Science 46(3), 300–301.

Nath, C.P., Dubey, R.P., Sharma, A.R., Hazra, K.K., Kumar, N., Singh, S.S., 2017. Evaluation of new generation post-emergence herbicides in chickpea (*Cicer arietinum* L). National Academy Science Letters 41(1), 1–5. http://dx.doi.org/10.1007/s40009-017-0604-z

Panda, S., Kewat, M.L., Saini, M.K., 2017. Efficacy of propaquizafop and imazethapyr mixture against weeds in soybean. In Proceedings 25th Asian-Pacific Weed Science Society Conference on Weed Science for Sustainable Agriculture, Environment and Biodiversity, 185. https://doi.org/10.20546/ijcmas.2017.610.381

Commented [KML27]: ou're always making comparisons. tell us what we can learn from this study.

Commented [KML28]:

Commented [KML29R28]: we need to harmonize

Formatted: Highlight

Formatted: Highlight

Formatted: Spanish (Guatemala), Highlight

Formatted: Highlight

Formatted: Spanish (Guatemala)

Rana, S.S., Singh, G., Rana, M.C., Sharma, N., Kumar, S., Singh, G., Badiyala, D., 2019. Impact of imazethapyr and its ready-mix combination with imazamox to control weeds in blackgram. Indian Journal of Weed Science 51(2), 151–157. http://dx.doi.org/10.5958/0974-8164.2019.00033.9

Sandil, M.K., Sharma, J.K., Sanodiya, P., Pandey, A., 2015. Bioefficacy on tank-mixed propaquizafop and imazethapyr against weeds in soybean. Indian Journal of Weed Science 47(2), 158–162.

Suryavanshi, T, Kewat M L, Lal S and Porte S S, (2018). Weed indices as influenced by propaquizafop and imazethapyr mixture in blackgram. *International Journal of Current Microbiology Applied Science*, 7: 738-744.