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Original Article

Effect of Diverse Nipping Dates on the Infestation of Helicoverpa Armigera on Chickpea Crops under Arid Climate Conditions of Dera Ismail Khan: A Public Health Perspective

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Abstract

This research investigates an alternative management strategy involving different nipping dates in chickpea cultivation to reduce the reliance on chemical pesticides for food legumes. The current study conducted during the 2022-23 that utilized a randomized complete block design (RCBD). A total of six treatments, consisting of both nipping and non-nipping methods, were implemented starting December 1, 2022, with subsequent treatments applied at 15-day intervals (December 1, December 15, December 30, January 15, and January 30, 2023). A control group was maintained without nipping, allowing for natural growth, to assess the impact of pod borer infestation. The findings indicate that nipping at earlier dates significantly diminished pest infestations and improved grain yields compared to both later nipping and the control group. However, the study's findings may have limitations due to their dependence on specific environmental conditions and the focus on a single growing season, which could affect broader applicability. This research underscores the advantages of early nipping in enhancing yields and minimizing pesticide usage, contributing to sustainable pest management practices in arid regions. The results advocate for the implementation of early nipping within integrated pest management strategies in similar agro-climatic environments.

Keywords: Chickpea, Nipping dates, Variety Karak-1, Gram Pod Borer, Infestation of Helicoverpa Armigera.

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Introduction

Chickpeas are a crucial legume crop, ranking third in importance behind peas and soybeans (Food and Agriculture Organization [FAO], 2021). According to the FAO, they account for approximately 15% of worldwide legume production (FAO, 2021). This crop has its roots in the Middle East, where it has been cultivated for over 7,000 years (Hanelt & Institute of Plant Genetics and Crop Plant Research, 2001). Today, chickpeas are grown in more than 40 countries across every continent (World Bank, 2020). The leading chickpea-producing nations include India, Turkey, Iran, Pakistan, Canada, Australia, Ethiopia, Myanmar, and Mexico (FAO, 2021). In Pakistan, chickpeas are primarily grown in provinces such as Punjab, Khyber Pakhtunkhwa, Sindh, and Baluchistan, under rain-fed conditions (Pakistan Agricultural Research Council [PARC], 2020). The Thal region in Punjab is a significant production area, with the crop relying on residual moisture after the rice harvest (PARC, 2020). It is reported that 80.1% of Pakistan's chickpea production comes from Punjab, with the majority being cultivated under rain-fed conditions (PARC, 2020). Chickpeas come in two main market varieties: Desi and Kabuli. The Desi type has thick, colorful seed coats with small, angular seeds and a coarse surface, with flowers that can be pink or white. The plants show varying levels of anthocyanin pigmentation (Gaur *et al*., 2019). Desi chickpeas constitute around 81-85.1% of the total chickpea area (Gaur *et al*., 2019). The characteristic white or beige seeds of chickpeas of the Kabuli variety are characterized by their ram's head shape, silky texture, and thin skin. These chickpeas are a sort of chickpea. Other than that, these plants have stems that are devoid of any purple coloring and produce white blooms, which contributes to their overall lighter appearance. Kabuli chickpeas tend to have higher sugar content and lower fiber content compared to desi chickpeas. As a result, they command a higher market price and have bigger seed sizes (Gaur *et al*., 2019). Chickpeas are a nutrient-rich dry legume with several health benefits. They contain approximately 23% easily digestible protein, 47% total carbohydrates, and 6% crude fiber (USDA, 2021). They are also rich in essential minerals like phosphorus, calcium, magnesium, iron, and zinc (USDA, 2021).

In terms of soil benefits, chickpeas form a symbiotic relationship with rhizobia, allowing them to obtain up to 140 kg of nitrogen from the air (Kumar *et al*., 2017). This partnership also aids in maintaining long-term soil health, fertility, and sustainability of the ecosystem (Kumar *et al*., 2017). The advantages of chickpeas have led to their rising acceptance in broad agricultural methods, especially in developed nations such as Canada and Australia (USDA, 2021). However, the crop faces challenges such as pest attacks, which can impact grain yield and reduce overall productivity (Gaur et al., 2019). Key findings from various studies on chickpeas have highlighted the importance of evaluating the impact of different factors on crop yields and pest management strategies (Khan *et al*., 2018). These studies have provided valuable insights into optimizing the production process and promoting long-term sustainability in chickpea farming (Khan *et al*., 2018).

Material and Method

Experimental Site

An investigation was carried out at the agricultural research site of Gomal University in Dera Ismail Khan, Pakistan, utilizing the well-known chickpea cultivar known as Karak-1. The evaluation of the effects of nipping on the occurrence of the gramme pod borer was the primary objective during this study. An RCBD, which stands for randomized complete block design, was utilized in the research project. It included three replications and six treatments, one of which was a control group. Heavy clay soil, which is known for its exceptional capacity to retain moisture, served as the environment for the experiment. Since the soil conditions were sufficient for moisture, the chickpeas did not require any irrigation during their growth phase. During the entire life cycle of the crop, the only source of water that was available was rain, if it was applicable. Other agricultural practices remained the same across all treatments.

Bioassay Procedure

The crop was sown in October 2022 on well-prepared land under wet conditions. Manual sowing was carried out using a hand drill to ensure proper spacing, with rows placed 60 cm apart plants were spaced 30 cm apart, with a one-meter

walkway established between replications to facilitate data collection and weeding activities. To achieve the desired plant population density, excess chickpea plants were thinned out. Nipping treatments were initiated on December 1, 2022, and repeated every 15 days (on December 1, December 15, December 30, January 15, and January 30, 2023), alongside a control group that received no nipping, allowing for natural plant growth. The level of pod borer infestation was monitored, and the vulnerability of pod development stages to gram pod borer attacks was also examined, along with comparisons of chickpea grain yields between the nipped and non-nipped treatments on the specified dates. During the study, data was collected on the following parameters:
Certainly! Here's a rephrased version of the provided list with added detail:

i. Count of larvae present on each individual plant.
ii. Percentage variation, whether an increase or decrease, in the yield of chickpeas.
iii. Quantity of pods that exhibit signs of damage or affliction per plant.
iv. Proportion of grain that has sustained damage within the chickpea yield.
v. Date marking the initial occurrence of pest attacks.
vi. Duration in days before flowering begins to take place.
vii. Average number of branches that each plant produces.
viii. Total count of pods that can be found on each chickpea plant.
ix. Average number of grains contained within each pod.
x. Measurement of the height of chickpea plants, recorded in centimeters.
xi. Mass of one hundred grains, measured in grams.
xii. Biological yield recorded in kilograms per hectare.
xiii. Yield of the grain produced.
xiv. Harvest Index (HI) expressed as a percentage.

Data Analysis

The data that was gathered was subjected to a comprehensive analysis using analysis of variance (ANOVA), along with mean comparisons. For this purpose, we applied the least significant difference (LSD) test, setting the significance threshold at a 5% level. The statistical analyses were conducted using Statistics software, version 25, which facilitated our evaluation of the results.

Results and Discussion

Number of Larvae Plant Per Plant

The data presented in Table 1 revealed significant differences in the number of larvae per plant across various treatments. The highest count of larvae per plant (26.0) was observed in treatment T6 (30th January), followed by T5 (15th January) with 18.00 larvae, and T4 (30th December) with 11.67 larvae. In comparison, the treatments T2 and T3, applied on 1st December and 15th December respectively, along with the control group designated as T1, demonstrated comparable outcomes. Specifically, the average number of larvae observed per plant for these groups were 5.67 for T2, 6.00 for T3, and 3.33 for the control T1. This indicates that both T2 and T3 had similar levels of larval presence, while T1 showed a significantly lower count. Notably, the control (T1) had the lowest larval count at 3.33. The reduced number of larvae in the control and earlier treatments can be attributed to their early maturity, resulting in fewer suitable feeding options for the larvae due to the hardening of pods and young leaves. The larvae tended to seek out young and tender pods and leaves for nourishment, which were abundantly available in the later nipped treatments T4, T5, and T6. Consequently, these treatments recorded the highest numbers of larvae, as they provided the preferred feeding resources for the young larvae.

Grain Damage %

The table shows significant damage variation in chickpeas across different treatment dates. The highest damage percentage of 34.49% was observed in the treatment where the last nipping occurred, followed by 26.68% in a treatment where nipping took place a month earlier, and 15.31% for the treatment with the earliest nipping date. Conversely, treatments nipped earliest showed minimal damage: the control treatment along with T2 and T3 had damage percentages of 6.1%, 7.05%, and 7.36%, respectively, with no statistically significant differences between these values.

As nipping dates progressed, damage percentages increased accordingly. The highest damage percentage (34.49%) observed in the last treatment might be due to a higher presence of immature pods on the chickpea plants, indicating that the larvae of the gram pod borer favor young, underdeveloped pods with tender grains. The results also suggest that the larvae prefer to feed on about 50% developed pods, which are the most favorable food for them.

In treatments where nipping occurred earlier, most pods were mature by the time of harvesting in the first week of April. Although there were some underdeveloped pods on the upper portion of the plants, damage percentages for these were low. Consequently, the insect could only damage a small percentage of mature pods, with 6-7% damage observed in early nipped plants compared to the higher damage percentages seen in treatments that were nipped later. This suggests that the larvae tend to favor tender and underdeveloped pods, leaving mature pods mostly unaffected.

Yield Increase or Reduction Percentage

Table 1 presents the percentages of yield reduction across different treatments. The highest yield reduction occurred in treatment T6 (30th January), with a decrease of 40.51%, followed by treatment T5 (15th January), which showed a reduction of 34.21%. In contrast, the control group maintained a 100% yield, while T2 (1st December) exhibited the greatest yield increase at 33.25%, closely followed by T3 (15th December) with a yield increase of approximately 9.18%. The smallest increase, at just 2.46%, was observed in T4 (30th December). Plants that were nipped early encountered less pest pressure, resulting in higher yields. Conversely, the yield reductions seen in later treatments may be attributed to increased infestations of larvae on immature pods, which could cause significant crop damage and thus a reduction in grain yield. This suggests that early-nipped plants are less appealing to pests compared to those nipped later. Therefore, it can be concluded that early nipping of plants is advantageous in reducing pest damage and enhancing yield.

Plant Height (cm)

Table 1 indicates notable differences in plant height based on the treatments applied. The control treatment, T1, exhibited the highest plant height at 62.53 cm, followed closely by T2 (1st December) at 61.86 cm. In contrast, the lowest plant heights were observed in T6 (30th January) at 41.72 cm and T5 (15th January) at 45.49 cm.

The greater height recorded in the control treatment (T1) may be attributed to the absence of nipping, allowing the plants to grow without interruption. Conversely, the observed decline in plant height with later nipping dates likely results from a shorter vegetative growth period. Plants subjected to nipping at later dates may not have had sufficient time to complete their vegetative phase, leading to an earlier onset of flowering as days lengthened in March. Consequently, these late-nipped plants displayed reduced heights compared to both the non-nipped and those nipped earlier. These findings align with the work of Kobir *et al*. (2021), who noted a reduction in maximum plant height to 46 cm. Additionally, Baloch and Zubair *et al*. (2010) observed decreased heights in plants topped at various stages-topping at 40 cm, ground level, and topping at 50 cm resulted in heights of 57 cm, 60 cm, and 65 cm, respectively, compared to the control group.

Branches Per Plant

The data in Table 1 indicated significant differences in the number of branches per plant across various treatments. The treatments T2 (1st December) and T3 (15th December) exhibited the highest branch counts of 13.03 and 12.07, respectively, while T4 (30th December) recorded a lower average of 10.83 branches. The control group (T1) had the least branches per plant, averaging at 7.27. The increased branching observed in T2 and T3 could be attributed to the removal of the terminal growth, which likely redirected the plant hormone auxin to side branches, promoting greater branch development compared to the unpruned control. In contrast, the lower branch count in the control treatment T1 may be due to auxin's influence on maintaining apical dominance, leading to increased vertical growth but fewer lateral branches.

These findings align with earlier studies by Khan et al. (2006), who noted an increase of 11.0% and 11.6% in branches per plant, and Kobir *et al*. (2021), An investigation revealed that certain plants exhibited an increase in the number of branches, with reports indicating that each plant could produce between three to four additional branches. In a similar vein, Khan et al. (2003) noted comparable findings in their research, highlighting the phenomenon of branch proliferation among various plant species an increase in branches, reporting counts from 4 to 6.6 branches. Regarding the number of pods per plant, Table 2 showed significant variations among the treatments. The highest pod count was found in T2 (1st December) with 48.54 pods, followed closely by T3 (15th December) at 46.96 and the control T1 at 35.33. Conversely, T6 (30th January) had the lowest number of pods (21.89), which was similar for T5 (15th January). The higher number of pods in T2 and T3 likely results from increased secondary branches and a broader canopy, enabling more flowers to develop and subsequently convert into pods. Lower pod counts in later treatments can be attributed to narrower canopies and smaller secondary branches, which limited flowering and pod formation. These observations coincide with research by Khan *et al*. (2018) and Kobir *et al*. (2021), who reported enhanced pod counts (25 to 30 pods per plant), while Khan et al. (2006) recorded a range of 22 to 36.3 pods per plant. Significant differences in grains per pod were also observed among the treatments (Table 2). T2 (1st December) had the highest grains per pod count at 2.67, compared to 2.47 in T1 (control) and 2.37 in T3 (15th December). The lowest counts of grains per pod were noted in T6 (30th January) at 1.80, with T5 and T4 reflecting counts of 2.0 and 2.07, respectively.

The variations in grains per pod among the treatments likely reflect nutrient availability and plant spacing. The higher counts in T1, T2, and T3 could stem from robust plant growth that optimized sunlight and air circulation, leading to healthy pod formation. In contrast, T4, T5, and T6 likely suffered lower yields due to shorter vegetative periods and the effects of delayed nipping. These results are consistent with those of Baloch and Zubair *et al*. (2010), who observed an increase in the number of grains per pod ranging from 1.29 to 1.44, and Khan *et al*. (2006), who reported variations from 1.3 to 1.6 grains per pod. When examining 100-grain weight, Table 2 demonstrated significant variations among treatment means. The maximum weight of 236.28 grams was observed in T1 (control), with T2 and T3 following closely at 236.28 and 232.54 grams, respectively. In contrast, T6 showed the minimum weight at 191.72 grams, with T5 and T4 at 195.24 and 213.47 grams, respectively.

The increased weight of 100 grains noted in treatments T1 and T2 can likely be explained by the higher density of the grains associated with these specific treatments. It appears that the interventions applied in T1 and T2 have led to the development of heavier grains, contributing to the elevated 100-grain weight measurements observed in these groups. The early nipping likely encouraged premature flowering and pod formation, providing sufficient time for both vegetative growth and grain filling. In contrast, the delayed nipping in T4, T5, and T6 led to later flowering and pod development, which subsequently shortened the grain-filling period, resulting in smaller grains and reduced weights. Supporting evidence from Aslam *et al*. (2010) indicated 100-seed weights between 28.07 and 28.21 grams, while Khan et al. (2006) reported 100-grain weights ranging from 15.7 to 18.0 grams.

The biological yield data (kg ha-1) shown in Table 1 demonstrated significant differences among treatments. The highest biological yield registered was in T3 (15th December) at 1830.3 kg ha-1, followed closely by T2 (1st December) at 1828.7 kg ha-1 and T4 (30th December) at 1737.7 kg ha-1. On the other hand, T6 (30th January) produced the lowest yield at 1240.1 kg ha-1, with T5 (15th January) slightly higher at 1265.6 kg ha-1. The increased biological yield in T2, T3, and T4 may be attributed to a higher number of branches, pods, and leaves, which resulted from a more expansive canopy and additional secondary branches due to early nipping. This condition facilitated extended periods of vegetative and reproductive growth. Conversely, the reduced biological yields in T5 and T6 were likely due to insufficient growth time. These results align with findings from Aslam *et al*. (2010), who reported a biological yield range between 3771.00 and 8571.4 kg ha-1. A higher harvest index indicates greater efficiency in converting photosynthesis into economic yield. The high values for T2 and T3 suggest effective conversion of nutrients into grain output, likely due to optimal growth conditions and extended growth periods. In contrast, the lower efficiency observed in T5 and T6 could be attributed to inadequate growth conditions or immature grains potentially affected by pest damage, leading to lower yields.

The findings presented here align with the observations made by Aslam *et al*. (2010), who reported that various de-topping treatments had a significant impact on the harvest index. Specifically, their research revealed that the harvest index percentages varied considerably, falling within a range of 37.18% to 42.89%. This variation highlights the potential effects of different agricultural practices on crop yield efficiency. Finally, the grain yield results detailed in Fig. 1 exhibited significant differences between treatments. The highest grain yield of 953.09 kg ha-1 was recorded in T2 (1st December), followed by T3 (15th December) at 923.99 kg ha-1 and T4 (30th December) at 732.86 kg ha-1. The lowest yields were observed in T6 (30th January) at 432.81 kg ha-1, with T5 (15th January) at 473.62 kg ha-1. The superior grain yield recorded in T2, T3, and T4 can likely be linked to the combination of higher branch, pod, and leaf counts due to broader canopies and increased secondary branching, allowed by early nipping, which provided ample time for both vegetative and reproductive development. The lower yields observed in T5 and T6 appear to be the result of limited growth duration. Similar results were reported by Kabir et al. (2021), who noted significant impacts of various nipping treatments on grain yield, with reported ranges between 974 and 1150 kg ha-1.

Table 1

The impact of the timing of nipping (specific dates) on various parameters in chickpea, including the number of larvae per plant, percentage of grain damage, percentage change in yield, plant height in centimeters, and the number of branches per plant.

Treatment	Number of larvae per plant	Grain Damage %	Yield increase/ reduction %	Plant height (cm)	Number of Branches per plant
1st December	5.66 d	7.05 d	+133.27 a	62.52 b	13.03 a
15th December	6.00 d	7.36 d	+129.20 b	61.86 b	12.06 ab
30th December	11.66 c	15.31 c	+102.48 c	56.22 c	10.82 b
15th January	18.00 b	26.68 b	-65.53 d	45.49 d	7.90 c
30th January	26.00 a	34.49 a	-60.53 e	41.72 e	7.46 c
Control	3.33 d	6.10 d	100 c	77.78 a	7.26 c
$LSD_{0.05}$	**3.0382**	**1.6260**	**2.5021**	**1.6911**	**1.5610**

Table 2

Impact of nipping dates on the number of pods per plant, grains per pod, weight of 100 grains (g), and biological yield (kg/ha) in chickpea.

Treatment	Number of pods per plant	Grains per pod	100-grains weight (g)	Biological yield (kg ha^{1})
1st December	48.54 a	2.66 a	236.28 a	1828.7 a
15th December	46.96 a	2.36 ab	232.54 b	1830.3 a
30th December	33.28 b	2.06 bc	213.47 c	1737.7 a
15th January	24.22 c	2.06 bc	195.24 d	1265.6 c
30th January	21.88 c	1.80 c	191.72 e	1240.1 c
Control	35.33 b	2.46 ab	236.80 a	1507.2 b
$LSD_{0.05}$	2.624	0.462	3.451	97.87

Figure 1

Effe of nipping (dates) on grain yield of chickpea

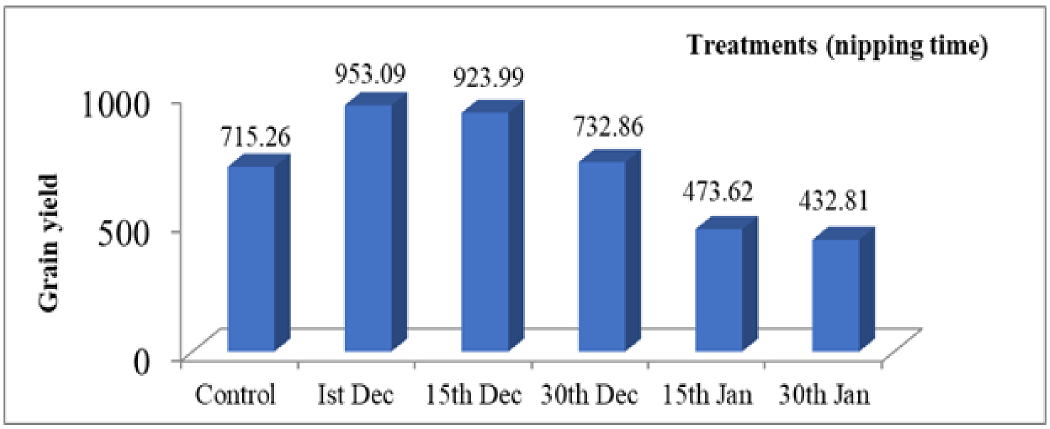


Figure 2

The impact of the timing of nipping (specific dates) on the harvest index percentage of chickpea.

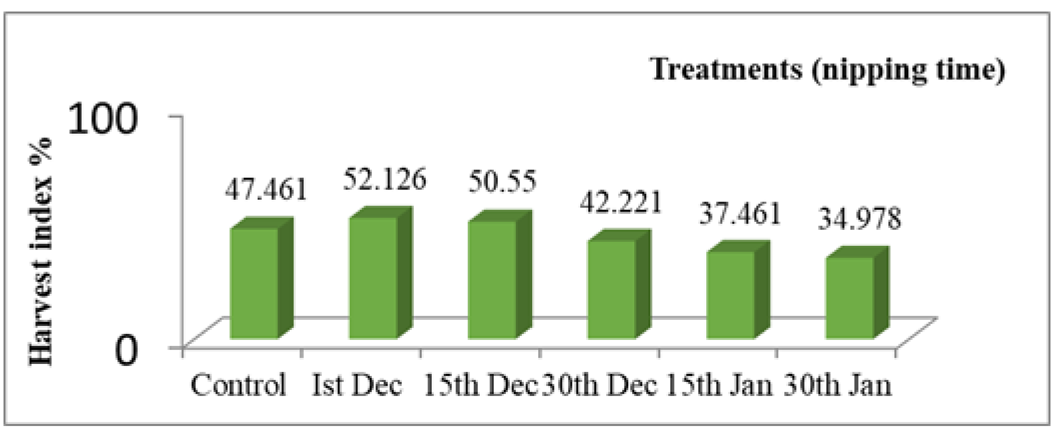
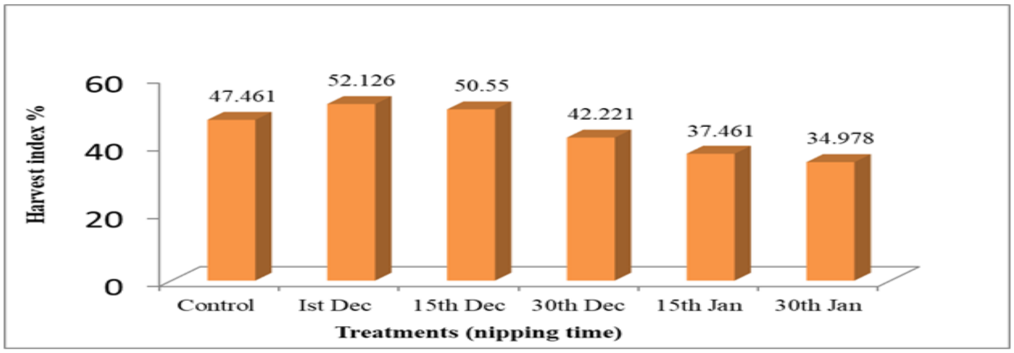


Figure 3

Pping (dates) on Grain Yield of Chickpeas



Conclusion and Recommendations

Based on the experimental results, it was found that the treatment involving nipping at the latest stage (30th January) resulted in the highest number of larvae per plant while the control group, along with the early nipping treatments designated as T2 and T3, exhibited the lowest levels of grain damage. In contrast, the late nipping treatments demonstrated a significantly higher percentage of grain damage when analyzed against both the control group and the early nipping treatments. This finding suggests that the timing of the nipping treatments has a considerable impact on the extent of grain damage, with late treatments being particularly detrimental in comparison. Similarly, the most significant decrease in grain yield was recorded in the late nipped treatments in contrast to those that were nipped earlier. The larvae exhibited a preference for targeting younger pods, leaves, and branches as the growing season progressed. In contrast, the early nipped treatments led to earlier production of flowers and mature pods, which decreased their susceptibility to borer attacks due to their tougher outer layers and the lower availability of food for the larvae. Nipping generated a greater number of secondary branches in chickpeas compared to the control group, and the early nipped treatments yielded a higher number of pods per plant. Consequently, these early nipped treatments exhibited the highest grain yield in comparison to those nipped later. It is advisable to start nipping early in the chickpea growth cycle, specifically around December 1st and December 15th, as this practice helps reduce borer infestations and increases grain yield. This approach can enhance agricultural productivity and improve the net income for farmers in the Dera Ismail Khan region (Daman).

Limitations and Future Directions

This study was limited to a single cropping season and specific environmental conditions in Dera Ismail Khan, which may restrict the generalizability of the results to other regions with different climatic conditions. Future research should focus on validating these findings across a variety of agro-climatic zones and over multiple growing seasons. Investigating additional factors alongside nipping, such as the integrated use of biological control agents, could further enhance pest management strategies. Moreover, conducting an economic analysis of the early nipping practice, including cost-benefit evaluations, would offer valuable insights into its feasibility for farmers. These suggested research directions could contribute to reducing chemical pesticide usage in food legume cultivation and improving sustainable pest control methods.

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Declaration of Interest

The authors declare no conflicts of interest related to the findings or content of this study. This research was conducted independently, without any support or funding from commercial entities that could have influenced the interpretations or outcomes presented

References

Ahmad, H. K., Mansoor, M., & Hussain, K. (2010). Effect of soil moisture and de-topping on yield and yield components of chickpea. *Journal of Agricultural Science and Technology*, 12(5), 621-629.

Baloch, M. S., & Zubair, M. (2010). Effect of nipping on growth and yield of chickpea. *Journal of Animal & Plant Sciences*, 20(3), 208-210.

Choudhary, A., Kumar, S., Pareek, B., & Shekhawat, P. S. (2020). Performance of chickpea (Cicer arietinum L.) varieties to seed rate and nipping in arid irrigated western plain zone. *International Journal of Current Microbiology and Applied Sciences*, 9(5), 2020.

Choudhary, A., Shekhawat, P. S., Godara, A. S., Singh, S. P., Regar, M. L., & Rakesh, S. (2021). Influence of seed rate and nipping practice on yield, nutrient uptake and quality of chickpea (Cicer arietinum) varieties in irrigated arid western plains zone. *Indian Journal of Agronomy*, 66(1), 103-107.

Choudhary, A., Shekhawat, P. S., Singh, S. P., & Godara, A. S. (2022). Effect of seed rate on chickpea in the western plain zone. *The Pharma Innovation Journal*, 11(2), 840-842.

FAO (Food and Agriculture Organization of the United Nations). (2010). *Agricultural Production Yearbook*. Retrieved from http://faostat.fao.org.

FAO. (2021). *FAOSTAT: Statistics Division*. Retrieved from http://www.fao.org/faostat/en#data.

Freed, R. D., & Eisensmith, S. (1989). *MSTAT-C: A software package for the design management, and analysis of agronomic experiments*. Michigan State University.

Gaur, P. M., Mallikarjuna, N., & Singh, M. B. (2019). Chickpea breeding: An overview. *Agronomy*, 9(2), 1-12.

Gnyandev, B., Kurdikeri, M. B., & Salimath, P. M. (2019). Effect of nipping and foliar spray of growth regulators on plant growth, seed yield, and quality in chickpea varieties. *Journal of Entomology and Zoology Studies*, 7(2), 318-321.

Hanelt, P., & Institute of Plant Genetics and Crop Plant Research. (2001). Wild crop relatives: Genomic and breeding resources - legume crops. *Springer*.

Helbaek, H. (1970). *The plant husbandry at Hacilar*. In Mellaart, J. (Ed.), Excavation at Hacilar (p. 189). Edinburgh University Press.

Jadav, D. A., Kumawat, P. D., Dharaiya, B. K., & Ghetiya, K. P. (2022). Effect of sowing time, plant growth regulators, and nipping on yield attributes and yield of chickpea (*Cicer arietinum* L.) under south Saurashtra conditions. *Journal of Plant Growth Regulation*, 41(3), 1234–1245.

Khan, E. A., Hussain, I., Ahmad, H. B., & Hussain, I. (2018). Influence of nipping and foliar application of nutrients on growth and yield of chickpea in rain-fed conditions. *Legume Research: An International Journal*, 41(5), 740-744.

Khan, H., Gul, R., & Khan, N. U. (2017). Appraisal of interaction among nipping and chickpea (*Cicer arietinum* L.). *Journal of Animal and Plant Sciences*, *27*(3), 899-906.

Khan, H., Latif, A., Mahmood, S., & Khan, M. S. S. (2006). Effect of nipping at various stages on yield and yield components of chickpea (Cicer arietinum L.). *Journal of Research Science*, *Bahauddin Zakariya University, Multan, Pakistan*, *17*(2), 123-128

Khan, R. U., Rashid, A., & Khan, A. (1998). Effect of cutting chickpea at different levels on green fodder and seed yield under rainfed conditions. *Pakistan Journal of Biological Sciences*, 1, 329-331.

Kumar, V., Kumar, A., & Meena, R. (2017). Role of chickpea in sustainable agriculture: A review. *Indian Journal of Agricultural Science*, 87(6), 723-729.

Makwana, N. D., Kacha, H. L., Bhabhor, G. K., & Bhalani, R. B. (2023). Effects of spacing and nipping on yield attributes and yield of chickpea. *Current Journal of Applied Science and Technology*, 42(26), 44-48.

Pandey, B. K., Verma, N. K., Devi, N., Singh, N. K., Tripathi, U. C., & Singh, D. (2022). Effect of nipping and planting geometry on the growth and yield of chickpea (*Cicer arietinum* L.) in Bundelkhand region of Uttar Pradesh, India. *Journal of Agricultural Science and Practice*, *7*(3), 45-52.

Pundir, R. P. S., Rao, N. K., & van der Maesen, L. J. G. (1985). Distribution of qualitative traits in the world germplasm of chickpea (Cicer arietinum L.). *Euphytica*, 34, 697.

Rani, J., & Paul, B. (2023). Challenges in arid region reclamation with special reference to the Indian Thar Desert—its conservation and remediation techniques. *International Journal of Environmental Science and Technology*, 1-22.

Rao, J. V. D. K., Johansen, C., & Rego, T. J. (Eds.). (1998). *Residual effects of legumes in rice and wheat cropping systems of the Indo-Gangetic Plain*. Oxford and IBH Publishing Co. Pvt. Ltd.

Reddy, A. R., Chaitanya, K. V., & Vivekanandan, M. (2004). Drought-induced responses of photosynthesis and antioxidant metabolism in higher plants. *Journal of Plant Physiology*, 161, 1189-1202.

Shubha, S., Devaranavadagi, V. S., & Hotkar, S. (2021). Effect of nipping on growth and yield of chickpea (Cicer arietinum L.) under rain-fed conditions of Karnataka. *The Pharma Innovation Journal*, 848-851.

Shukla, A. K., Singh, R. K., Pandey, A. K., Gautam, M. K., & Vishen, G. S. (2018). Effect of growth regulators and nipping on biochemical traits and yield attributes of chickpea (Cicer arietinum L.). *International Journal of Chemical Studies*, 6(1), 438-442.

Sraf, C. S., Moin, A., Singh, P., & Jat, M. L. (2018). Biological nitrogen fixation and residual effects of winter grain legumes in rice and wheat cropping systems of the Indo-Gangetic plain. In R. P. Singh, S. K. Singh, & J. P. Sharma (Eds.), Residual effects of legumes in rice and wheat cropping systems of the Indo-Gangetic Plain (pp. 1-20). *Springer.*

United States Department of Agriculture. (2021). *Chickpeas*. Retrieved from https://fdc.nal.usda.gov

Williams, P.C. and Singh, U., *The Chickpea Đ Nutritional quality and the evaluation of quality in breeding programmes*. In the Chickpea, Saxena, M.C. and Singh, K.B., Eds., ICARDA, Aleppo, Syria, 329, 1987.

World Bank. (2020). *Agricultural production and food security*. Retrieved from https://www.worldbank.org

Yu, L. X. and T. L. Setter (2003). Comparative transcriptional profiling of placenta and endosperm in developing maize kernels in response to water deficit. *Plant Physiol*., 131, 568-582.

Zohary, D., & Hopf, M. (2000). Pulses. In *Domestication of plants in the Old World: The origin and spread of cultivated plants in West Asia, Europe, and the Nile Valley* (3rd ed., pp. 108–120). Oxford University Press.

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