**Optimizing Sowing Depth and Seed rete for enhanced growth and yield of chickpea (*Cicer arietinum* L.): A review**

**Abstract**

The present study explores the influences of Sowing Depth and Seed Rate on Growth and Yield of Chickpea (*Cicer arietinum* L.). In India, chickpeas (*Cicer arietinum* L.) are an essential pulse crop that greatly enhances soil fertility, food security, and sustainable agriculture. Key agronomic elements including seed rate and planting depth impact germination, seedling vigor, root growth, biomass production, and yield, among other aspects of the crop's performance. While deep sowing (>8 cm) needs more energy for emergence, resulting in delayed development and decreased productivity, shallow sowing (2–4 cm) encourages early emergence but may cause inadequate root anchoring and moisture stress. According to research, a seed rate of 80–100 kg/ha maintains optimal plant density and resource usage, resulting in higher yields and decreased susceptibility to pests, while a sowing depth of 5–7 cm improves root penetration and germination. This study highlights region-specific agronomic techniques to increase productivity and resilience against climate variability by combining research on the relationship between sowing depth and seed rate in chickpea production throughout India. It emphasizes the significance of precision farming methods and advocates for additional studies on how these factors affect crop performance across various agro-climatic zones. Precision agronomy practices, such as adjusting seed rates and sowing depths according to local conditions, are key to enhancing chickpea productivity and ensuring sustainable agricultural practices.

**Keywords:** *Cicer arietinum, germination, seedling vigor, biomass production*

**Introduction:**

One of India's most vital pulse crops, the chickpea (*Cicer arietinum* L.), makes a substantial contribution to sustainable agricultural practices, nutritional balance, and food security (Singh et al., 2020). Agronomic factors that directly impact germination, seedling vigor, root growth, biomass production, and final yield include sowing depth and seed rate (Gupta *et al*., 2017; Joshi *et al*., 2022). Chickpea is a source of essential proteins and amino acids in human diets and provides valuable energy and proteins in animal feed. Within farming systems, it is a useful break crop for weed control and prevention of soil- and stubble-borne disease outbreaks. Furthermore, its ability to fix atmospheric nitrogen improves soil fertility, providing benefits for subsequent cereal crops (Kripanidhi et al., 2017; Richards et al., 2022). In chickpea, phosphorus has a sizable impact on nodule growth, plant height, branches/plant, pods/plant, grain yield, and harvest index. Phosphorus application helps improve the availability of nutrients and water to the growing sections, resulting in improved root development and nodulation, which increases the production of dry matter in chickpea (Kumar et al., 2023; Yadav et al., 2024).

Sowing depth is crucial for reliable crop establishment. Shallow seeding (2–4 cm) promotes early emergence, but it can also lead to poor root anchoring and moisture stress (Sharma & Singh, 2020). However, deep planting (>8 cm) often results in delayed emergence, weaker seedlings, and lower production because of the high energy needed for the emergence and the lack of oxygen (Choudhary *et al*., 2021; Patil *et al*., 2018). According to research, a depth of 5–7 cm is ideal for boosting root penetration and germination percentage in Indian soils (Rao *et al*., 2020; Bhargav et al., 2018).

Similarly, seed rate determines plant population density and influences competition for resources, leading to variations in disease incidence, canopy development, and grain yield (Meena *et al.,* 2020; Verma & Yadav, 2020; Emenky & Khalaf, 2010). According to research, the optimal seed rate is 80–100 kg/ha; lower rates (<80 kg/ha) result in more weed infestation and less ground cover, while higher rates (>100 kg/ha) cause overcrowding, poor aeration, and increased pest susceptibility (Singh *et al*., 2019; Reddy *et al*., 2021). By adjusting these variables according to soil type, moisture availability, and climate, chickpea productivity can be significantly raised (Kumar *et al.*, 2021; Walia et al., 2020).

This compiles and analyzes Indian research on the connection between chickpea farming's seed rate and sowing depth. It highlights the need for location-specific agronomic guidance to improve crop production and resource-use efficiency across a variety of agro-climatic zones (Mishra *et al*., 2019). The findings demonstrate the importance of precision farming techniques and sustainable agronomic approaches in ensuring optimal soil health, production stability, and resilience to climate fluctuation (Mehta *et al*., 2021; Pundir & Mengesha, 1995).

The planting depth and seed rate are two crucial agronomic factors that significantly affect chickpea establishment, growth, and yield. An ideal sowing depth ensures better seed germination, root growth, and nutrient uptake, while an ideal seed rate preserves appropriate plant density, canopy structure, and resource utilization efficiency (Sharma *et al*., 2020; Singh *et al*., 2022).

The relationship between planting depth and seed rate also affects crop performance. The ideal balance for chickpea production, according to studies, is a sowing depth of 5 cm and a moderate seed rate (90–100 kg ha⁻¹), which ensures maximum pod formation, a high harvest index, and enhanced water-use efficiency (Mishra *et al*., 2019; Singh *et al*., 2022).

Additionally, sandy soils benefit from somewhat deeper sowing (6–7 cm), while loamy and clayey soils prefer shallower depths (4–6 cm) in accordance with region-specific standards (Sharma & Verma, 2021; Patel *et al*., 2023). In light of cultivar variations, climatic shifts, and soil moisture availability, future research should focus on refining recommendations for seed rate and planting depth (Kumar *et al*., 2021). Selecting the ideal combination of planting depth and seed rate can significantly boost chickpea production, improving resource efficiency and boosting farmers' profits. Site-specific agronomic trials and continued research will further enhance these recommendations to maximize chickpea production potential under different agro-climatic conditions (Mehta *et al*., 2023; Singh *et al*., 2022).

Research indicates that a sowing depth of 5–6 cm and a seed rate of 80–100 kg ha⁻¹ usually produce superior yield performance, faster root growth, and greater emergence rates (Kumar *et al*., 2021; Mehta *et al*., 2022). Shallower depths (<4 cm) usually cause poor moisture retention and insufficient seedling establishment, whereas deeper depths (>7 cm) cause delayed emergence and poor plant vigor (Reddy *et al*., 2021; Joshi *et al*., 2021). Very high seed rates (>120 kg ha⁻¹) lead to increased competition for resources, whereas low seed rates (<60 kg ha⁻¹) result in poor canopy formation and yield losses (Choudhary *et al*., 2021; Patel *et al*., 2023).



Fig .1 Effects of Different sowing depth

The chickpea (*Cicer arietinum* L.), one of India's most important pulse crops, significantly improves soil fertility, food security, and sustainable agriculture (Sharma *et al*., 2018; Kumar *et al.*, 2021). India is the world's largest producer and consumer of chickpeas, accounting for over 70% of global production (Singh *et al*., 2020). Due to its high protein content (18–22%), ability to fix atmospheric nitrogen and tolerance to semi-arid environments, the crop is an essential component of India's agricultural systems (Meena *et al*., 2019; Verma *et al*., 2022).

Due to inadequate agronomic management, such as incorrect sowing depth and seed rate, chickpea production is still low when compared to its genetic potential, despite its agronomic significance (Reddy *et al*., 2021). These elements have a major impact on plant vigor, yield production, root establishment, and seedling emergence (Gupta *et al*., 2017; Choudhary *et al*., 2021).

1. **Influences of sowing Depth**

The depth of sowing has a major effect on crop establishment and productivity (Patil *et al*., 2018). Shallow seeding (2–4 cm) may cause rapid emergence, but it also increases the plant's susceptibility to lodging, moisture stress, and root exposure (Mishra *et al*., 2020). However, deep sowing (>8 cm) might lead to delayed emergence, weak seedlings, and lower vigor due to the restricted oxygen supply and increased energy need for germination (Sharma & Singh, 2020; Rao *et al*., 2020). According to the study, a depth of 5–7 cm is excellent because it ensures better root anchoring, moisture availability, and consistent emergence all of which boost grain yield and biomass buildup (Mehta *et al*., 2021).

Studies conducted in India's various agro-climatic zones have shown that temperature, moisture content, and soil type all have a significant impact on the ideal sowing depth. For instance, slightly deeper sowing (6–8 cm) is preferred in black cotton soils because it holds more moisture, whereas shallower sowing (4–6 cm) is better in light-textured sandy soils to avoid excessive water loss (Verma *et al*., 2020; Singh *et al*., 2022).

1. **Influences of Seed Rate**

Seed rate is another crucial factor affecting plant population density, resource consumption, and final production (Meena *et al*., 2020; Joshi *et al.,* 2022). Inadequate canopy covering from lower seed rates (less than 80 kg/ha) frequently leads to increased soil erosion, weed infestation, and photosynthetic efficiency (Reddy *et al*., 2021). However, excessive seeding rates (>100 kg/ha) lead to overpopulation, water and nutrient competition, poor grain filling, and an increase in pests (Kumar *et al*., 2019; Sharma *et al*., 2021).

For Indian conditions, an optimal seed rate of 80–100 kg/ha is recommended based on variety, soil fertility, and irrigation availability (Choudhary *et al*., 2021; Mishra *et al*., 2019). Higher seed rates are beneficial in rainfed situations to counteract seedling mortality, whereas lower seed rates are more effective in irrigated environments where plant survival is higher, according to research (Singh *et al*., 2018; Patel *et al*., 2020).

1. **Need for Optimized Agronomic Practices**

Given that soil degradation and climate change affect chickpea production, it is imperative to optimize sowing depth and seed rate in order to improve yield stability and resource-use efficiency (Kumar *et al*., 2021; Mehta *et al*., 2021).

Research indicates that precision agriculture techniques such as conservation tillage and site-specific seed rate adjustments can significantly improve the long-term sustainability, soil structure, and water-use efficiency of chickpeas (Sharma & Verma, 2022; Joshi *et al*., 2023).
This review highlights research conducted in Indian agro-climatic zones to evaluate the impact of planting depth and seed rate on chickpea development and production. In rainfed and irrigated environments, it aims to provide chickpea farmers with practical guidance and scientific insights to optimize yield (Mishra *et al*., 2019; Singh *et al*., 2022).

**2. Effect of Sowing Depth on Growth and Yield of Chickpea**

Sowing depth has a major effect on yield formation, root growth, crop establishment, and seedling emergence (Sharma *et al*., 2020; Mehta *et al*., 2022). Proper planting depth results in optimal soil moisture availability, nutrient uptake, and consistent stand establishment, all of which have a direct impact on grain production, biomass buildup, flowering, and pod formation (Kumar *et al*., 2019; Singh *et al*., 2021).

**Influences on Germination and Seedling Emergence**

The soil needs to be well-aerated for chickpeas to germinate. Shallow sowing (2–4 cm) promotes faster germination and early seedling emergence due to improved oxygen availability and faster access to sunlight (Patel *et al*., 2021; Choudhary *et al*., 2022).
Conversely, shallow seeding can lead to poor root anchoring, higher seedling mortality, and greater vulnerability to drought stress (Meena *et al*., 2020).
However, deep sowing (>8 cm) may result in weak seedlings, poor stand establishment, and delayed emergence due to low oxygen levels, high soil resistance, and increased germination energy costs (Verma *et al*., 2021; Reddy *et al*., 2022).



Richards *et al*., 2020

Fig .2 Influences on Germination and Seedling Emergence

Research in Madhya Pradesh revealed that chickpeas sown at a depth of 6 cm had 15% higher emergence rates than those sown at 8 cm, highlighting the need of a moderate sowing depth (Sharma & Singh, 2021).

1. **Impact on Root Development and Nutrient Uptake**

The architecture of chickpea roots responds well to the depth of sowing. Research indicates that taproot penetration, which fortifies root systems and boosts their ability to absorb moisture and nutrients, is best done at a depth of 5–7 cm (Rao *et al*., 2019; Joshi *et al*., 2021).

 Conversely, shallow seeding produces shallow root systems, making plants more susceptible to moisture stress and nutrient shortages (Mishra *et al*., 2019).

Field tests carried out in Rajasthan revealed that chickpea plants sown at 6 cm had a 20% greater root length density than those sown at 3 cm, improving water-use efficiency and drought resilience (Singh *et al*., 2020). Additionally, delayed root extension from deep seeding (>8 cm) can make seedlings more vulnerable to diseases like *Rhizoctonia* root rot. (Mehta *et al.*, 2022; Patel *et al.*, 2023).

1. **Effect on Biomass Accumulation and Canopy Development**

The right sowing depth affects biomass buildup and canopy coverage, both of which are necessary for a higher yield potential (Sharma *et al.,* 2020). By raising the leaf area index (LAI), chlorophyll content, and photosynthetic efficiency, moderate sowing depths (5–7 cm) have been demonstrated to enhance vegetative development (Gupta *et al*., 2021). In a Punjabi study, plants seeded at 6 cm accumulated 12% higher biomass than those sown at 3 cm, mostly due to stronger root development and improved nutrient uptake (Verma & Singh, 2021). Furthermore, enhanced canopy closure at the proper depth reduces weed competition and soil moisture loss, further boosting plant productivity (Reddy *et al*., 2021; Joshi *et al*., 2022).

**Influences on Flowering, Pod Formation, and Grain Yield**

Sowing depth has a direct effect on two reproductive stages: flowering and pod development (Sharma *et al*., 2019). Studies have shown that planting depths that are too shallow or too deep can lead to physiological stress and insufficient nutrient uptake, which can decrease grain weight, delay blooming, and produce fewer pods per plant (Kumar *et al*., 2020).

Field testing in Madhya Pradesh and Uttar Pradesh showed that chickpeas planted 6 cm deep produced 14% more grain and 18% more pods than crops planted 3 or 9 cm deep (Singh et al., 2022). According to Choudhary *et al*. (2021) and Patel *et al*. (2023), this is explained by the proper depths of balanced moisture availability, which promote efficient nutrition partitioning towards reproductive organs.**Regional Adaptation of Sowing Depth**

The optimal sowing depth is influenced by climate, soil composition, and moisture availability. Deeper sowing (6–8 cm) is preferred in black cotton soils, which have superior moisture retention, but shallower seeding (4–6 cm) ensures faster emergence and stronger root establishment in sandy loam soils (Mishra *et al*., 2019; Verma *et al.,* 2020).
According to research conducted in Central India, for example, planting above 7 cm increased yields by 15% compared to shallower sowing because it better-retained soil moisture under rainfed conditions (Kumar *et al*., 2021). However, in semi-arid regions, it was shown that 5 cm was the ideal planting distance for early crop establishment and enhanced pod production (Sharma & Verma, 2022).

**3. Effect of Seed Rate on Growth and Yield of Chickpea**

The number of seeds sown per unit area, or seed rate, is a crucial agronomic factor that significantly affects crop establishment, plant population density, resource consumption, and ultimately yield formation (Sharma *et al*., 2020; Mehta *et al*., 2022).

An ideal seed rate ensures equal plant dispersion, efficient canopy formation, and enhanced nutrient uptake, whereas an improper seed rate might lead to resource competition, low yield, and increased disease incidence (Kumar *et al*., 2019; Singh *et al*., 2021).

**Influences on Plant Population and Emergence**

A proper seed rate guarantees the optimal plant density for better field establishment. Studies have shown that lower seed rates (<60 kg ha⁻¹) often result in gaps in the crop stand, which can lead to poor canopy coverage, increased weed infestation, and decreased biomass building (Reddy *et al*., 2020; Choudhary *et al*., 2022). However, excessive seeding rates (>120 kg ha⁻¹) can lead to overcrowding and fierce competition for sunshine, water, and nutrients, which can weaken plants and lower pod yields (Joshi *et al*., 2021).

A field trial conducted in Madhya Pradesh revealed that chickpeas planted at 80 kg ha⁻¹ had an 18% better emergence rate than those put at 50 kg ha⁻¹. Better vegetative growth and a taller plant stand were the outcomes of this (Sharma & Verma, 2021). On the other hand, significant intra-plant competition caused by a relatively high seed rate (140 kg ha⁻¹) resulted in a 12% decrease in germination efficiency (Mehta *et al*., 2023).

1. **Impact on Canopy Development and Light Interception**

Seed rate has a direct effect on canopy design, photosynthetic efficiency, and light interception (Sharma *et al*., 2020). A moderate seed rate of 80 to 100 kg ha⁻¹ is appropriate for regular canopy closure, which enhances light penetration to lower leaves and increases photosynthetic and total biomass accumulation (Kumar *et al*., 2022).

A study conducted in Punjab found that the leaf area index (LAI) of chickpea crops planted at 90 kg ha⁻¹ was 22% higher than that of those planted at 60 kg ha⁻¹. A higher chlorophyll content and better pod development were cited as the reasons for this discrepancy (Verma *et al*., 2022).

On the other hand, mutual shadowing caused by an excess of seeds (>120 kg ha⁻¹) reduced light penetration and chlorophyll synthesis, ultimately affecting yield potential. (Patel and others, 2023).

**Effect on Root Development and Nutrient Uptake**

Root competition is significantly impacted by changes in seed rate. Chickpea plants require adequate root space in order to effectively absorb moisture and nutrients (Rao *et al*., 2019; Singh *et al*., 2021). According to research, larger seed rates (>120 kg ha⁻¹) lead to limited root development and decreased nutrient-use efficiency, whereas moderate seed rates (~80–100 kg ha⁻¹) allow for stronger root elongation and better nutrient acquisition (Gupta *et al*., 2021).

In an experiment conducted in Rajasthan, chickpea plants grown at 100 kg ha⁻¹ had a 15% higher root length density than those planted at 130 kg ha⁻¹. This enhanced biomass output and improved drought resilience (Singh *et al*., 2022). However, fewer plants and a worse overall yield were the results of excessive root extension at lower seed rates (<60 kg ha⁻¹) (Mishra *et al*., 2020).

1. **Impact on Flowering, Pod Formation, and Grain Yield**

Seed rate has a major impact on flowering time, pod setting, and eventual grain yield (Sharma *et al*., 2019). Higher seed rates (>120 kg ha⁻¹) usually result in smaller pod diameters and lower seed weights because of nutritional limitations and physiological stress (Kumar *et al*., 2020). A study in Madhya Pradesh and Uttar Pradesh revealed that chickpeas sown at 90 kg ha⁻¹ produced 16% more seed weight and 19% more pods per plant compared to crops cultivated at 140 kg ha⁻¹ (Singh *et al*., 2022).

**Seed Rate Recommendations for Different Soil and Climatic Conditions**

The optimal seed rate varies according on the soil type, moisture content, and local climate:
Sandy soils require a higher seed rate (100–120 kg ha⁻¹) to compensate for reduced seed-soil contact and moisture retention (Mishra *et al*., 2019). Loamy soils benefit from moderate seed rates (80–100 kg ha⁻¹), which ensure balanced emergence and growth (Verma *et al*., 2020).

Clayey Soils → Lower seed rates (70–90 kg ha⁻¹) are preferred to avoid illness and excessive vegetative development (Kumar *et al*., 2021).

Research in Central India found that 90 kg ha⁻¹ was the optimal seed rate for rainfed conditions, resulting in the largest grain output, the ideal plant population, and increased pod formation (Sharma & Verma, 2022).

**4. Interaction between Sowing Depth and Seed Rate**

Planting depth and seed rate interact to significantly affect chickpea establishment, growth, and yield (Sharma *et al*., 2020; Singh *et al*., 2022). While sowing depth determines germination success and root growth, seed rate influences plant population density and competition for resources (Kumar *et al*., 2021). Better crop establishment and yield optimization are guaranteed by a well-balanced combination (Mehta *et al*., 2022).

**Effect on Germination and Seedling Growth**

The proper seed rate and sowing depth are crucial for reliable germination. Shallow sowing (2–3 cm) with high seed rates (>120 kg ha⁻¹) usually leads to poor emergence, whereas deep sowing (>7 cm) with low seed rates (<60 kg ha⁻¹) suppresses germination (Reddy *et al*., 2021; Joshi *et al*., 2021). Using a 5 cm planting depth and 90 kg ha⁻¹ seed rate resulted in an 18% improvement in emergence in Madhya Pradesh (Singh & Verma, 2022).

1. **Root Development and Nutrient Absorption**

The right seeding depth ensures strong root development and efficient nutrient uptake. Shallow sowing at high seed rates restricts root growth, whereas deep seeding damages seedlings (Sharma et al., 2019; Patel et al., 2023).

Research in Punjab revealed that a 5 cm depth with 90 kg ha⁻¹ increased root length density by 16% compared to deeper sowing at 8 cm (Kumar et al., 2022).

**Canopy Formation and Yield**

Planting depth and seed rate also affect canopy structure and light interception. Dense canopies (high seed rates, shallow sowing) reduce photosynthesis, whereas low seed rates with deep sowing produce uneven stands (Choudhary *et al*., 2021; Joshi *et al*., 2021).

A study carried out in Uttar Pradesh found that a 20% higher leaf area index (LAI) was obtained with a sowing depth of 6 cm and a seed rate of 100 kg ha⁻¹ as opposed to shallow sowing (Mehta *et al*., 2023).

**Yield Optimization**

When the planting depth and seed rate are appropriately adjusted, pod development and seed yield are maximized. A 5 cm seeding depth with 90 kg ha⁻¹ produced 22% more pods per plant than deeper sowing, according to research done in Madhya Pradesh and Rajasthan (Kumar *et al*., 2021).

1. **Recommended Practices**

**Sandy soils** → 6–7 cm depth, 100–120 kg ha⁻¹ seed rate (Mishra *et al.*, 2019).

**Loamy soils** → 5–6 cm depth, 80–100 kg ha⁻¹ seed rate (Sharma & Verma, 2021).

**Clayey soils** → 4–5 cm depth, 70–90 kg ha⁻¹ seed rate (Patel *et al.*, 2023).

A Central India study recommended 5 cm sowing depth with 90 kg ha⁻¹ for maximum yield (Singh *et al.*, 2022)

**5. Conclusion**

Sowing depth and seed rate are two of the most critical agronomic factors influencing chickpea establishment, growth, and yield. Proper sowing depth ensures uniform emergence, strong root development, and optimal nutrient uptake, while an appropriate seed rate maintains ideal plant density and canopy structure. Research has shown that a sowing depth of 5–6 cm and a seed rate of 90–100 kg/ha generally optimize chickpea growth, leading to higher yields, better water-use efficiency, and improved disease resistance. Regional variations, such as soil type and climate, should guide the specific recommendations for these factors. For example, sandy soils may benefit from slightly deeper sowing and higher seed rates, while loamy and clayey soils perform better with shallower sowing. Precision agronomy practices, such as adjusting seed rates and sowing depths according to local conditions, are key to enhancing chickpea productivity and ensuring sustainable agricultural practices.

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