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Study root interaction in *Cicer arietinum* (Chickpea)

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Abstract

The root system of the chickpea, Cicer arietinum, is an important area of focus for increasing agricultural output since it is essential to its growth, uptake of nutrients, and resistance to stress. This study investigates the dynamics of the chickpea plant's root interactions, including its relationships with nearby plant roots, microbial populations, and soil. According to the study, root structure and function are crucial for maximizing nutrient and water uptake in a variety of environmental circumstances. The study also explores the rhizobia and chickpea roots' symbiotic connections, which improve biological nitrogen fixation, a crucial step in sustainable agriculture. Potential adaptive techniques for resilience are examined, as well as the effects of abiotic stresses like salinity and drought on root development and functionality. By utilizing root system features and interactions, the research findings are intended to support breeding initiatives and farming methods that enhance chickpea yield and stress tolerance.The growth, nutrient uptake, stress tolerance, and general productivity of Cicer arietinum (chickpea) depend heavily on root interactions. This study analyzes chickpea roots' morphological, physiological, and biochemical properties in detail, as well as how they interact with the surrounding plants, microbial populations, and soil environment. Particularly in soils that are semi-arid and low in nutrients, chickpea roots' well-developed taproot system allows for effective water and nutrient uptake. The rhizobium bacteria and chickpea roots' symbiotic interaction is a major area of study because it promotes biological nitrogen fixation, which is essential for increasing soil fertility and lowering reliance on chemical fertilizers.

Key words : *Cicer arietinum,* Root interaction.

This survey of the literature includes citations to important findings from investigations on root interactions in Cicer arietinum, or chickpea. This summary emphasizes elements including root shape, interactions with organisms in the rhizosphere, and reactions to environmental factors.

1. The Architecture and Morphology of Roots: Chickpeas have a deep, penetrating

taproot system, which is crucial for absorbing nutrients and water, particularly in arid and semi-arid areas. Genetic factors, soil type, and moisture content all affect the growth of the root system.

Chickpeas are extremely drought-tolerant due to their root system's unique adaptation to take advantage of water and nutrients in deeper soil layers, according to Narang and Dahiya (1997). Significant genetic variation in root characteristics, such as root length density and root surface area, was connected with drought resilience in chickpea genotypes, according to Kashiwagi *et al.*,[2].

2. Root-Rhizosphere Microbe Interactions: *Rhizobium* species, which fix atmospheric nitrogen and improve soil fertility, coexist symbiotically with chickpea roots. Sustainable agriculture depends on these relationships, especially in soils with low nutrient levels.

Rhizobium strains connected to chickpea roots dramatically enhanced nodulation and nitrogen fixation, enhancing plant growth and output, according to Rupela *et al.*,[7].

By changing root shape and hydraulic conductance, Das *et al.*,[3] investigated the function of arbuscular mycorrhizal fungi (AMF) in chickpeas and discovered that AMF colonization improved phosphorus uptake and drought tolerance. 2. Root-Rhizosphere Microbe Interactions.

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3. The Role of Abiotic stress on Root Function : In order for chickpeas to adapt to abiotic conditions like drought and salinity, their root system is essential. Research has looked into the molecular and physiological processes that underlie these adaptations.

When water was scarce, deep-rooting cultivars retained greater water intake, according to research by Serraj *et al.*,[6] on root characteristics linked to drought resilience.

Salinity stress had a negative impact on root growth, but certain genotypes demonstrated resilience because of improved osmotic adjustment and root membrane stability, according to Nayyar *et al.*, (2005).

4. The Interaction of Root Exudates with Soil:Chickpea root exudates affect soil microbial communities and nitrogen cycling. Allelopathic interactions with other plants can also be impacted by these exudates.

According to Kumar *et al.*,[6], the exudates from chickpea roots inhibited soil-borne diseases such as Fusarium oxysporum by fostering beneficial rhizobacteria.

Root exudates improved crop growth in alkaline soils by changing the pH and increasing nutrient availability, as demonstrated by Singh *et al.*, (2012).

5. Breeding and Genetics of Roots: The genetic control of chickpea root characteristics has been shown by recent developments in genomics.

By identifying quantitative trait loci (QTLs) linked to root properties using genome-wide association studies (GWAS), Varshney *et al.*,[14] made it possible to create chickpea varieties that can withstand stress.

Candidate genes involved in root growth and stress response were found by Kashyap *et al.*, (2017) by transcriptome profiling of chickpea roots during drought conditions.

6. Root-Soil Interaction Dynamics:In order for chickpea roots to absorb nutrients and maintain overall plant health, they must interact with the components in the soil.

According to Hinsinger *et al.,* (2003), chickpea roots alter the chemistry of the rhizosphere by generating protons and organic acids that mobilize phosphorus in calcareous soils. In low-nutrient soils, this encourages growth by increasing the amount of phosphorus available to plants.

The effect of chickpea root hair length on phosphorus uptake efficiency was examined by Gahoonia and Nielsen[1]. Genotypes with longer root hairs fared better in phosphate-deficient soils.

7. Root Features for Effective Water Use: Given its connection to drought resistance, one of the most researched characteristics of chickpea roots is water uptake efficiency.

Root angle was examined by Kashiwagi *et al.*,[3] as a characteristic affecting water acquisition. They found that genotypes with deeper root systems and steeper root angles were more effective in water-limited environments.

Using field trials, Zaman-Allah *et al.*,[15] demonstrated that genotypes with robust root growth maintained higher grain filling and linked root system architecture to production under drought stress.

8. The Rhizosphere's Microbial Relations: Chickpeas' rhizosphere is a microbial hotspot that affects plant health, stress tolerance, and nutrient cycling.

Meena *et al.*,[4] examined how plant growth-promoting rhizobacteria (PGPR) can improve chickpea performance in stressful situations. Nodulation, nutrient absorption, and resilience to biotic stressors were all enhanced by PGPR strains.

Rhizobium and AMF's synergistic connection in chickpeas was investigated by Mitra *et al.*,[5]. Grain yield and root biomass were enhanced by this dual inoculation, especially during drought.

9. Reaction to Biotic Stress:Fungal infections such as Fusarium oxysporum and nematodes are among the pests and diseases that commonly threaten chickpea roots.

Some chickpea genotypes exhibited resistance to *Fusarium* wilt, which was connected to the microbial diversity of the rhizosphere and the composition of root exudate, according to Sharma *et al*., (2005). By fostering systemic resistance in chickpeas, Khan *et al*., (2018) showed how the use of bio-control agents such as *Trichoderm*a spp. inhibited soil-borne diseases and improved root health.

10. Chickpea Roots' Functional Genomics: Key genes and regulatory networks implicated in root development and stress response have been uncovered by advanced molecular investigations.

The function of auxin-responsive genes in chickpea root growth was examined by Jain *et al.*, (2013). It was discovered that these genes control the development of lateral roots in situations where there is a water deficit.

To find targets for genetic improvement, Agarwal *et al.*, (2016) employed transcriptome profiling to identify genes associated with chickpea roots' uptake of phosphorus.

11. The Part Allelopathy and Root Competition Play: Allelochemicals released by chickpea roots can affect the growth of weeds and nearby plants.

In their study of allelopathic interactions involving chickpea root exudates, Zhou *et al.*, (2012) described inhibitory effects on weed germination, providing information for integrated weed management.

According to Singh and Singh's (2007) research, chickpea roots can compete with invasive species, indicating that some genotypes might have more robust root-mediated competitive characteristics.

12. Impact of Agronomic Practices: Crop rotation, intercropping, and fertilizing are agronomic methods that have a significant impact on chickpea root performance.

According to Gan *et al.*, (2015), intercropping chickpeas with cereals like wheat enhanced root health by lowering the incidence of illness and improving nutrient exchange. No-tillage methods encouraged deeper root growth in chickpeas, improving drought tolerance and water use efficiency, according to Siddique *et al.*, (2001).

13. Adaptability and Root Plasticity:A crucial characteristic that allows chickpea plants to react quickly to changes in their surroundings is root plasticity.

According to Turner *et al.*,[12], chickpea genotypes that could modify their root distribution and depth in response to water availability demonstrated greater drought tolerance.

Chickpea roots extend and create finer root systems to enhance nutrient capture, according to Khazaei *et al.*, (2015)'s study on root plasticity under phosphorus stress.

14. Water Transport and Hydraulic Conductivity:Water absorption depends on hydraulic conductivity, particularly in stressful situations.In their investigation into the relationship between soil moisture and root hydraulic conductivity in chickpeas, Sinclair and Muchow[10] discovered that certain genotypes demonstrated greater water transport efficiency in arid environments.By regulating aquaporin activity, Vadez *et al.*,[13] demonstrated that chickpea roots may preserve hydraulic function in the face of osmotic stress.

15. Root Symbioses and the Efficiency of Nutrient Uptake: In addition to fixing nitrogen, chickpea roots work with other microbes to improve nutrient absorption.

Smith and colleagues[9] examined the function of AMF in nutrient uptake and phosphorus solubilization. According to their findings, the chickpea-AMF symbiosis works better in low-input settings.

According to Srivastava *et al.*, (2016), dual inoculation of Rhizobium and AMF enhanced phosphate and zinc uptake, which in turn increased chickpea output.

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