Research Article

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Influence of rhizosphere soil from various tree species on soil characteristics of jackfruit (*Artocarpus heterophyllus* L.) cv. Chandra

Sonali Gahlot[1], Jitendra Singh[1], Prerak Bhatnagar[1], Kavita Aravindakshan[2], Ashok Kumar[3], S.K. Jat[4] and Sunil Kumar Bairwa[1]

[1]Deptt. of Fruit Science, [2]Deptt. of Vegetable Science, [3]Deptt. of Basic Science, [4]Deptt. of Entomology, College of Horticulture and Forestry, Jhalrapatan, Jhalawar-326 023 (AU, Kota), Rajasthan, India

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ABSTRACT

A field experiment was conducted during the year 2023-24 on Chandra variety of jackfruit, at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalawar. The result indicated that the application of treatment T_1 (soil under banyan tree canopy) was the most effective in increasing the soil porosity (47.84%) and it reduced the soil pH (7.14), electrical conductivity (0.22 dS m^{-1}), bulk density (1.13 g cm^{-3}) and particle density (2.32 g cm^{-3}). Thus, the T_1 (soil under banyan tree canopy) treatment significantly improved all soil parameters in orchard of jackfruit.

Introduction

The Jackfruit (*Artocarpus heterophyllus* L.) is well-known as "poor man's food" fruit in Bangladesh. It is widely consumed by most of the rural people, and it is the national fruit of Bangladesh. Jackfruit contains anti-bacterial, anti-diabetic, anti-oxidant, anti-inflammatory, and anti-helminthic properties. Leaves are dark green, alternate, entire, simple, glossy, leathery, stiff, large (up to 16 cm in length), and elliptic to oval in form. Leaves are often deeply lobed when juvenile and on young shoots. The seed is rich in manganese, magnesium, potassium, calcium, iron, and lectins and thus meets up nutritional requirements for the rural people. (Khan *et al*., 2021). Jackfruit is a medium-size, evergreen tree that typically attains a height of 8-25 m (26-82 ft) and a stem diameter of 30-80 cm (12-32 in). The canopy shape is usually conical or pyramidal in young trees and becomes spreading and domed in older trees. The canopy diameter at 5 years old ranges from 3.5-6.7 m (11-22 ft) and can reach 10 m or more in older trees. The tree casts a very dense shade. Heavy side branching usually begins near the ground. All parts of the tree exude sticky white latex when injured (Elevitch and Manner, 2006). The total area in India under jackfruit cultivation is 1.85 lakh hectares and production is 31.99 lakh metric tonnes (Anonymous, 2023-24). The major area under jackfruit is in the Kerala state. Recently Kerala declared jackfruit as the state fruit.

Research highlights that exudates persisting in the rhizosphere vary according to the stage of plant growth. High available water and mineral nutrients in the soil under tree canopy are favourable sites for numbers of microorganisms than elsewhere in the soil. The constitution and form of root exudates influence microbial action and population intensity which, might impact rest of microorganisms that survive in the environment. It has been found that soil of rhizosphere is considerably better than bulk soil, which protects roots from moisture loss and drying out. The canopy characteristics of trees directly or indirectly, affect the soil fertility (Hinsinger

Corresponding author
Email: sonaligahlot98@gmail.com (Sonali Gahlot)

et al., 2009). Now-a-days, the soil physico-chemical and bio-properties are observed to deteriorate due to higher use of inorganic fertilizer in the plant and ultimately poor effect on plant growth and development are observed. Rhizosphere soil has been reported useful in improving the soil microorganism for plants and subsequently growth and development. Hence, it is proposed to evaluate its impact on the growth and development of jackfruit.

Material and Methods

Jhalawar district is situated between 23°4" to 24°52" N latitude and 75°2" to 76°56" E longitude in South Eastern Rajasthan. Agro-climatically, it falls in Zone V, known as the Humid-South Eastern Plain.

The present investigation was carried out during the year 2022-23 to 2023-24 at the Instructional Farm, Department of Fruit Science, College of Horticulture and Forestry, Jhalrapatan, Jhalawar, in the newly established orchard of 1.5 year old Jackfruit (*Artocarpus heterophyllus* L.) cv. Chandra plants. The experiment consisted of 8 treatments, viz. T_0 (control), T_1 (soil under banyan tree canopy), T_2 (soil under palash tree canopy), T_3 (soil under babul tree canopy), T_4 (soil under jamun tree canopy), T_5 (soil under tamarind tree canopy), T_6 (soil under neem tree canopy), and T_7 (soil under mandarin tree canopy). The experiment was laid out in Randomized Block Design with three replications. A plantation of twenty four plants spaced at a distance of 8m x 8m under square system was selected for the purpose of study. Different tree species Rhizosphere soil samples were collected from the area of highest feeder root concentration (1-1.5 meters distance from the trunk) from a soil depth of 0-20 cm. A total of fifteen kilograms of soil from each identified tree species was collected during March, 2023. The rhizosphere soil was applied to the plants in the month of March (2023) at the start of the experiment. The treatments were administered in the root zone of the plants. These treatments were applied after recording the initial parameters of the plants, just before the treatment application.

Soil pH was determined by using 1:2 soil water suspensions by glass electrode pH meter. Soil water suspension of 1:2 was prepared by taking 20g of soil and 40ml distilled water in 100 ml beaker. Electrical conductivity of soil water suspensions (1:2.5) was measured using EC meter (Model Elico CL 180) as elaborated by Jackson (1973). These EC 2.5 values were converted later to saturation paste value (EC).

Bulk density of soil of 0-30 cm depth was determined. The core sampler was pressed in the soil for enough depth to fill the core. Carefully removed the sampler and trimmed the soil extending out of the core with a sharp knife. Soil was oven dried at 105 °C to a constant weight, cooled and weighed. Soil volume was taken equal to inner volume of core sampler. Bulk density was calculated using the following formula and expressed as g cm^{-3} suggested by Piper (1950).

$$\text{Bulk density} = \frac{\text{Mass of oven dry soil}}{\text{Total volume of soil}}$$

To calculate soil particle density, the mass and the volume of the solid particles in a soil sample was measured. For this purpose, soil sample was put in a flask with distilled water. The soil and water were mixed and then boiled to remove all air from the sample. After the mixture was cooled, water was added to the mixture to obtain a specified volume. The mass of this mixture was then measured. The mass of the water was then subtracted from the mass of the soil and water. The particle density was calculated from the mass of the solid particles in a specified volume

$$\text{Particle density} = \frac{\text{Mass of soil}}{\text{volume of soil solid}}$$

The porosity was calculated at the end of experiment as per the formula as under:

$$\text{Porosity (\%)} = 1 - \frac{\text{Bulk density}}{\text{Particle density}} \times 100$$

Results and Discussion

In present study, all recorded parameters for soil nutrient status (Table 1 and Fig. 1) were found significantly influenced by rhizosphere soil. Data linked to the effect of rhizosphere soil on soil parameters like soil pH (7.14), EC (0.22 dS m^{-1}), bulk density (1.13 g cm^{-3}), particle density (2.32 g cm^{-3}), and porosity (47.84%) were observed comparatively better in treatment T_1 (soil under banyan tree canopy).

Banyan tree roots release organic acids (like citric acid, malic acid, and oxalic acid) into the soil sphere. These compounds can lower the soil pH by increasing the hydrogenion concentration. The organic acids and other compounds released by the roots provide a substrate for soil microorganisms. The increased microbial activity can lead to the production of additional organic acids and the faster decomposition of organic matter. All these effect of rhizosphere soil of banyan tree might be there behind lowering the soil pH. The increased microbial activity and the breakdown of organic matter in the rhizosphere can lead to the leaching of salts from the root zone, reducing the overall concentration of soluble salts and thereby decreasing the EC (Solanki *et al.*, 2020 and De Castro *et al.*, 2024).

Higher amount of organic mass under the influence of rhizosphere soil of banyan tree might have a substantial effect on increasing its pore space, which in turn might improve its porosity, reduce bulk density and also particle density. It may be further added that banyan rhizosphere soil holds nitrogen fixing (*Rhizobium* and *Azotobacter*), phosphorus (*Pseudomonas* and *Bacillus* spp.) and potash solubilizing bacteria (*Enterobacter* spp. and *Acinetobacter* spp.) which fix the nutrients and increase the macro-nutrients particularly N, P and K in soil. Plant residues (leaves, fruits and roots etc.) form food of microbes. Treatment T1 (soil under banyan tree canopy) had a high portion of organic carbon in the soil that's why there might be maximum number of bacteria and fungi population in the soil. The observation of current experiment corroborates with the study as reported by Potphode *et al.* (2018) and Shlipkar *et al.* (2009).

Table 1. Effect of different tree species rhizosphere on soil parameters of jackfruit

Treatments	pH	Electric conductivity ($dS\ m^{-1}$)	Bulk density ($g\ cm^{-3}$)	Particle density ($g\ cm^{-3}$)
Initial value	7.59	0.40	1.33	2.44
T_0	7.59	0.40	1.38	2.47
T_1	7.14	0.22	1.13	2.32
T_2	7.30	0.32	1.20	2.35
T_3	7.36	0.33	1.24	2.37
T_4	7.42	0.35	1.30	2.40
T_5	7.38	0.31	1.27	2.38
T_6	7.25	0.27	1.18	2.34
T_7	7.20	0.26	1.17	2.33
SEm±	0.01	0.01	0.01	0.01
CD at 5%	0.04	0.03	0.03	0.02

According to Khan *et al.* (2024) the decrease in electrical conductivity (EC), pH, bulk density, and particle density, along with the increase in porosity of jackfruit soil when influenced by banyan (*Ficus benghalensis*) rhizosphere soil can be explained through a combination of biological, chemical, and physical processes. The rich microbial activity within the banyan rhizosphere also contributes to changes in soil characteristics. Microorganisms break down organic matter, producing additional organic acids and releasing nutrients that plants can absorb. This microbial decomposition reduces soil EC by consuming soluble salts during various metabolic processes. Moreover, the microbial activity contributes to nutrient cycling; enhancing soil fertility while simultaneously reducing the concentration of free ions, which further decreases EC. As these microbes interact with the soil, they contribute to aggregate formation, improving soil structure and reducing compaction Pande and Tarafdar (2004).

Cheke *et al.* (2018) analysed that physically, the banyan tree's vast and deep root system exerts a significant impact on the soil's structure. As the roots grow and expand, they create channels and break apart compacted soil layers, reducing bulk density and particle density. Bulk density decreases because of the presence of organic matter and root channels might lighten the soil mass per unit volume. This allows for better root penetration, water infiltration, and gas exchange, all of which improve soil health. The reduction in particle density occurs as organic matter, which is less dense than mineral particles, accumulates in the soil. The increase in organic matter and root penetration leads to greater soil porosity, which is the proportion of soil volume occupied by air and water spaces.

Furthermore, the banyan rhizosphere holds the ability to enhance soil aggregation through the secretion of polysaccharides by both roots and soil microorganisms. These substances bind soil particles together into stable aggregates, increasing porosity and improving water-holding capacity. Higher porosity also supports better microbial activity and root respiration, fostering a healthier soil ecosystem overall. This might improved structure and reduced soil compaction, making it easier for plant roots to access water and nutrients (Ghagare *et al.*, 2017).

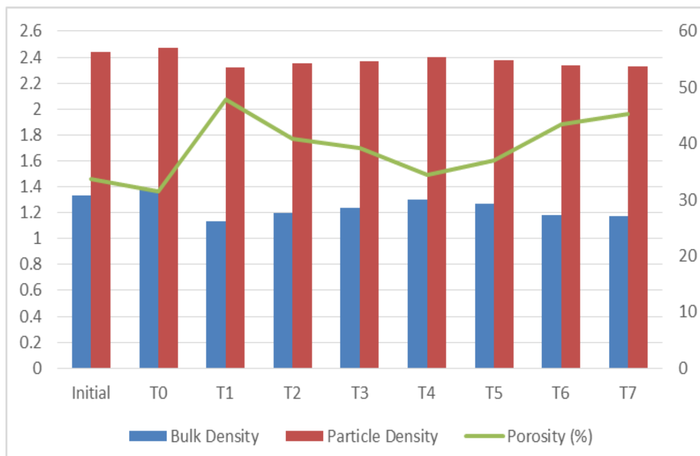

Fig.1. Effect of rhizosphere soil on bulk density, particle density and porosity of jackfruit orchard

Conclusion

The significant influence of *Ficus benghalensis* (banyan tree) rhizosphere soil on *Artocarpus heterophyllus* (jackfruit) soil characteristics is highlighted in the present research. The study found that using soil from the rhizosphere of the banyan tree significantly improved the soil properties of jackfruit plants. Applying soil under banyan tree canopy (T_1) led to increased porosity and notable reductions in soil pH, electrical conductivity, bulk density, and particle density. This treatment proved to be more effective than other rhizosphere soils and the control.

In conclusion, the banyan tree's rhizosphere soil enhances soil fertility and microbial diversity, which can significantly benefit the growth and resilience of jackfruit plants, making it a promising factor in integrated agroforestry systems.

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Conflict of Interest

The authors have no conflict of interest.

Data Sharing

All relevant data are within the manuscript.

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