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Influence of different aged Jackfruit (*Artocarpus heterophyllus* L.) rootstocks on soil and plant nutrient dynamics under varying environmental conditions

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Abstract
This study was carried out in 2023 at the Department of Biotechnology and Crop Improvement, College of Horticulture, Kolar, Karnataka to evaluate the effect of different-aged jackfruit (*Artocarpus heterophyllus* L.) rootstocks on the success of softwood grafting under varied environmental conditions. The experiment followed a factorial completely randomized design with four replications, each containing 10 plants. Results demonstrated that rootstock age and growing environmental conditions significantly influenced nutrient content and chemical characteristics of the growing medium, including pH, EC (dSm^{-1}), total carbon (%), nitrogen (%), phosphorus (%), and potassium (%) and with their interaction. Among all treatments, grafting on 90-day-old rootstocks under polyhouse conditions produced the better graft growth and development performance, while grafting on 15-day-old rootstocks under shade net conditions gave the poorest performance.

Keywords: Jackfruit, softwood grafting, age, rootstocks and environment

Introduction
Jackfruit (*Artocarpus heterophyllus* Lam.) belongs to the family 'Moraceae' and is considered one of the largest edible fruits borne on trees. It is indigenous to the Western Ghats of India and Malaysia but is now distributed widely across tropical and subtropical regions including Southeast Asia, Central and Eastern Africa, the Caribbean, Brazil, and Pacific islands. Within India, jackfruit is cultivated extensively in Kerala, Karnataka, Tamil Nadu, Andhra Pradesh, West Bengal, Maharashtra, and Assam. It is the national fruit of Bangladesh and is often referred to as the "poor man's fruit" in southern and eastern India because of its availability and affordability. By 2021-22, the fruit was cultivated over 1.95 lakh hectares in India, with an estimated production of 33.01 lakh metric tonnes (Agricoop, 2021-22).

The jackfruit tree is medium to large (7-10 m tall), evergreen, monoecious, and latex-producing. Its fruits typically weigh 10-25 kg and mature during the summer, coinciding with periods of staple food scarcity. Fruiting occurs cauliflorously, developing on the trunk and main branches. Botanically, the fruit is classified as a 'sorosis', with catkin inflorescences. Leaves are 10-20 cm long, elliptic, leathery, glossy dark green above, and rough pale green beneath (Santapau, 1966) [12].

Although jackfruit is commonly propagated by seeds, this method is unreliable due to high heterozygosity and cross-pollination, resulting in wide variation in yield, fruit size, pulp quality, and maturity. Vegetative propagation ensures uniformity and true-to-type plants, making it vital for large-scale multiplication of elite genotypes. Therefore, in order to satisfy the increasing demand for planting material, suitable vegetative propagation techniques needs to be standardized.

Approach grafting and other attached grafting methods have been successfully employed in jackfruit propagation (Nazeem *et al*., 1984) [9], though they are often costly and time-consuming. Detached scion methods such as veneer, wedge, and splice grafting have shown variable results. Since raising rootstocks to graftable size requires significant investment, the identification of optimal rootstock age and grafting conditions is essential for improving success rates and reducing costs (Swamy, 1993) [13].

This research therefore aimed to examine how different rootstock ages and growing environments influence softwood grafting performance in jackfruit, with specific emphasis on nutrient uptake and soil chemical properties.

Material and Methods

The experiment was conducted at the Department of Biotechnology and Crop Improvement, College of Horticulture, Kolar, located in the Eastern Dry Zone of Karnataka (Zone-5) at 13°08′ N latitude, 78°08′ E longitude, and 849 m above mean sea level.

Experimental Design

The study carried in a factorial completely randomized design (FCRD) with two factors A and B. The factor A comprises different age of rootstock and the factor (B) is different environmental conditions. Factor A includes six different aged rootstocks *viz.,* 15 (A_1), 30 (A_2), 45 (A_3), 60 (A_4), 75 (A_5), and 90 days (A_6) used for the study. The factor B includes three different environmental conditions *viz*., shade net (B_1), polytunnel (B_2), and polyhouse (B_3) (Fig 1).

The experiment was laid out with four replications with10 Jack fruit plants per each replication. The grafting operation was done at 15 days intervals using scion sticks of jack on the raised rootstock and their growth performance were evaluated (Fig 2).

Rootstock Preparation:

Seeds were collected from mature jackfruit fruits in the College of Horticulture, Kolar orchard. To minimize disease incidence, they were soaked overnight in a fungicidal solution before sowing in perforated polythene bags (15 × 20 cm) with sufficient holes for good aeration in. The bags were filled with a soil mixture of red soil, sand, and farmyard manure in equal proportions (1:1:1). Sowing was carried out in January 2023. Germination began after 25-30 days, and healthy, uniformly growing seedlings were selected as rootstocks for further grafting with scion.

Scion Preparation

Scions were obtained from elite ‘Chandra Halasu’ mother plants. Vigorous shoots with 2-3 leaves and a unopened bud were trimmed to 25-30 cm length. Prior to grafting, the scions were kept in water for 24 hours.

Grafting

Softwood grafting was carried out using uniformly sized rootstocks of different ages. The rootstocks were cut back 15-20 cm above ground level, and a vertical slit, 3-5 cm long, was made with a budding knife. A scion shoot, 8-10 cm in length and about pencil-thick in girth, was selected and given matching slanting cuts on both sides of its lower end. The prepared scion was then inserted into the slit of the rootstock. The grafted area was immediately wrapped with a transparent polythene strip (1.5 cm wide, 200 gauge), and the scion along with the graft union was covered with a poly cap to prevent desiccation and maintain a favorable microclimate.

Observations

Different growth and development parameters on graft success were recorded and were statistically analyzed with ANOVA.

Results and Discussion

In this study, an attempt has been made to propagate on the ruling Chandra Halasu (Scion) genotype jackfruit rootstock through softwood grafting with different age of rootstocks and grown under different environmental conditions.

A. Total primary nutrients content

At 90 days after grafting (DAG), the nutrient status of the grafts was significantly influenced by rootstock age and growing conditions.

Maximum nitrogen (0.72%), phosphorus (0.19%), and potassium (0.49%) contents were observed in grafts performed on 90-day-old rootstocks. Conversely, 15-day-old rootstocks recorded the lowest nitrogen (0.45%) and phosphorus (0.14%), while 30-day-old rootstocks showed the lowest potassium (0.42%) at 90DAG (Table 1).

Older rootstocks likely accumulated more nutrients due to their well-developed root systems, facilitating higher uptake. Polyhouse conditions further supported nutrient absorption by providing an optimal microclimate for growth and development f the grafts. In contrast, shade net conditions produced weaker grafts with lower nutrient levels. These findings agree with Basalo *et al*. (2020) [4] and align with earlier studies highlighting nitrogen’s role in photosynthesis, protein formation, and energy transfer (Horneck *et al.*, 2011) [8].

Nutrient uptake variations can be linked to differences in root biomass and rooting depth, affecting the ability to extract nutrients from soil (Colla *et al*., 2006; Petropoulos *et al*., 2014) [6, 10]. Rootstocks with own forceful root biomass are better at supporting scion growth.

B. Soil Chemical Properties of growing media at 90 DAG (days after grafting)

The media pH varied significantly due to rootstock age and environmental conditions at 90 DAG, but remained near neutral in reaction, ranging from 7.01 to 7.25. Acedo (1992) [1] recommends a pH range of 5.0-7.5 for jackfruit seedling considered favorable for jackfruit seedling development. The pH plays a crucial role in nutrient accessibility, with low and high pH levels affecting nutrient availability and availability, respectively, as per Basalo *et al*. (2020) [4]. Electrical conductivity was highest under shade net conditions (0.50 dS m^{-1}), followed by polytunnel (0.46 dS m^{-1}) and polyhouse (0.44 dS m^{-1}), consistent with Gholizadeh *et al*. (2011) [7].

Total carbon content was highest in soils supporting 15-day-old rootstocks (12.69%). Shade net and polytunnel conditions maintained higher carbon values (11.52%) compared to polyhouse. Wang *et al*. (2023) [14] found that prolonged polyhouse conditions resulted in lower total carbon content in growing media due to higher temperature-induced mineralization (Table 2).

The results indicate that, highest total N, P, and K contents were found in growing media grafted on 15 days old rootstocks. Younger aged rootstock grafts exhibited poor growth, unable to absorb more nitrogen from soil, while older aged rootstocks absorbed more nitrogen from media and had the lowest P (0.13%). The study found that media grown under shadenet conditions had significantly higher total N, P, and K content compared to grafts grown under polytunnel and polyhouse conditions. Low primary nutrient utilization in shadenet and polyhouse conditions may be due to better graft growth, while high temperatures decrease total carbon and nitrogen content. The studies are in line with Yadav *et al.* (2000) [15] reports. Aslam *et al.* (2020) [3] and Yuan *et al.* (2021) [16] conducted research on pumpkin, eggplant plants and Torubamu, observing similar results. The physiological phenomenon is linked to rootstock growth and structure, as well-nourished roots absorb more nutrients from the soil, reducing major nutrients from the soil. Ruchitha*et al.* (2022) [11] reported similar findings on the soft wood grafting of elite Jamun genotypes.

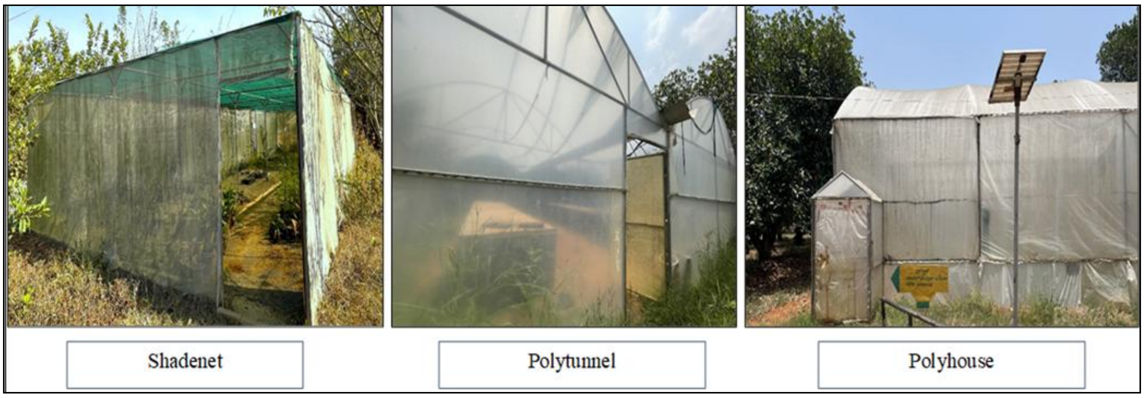

Fig 1: View of different environmental conditions used to study soft wood grafting of Jack fruit

Fig 2: Jackfruit grafts and their root performance influenced by different aged rootstocks and environments at 90 days after grafting.

Table 1: Total primary nutrients content (%) of 90 days old jackfruit grafts as influenced by different aged rootstocks and environmental conditions.

Age of the rootstock (A)	Total primary nutrients content (%)													
	Total N (%)				Total P (%)					Total K (%)				
	Environmental conditions (B)													
	B_1	**B_2**	**B_3**	**Mean (A)**		**B_1**	**B_2**	**B_3**	**Mean (A)**		**B_1**	**B_2**	**B_3**	**Mean (A)**
A_1	0.43	0.46	0.46	0.45	A_1	0.13	0.15	0.16	0.14	A_1	0.39	0.43	0.47	0.43
A_2	0.47	0.48	0.49	0.48	A_2	0.13	0.15	0.13	0.15	A_2	0.40	0.44	0.42	0.42
A_3	0.51	0.51	0.53	0.52	A_3	0.14	0.16	0.17	0.16	A_3	0.40	0.44	0.48	0.44
A_4	0.55	0.57	0.58	0.56	A_4	0.15	0.17	0.18	0.17	A_4	0.42	0.46	0.50	0.46
A_5	0.61	0.62	0.64	0.62	A_5	0.16	0.18	0.19	0.18	A_5	0.43	0.47	0.51	0.47
A_6	0.71	0.72	0.74	0.72	A_6	0.17	0.19	0.20	0.19	A_6	0.45	0.49	0.53	0.49
Mean (B)	0.55	0.56	0.57		Mean (B)	0.15	0.16	0.17		Mean(B)	0.41	0.45	0.48	
	A	**B**	**AxB**			**A**	**B**	**AxB**			**A**	**B**	**AxB**	
S. Em ±	0.01	0.01	0.02		S. Em ±	0.01	0.00	0.01		S. Em ±	0.01	0.01	0.01	
C.D @ 5%	0.03	NS	NS		C.D @ 5%	0.02	0.01	NS		C.D @ 5%	0.02	0.02	NS	

A_1 - 15days old rootstock, A_2 - 30 days old rootstock, A_3 - 45 days old rootstock, A_4 - 60 days old rootstock, A_5 - 75 days old rootstock, A_6 - 90 days old rootstock, B_1 - Shadenet, B_2 - Polytunnel, B_3 - Polyhouse

Table 2: Influence of different aged rootstocks and environmental conditions on chemical properties of growing soil media at 90 DAG

Age of the rootstock (A)	Chemical properties of growing media at 90 DAG													
	pH (1:10)				EC (dS m^{-1})					Total C (%)				
	Environmental conditions (B)													
	B_1	B_2	B_3	Mean (A)		B_1	B_2	B_3	Mean (A)		B_1	B_2	B_3	Mean (A)
A_1	7.07	7.02	6.96	7.01	A_1	0.61	0.56	0.50	0.56	A_1	13.49	12.52	12.07	12.69
A_2	7.16	7.10	7.04	7.10	A_2	0.56	0.52	0.58	0.55	A_2	11.84	11.92	11.91	11.89
A_3	7.21	7.15	7.08	7.15	A_3	0.50	0.46	0.42	0.46	A_3	11.65	11.50	10.96	11.37
A_4	7.24	7.18	7.11	7.18	A_4	0.46	0.43	0.39	0.43	A_4	11.06	10.93	10.71	10.90
A_5	7.27	7.21	7.15	7.21	A_5	0.45	0.42	0.38	0.42	A_5	11.07	10.69	10.32	10.69
A_6	7.31	7.25	7.19	7.25	A_6	0.43	0.39	0.35	0.39	A_6	10.02	9.94	9.59	9.85
Mean (B)	7.21	7.15	7.09		Mean (B)	0.50	0.46	0.44		Mean (B)	11.52	11.25	10.93	
	A	B	AxB			A	B	AxB			A	B	AxB	
S. Em ±	0.01	0.01	0.01		S. Em ±	0.01	0.01	0.01		S. Em ±	0.10	0.07	0.17	
CD @ 5%	0.02	0.02	NS		CD @ 5%	0.02	0.02	0.03		CD @5%	0.27	0.19	0.47	
Age of the rootstock (A)	Chemical properties of growing media at 90 DAG													
	Total N (%)				Total P(%)					Total K(%)				
	Environmental conditions (B)													
	B_1	B_2	B_3	Mean (A)		B_1	B_2	B_3	Mean (A)		B_1	B_2	B_3	Mean (A)
A_1	0.57	0.56	0.53	0.55	A_1	0.18	0.17	0.15	0.17	A_1	0.64	0.55	0.53	0.58
A_2	0.54	0.53	0.52	0.53	A_2	0.17	0.16	0.15	0.16	A_2	0.55	0.53	0.58	0.55
A_3	0.52	0.51	0.48	0.50	A_3	0.15	0.14	0.13	0.14	A_3	0.53	0.51	0.49	0.51
A_4	0.50	0.49	0.46	0.48	A_4	0.16	0.15	0.13	0.15	A_4	0.50	0.48	0.46	0.48
A_5	0.47	0.46	0.43	0.45	A_5	0.15	0.14	0.12	0.13	A_5	0.49	0.47	0.45	0.47
A_6	0.46	0.44	0.42	0.44	A_6	0.16	0.15	0.13	0.15	A_6	0.48	0.46	0.44	0.46
Mean (B)	0.51	0.50	0.47		Mean (B)	0.16	0.15	0.13		Mean (B)	0.53	0.50	0.49	
	A	B	AxB			A	B	AxB			A	B	AxB	
S. Em ±	0.01	0.01	0.02		S. Em ±	0.01	0.01	0.01		S. Em ±	0.01	0.01	0.01	
C.D @ 5%	0.03	0.02	NS		C.D @ 5%	0.02	0.02	NS		CD @ 5%	0.02	0.02	0.03	

A1 - 15 days old rootstock, A2 - 30 days old rootstock, A3 - 45 days old rootstock, A4 - 60 days old rootstock, A5 - 75 days old rootstock, A6 - 90 days old rootstock, B1 - Shadenet, B2 - Polytunnel, B3 - Polyhouse

Conclusion

Softwood grafting performance in jackfruit was significantly affected by the interaction between rootstock age and environmental conditions. Rootstocks aged 90 days under polyhouse conditions exhibited superior graft success, survival, root biomass, nutrient uptake, and favorable soil chemical properties. In contrast, grafts performed on 15-day-old rootstocks under shade net conditions showed poor results. The study highlights the importance of selecting appropriate rootstock age and controlled environments for improving grafting efficiency in jackfruit.

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Conflict of interest

None

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