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DEVELOPMENT OF CULTIVATION PRACTICES OF *BACCAUREA COURTALLENSIS* (MUELL.) ARG.: AN UNDERUTILIZED WILD EDIBLE FRUIT TREE OF THE WESTERN GHATS

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ABSTRACT

Experiments were conducted in nursery conditions to assess the sunlight exposure and soil type impact on the growth and survival of *Baccaurea courtallensis* seedlings, an underutilized wild edible fruit tree of the Western Ghats. The seedlings were subjected to three levels of sunlight intensity; full exposure (100% sunlight), moderate shade (50% sunlight), and heavy shade (25% sunlight) and four different soil types- forest soil, hill soil, laterite soil, and coastal alluvium. The performance of the seedlings was assessed across various combinations of light and soil conditions, revealing that the highest levels of survival and growth were observed in moderate shade conditions, followed by heavy shade and full exposure. Additionally, a preference for forest soil was evident, with hill soil, laterite soil, and coastal alluvium showing progressively lower suitability for seedling growth.

Key words : *Baccaurea courtallensis*, Wild fruit tree, Seedling growth, Sunlight intensity, Soil type, Domestication.

Introduction

The quality and quantity of fruits serve as crucial indicators of the specific cultivation methods, ecological conditions, and environmental factors that influence the growth of a plant. Among these factors, sunlight and soil are the most significant variables affecting plant production, growth and development (Smith, 2000; Gentili *et al*., 2018). Soil nutritional elements such as Nitrogen (N), Phosphorus (P), Potassium (K), Calcium (Ca) and Magnesium (Mg), as well as soil structure and pH, play key roles in the life of a plant. Understanding the interactions between these elements is essential for the successful survival and growth of plants.

Baccaurea courtallensis (Muell.) Arg. is an evergreen, small tree belonging to the family, Phyllanthaceae. The tree reaches a height of up to 15 meters. It is endemic to Peninsular India and distributed in the evergreen and semi-evergreen forests up to 1,200 meters above sea level. The ripe fruits, known locally as Mootilpazham (clusters of fruits found at the base of tree trunks) are edible and are consumed by local tribes. These ripe fruits are notably rich in protein, potassium, reducing and non-reducing sugars, carbohydrates, total phenols, antioxidants, and flavonoids (Nazarudeen, 2010; Yogeesha *et al*., 2016). Additionally, the tree has biotic interactions with mammals and birds that consume its fruits. The entire plant contains bioactive compounds of medicinal importance. Different parts of the plant have been traditionally used for wound healing, diabetes control, treating piles, addressing cases of poison ingestion, and for various health concerns (John and Mahesh, 2007; Devi Prasad *et al*., 2013; Divya *et al*., 2013; Aiswarya *et al*., 2016). The leaves possess properties with benefits for reducing lipid levels and antibacterial effects (Sreelakshmi *et al*., 2017). The seed oil is utilized as a

lubricant and as an additive in industrial preparations (Srinivasa, 2009).

Wild edible fruits have played a significant role in human dietary needs. The lesser-known and underutilized wild fruits are of urgent importance for cultivation and promotion, benefiting broader communities. In this context, the seedling's survival and growth of *Baccaurea courtallensis* were assessed under various soil types and levels of sunlight intensity in the nursery conditions. This study is a step towards the domestication of the species.

Materials and Methods

The experiments were conducted at the nursery of the Kerala Forest Research Institute, Peechi. Fresh and ripened fruits of *B. courtallensis* (Fig. 1A) were collected during June- July 2020-21 from Vazhachal forest areas of Thrissur district (N 10° 18.195' E 076° 38.022'; 400m above sea level). The seeds were processed manually by removing the pulp and then sown for germination. Two-month-old ten healthy seedlings, with three replications (a total of 30 seedlings), were transplanted into 12 different combinations of soil types and light intensities (T_1-T_{12}) (Table 1). The soil types included forest soil, hill soil, laterite soil, and coastal alluvium collected from various edaphic gradients in Kerala. Light conditions were regulated using agro-shade nets with different levels of sunlight reduction; Full exposure (no shade net), moderate shade (50% shading net) and heavy shade (75% shading net).

Table 1 : Experimental design for evaluation of seedlings.

Treatment	Light conditions and soil type
T_1	Full exposure and forest soil
T_2	Full exposure and hill soil
T_3	Full exposure and laterite soil
T_4	Full exposure and coastal alluvium
T_5	Moderate shade and forest soil
T_6	Moderate shade and hill soil
T_7	Moderate shade and laterite soil
T_8	Moderate shade and coastal alluvium
T_9	Heavy shade and forest soil
T_{10}	Heavy shade and hill soil
T_{11}	Heavy shade and laterite soil
T_{12}	Heavy shade and coastal alluvium

Various growth characteristics of the seedlings were measured after six months of growth. This included stem girth (measured 2cm above the base of the stem using a vernier caliper) along with growth parameters such as seedling weight (gm), number of leaves, shoot length (cm), root length (cm) and stem girth (mm).

The physicochemical properties of the different soil types were analyzed at the KFRI soil laboratory using standard procedures. Light intensities were monitored daily by using a luxmeter. Data on growth characters such as seedling weight, number of leaves, shoot length, root length, and stem girth of seedlings planted in 12 different combinations were analyzed using two-way ANOVA.

Results and Discussion

The physico-chemical properties of the different soil types and light intensities monitored were presented in Tables 2 and 3. A two-way analysis of variance was done to compare different variables between light

Table 2: Physico-chemical properties of the soil types

Growth parameters \ Soil		Forest soil	Hill soil	Laterite soil	Coastal alluvium
pH		5	6	6	7
N (Kg/ha.)		313.6	200.7	163	87.8
P (Kg/ha.)		22.66	28.01	16.85	35.15
K (Kg/ha.)		240.8	464.8	63.84	68.32
Organic carbon (%)		2.94	0.93	0.57	0.24
Water holding Capacity (%)		19%	28%	18%	15%
Zn (mg/kg)		1.76	2.25	-5.43	0.65
Fe (mg/kg)		16.59	15.46	41.36	37.89
Cu (mg/kg)		1.9	4.24	1.32	0.78
Mn (mg/kg)		10.04	3.82	7.49	0.91
Texture	**Clay (%)**	16.16	32.16	22.16	14.16
	Silt (%)	2	4	4	2
	Sand (%)	81.84	63.84	73.84	83.84

Optimum range of organic carbon and nutrients: N: 280-560, P: 10-24, K: 115-275, OC: 0.76-1.5, Zn: 1-40, Fe: 9-18, Cu: 1-20, Mn: 3.5-7 (Kerala State Planning Board,2013)

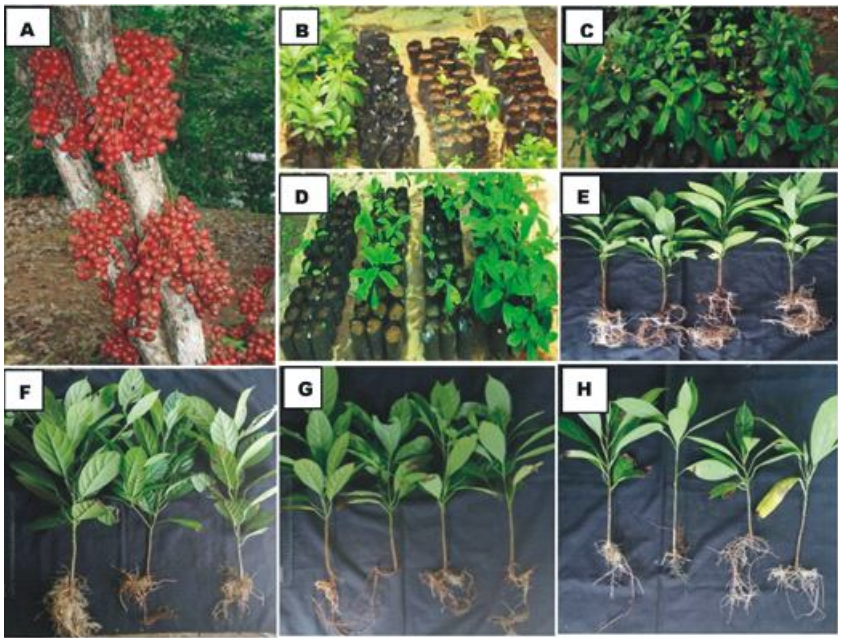

Fig. 1 : A. *Baccaurea courtallensis* Tree trunk showing ripened fruits. **B, C & D.** Seedlings kept in full exposure, moderate shade and heavy shade conditions. **E, F, G & H.** Seedlings grown in forest soil, hill soil, laterite soil and coastal alluvium.

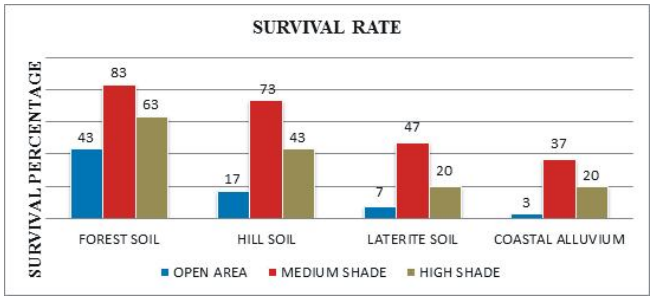

Fig. 2 : Survival rate of seedlings under different light conditions and soil types.

conditions, between soil type and their interactions. Results of the comparison of seedling weight, root length, leaf number, stem girth and shoot length using two-way ANOVA were given in Tables 4 and 5.

Under moderate shade conditions with a 50% shade net, the sunlight exposure was reduced by half, while in heavy shade conditions with a 75% shade net, sunlight was reduced by 75%. In contrast, seedlings grown in full exposure received full sunlight intensity. The growth performance of *B. courtallensis* seedlings varied depending on the light conditions (Fig. 1B, 1C and 1D). The analysis of seedling growth in different soils (forest, hill, laterite and coastal alluvium) under three light conditions (Full exposure, Moderate shade and heavy shade) revealed that medium shade (T_5, T_6, T_7 and T_8) was most favourable for seedlings survival and growth (Table 4). There were no significant variations observed in most growth parameters among the different light conditions except root length exhibited notable differences. However, the survival rate of seedlings showed significant variations across the three light conditions.

Table 3: Details of sunlight intensity provided

Condition	Light Intensity (lux)
Full exposure	≈248
Moderate shade	≈126
Heavy shade	≈69

Optimal levels of sunlight or shade are crucial for the healthy development of seedlings across various categories (Aderounmu, 2010). The seedlings exposed to moderate shade conditions consistently exhibited better growth and survival rates compared to those in full exposure receiving 100% light intensity. This implies that the species has a low tolerance for 100% light conditions, likely due to its natural habitat in semi-evergreen to evergreen environments. It's important to note that seedlings of different tree species have varying light requirements, which explains why some thrive in habitats where others struggle, as both insufficient and excessive light can be harmful to plants (Nwoboshi, 1982; Adelusi, 1998). High light intensities lead to increased energy requirements for the plant, resulting in the production and accumulation of Reactive Oxygen Species (ROS), ultimately hindering photosynthesis and impeding overall growth and development (Dat *et al*., 2000). Studies on one-year-old seedlings of *Quercus leucotrichophora* and *Pinus roxburghii* demonstrated improved growth performance with reduced shade under different light and watering conditions (Rao and Singh, 1986). Environmental factors like light and relative humidity (RH) prior to harvest impact the growth, development, and post-harvest quality of rose plants (Fanourakis *et al*., 2013). Siebert (2002) noted that shading reduces the amount of radiant flux reaching the soil, thus stabilizing surface soil temperatures. Shade-grown coffee plants also yield higher-quality beans with superior taste due to reduced environmental stress and they possess a greater biochemical and physiological capacity for carbon fixation compared to those grown in direct sunlight (Adugna and Paul, 2011).

Based on the comparison between the four types of soil (Table 5), the growth parameters was found highest in forest soil but not much significant variation was found in growth parameters between hill soil, laterite soil and

Table 4 : Effect of sunlight and soil types on seedling growth parameters.

	Full exposure	Moderate shade	Heavy shade
Forest soil	SW: 19.11±3.35 RL: 31.69±1.68 LN: 14.78±3.74 SG: 4.80±0.21 SL: 25.47±1.78 SR: 43%	SW: 21.35±3.88 RL: 27.99±1.17 LN: 14.85±1.50 SG: 4.59±0.22 SL: 26.40±1.48 SR: 83%	SW: 20.08±0.74 RL: 27.42±2.35 LN: 14.75±0.58 SG: 5.11±0.22 SL: 26.07±0.18 SR: 63%
Hill soil	SW: 8.81±2.69 RL: 23.28±2.35 LN: 9.64±2.31 SG: 2.57±1.19 SL: 18.38±1.30 SR: 17%	SW: 11.93±2.86 RL: 26.28±2.06 LN: 12.79±2.11 SG: 3.98±0.40 SL: 24.22±2.07 SR: 73%	SW: 6.79±1.36 RL: 20.47±1.74 LN: 8.84±2.58 SG: 3.57±0.35 SL: 17.12±1.21 SR: 43%
Laterite soil	SW: 6.91±2.58 RL:14.10±2.59 LN: 7.40±1.32 SG: 3.06±0.45 SL: 17.78±2.26 SR: 7%	SW: 9.26±2.38 RL: 29.75±1.75 LN: 7.50±0.50 SG: 4.11±0.27 SL: 20.45±1.55 SR: 47%	SW: 5.03±1.25 RL: 29.25±4.63 LN: 6.50±0.87 SG: 3.13±0.34 SL: 16.26±1.73 SR: 20%
Coastal alluvium	SW: 2.59±0.00 RL: 25.40±1.47 LN: 4.00±0.00 SG: 2.97±0.00 SL: 12.30±0.00 SR: 3%	SW: 13.67±2.00 RL: 22.38±1.85 LN: 10.08±0.54 SG: 5.74±0.08 SL: 21.47±3.07 SR: 37%	SW: 9.71±0.76 RL: 24.73±1.16 LN: 9.89±2.11 SG: 4.04±0.15 SL: 18.33±1.20 SR: 20%

***SW**: Seedling Weight, **RL:** Root Length, **LN:** Leaf Number, **SG:** Stem Girth, **SL:** Shoot Length, **SR:** Survival Rate
*Mean±SE represents their standards of error, n=30

and biological characteristics that play a crucial role in the growth and development of plants (Li and Xiao, 2012). Soil structure and nutrient composition have a significant impact on plant growth. *B. courtallensis* seedlings exhibit superior survival rates and growth in forest soil (Fig. 1E), with no substantial differences observed in growth performance in hill soil, laterite soil, and coastal alluvium. However, the second highest survival rate was recorded in hill soil (Fig. 1F), while the lowest was in coastal alluvium (Fig. 1H). This is attributed to the presence of optimal levels of essential nutrients such as N, P, and K in forest soil, whereas other soils exhibit deficiencies (Table 2). Among these nutrients, nitrogen holds particular importance as it promotes root growth, development, and the uptake of other essential elements (Binglin *et al.*, 2016). Phosphorus is critical for all energy transfers within the cell, while potassium regulates stomata opening and closing and is vital for leaf and growing point functions (Mengel and Kirkby, 2004). It is well-established that, in addition to oxygen, carbon dioxide and water, plants require a minimum of 14 mineral elements for proper nutrition. Any deficiency or shortage of these essential elements (*e.g.*, N, P, K, Ca and Mg) will undoubtedly affect normal growth, development, and both internal and external qualities of plants, subsequently impacting crop yields (Al-Humaid, 2005). In coastal alluvium, nitrogen content falls below the optimal range required by plants, and this soil also exhibits poor water retention capabilities (Alka *et al.*, 2017). Hill soil, on the other hand, demonstrates a comparatively optimal water-holding capacity along with adequate levels of N, P and K, which accounts for its higher survival rate and enhanced growth performance when compared to laterite soil (Fig. 1G)

Table 5 : Effect of soil types on seedling growth parameters.

S. no.	Growth parameters	Forest soil	Hill soil	Laterite soil	Coastal alluvium	F-value	P-value
1	Seedling weight	20.18±1.53^{a}	9.18±1.42^{b}	6.79±1.21^{b}	10.74±1.81^{b}	18.13**	<0.001
2	Root length	29.03±1.28^{a}	23.34±1.33^{b}	23.69±3.32^{b}	23.29±1.22^{b}	3.353*	0.038
3	Leaf number	15.13±1.19^{a}	10.43±1.32^{b}	7.09±0.55^{b}	9.13±1.19^{b}	9.079**	<0.001
4	Stem girth	4.83±0.13^{a}	4.04±0.41^{ab}	3.35±0.25^{b}	4.61±0.43^{a}	4.336*	0.016
5	Shoot length	25.98±0.68^{a}	19.91±1.35^{b}	17.88±1.15^{b}	18.82±1.75^{b}	13.102*	<0.001

*Mean±SE represents their standards of error, n=30
Means having different small letter as superscriptsdiffer significantly within a column
**Significant at 0.01 level; *Significant at 0.05 level.

coastal alluvium. Seedlings showed maximum weight, root length, leaf number, stem girth and shoot length in forest soil. Forest soil shows an average of 63% of survival rate, hill soil- 43%, laterite soil- 25% and coastal alluvium- 20% (Fig. 2).

Various types of soil possess distinct physico-chemical and coastal alluvium. Although laterite soil lacks fertility due to lower base-exchange capacity and reduced nitrogen, phosphorus, and potassium content, it can be made suitable for cultivation through proper irrigation and fertilizer application.

Conclusion

In summary, *B.courtallensis* seedlings exhibit the highest survival rates under moderate shade conditions and in forest soil compared to other light conditions and soil types. Among the soils tested, hill soil outperforms laterite and coastal alluvium soil. Augmenting these soils with nutrients at the appropriate time could further enhance survival rates and growth performance. It is evident that the seedlings are not well-suited for intense light conditions during their early developmental stages. Given its natural habitat as an under storey species in forested areas with ample light and nutrients, this study underscores the importance of providing these conditions for its successful growth. Inadequate light and nutrition have been shown to impede seedling survival. Therefore, any efforts to cultivate this species should prioritize its light and nutrient requirements, especially in the initial stages of growth. Additionally, considering its optimal light requirements, this plant could serve as an intercrop in agro-ecosystems to enhance yield and resource efficiency.

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