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EVALUATION OF ROSELLE PERFORMANCE AS A MONTHLY INTERCROP IN YOUNG SAPOTA ORCHARDS UNDER VARYING PLANT DENSITIES

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ABSTRACT

Sapota (*Manilkara zapota*) orchards, cultivated with wide spacing (10 x 10 m), leave substantial inter-row space unutilized during the pre-bearing period. This study explores the potential of intercropping Roselle (*Hibiscus sabdariffa*) as a high-value leafy vegetable to utilize this space effectively and provide additional income to farmers. This experiment was conducted to study the effect of different plant densities and spacing (5.0 x 5.0 cm to 10 x 10 cm) on Roselle's growth parameters, leaf and stalk yield, and harvest index. Results showed that the spacing of 7.5 x 7.5 cm significantly increased plant height (42.32 cm), total biomass (20.35 g/plant), and leaf yield (8.60 g/plant) while maintaining an optimal harvest index. Conversely, closer spacings (5.0 x 5.0 cm) reduced plant height, biomass, and leaf yield, although, maximized the harvest index (0.53). These findings highlighted the suitability of moderate spacing (7.5 x 7.5 cm) for maximizing yield and resource utilization in intercropping systems with Sapota, supporting more efficient land use and profitability for farmers.

Key words : Intercropping, Planting densities, Roselle, Sapota.

Introduction

Intercropping is highly favored for its advantages over sole cropping, providing more consistent returns and enhanced profitability through greater cumulative yields per unit of land (Javanmard *et al*., 2009). Intercropping enhances nutrient uptake and improves water use efficiency through synergistic interactions between crops. It also aids in reducing weed, disease, and pest cycles by incorporating crop rotation, while sequential planting provides complementary fertilization. Common in tropical small-scale farming, intercropping supports risk mitigation through on-farm diversification (Lithourgidis *et al*., 2011), especially in areas lacking social security systems. Additionally, intercropping contributes to soil fertility, conserves soil and water, improves microclimate conditions, and protects plants (Ehrmann *et al*., 2014).

Roselle is an annual herbaceous shrub (Dejene *et al*., 2019), native to Africa (Purseglove, 1991) belongs to the family Malvaceae (Dhar *et al*., 2015) and having common names like hibiscus, Indian sorrel, Karkade red sorrel, Jamaican sorrel, rosella, (EI Naim *et al*., 2012). Leaves of roselle are rich source of calcium, potassium, phosphorus and magnesium and calyx of roselle plant is having high antioxidant activitiy and rich in anthocyanin, organic acids and phenols (Da-Costa-Rocha *et al*., 2014) used in making jellies cakes, wines, beverages, syrups (Mahadevan and Kamboj, 2009).

Sapota is typically cultivated as a monoculture crop with a wide spacing of 10 x 10 meters. During the pre-bearing period, sapota growth is minimal, leaving much of the inter-row space vacant. This unused space not only invites weed growth but also leads to nutrient and moisture loss from the soil, soil erosion in sandy loams, and no immediate income for farmers. In this context, cultivating high-value leafy vegetable roselle as an intercrop within sapota orchards offers a promising opportunity. By integrating roselle at optimized planting densities and spatial arrangements, farmers can maximize resource use during the sapota pre-bearing phase, providing supplemental income and reducing soil degradation. Therefore, the present investigation will focus on evaluating the effects of different plant densities and planting geometries of roselle as an intercrop, aiming to enhance yield potential in sapota-based intercropping systems.

Materials and Methods

Plant materials, experimental set up and growth conditions

The present investigation was conducted at Horticultural Research Station aswaraopet, Kothagudem district of SKLTGH University Telangana, Yazd province (17°14′ N latitude, 18°8′ E longitude and 167 m above sea level) during 2021-22. The experiment was laid out in a randomized block design with five treatments and four replications (T_1 – 5.0 × 5.0 cm, T_2– 7.5 × 7.5 cm, T_3 – 10.0 × 10.0 cm, T_4 – 5.0 × 10.0 cm, T_5 – 5.0 × 20.0 cm). The treatments of different planting densities of roselle were planted as intercrop in pre bearing sapota orchard. The roselle seeds were sown in sapota pre bearing orchard of 2 years in 2021-22. Observations were recorded for the following parameters plant height (cm), Total biomass (g/plant), Leaf yield (g/plant), Stalk yield (g/plant), Leaf stalk ratio, Harvest index. The data were statistically analysed using analysis of variance (ANOVA) for RBD following the standard procedure as suggested by Panse and Sukhatme (1985) and for comparison of means, Duncan Multiple Range Test was used (DMRT).

Soil physicochemical characteristics and meteorological information

Planting was carried out in soil with a loam texture. The soil physical and chemical characteristics are given in Table 1. Using hand hoes, weed control was performed manually.

Table 1 : Soil physical and chemical characteristics of roselle as intercrop in pre-bearing sapota orchard.

S. no.	Parameter
pH	5.89
EC (dS/m)	0.158
Organic carbon (%)	1.23
Available N (Kg/ha)	520
Available P (Kg/ha)	12.90
Available K (Kg/ha)	405

Results and Discussion

According to the ANOVA, intercropping with different plant densities was significant for all investigated traits of roselle except leaf: stalk ratio(p<0.01) (Table 2). The results demonstrated that intercropping with different plant densities significantly affected plant height, total biomass, leaf yield (g/plant), stalk yield (g/plant), and harvest index in sapota (p<0.01) (Table 2).

Increasing the number of plants per unit area generally intensifies competition among them for essential resources like soil moisture, nutrients, light, and carbon dioxide. In contrast, plants at lower densities grow more independently for much of their early development, resulting in minimal interference with one another compared to plants at higher densities. This difference likely accounts for the significant impact of crop density on the various parameters measured in the current study.

Among plant morphological characters *viz*., plant height and total biomass were significantly influenced by roselle planting densities. The maximum plant height (42. 32 cm) and total biomass (20.35 g/plant) was recorded in 7.5 × 7.5 cm spacing (T_2), which was at par with 5.0cm × 10.0 cm spacing (T_4) in terms of plant height (41.67 cm) and total biomass (19.25 cm), respectively. This finding is consistent with previous studies, such as those by Ahmed *et al.* (2020), who noted that intermediate planting densities often optimize vertical growth and biomass accumulation in similar crops. Moderate spacing may reduce excessive competition for sunlight, water, and nutrients, allowing plants to grow taller and accumulate greater biomass (Sharma and Verma, 2019). The significant effect of crop density on mean plant height observed in this study may be attributed to the fact that crop density has often, but not always been associated with increased plant height supporting evidences were reported by El Naim and Jabereldar (2010) and El Naim *et al.* (2011). El Naim *et al.* (2012), results were contrast to present study that crop density had no significant effect on plant height.

The minimum plant height recorded in the widest spacing of 5.0 × 20.0 cm (T_5) (36.60 cm) is likely due to less competition and shading, which leads to shorter, more robust plants. According to findings by Patel and Singh (2018), widely spaced crops often exhibit reduced plant height due to increased light exposure, which decreases the tendency for vertical growth. The lowest biomass observed in the densest spacing (5.0 × 5.0 cm, T_1) at 12.65 g/plant may be attributed to excessive competition among plants, which limits resources and results in lower overall biomass production. This aligns with observations made by Choudhary *et al.* (2021), who found that high planting densities restrict individual plant biomass due to intense intraspecific competition. These results suggest that moderate spacing, such as 7.5 × 7.5 cm, optimally

Table 2 : Influence of plant morphological and yield attributes of roselle as intercrop in pre-bearing sapota orchard.

Treatment	Plant height (cm)	Total biomass (g/plant)	Leaf yield (g/plant)	Stalk yield (g/plant)	Leaf: Stalk ratio	Harvest index
T_1 – 5.0 × 5.0 cm	37.05[b]	12.65[c]	6.60[b]	6.20[b]	1.17	0.53[a]
T_2 – 7.5 × 7.5 cm	42.32[a]	20.35[a]	8.60[a]	11.60[a]	0.73	0.43[b]
T_3 – 10.0 × 10.0 cm	38.07[b]	16.67[b]	8.27[a]	8.25[b]	1.04	0.48[a]
T_4 – 5.0 × 10.0 cm	41.67[a]	19.25[a]	7.95[a]	11.25[a]	0.70	0.39[b]
T_5 – 5.0 × 20.0 cm	36.60[b]	18.75[a]	8.40[a]	10.35[a]	0.81	0.46[a]
F -Test	*	*	*	*	*	*
S.Em ±	1.023	0.685	0.436	0.677	0.171	0.026
CD at (5%)	3.187	2.135	1.358	2.108	NS	0.081
CV	5.330	7.811	10.945	14.199	27.058	11.298

Figures with same alphabets did not differ significantly.
** Significant at (p= 0.01 LOS), *Significant at (p= 0.05 LOS). Values were compared with respective C.D values.

balances plant growth by allowing sufficient height and biomass accumulation without inducing excessive competition. This spacing strategy not only enhances the plant's structural development but also promotes higher resource utilization efficiency, which is essential for achieving maximum yield potential (Meena *et al.*, 2019).

Significantly maximum leaf yield (8.60 g/plant) was recorded in 7.5 × 7.5 cm spacing (T_2) which was at par with 5.0 × 20.0 cm (T_5) (8.40 g/plant), 10.0 × 10.0 cm (T_3) (8.27 g/plant) and 5.0 × 10.0 cm (T_4) (7.95 g/plant). Whereas, minimum leaf yield was recorded in 5.0 × 5.0 cm (T_1) (6.60 g/plant). These results were similar with the findings of Dutta *et al.* (2021), who reported that moderate spacing in leafy crops like spinach and amaranth enhanced leaf production because moderate spacing may promote leaf expansion by allowing sufficient light penetration and minimizing extreme competition for resources among plants, a phenomenon also observed in other leafy vegetables (Sharma and Singh, 2020). Conversely, the minimum leaf yield observed at the densest spacing of 5.0 × 5.0 cm (T_1) (6.60 g) confirms previous studies, such as Kumar *et al.* (2018), who noted that high plant density reduced individual plant yields due to intense competition for essential nutrients, water, and sunlight. In tightly spaced conditions, plants often face limited resource availability, which restricts individual growth and leads to decreased leaf yield per plant.

For stalk yield, the highest value was recorded in the 7.5 × 7.5 cm spacing (T_2) (11.60 g), which was statistically similar to 5.0 × 10.0 cm (T_4) (11.25 g) and 5.0 × 20.0 cm (T_5) (10.35 g). Moderate densities favor stalk growth by reducing competition, thereby facilitating better resource allocation to stem development. This finding is similar with the earlier reports of Nambiar and Lal (2019), who noted that plants in moderately spaced environments showed enhanced stem growth due to reduced intraspecific competition. Interestingly, the lowest stalk yield was recorded in the 5.0 × 5.0 cm spacing (T_1) (6.20 g), which is consistent with the observations of Patel *et al.* (2020), who found that dense spacing limits stem biomass accumulation due to increased competition stress. As plant density increases, resources are diverted to survival mechanisms rather than optimal stem growth, leading to lower yields per plant.

The maximum harvest index was recorded at the densest spacing, 5.0 × 5.0 cm (T_1) (0.53), indicating a higher proportion of biomass allocated to leaves rather than stalks. This finding is consistent with the conclusions of Singh and Mishra (2017), who observed that in densely planted crops, plants tend to maximize their photosynthetic surface area, thereby enhancing leaf biomass allocation relative to stem biomass. Moderate harvest index values in the 10.0 × 10.0 cm (T_3) (0.48) and 5.0 × 20.0 cm (T_5) (0.46) spacings suggest a balanced resource distribution between leaves and stems, which is ideal for optimal growth. However, the minimum harvest index observed in the 5.0 × 10.0 cm (T_4) (0.39) suggests a greater allocation to stalk growth rather than leaf production, as also noted by Kumar and Gupta (2018) in similar studies.

Conclusion

From the experimental results the treatment (T_2) spacing of 7.5 × 7.5 cm provided a balanced arrangement that maximizes both leaf and stalk yield, whereas the densest spacing, 5.0 × 5.0 cm (T_1), though yielding the highest harvest index, compromises total yield due to increased competition stress.

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