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ENHANCING PRODUCTIVITY OF CUSTARD APPLE (cv. APK (CA) 1) THROUGH PLANT DENSITY STANDARDIZATION AND CANOPY MANAGEMENT

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ABSTRACT

A field experiment was conducted at the Regional Research Station, Tamil Nadu Agricultural University, Aruppukottai, Tamil Nadu, to standardize plant density through canopy management in custard apple. The variety APK (Ca) 1 was used as the experimental material. The trial was laid out in the C1 field. Custard apple grafts were prepared and established at the Regional Research Station, Aruppukottai. The planting of custard apple was carried out during 2004. The experiment was laid out in a Randomized Block Design (RBD) with five replications and four treatments, viz., T_1 (plant spacing of 6 m × 6 m; 36 m²), T_2 (plant spacing of 6 m × 5 m; 30 m²), T_3 (plant spacing of 6 m × 4 m; 24 m²), and T_4 (plant spacing of 6 m × 3 m; 18 m²). Observations on soil moisture content (at 15, 30, and 60 cm depths), plant height (m), stem girth (cm), number of branches, number of secondary branches, and tree spread in the north–south and east–west directions were recorded. Physiological parameters such as Chlorophyll Stability Index (CSI), Relative Water Content (RWC), proline content, and nitrate reductase enzyme activity were also measured and estimated in all treatments. The results indicated that custard apple cv. APK (Ca) 1 planted at a spacing of 6 m × 6 m recorded higher values for all morpho-physiological and biochemical parameters compared to the other high-density planting treatments under rainfed conditions. The same treatment (T_1: 6 m × 6 m) also maintained its superiority in improving yield and yield attributes, recording a higher single fruit weight (155.8 g), pulp weight (92.4 g fruit^{-1}), and fruit yield (24.7 kg tree^{-1}) than the other high-density planting treatments under rainfed conditions. Based on the results, it can be concluded that a spacing of 6 m × 6 m is highly suitable for custard apple cultivation under rainfed conditions and is recommended for obtaining the highest yield.

KEYWORDS: Planting density, Canopy management,Morpho-Physiology, Yield, Custard Apple

INTRODUCTION

Custard apple (Annonasquamosa L.) is considered one of the best fruit crops for dryland cultivation. It possesses a pleasant flavour, mild aroma, and sweet taste, which contribute to its widespread acceptance. This subtropical fruit tree is distributed across Asia, Africa, and the Americas (Kadamet al., 2018). Custard apple is commercially cultivated in the West Indies, Florida, Mexico, Brazil, Malaysia, Thailand, the Philippines, and Egypt. In India, the area under custard apple cultivation is approximately 35,000 ha, with a production of 271,000 MT. Of this, Maharashtra contributes about 8,660 ha of cultivated area and 59,300 MT of production (Thorat et al., 2018). Custard apple is used in both the Ayurvedic and Unani systems of medicine (Jamkhandeet al., 2017). Annonasquamosa has been utilized as a natural medicine and in various food applications. For example, its pulp is used as a flavouring agent in ice cream, and 50–80% of the fruit is edible and can be processed into juice. The fruit contains an appreciable amount of vitamin C, ranging from 35 to 42 mg per 100 g, and is also rich in dietary fibre, vitamin B1 (thiamine), and potassium. Furthermore, custard apple possesses significant pharmaceutical potential for the treatment of cardiac ailments, thyroid disorders, diabetes, and cancer (Kumar et al., 2021).

Custard apple requires regular corrective pruning to maintain proper growth and productivity. Initially, pruning is essential for developing a strong framework that supports sustained growth and higher yields over a long period. In the absence of pruning, plants become bushy, resulting in reduced bearing efficiency. However, severe pruning is detrimental to plant growth. The leaves begin to yellow after the fruit harvesting season and gradually fall with the onset of winter. Fresh vegetative growth emerges during spring. Flowering occurs either singly or, less commonly, in small clusters, predominantly on the current season's growth and occasionally on older wood. When rootstocks are used, training the plant to a single stem is recommended. Young plants require proper training to develop a strong framework. The main stem should be kept free of branches up to a height of 50–60 cm above ground level. Timely removal of misplaced limbs is necessary for building a sturdy framework. During the early years of orchard establishment, four to five scaffold branches with wide crotch angles should be encouraged to grow in different directions. Pruning is generally carried out during March–April to stimulate new growth, on which flower buds are usually formed. Tree height is typically maintained at about 3 m. Pruning is also undertaken to remove dead wood and old branches that bear fewer fruits.

There has been considerable interest in establishing orchards under high-density planting (HDP) systems to achieve early production and increase economic returns (Menzel and Le Lagadec, 2017). Although custard apple is well suited for cultivation in dry regions, limited research has been conducted to enhance its yield. Considering the potential benefits of improving productivity, the present investigation was undertaken to study the morpho-physiological, biochemical, and yield parameters of custard apple under different planting systems and to identify the most suitable planting system for achieving higher yield and better fruit quality under rainfed conditions.

MATERIALS AND METHODS

Research on the standardization of plant density through canopy management in custard apple was carried out under the All India Coordinated Research Project on Arid Zone Fruits (ICAR–AICRP on Arid Zone Fruit Crops) at the Regional Research Station, Tamil Nadu Agricultural University, Aruppukottai, Virudhunagar District, Tamil Nadu. The experiment was conducted in a portion of the C1 field. Custard apple grafts were prepared, and the seedlings were established at the Regional Research Station, Aruppukottai. The custard apple variety APK 1, released from this station, was selected for the study. The crop was planted at different spacings, namely 6 × 6 m, 6 × 5 m, 6 × 4 m, and 6 × 3 m. The experiment was laid out in a Randomized Block Design (RBD) with five replications. Morphological parameters, including plant height (m), stem girth (cm), number of primary branches, number of secondary branches, and plant spread (m), were recorded. Similarly, biochemical parameters such as Relative Water Content (RWC; %), as suggested by Weatherley (1950), Chlorophyll Stability Index (CSI; %), proline content (μg g^{-1} fresh weight), as described by Bates et al. (1973), and nitrate reductase enzyme activity (NRase; μmol NO_2 g^{-1} fresh weight) were assessed during the experimental period. Yield and fruit quality parameters, including single fruit weight (kg), pulp weight (g), total soluble solids (°Brix), and yield per plant (kg), were recorded periodically during the harvesting stage. Irrigation was provided through a drip irrigation system. In this experiment, a uniform dose of manures and fertilizers was applied to all treatments. The recommended dose of fertilizers per tree per year consisted of 10 kg farmyard manure (FYM), 1 kg neem cake, 250 g nitrogen (N), 125 g phosphorus (P), and 250 g potassium (K). Fifty percent of the recommended manures and fertilizers were applied at the onset of the South-West monsoon, while the remaining fifty percent were applied during the North-East monsoon. A circular basin was formed around each tree at a distance of approximately 60 cm (2 feet) from the trunk, and the manures and fertilizers were applied within the basin. Irrigation was provided immediately after fertilizer application to ensure effective nutrient utilization by the plants. Regular irrigation was administered once every six days, depending on the prevailing climatic conditions. The cultivar was planted at different spacings in a Randomized Block Design (RBD) with three replications and ten plants per replication. Analysis of variance (ANOVA) was performed following the procedure described by Gomez and Gomez (1984). The significance of treatment effects was tested using the Critical Difference (CD) at the 5% probability level to compare differences among treatment means.

Table 1. Initial Soil moisture status

Sl. No.	Soil depth (cm)	Soil moisture (%)
1.	15	12.84
2.	30	16.56
3.	60	17.94

RESULT AND DISCUSSION

Growth Characters

The results on plant height (m), Stem girth (cm), number of primary and secondary branches per plant and plant spread (East – West) and (North – South) were recorded in all the four different planting density viz., 6 x 6 m, 5 x 5 m, 4 x 4 m and 3 x 3 m. The results on aforesaid morphological parameters were statistically varied amount the planting density treatment. Comparing the four treatments, T_1 (6 x 6 m) registered highest value in pH (1.72 m), stem girth (15.0 cm), No. of primary branches (2.70), number of secondary branches (7.60), plant spread about 0.82 m in North to south and 0.85 m in East to West (Table 2.). However, the treatment T_4 (3 x 3 m) recorded lowest value in plant height (1.41 m), stem girth (10.49 cm), number of primary branches (1.92), number of secondary branches (7.19), plant spread (0.66m North-South), (0.49m East-West) respectively.This might be due to higher nutritional availability in the soil and more light penetration under wider plant spacing (Ram et al., 1996).

Physio-biochemical parameters

The data on physio-biochemical parameters viz., Chlorophyll Stability Index (CSI), Relative Water Content (RWC), Proline and Nitrate Reductase (NRase) enzyme activity were measured and differed statistically among the treatments. The data revealed that, among the four treatments T_1 (6 x 6 m) planting density maintained its superiority in CSI (72.0%), RWC (84.78%) proline (71.70 µg g^{-1} FW) and NRase (310.0) µmol NO_2 / g FW), which was followed by the treatment T_2 (5 x 5 m) had the value of 70.98 % (CSI), 83.0 % (RWC), 69.0 µg g (proline) and 30.4 µ mol NO_2 / g FW (NRase enzyme activity) (Table 3.). The lowest value of CSI (70.18%), RWC (82.69 %), proline (66.10µg g^{-1} FW) and NRase (292.6 µ mol NO_2 / g FW) was registered by the T_4 (3 x 3 m) treatment.

Fig 1. Planting density through canopy management on Physio-Biochemical parameters in custard aplle (cv APK (Ca) 1)

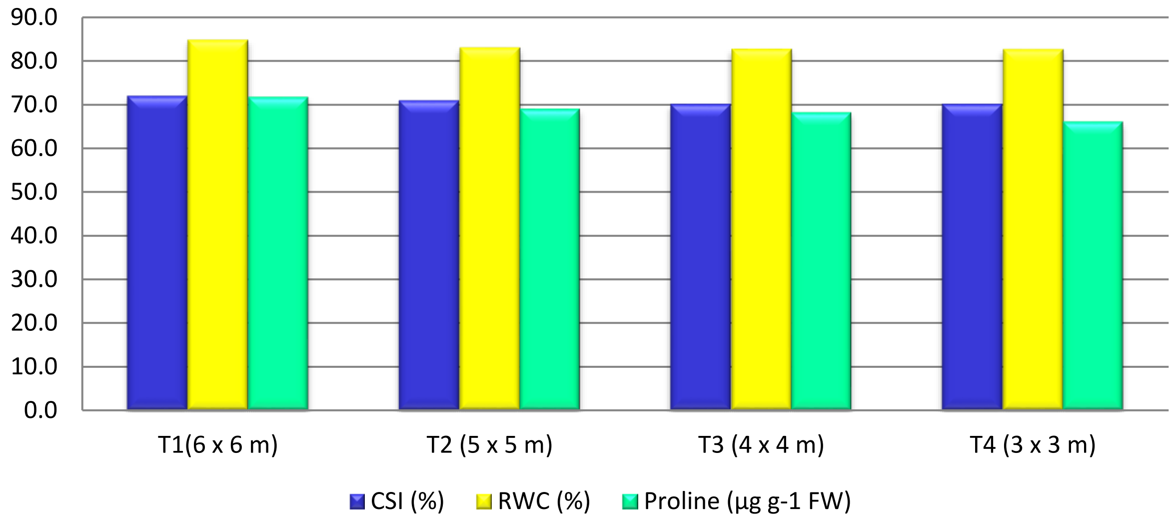
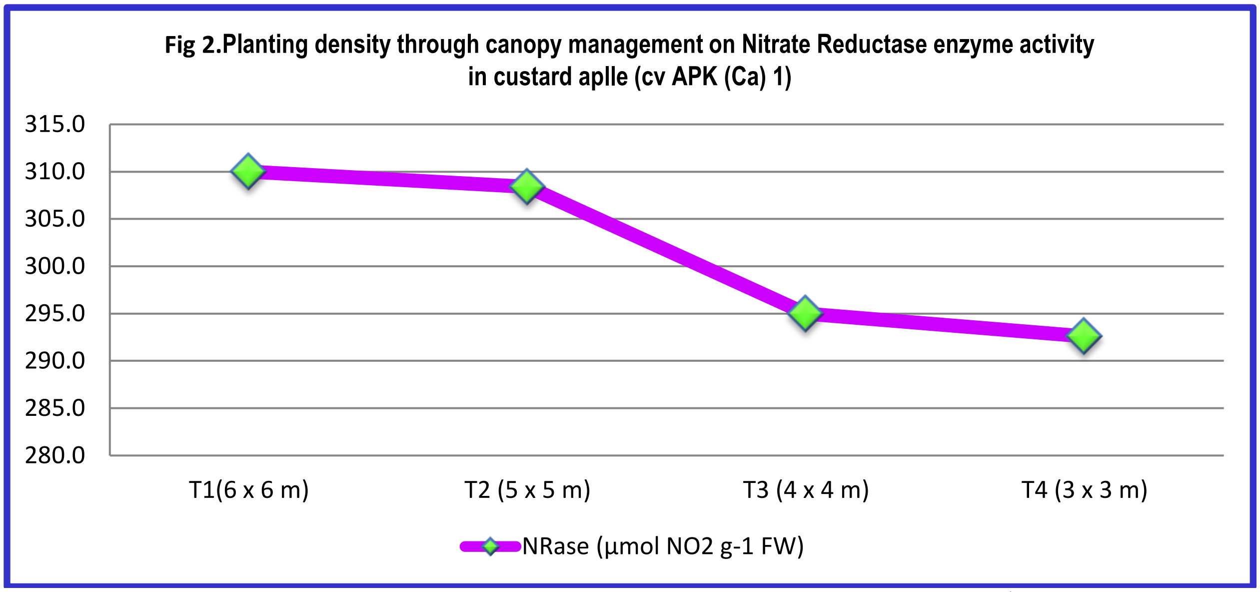


Table 2. Planting density through canopy management onmorphological parameters in custard aplle (cv APK (Ca) 1)

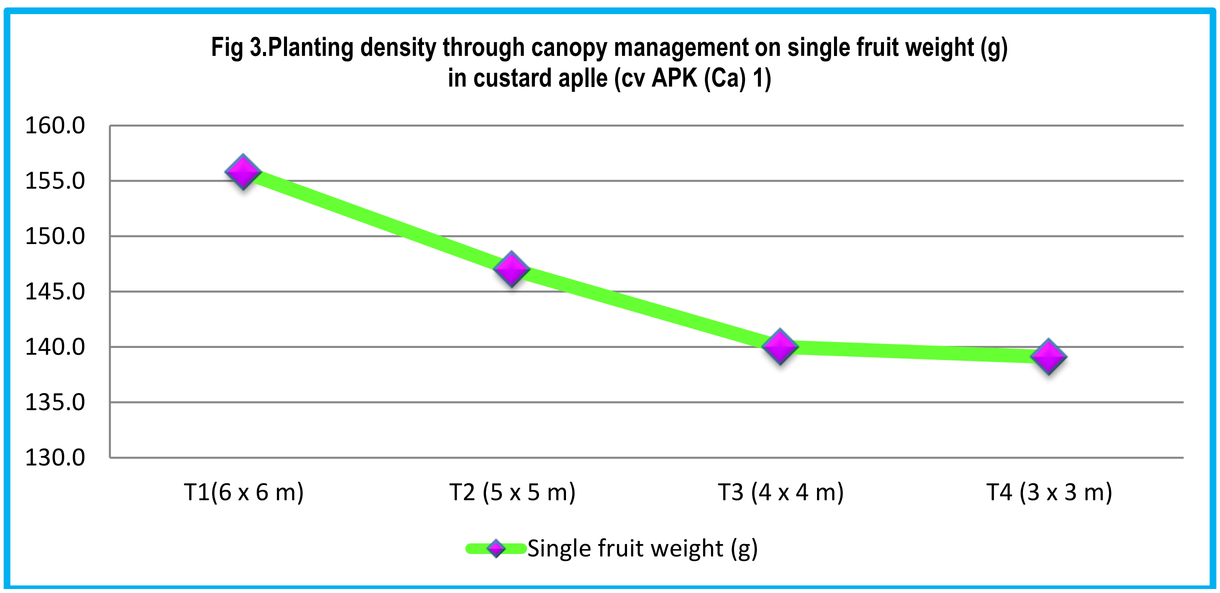
Treatments	Plant height (m)	Girth (cm)	Primary branches (No. / plant)	Secondary branches (No. / plant)	Plant spread (m)	
					N-S	E-W
T_1 (6 x 6 m)	1.72	15.00	2.70	7.60	0.82	0.85
T_2 (5 x 5 m)	1.40	12.25	2.25	6.75	0.81	0.83
T_3 (4 x 4 m)	1.25	11.29	2.41	7.20	0.62	0.41
T_4 (3 x 3 m)	1.41	10.49	1.92	7.19	0.66	0.49
Mean	**1.41**	**12.26**	**2.32**	**7.18**	**0.72**	**0.64**
SEd	**0.23**	**0.47**	**0.42**	**0.28**	**0.15**	**0.18**
CD 5%	**0.48**	**1.10**	**0.86**	**0.53**	**0.30**	**0.36**

Table 3.Planting density through canopy management onPhysio-Biochemical parameters in custard aplle (cv APK (Ca) 1)

Treatments	CSI (%)	RWC (%)	Proline (µg g^{-1} FW)	NRase (µmolNO_2g^{-1} FW)
T_1(6 x 6 m)	72.00	84.78	71.70	310.0
T_2 (5 x 5 m)	70.98	83.00	69.00	308.4
T_3 (4 x 4 m)	70.20	82.75	68.23	295.0
T_4 (3 x 3 m)	70.18	82.69	66.10	292.6
Mean	**70.84**	**83.30**	**68.76**	**301.5**
SEd	**0.91**	**0.51**	**0.88**	**3.15**
CD 5%	**1.80**	**0.94**	**1.67**	**6.11**



The observations on yield and yield characters viz., single fruit weight (g), pulp weight (g fruit^{-1}),Total Soluble Solids (^{O}brix) and yield (kg tree^{-1}) were measured during harvest stage in all the four treatments. Comparing the four different planting density treatments T_1 (6 x 6 m) recorded highest value in single fruit weight (155.8 g), pulp weight (92.4 g fruit^{-1}), Total Soluble Solids (22.0^{O}brix) and yield (24.7 kg tree^{-1}) (Table 3. Fig.3 & 4).According to Singh et al. (2009) who reported that, the fruit yield per tree was recorded slightly higher under normal density, as the competition for nutrition and also enhanced light penetration. However, the lowest value on yield and yield characters were recorded in T_4 (3 x 3 m) treatments.



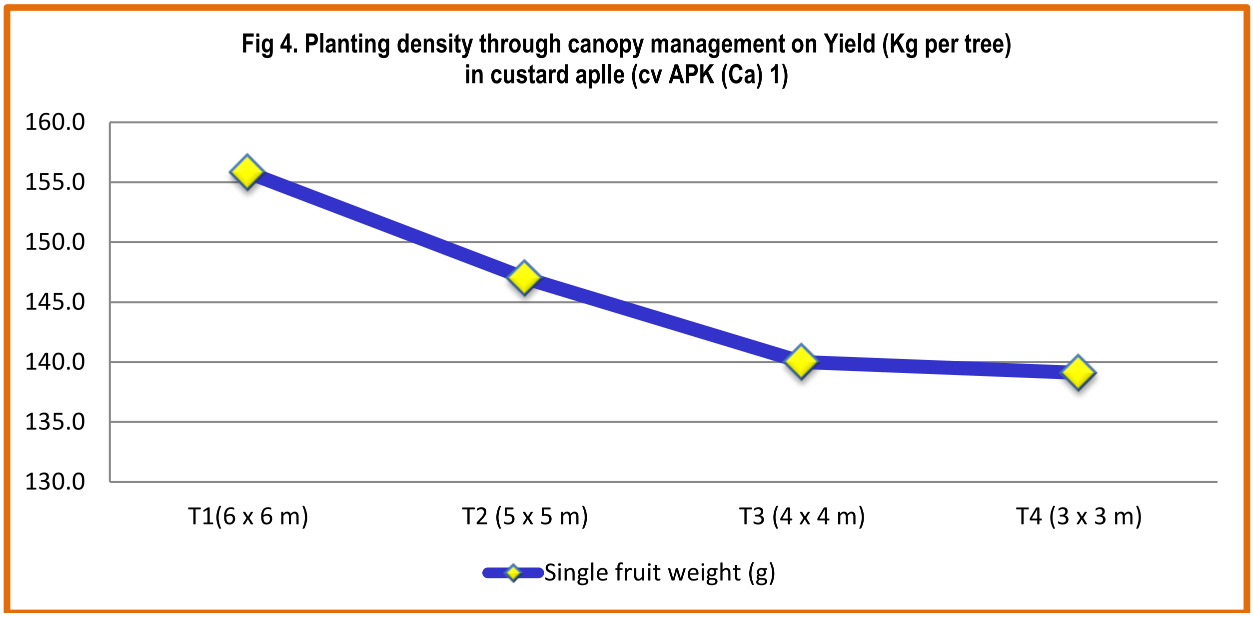
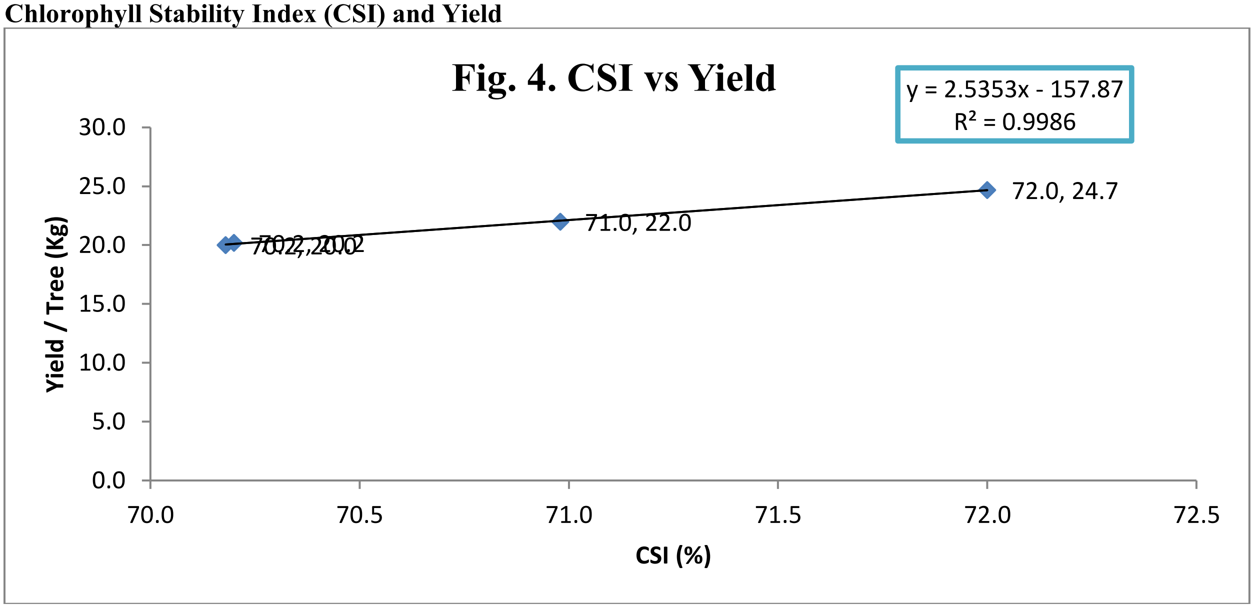


Table 3.Planting density through canopy management on Yield and yield characters in custard aplle (cv APK (Ca) 1).

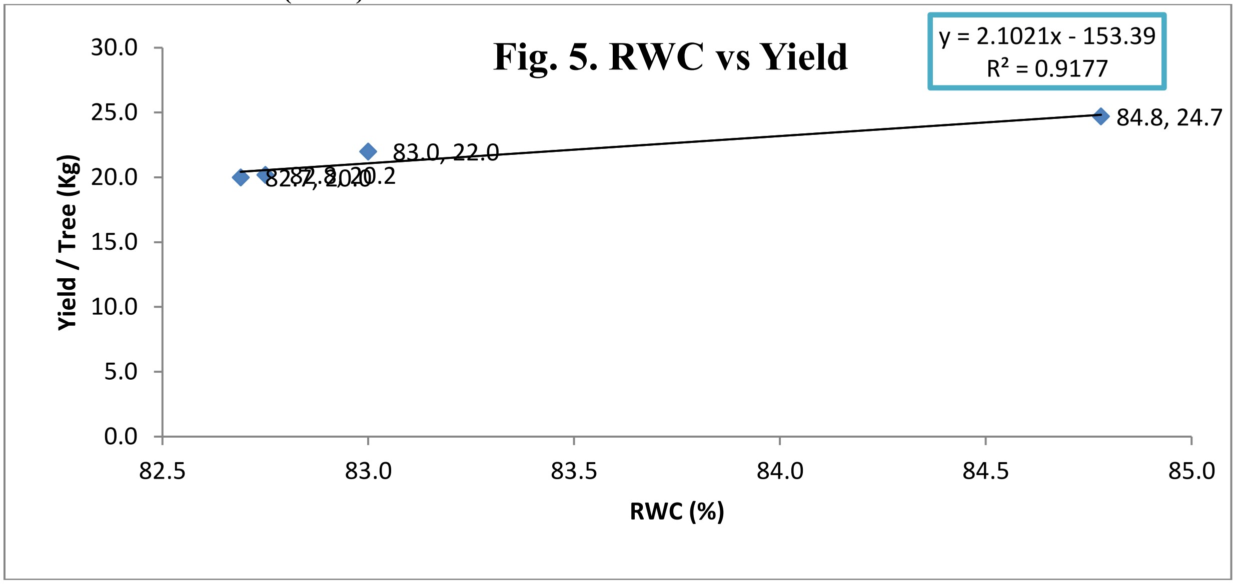
Treatments	Single fruit weight (g)	Pulp weight (g fruit^{-1})	TSS (ºbrix)	Yield (Kg tree^{-1})
T_1(6 x 6 m)	155.8	92.4	22.0	24.7
T_2 (5 x 5 m)	147.0	89.0	21.0	22.0
T_3 (4 x 4 m)	140.0	87.1	19.5	20.2
T_4 (3 x 3 m)	139.1	85.0	19.5	20.0
Mean	**145.5**	**88.4**	**20.5**	**21.7**
SEd	**0.08**	**0.06**	**0.09**	**0.03**
CD 5%	**0.16**	**0.13**	**0.20**	**0.07**

Correlation Studies on Attributes Contributing to Yield Enhancement
Chlorophyll Stability Index (CSI) and Yield



The relationship between the Crop Stress Index (CSI) and yield per tree showed a strong positive linear trend (Fig.4). As CSI increased from 70.2% **to** 72.0%**,** the yield increased from 20.0 kg tree^{-1} **to** 24.7 kg tree^{-1}**.** Linear regression analysis produced the equation $y = 2.535x - 157.8$with a coefficient of determination of $R^2 = 0.998$**,** indicating that 99.8% of the variation in yield was explained by CSI**.** This strong positive correlation suggests that higher CSI values were associated with increased yield under the conditions of the study.

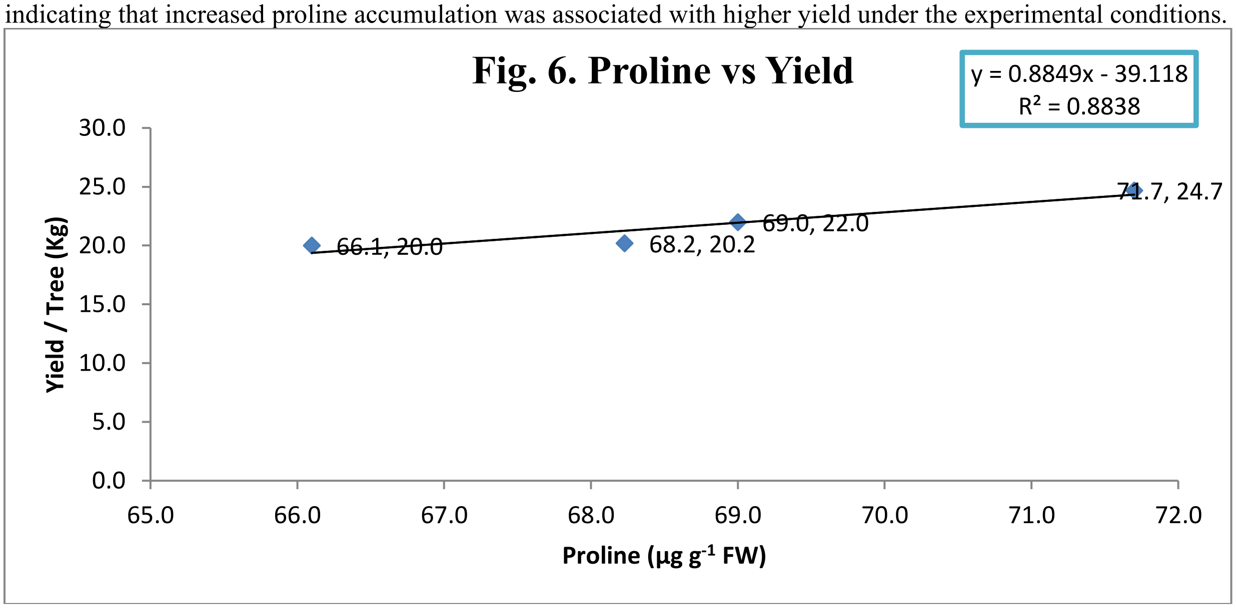
Relative Water Content (RWC) and Yield



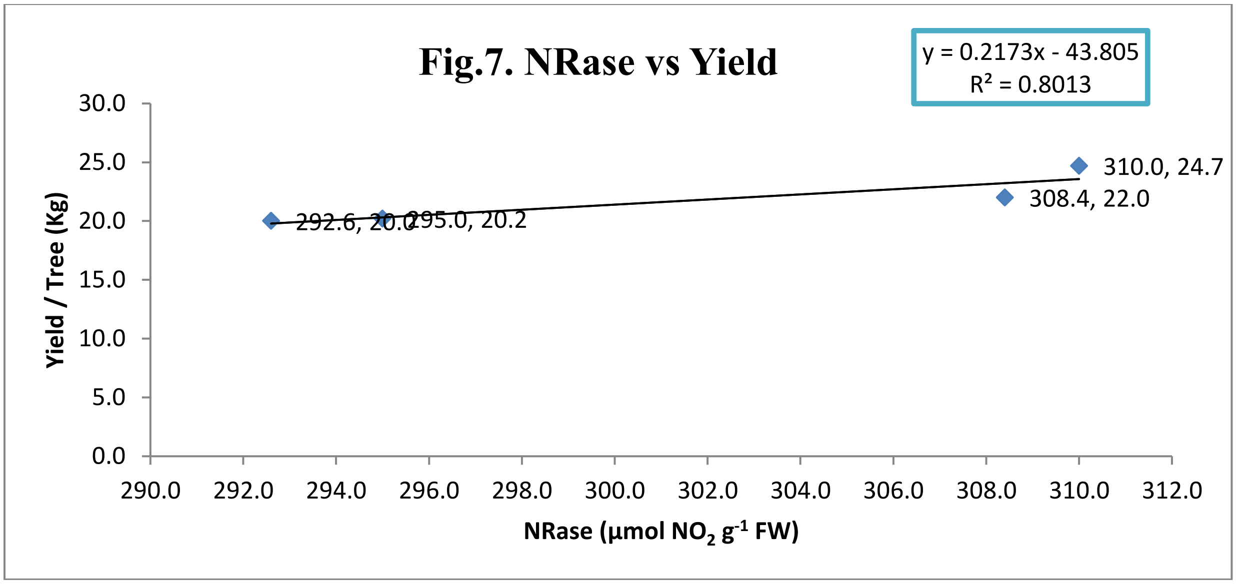
A positive linear relationship was observed between relative water content (RWC) and yield per tree (Fig.5). As RWC increased from 82.7% **to** 84.8%**,** the yield increased from 20.0 kg tree^{-1} **to** 24.7 kg tree^{-1}**.** The linear regression equation **(**$y = 2.102x - 153.3$**)** showed a strong relationship between the two variables, with a coefficient of determination **(**$R^2 = 0.917$**).** This indicates that 91.7% of the variation in yield was explained by RWC**,** suggesting that higher leaf relative water content was associated with increased fruit yield under the conditions of the study.

Proline and Yield

A positive linear relationship was observed between proline content and yield per tree (Fig.6). As proline content increased from 66.1 to 71.7 µg g^{-1} FW**,** the yield increased from 20.0 to 24.7 kg tree^{-1}**.** The linear regression equation **(**$y = 0.884x - 39.11$**)** with a coefficient of determination **(**$R^2 = 0.883$**)** indicated a strong positive association between proline content and yield. The R^2 value suggests that 88.3% of the variation in yield was explained by prolinecontent**,** indicating that increased proline accumulation was associated with higher yield under the experimental conditions.



Nitrate reductase activity and Yield



The relationship between nitrate reductase (NRase) activity and yield per tree showed a positive linear trend (Fig. 7.). As NRase activity increased from 292.6 to 310.0 µmol NO_2 g^{-1} FW**,** the yield increased from 20.0 to 24.7 kg per tree**.** The regression equation **(**$y = 0.217x - 43.80$**)** indicates that for every one-unit increase in NRase activity, the yield increased by approximately 0.217 kg per tree**.** The coefficient of determination **(**$R^2 = 0.801$**)** suggests that about 80.1% of the variation in yield was explained by NRase activity, indicating a strong positive association between the two variables.

CONCLUSION

Based on the results it could be concluded that, custard apple grown underWider spacing with 6 x 6 m recorded higher values in all morphological, biochemical and yield than other treatments.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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