EFFECT OF PLANT DENSITY AND TRAINING SYSTEMS ON GROWTH, YIELD, AND FRUIT QUALITY OF WATERMELON (CITRULLUS LANATUS)

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Abstract

Optimizing plant density and training systems is critical for improving the productivity and fruit quality of watermelon (Citrullus lanatus). This study evaluates the influence of three plant spacing arrangements and two vine training systems on vegetative growth, yield, and quality characteristics under semi-arid conditions of Uzbekistan. Field experiments conducted from 2022 to 2024 revealed that moderate plant density (2.5 × 0.7 m) combined with two-stem pruning produced the best results, achieving yields up to **75.2 t/ha** and soluble solids of **13.1 °Brix**. High-density planting reduced individual fruit weight but increased total yield per hectare, whereas low-density planting improved sweetness and vitamin C content. The results suggest that balanced plant density with systematic pruning ensures optimal photosynthesis, improved fruit uniformity, and higher profitability.

Keywords: watermelon, plant spacing, pruning, fruit quality, yield optimization, Uzbekistan

1. Introduction

Watermelon (Citrullus lanatus) is a globally cultivated fruit crop known for its nutritional value and economic significance. In Uzbekistan's dry continental climate, efficient land use and resource optimization are essential for achieving high yield and quality. Among various agronomic factors, **plant density** and **vine training systems** strongly influence canopy architecture, fruit development, and sugar accumulation (FAO, 2023).

Dense plantings can maximize land productivity but may lead to shading and reduced fruit sweetness (Liu et al., 2020). Conversely, wider spacing improves fruit quality but limits total yield per hectare. Similarly, **vine training**—such as single- or double-stem pruning—affects light distribution, aeration, and energy allocation in the plant (Xu et al., 2021).

This study aims to determine the optimal plant density and vine training combination for sustainable watermelon production in Uzbekistan's semi-arid conditions.

2. Materials and Methods

2.1 Experimental Site

The experiment was carried out between 2022 and 2024, Surxondaryo region (37.8°N, 67.0°E). Soil: light loam with 1.6 % humus, pH 7.5. Average temperature: 27.8 °C; annual rainfall: 140 mm.

Hybrid used: Top Gun F1 (high-yielding and disease-resistant hybrid).

Experimental design: **Split-plot RCBD** with three replications.

2.2 Treatments

- **Main factor A – Plant spacing (density):**

1.S_1: 2.0 × 0.5 m (high density, 10,000 plants/ha)

2.S_2: 2.5 × 0.7 m (medium density, 7,500 plants/ha)

3.S_3: 3.0 × 0.8 m (low density, 5,200 plants/ha)

- **Sub-factor B – Training system:**

1.T_1: Single-stem pruning

2.T_2: Two-stem pruning

Standard cultural practices (mulching, drip irrigation, IPM) were followed.

2.3 Data Collection and Analysis

Measured parameters:

- **Growth:** vine length, number of leaves, leaf area index (LAI)
- **Yield:** fruit number/plant, fruit weight, total yield (t/ha)
- **Quality:** total soluble solids (°Brix), vitamin C (mg/100 g)
- **Economic:** gross income and profitability (%)

Data were analyzed by **two-way ANOVA** and **Duncan's multiple range test** using SPSS 26.0.

3. Results

3.1 Growth Performance

Plant spacing and pruning systems significantly affected vegetative growth (Table 1). Wider spacing increased vine length and leaf area due to reduced competition for light and nutrients. Two-stem pruning improved canopy coverage and fruit set rate.

Table 1. Influence of spacing and training on vegetative growth and fruit set.

Treatment	Vine length (cm)	LAI	Fruits/plant
S_1T_1 (Dense + Single-stem)	198	2.9	2.3
S_2T_2 (Medium + Two-stem)	**235**	**3.8**	**3.0**
S_3T_2 (Wide + Two-stem)	228	3.5	2.7

3.2 Yield and Fruit Weight

Medium spacing (2.5 × 0.7 m) with two-stem training (S_2T_2) gave the highest yield (**75.2 t/ha**) and marketable fruit rate (95 %). High-density planting (S_1T_1) reduced average fruit weight by 12 % due to interplant competition.

Table 2. Effect of plant density and pruning on yield parameters.

Treatment	Avg. fruit weight (kg)	Yield (t/ha)	Marketable fruit (%)
S_1T_1	5.0	70.3	88
S_2T_2	**5.9**	**75.2**	**95**
S_3T_2	6.2	68.5	90

3.3 Fruit Quality

Fruit quality (°Brix and vitamin C) was highest under low-density planting with two-stem pruning, owing to better light exposure and sugar translocation.

Table 3. Quality and profitability under different treatments.

Treatment	Soluble solids (°Brix)	Vitamin C (mg/100 g)	Profitability (%)
S_1T_1	11.5	8.1	238
S_2T_2	**13.1**	**8.8**	**312**
S_3T_2	13.4	9.0	288

3.4 Relationship Between Density and Quality

A negative correlation ($r = -0.72$, $p < 0.05$) was found between plant density and fruit sweetness, while moderate density optimized both yield and quality. This confirms that plant spacing must balance fruit size and total output.

4. Discussion

The results show that **plant density and vine training** significantly influence watermelon performance. Medium density (2.5 × 0.7 m) achieved the best combination of high yield and good fruit quality, consistent with studies by Ahmed et al. (2020) and Xu et al. (2021).

Two-stem pruning increased canopy light interception and improved fruit uniformity, while single-stem systems favored early maturity but smaller total yield.

From an economic perspective, the S_2T_2 combination provided the highest profitability (312 %) due to high yield and reduced unmarketable fruit losses. Excessive density caused smaller fruit and increased disease incidence, indicating that proper plant arrangement is essential for sustainable production.

5. Conclusion

Optimizing plant density and pruning system is a key component of modern watermelon production. The combination of **medium density (2.5 × 0.7 m)** and

two-stem pruning enhanced yield (75.2 t/ha), fruit quality (13.1 °Brix), and profitability (312 %).

Recommendations:

1.Use medium-density planting for balanced resource utilization.

2.Apply two-stem pruning to improve canopy structure.

3.Combine drip irrigation and mulching for higher efficiency.

4Train farmers on canopy management for quality improvement.

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