Influence of Training and Tomato Hybrids on, Yield of Tomato Under Shade Net House

Abstract

This study investigates the impact of training systems and hybrid selection on the yield of tomato (*Solanum Lycopersicon*) grown under a shade net house environment. The experiment, conducted at the Hi-Tech Horticulture Unit, Centre of Excellence for Vegetables, Karnal, utilized a Factorial Randomized Block Design with three replications. Two training systems (one-stem and two-stem) and four indeterminate hybrids (STH-39, STH-901, STH-801, and STH-701) were evaluated for their influence on key vegetative and reproductive parameters. Results revealed that the two-stem system significantly improved yield per plant (6.93 kg) and per square meter (15.36 kg) due to increased cluster formation and fruit set percentage. Conversely, the one-stem system promoted larger fruit size, with an average fruit weight of 105.50 g, indicating its suitability for markets valuing larger produce. Hybrid STH-801 exhibited superior performance, recording the highest yield per plant (6.52 kg) and yield per square meter (15.68 kg), along with the greatest number of fruits per cluster (7.75) and highest fruit set percentage (93.17%). Additionally, the STH-39 hybrid produced the largest fruits with an average diameter of 6.30 cm and volume of 157 cc. The findings underscore the importance of selecting appropriate training systems and hybrids to optimize productivity and fruit quality under protected cultivation. This research offers practical insights for growers seeking to enhance profitability through sustainable agricultural practices, particularly during off-season periods under challenging climatic conditions.

Keywords: *Shade Net, Yield, Tomato, Greenhouse, Training, Hybrid*

Introduction

Tomato (*Solanum Lycopersicon*), a member of the Solanaceae family, is one of the most widely cultivated and economically important vegetable crops across the world. The fruit is highly valued both for fresh consumption and for its extensive use in the processing industry. Native to South America, tomato cultivation has spread globally, with key production centres in countries like the USA, China, India, Italy, Turkey, and Russia, where extensive research and innovation have been focused on improving yield, quality, and resistance to biotic and abiotic stresses. India, ranked fourth in global tomato production, plays a crucial role in the global market with an area of 0.54 million hectares producing 7.6

million tonnes annually, accounting for significant export and domestic consumption (Anonymous, 2015).

Despite the extensive cultivation of tomatoes in India, productivity is often reduced due to high temperatures, particularly during the summer months in tropical regions. These conditions hinder fruit set and overall yield, presenting a major challenge to farmers (Berry and Uddin, 2003). The development and optimization of advanced agricultural techniques, such as protected cultivation under shade net structures, have shown promise in mitigating the adverse effects of high temperature on tomato production. The use of shade nets helps create a favourable microclimate by reducing heat stress, resulting in improved fruit quality, increased yield, and extended growing seasons (Tiwari et al., 2002). Incorporating improved cultural practices, such as training systems and pruning methods, alongside shade net cultivation, can further enhance tomato productivity. Training tomato plants to specific growth habits—especially indeterminate hybrids that are best suited for vertical cultivation in protected environments—has been demonstrated to optimize space utilization, increase early yield, improve fruit size, and enhance aeration, which collectively improve overall plant health and marketability of the produce (Edmund et al., 1979). Additionally, shade net cultivation provides farmers with an opportunity to produce tomatoes during the off-season when market demand is high, thereby offering higher profit margins and reducing the financial risks posed by seasonal price fluctuations. Given the increasing demand for high-quality tomatoes during summer and the limitations posed by high-temperature conditions, research into the optimization of training systems under shade net cultivation is of paramount importance. This study aims to explore the influence of different training systems and hybrid varieties on the yield and quality of tomatoes grown under shade net conditions in Haryana, India. The findings of this research will have practical implications for farmers seeking to maximize their productivity and profitability by utilizing innovative and sustainable agricultural practices in the face of climate challenges. This study draws upon existing research findings to substantiate the potential of shade net cultivation, hybrid selection, and training systems to improve tomato yields during off-season periods and under suboptimal environmental conditions. The primary objective of this research is to standardize training systems for indeterminate tomato hybrids under shade net structures to maximize yield and quality.

Materials and method

The investigation was conducted at the Hi-Tech Horticulture Unit, Department of Horticulture, Centre of Excellence for Vegetables Indo-Israel Project, Karnal, during the

2016-17 growing season. Karnal, located in the Northern Transitional Tract of Haryana, lies at 29.5424°N latitude and 76.9701°E longitude, at an altitude of 213 meters above mean sea level, and is considered a tropical region. The experimental design employed was a Factorial Randomized Block Design (FRBD) with three replications and eight treatments in total. Two main factors were examined: tomato hybrids and training systems. Four tomato hybrids were selected for evaluation, labeled as G1: STH-39, G2: STH-901, G3: STH-801, and G4: STH-701. Each hybrid was subjected to one of two training systems: T1, where plants were trained using the single-stem method, and T2, where plants were trained using the double-stem method. These combinations of hybrids and training methods were assessed to examine their impact on growth, yield, and fruit quality under shade net house conditions. The data collected on various parameters related to growth, yield, and quality were analyzed statistically, following the method outlined by Gomez and Gomez (1984). The critical difference (CD) values were computed at a 5% probability level ($p=0.05$) when the F-test indicated significance.

Results and discussion

The study examined the effects of two training systems (single-stem and double-stem) and four hybrid variants (including STH-39) on plant growth, fruit development, and yield-related traits. The training system did not influence reproductive parameters such as days to fifty percent flowering, days from flowering to fruit development, number of fruits per cluster, and percent fruit set. This is likely because these traits are largely governed by the plant's genotype and are not impacted by the training system. The only reproductive parameter significantly affected by the training system was the number of clusters per plant, which was notably higher in plants trained with a double-stem system (12.41 clusters per plant). The increase in clusters could be attributed to the presence of two stems, a greater number of leaves, and additional points for inflorescence production. Similar results were found by Mangal et al. (1981) in tomatoes under polyhouse conditions, and by Yeongcheol et al. (1997), Borelli (1983), Buitelaar (1984), Veselinov (1977), and Cordt (1999) in greenhouse tomatoes.

Tomato plants trained using the double-stem system produced significantly higher yields, with 6.93 kg per plant and 15.36 kg per square meter. This increased yield is likely due to the presence of two stems, a higher number of clusters per plant, a greater fruit set percentage, and more leaves, all of which boost photosynthesis and ultimately result in a higher yield. Similar findings were reported by Mangal et al. (1981) and Sharfuddin and Ahmed (1986). In terms of reproductive characteristics, hybrid tomato plants grown in shade houses also showed significant variation. The STH-801 hybrid recorded a significantly higher number of clusters per plant (12.15), fruits per cluster (7.75), and fruit set percentage (93.17%), which could be attributed to the genetic potential of these hybrids in response to the favorable microclimate provided by the shade house. These observations align with those of Papadopoulos and Ormrod (1991) in tomatoes grown under greenhouse conditions.

Tomato genotypes were similar in terms of days to fifty percent flowering and days from flowering to fruit development, likely because these traits are genetically controlled and minimally influenced by microclimate variations in the shade house. However, hybrid tomato plants grown in shade houses exhibited significant differences in yield parameters. The STH-801 hybrid produced significantly higher yields per plant (6.52 kg), yields per square meter (15.68 kg), and more seeds per fruit (141.50). These improvements in yield-related traits may be due to a higher number of clusters per plant, more fruits per cluster, a higher fruit set percentage, and more efficient chloroplast development in the leaves, triggered by the diffused sunlight in the shade house. These findings are supported by Goodchild and Bjorkman (1972), Anderson et al. (1973), Pitamchandra et al. (2000), Fontes et al. (1997), and Kavita et al. (2008).

The STH-39 hybrid exhibited significantly larger average fruit diameter (6.30 cm), fruit volume (157.01 cc), and fruit weight (115.50 g), likely due to the plant's genetic potential to produce fewer but larger fruits. Genotypic combinations play a vital role in determining fruit size and weight. Similar findings were reported by Mangal and Jasim (2001) in plastic house conditions, Papadopoulos and Ormrod (1991) in greenhouse conditions, and Choudhury and Bhuyan (1992) in shade house conditions. The interaction between hybrid tomato plants cultivated under greenhouse conditions and the training system was found to be non-significant for all traits except for average fruit diameter, which was significant in STH-39 (6.30 cm). This can be attributed to the semi-determinate growth habit and smaller plant size of this genotype compared to others with determinate habits.

Conclusion

The study highlights the importance of both training systems and hybrid selection in enhancing the growth, yield, and fruit quality of tomatoes under shade net conditions. Results indicate that the double-stem training system significantly increased the number of clusters per plant, leading to higher yields per plant and per square meter. Conversely, the single-stem system promoted larger fruit sizes, making it more suitable for markets where larger fruits are valued. Among the hybrids, STH-801 exhibited superior performance in yield-related traits, such as the highest fruit set percentage and number of clusters per plant, while STH-39 produced the largest fruits. These findings underscore the potential of combining the appropriate training system with the right hybrid to optimize tomato production in protected environments, especially during off-seasons when climatic conditions are challenging.

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Table 1Influence of training and tomato hybrids on, yield of tomato under shade net house

Treatments	Days to fifty per cent flowering	Days taken from flowering to fruit development	Number of clusters per plant	Number of fruits per cluster.	Fruit set percentage	Yield per plant (kg)	Yield per meter square (kg)	Average fruit weight (g)	Average fruit diameter (cm)	Average fruit volume (cc)
Factor A (Training)										
T_1 (One stem)	36.25	42	8.86	6.33	90.33	4.91	11.56	105.50	5.59	143
T_2 (Two stem)	36.08	42	12.41	6.23	88.08	6.93	15.36	93.80	5.41	129
SEm (±)	0.15	0.15	0.23	0.24	0.80	0.09	0.20	2.01	0.09	1.74
CD (P=0.05)	NS	0.46	0.71	NS	NS	0.29	0.62	6.11	0.29	5.29
Factor B (Hybrids)										
G_1 (STH-39)	36.17	41	8.30	5.72	88.33	5.07	11.21	115.50	6.30	157
G_2 (STH-39)	36.33	42	10.78	5.65	86.33	5.97	12.96	92.30	5.48	125
G_3 (STH-39)	36.17	41	12.15	7.75	93.17	6.52	15.68	97.30	5.40	132
G_4 (STH-39)	36.00	41	11.33	6.96	89.00	6.13	14.00	93.30	4.84	130
SEm (±)	0.22	0.11	0.33	0.34	1.14	0.13	0.28	2.85	0.06	1.24
CD (P=0.05)	NS	NS	0.99	1.02	3.46	0.40	0.87	8.65	0.20	3.75
Interaction (Training x Hybrids)										
T_1G_1	36.33	42	7.23	5.94	92.00	4.29	9.86	125.30	6.75	165
T_1G_2	36.33	41	8.87	5.55	84.67	4.71	10.70	95.70	5.44	129
T_1G_3	36.00	41	9.83	6.59	95.00	5.42	13.47	100.70	5.48	137
T_1G_4	36.33	42	9.53	7.23	89.67	5.25	12.24	100.30	4.72	140
T_2G_1	36.00	42	9.37	5.50	84.67	5.85	12.56	105.70	5.48	148
T_2G_2	36.33	42	12.70	5.75	88.00	7.25	15.10	89.00	5.52	122
T_2G_3	36.17	41	14.47	6.99	91.33	7.62	17.90	94.00	5.32	127
T_2G_4	36.60	42	13.13	668	88.33	7.02	15.75	86.70	5.95	130
SEm (±)	0.31	0.21	0.46	0.48	1.61	0.19	0.41	4.03	0.08	2.47
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	0.30	NS

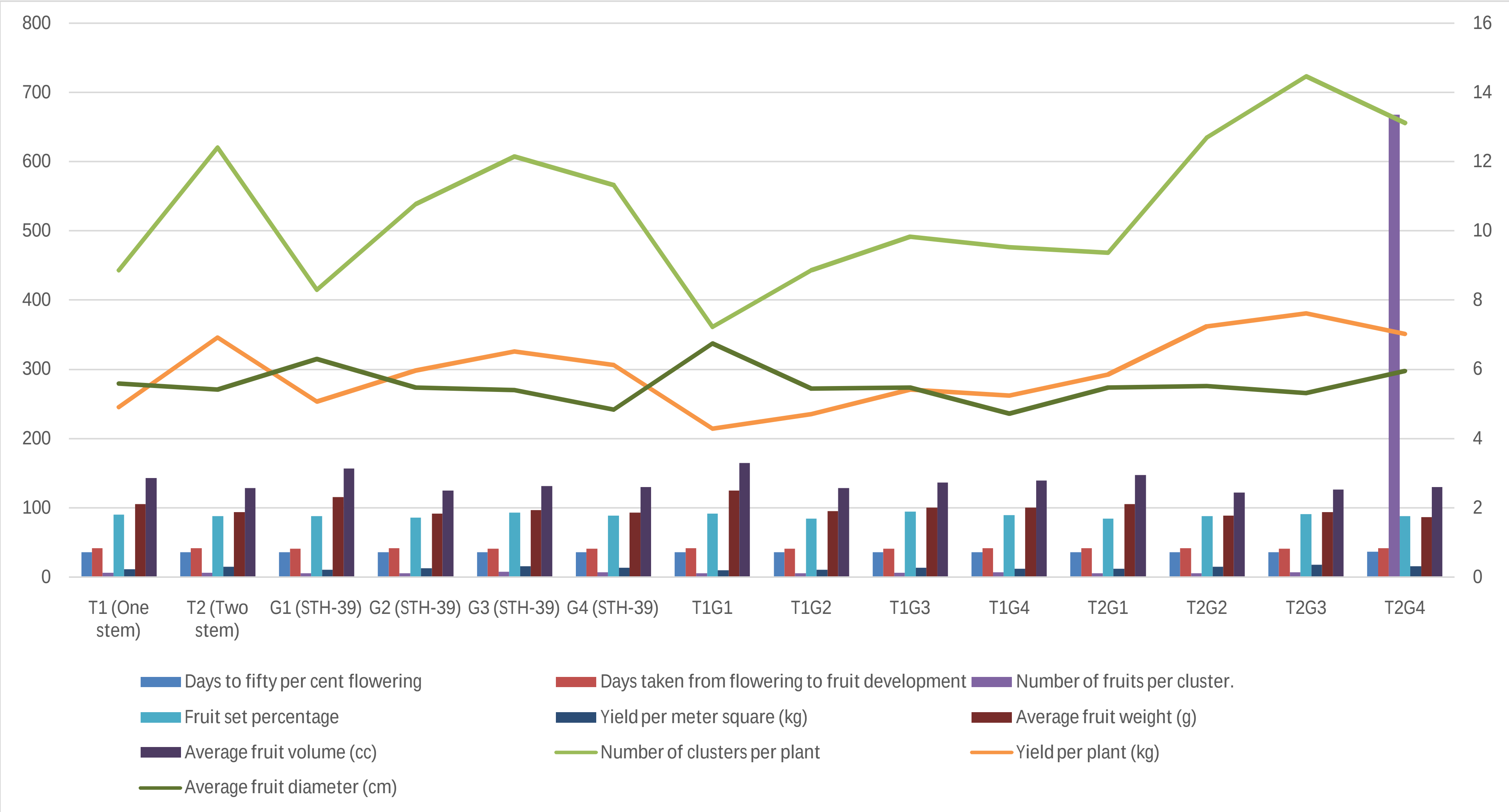

Figure 1 Influence of training and tomato hybrids on, yield of tomato under shade net house