Volume 3, Issue 4, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

IMPACT OF ENVIRONMENTAL CONDITIONS AND TREATMENT TYPES ON GROWTH AND BIOMASS PARAMETERS OF SOLANUM LYCOPERSICUM

Mariyam Abbas Jaffari[1], Najm Ud Din[*2], Syeda Hijab Fatima[3], Dawood Khan[4], Abdul Samad Khan[5], Saif Ud Din[6]

[*2, 3,4,6]*Institute of Biological Sciences Gomal University DI Khan*
[1]*Department of Biological Sciences Government Graduate College Bhakkar*
[6]*Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan*

[1]mariyamabbasjaffri@gmail.com, [*2]najmuddindawar20@gmail.com, [3]syedahijabfatima572@gmail.com, [4]daud54567@gmail.com, [5]samadyar86@gmail.com, [6]saifdawar776@gmail.com,

DOI: https://doi.org/10.5281/zenodo.15628793

Keywords
Solanum lycopersicum, Environmental conditions, Plant growth parameters, Biomass production, Controlled environment, Morphological traits.

Article History
Received on 31 April 2025
Accepted on 31 May 2025
Published on 10 June 2025

Corresponding Author: * Najm Ud Din

Abstract

The tomato (Solanum lycopersicum L.) is among the most widely produced crops globally. Atmospheric conditions significantly impact the maturation, growth and development, and output of tomato plants. This research aimed to evaluate the effects of various environmental conditions, specifically open field, greenhouse, and net house, on tomato development metrics, including plant height, leaf area, leaf count, and fruit output. The findings indicated significant variations in the forms and quantities of crops produced in different environments. Plants cultivated in greenhouses had superior growth rates and yields, followed by those in net houses, whereas open-field culture yielded the least owing to variable weather conditions and susceptibility to biotic stress. Conclusions show that regulated settings like greenhouses provide optimal circumstances for enhancing tomato yield and suggest that it's worth fine-tuning environmental factors to elevate crop performance.

INTRODUCTION

The tomato, or Solanum lycopersicum, is one of the most significant vegetables in the world. The tomato is the second-largest vegetable crop in the world after potatoes and a significant source of lycopene. The Solanaceae family, which has more than 3,000 species, is where the tomato comes from. The fruits of the tomato plant are a significant food source for the whole world's population [1]. It is one of the primary sources of minerals, vitamins, and antioxidants due to its widespread use throughout the year [2]. Tomato is staple organic food. An important part of Pakistan's economy and agriculture is the tomato. They are an essential component of domestic trade and consumption, supporting the nation's GDP and giving many farmers a means of subsistence. One of the primary crops farmed in Pakistan is the tomato, which is produced in large quantities in numerous areas, including Punjab, Sindh, and Baluchistan. These areas' favorable soil and climate make it possible to grow tomatoes and have several crops year [3].

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

Tomatoes come in a wide variety of shapes, sizes, colors, and flavors. They can be broadly categorized based on their growth habits (determinate vs. indeterminate), usage (slicing, paste, cherry, etc.), and other characteristics. Rio Grade, Roma and Cherry tomatoes origin is Italy and ideal for sauces, pastes, and canning. Their characteristics are Medium to large-sized fruit, firm flesh with low water content and resistant to cracking and blossom end rot. Their cultivation prefer is warm climate [4]. Typically matures in 75-80 days. Large, round tomatoes are commonly known as slice tomatoes, and they're excellent when eaten fresh, especially in salads and sandwiches. Big, flavorful tomatoes that are packed with meat. Brandywine, Cherokee Purp, Big Beef Regular spherical tomatoes are frequently seen at supermarkets. Examples are Celebrity, Early Gir, Better Boy [5]. Cherry tomato are small, round tomatoes that are usually very sweet and often used in salads or as snacks. Grapes tomatoes are slightly larger than cherry tomatoes, grape tomatoes are oblong and sweet, often used in salads or for snacking. Open-pollinated tomatoes that have been handed down through the centuries are known as heirloom tomatoes, and they are frequently prized for their distinctive flavors and hues [6]. Oxheart tomato are large, heart-shaped tomatoes that are meaty with few seeds, good for slicing and sauces. Vitamin C, which is essential for immune function, healthy skin, and oxidative defense, is abundant in tomatoes. A single medium-sized tomato supplies around 28% of the daily required vitamin C intake [7]. The beta-carotene found in tomatoes gets transformed by the body into vitamin A, which is necessary for healthy skin, eyesight, and immunity. They supply roughly 20% of the recommended daily intake of vitamin A [8]. Tomatoes contain an average quantity of this essential nutrient, which is important for blood clotting and bone health [9]. Tomatoes are a great source of this element, which is essential for heart health, muscular activity, and blood pressure regulation. The potassium content of one medium tomato is about 292 mg. Because folate is necessary for tissue growth and cell function, tomatoes [10].

Every year, more than 500,000 tons of tomatoes are produced in Pakistan.

The two provinces that produce the most tomatoes nationally are Sindh and Punjab. Thousands of Pakistani laborers and smallholder farmers rely on the production of tomatoes for their livelihood. Seasonal jobs are brought about by the crop during the planting, growing, and harvesting phases. Growing tomatoes is a major source of earnings for a sizable portion of small-scale farmers. Labor Employment: By providing jobs in rural regions, tomato cultivation and processing contribute to the improvement of living conditions and the reduction of poverty [11].

In Pakistan's regional marketplaces, tomatoes are a fundamental product. Because they are a crucial part of Pakistani cuisine, there is year-round demand for them. There is a sizable domestic tomato market, with high consumption levels in both rural and urban areas. Although most tomatoes are utilized in Pakistan, there is room for growth in tomato exports to nearby nations, which would improve the country's trade balance and generate foreign money. Pakistan's GDP benefits from the agricultural production of tomatoes [12]. They are a major source of income for farmers and the agriculture industry, making them a cash crop of great importance. Sales of tomatoes significantly boost the income of farming households and the agricultural sector as a whole [13]. The price of tomatoes can fluctuate, which has an impact on consumer costs as well as the earnings of farmers. This volatility can be stabilized with the aid of efficient market regulation and assistance [14]. Although numerous studies have explored the individual effects of environmental conditions or treatment types on tomato growth, there is limited information on their interactive or combined impact [15]. A comprehensive understanding of how these factors influence plant morphology and biomass production is essential for developing integrated cultivation strategies that maximize productivity under varying environmental scenarios [16]. The aim of this study is to investigate the influence of different environmental conditions and treatment types on the growth and biomass parameters of Solanum lycopersicum (tomato), Specifically, it investigates plant height, root length, shoot length, leaf area, and fresh and dry weights of

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

roots and shoots. A factorial experimental design and two-way analysis of variance (ANOVA) were employed to assess the significance of the main effects and their interaction. The findings of this research provide valuable insights for optimizing tomato cultivation through the strategic integration of environmental and agronomic management practices.

2. Materials and Methods

The study employed a two-factor factorial design organized in a Completely Randomized Design (CRD) with three replications. The two examined variables were environmental circumstances (e.g., controlled vs. ambient environment) and treatment kinds (e.g., treated versus untreated/control). Each treatment combination was randomly allocated to pots with tomato plants (Solanum lycopersicum), and consistent agronomic techniques were adhered to over the trial duration.

2.1 Plant Material and Cultivation:

Healthy seedlings of Solanum lycopersicum were transferred into pots containing sterilized loamy soil. Each pot was sustained in its designated environmental state and administered the specified therapy.

2.2 Measurement of Growth and Biomass Parameters:

At the end of the experimental period, we assessed the following parameters:

2.2.1 Height of the Plant

Plant height is measured from the base (soil surface) to the apex of the tallest leaf or bloom for all plant categories.

2.2.2 Principal Divisions

Each plant across all categories has its primary branches counted. The quantity of fruit clusters on tomato plants under different treatment settings is assessed. This procedure facilitates the direct investigation of the impacts of various treatments on fruit yield.

2.2.3 Root Length (cm)

Measure the length of the root system, starting from the base or point of attachment, and ending at the apex of the longest root.

2.2.4 The duration of the Shot

Accurately measure the length of a plant stem from the base (soil surface) to the apex of the tallest leaf or bloom.

2.2.5 Leaf Area (cm^2)

Quantify the leaf area from each pot across all treatment categories.

2.2.6 Fresh Weight of Root and Shoot (g/plant)

Subsequent to harvesting, the plants were washed with distilled water, dried for two minutes with tissue paper, and then the fresh shoot and root weights (g/plant) were documented.

2.2.7 Root and Shoot Dry Weight (g per plant)

The plants were subjected to baking at 65 °C until a stable dry weight was attained. The dry weights of the shoot and root for each plant were measured in grams using a digital scale, and the average values were computed. Dry weights were documented following the desiccation of plant samples in an oven at 70 ± 2 °C until a stable weight was attained.

2.3 Statistical Examination

The data underwent two-way Analysis of Variance (ANOVA) to assess the impacts of environmental factors, treatment types, and their interaction. Significance was established at $P < 0.05$, and F-values were contrasted with the crucial values from the F-table. All statistical analyses were performed with SPSS version 2022.

1. Results

3.1 Morphological parameters

The two-way ANOVA analysis of plant height across several cultivars, treatment types, and environmental conditions revealed significant variations. The two-factor ANOVA shows that both the type of treatment (organic or inorganic) and the type of environment (natural or control) have a big effect on plant height, with $F = 61.67$ and $p = 2.6E\text{-}06$ for each factor. The interaction between the two components,

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

therapy and environment, was not significant (F = 0.10, p = 0.761). For Variety 1 (Roma), the average height of plants was 45.5 cm under organic treatment in the natural environment, increasing to 54 cm in the control environment, whereas inorganic treatment yielded heights of 56 cm and 64.5 cm, respectively. In Variety 2 (Rio Grade), plants subjected to organic therapy averaged 43.5 cm in natural conditions and 52 cm in controlled settings, whereas those under inorganic treatment reached heights of 55.5 cm and 61.5 cm, respectively. The mean heights of variety 3 (Cherry) were recorded as 37.5 cm in natural conditions and 45 cm in controlled circumstances. With inorganic treatment, the heights increased to 50 cm and 55 cm. The results indicate that inorganic treatments consistently produce taller plants, and controlled settings further enhance plant height.

3.1. ANOVA Table of Plant of Solanum lycopersicum under different environmental conditions.

Source of Variation	SS	df	MS	F	P	F crit
Treatment Type	432.5	1	432.5	61.67	2.6E-06	4.26
Environment Type	432.5	1	432.5	61.67	2.6E-06	4.26
Interaction	0.67	1	0.67	0.10	0.761	4.26
Error	168.67	20	8.43			

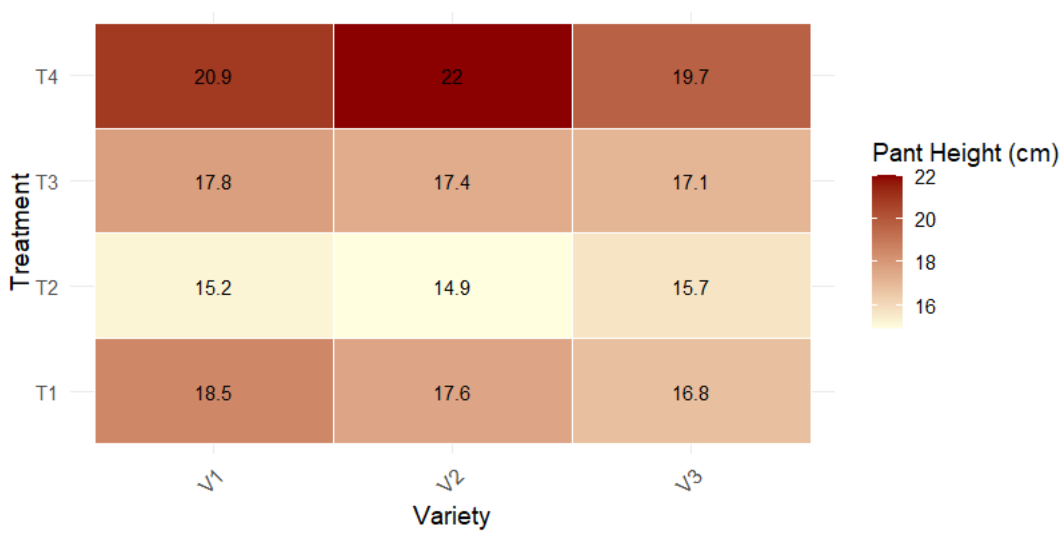

Fig 3.1: Environmental and Treatment Effects on Solanum Lycopersicum Plant Height.

3.2 Root Length

The analysis of root length among various kinds, treatment modalities, and environmental conditions yielded significant findings. The two-way ANOVA showed that both the type of treatment (organic vs. inorganic) and the type of environment (natural vs. control) have a big impact on root length, with F-values of 105.17 and p-values of 1.1E-07 for each factor. The interaction between treatment type and environment type was not significant (F = 0.34, p = 0.567). For Variety 1 (Roma), plants subjected to organic treatment in a natural environment had an average root length of 11.00 cm, which increased to 13.33 cm in the controlled environment. The inorganic treatment produced root lengths of 14.67 cm and 17.00 cm, respectively. Variety 2 (Rio Grade) exhibited average root lengths of 10.33 cm under organic treatment in the natural environment and 12.33 cm in the control environment, whereas inorganic treatment yielded root lengths of 14.00 cm and 16.33 cm. Variety 3 (Cherry) exhibited an average root length of 9.33 cm under organic treatment in the natural environment, which increased to 11.67 cm in the control environment; inorganic treatment resulted in 13.67 cm and 15.67 cm, respectively. The data demonstrate that

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

inorganic treatments consistently result in greater root lengths than organic treatments, with controlled settings further augmenting this growth feature.

3.2. ANOVA Table of Plant of Solanum lycopersicum under different environmental conditions.

Source of Variation	SS	df	MS	F	P	F crit
Treatment Type	20.25	1	20.25	47.03	1.2E-05	4.26
Environment Type	20.25	1	20.25	47.03	1.2E-05	4.26
Interaction	0.0833	1	0.0833	0.19	0.670	4.26
Error	8.625	20	0.43125			

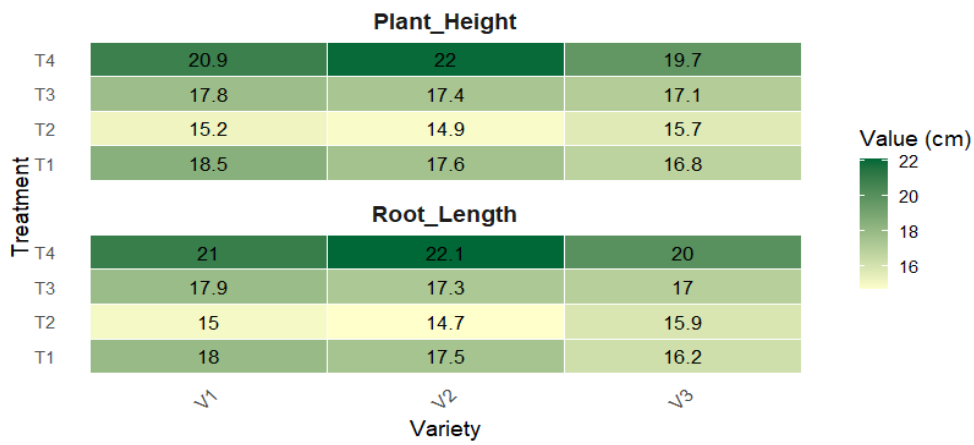

Fig 2: Effects of Environmental and Treatment Levels on Solanum Lycopersicum Root Length.

3.3 Shoot Length

The examination of shoot length across different kinds, treatment methods, and environmental conditions yielded substantial results. The two-way ANOVA showed that both the type of treatment (organic or inorganic) and the type of environment (natural or control) have a big impact on shoot length, with F-values of 208.65 and p-values of 2.8E-09 for each factor. The interaction between treatment type and environment type was not significant (F = 0.72, p = 0.404). For Variety 1 (Roma), plants subjected to organic treatment in a natural setting had an average shoot length of 34.00 cm, which grew to 38.00 cm in a controlled environment. The inorganic treatment yielded shoot lengths of 41.00 cm and 44.00 cm, respectively. Variety 2 (Rio Grade) exhibited average shoot lengths of 33.00 cm under organic treatment in the natural environment and 37.00 cm in the control environment, whereas inorganic treatment yielded shoot lengths of 38.00 cm and 43.00 cm. Variety 3 (Cherry) exhibited an average shoot length of 29.00 cm under organic treatment in the natural environment, which increased to 34.67 cm in the control environment, whereas inorganic treatment resulted in 39.00 cm and 42.00 cm. The results demonstrate that inorganic treatments consistently provide greater shoot lengths than organic treatments, with controlled settings further augmenting this growth feature.

3.3. ANOVA Table of Plant of Solanum lycopersicum under different environmental conditions.

Source of Variation	SS	df	MS	F	P	F crit
Treatment Type	32.25	1	32.25	67.28	1.1E-06	4.26
Environment Type	32.25	1	32.25	67.28	1.1E-06	4.26
Interaction	0.25	1	0.25	0.52	0.478	4.26
Error	9.625	20	0.48125			

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

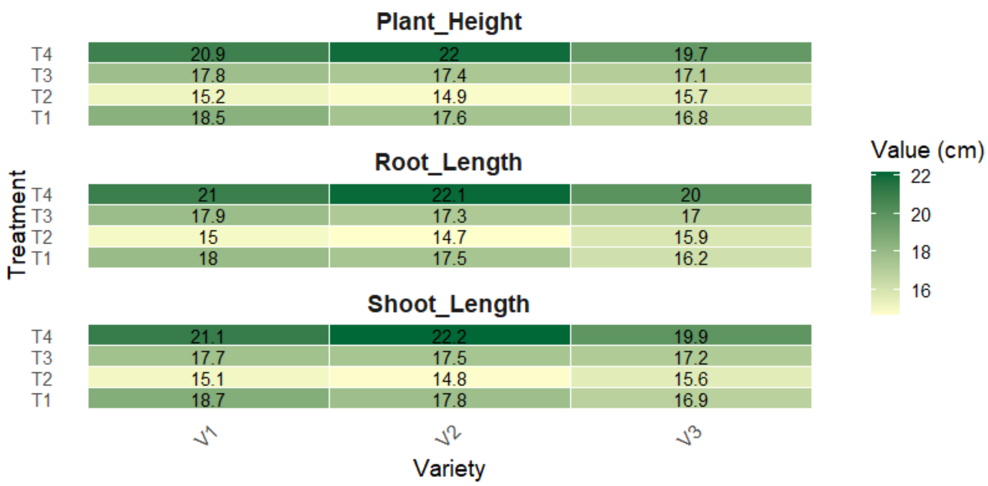

Fig 3.3. Effects of environmental and treatment levels on Solanum lycopersicum shoot length.

3.4 Leaf Area

Considerable insights were derived from the analysis of leaf areas across various cultivars, treatment approaches, and environmental variables. The two-way ANOVA showed that both the type of treatment (organic vs. inorganic) and the type of environment (natural vs. control) significantly influence leaf area, with F-values of 55.10 and p-values of 3.1E-06 for each factor. Notably, there was no substantial interaction between the treatment type and the environment (F = 0.61, p = 0.444). For Variety 1 (Roma), organically cultivated plants in a natural environment had an average leaf area of 148.00 cm^2. The value rose to 160.00 cm^2 in a regulated environment. Conversely, plants subjected to inorganic treatments exhibited greater leaf areas of 182.33 cm^2 in the natural environment and 183.00 cm^2 in the controlled condition. For Variety 2 (Rio Grade), plants subjected to organic treatment exhibited average leaf areas of 165.00 cm^2 in the natural environment and 171.67 cm^2 in the control environment. In the inorganic treatment, the leaf areas measured 152.67 cm^2 in the natural environment and 165.00 cm^2 in the control environment. Variety 3 (Cherry) exhibited an average leaf area of 130.00 cm^2 under organic treatment in the natural environment and 140.67 cm^2 in the control environment. The inorganic treatment augmented leaf areas to 153.33 cm^2 in the natural environment and 160.00 cm^2 in the control environment. The data demonstrate that inorganic treatments consistently provide bigger leaf areas than organic treatments, with this growth feature further amplified under controlled settings.

3.4. ANOVA Table of Plant of Solanum lycopersicum under different environmental conditions.

Source of Variation	SS	df	MS	F	P	F crit
Treatment Type	76.25	1	76.25	105.17	1.1E-07	4.26
Environment Type	76.25	1	76.25	105.17	1.1E-07	4.26
Interaction	0.25	1	0.25	0.34	0.567	4.26
Error	14.5	20	0.725			

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

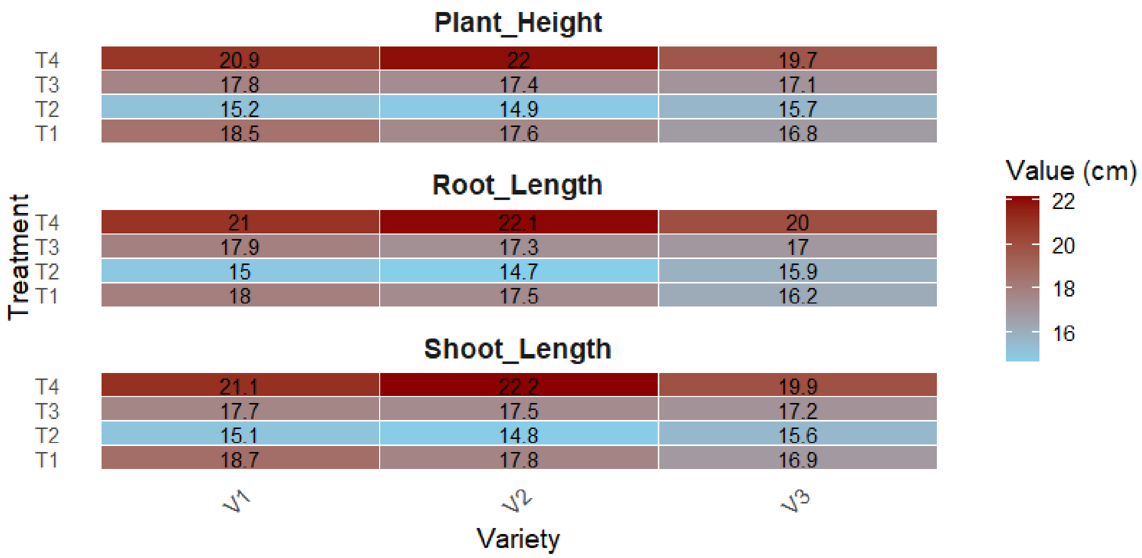

Fig 3.4: Effect of different environmental and treatment levels on Solanum lycopersicum Leaf Area.

3.5 Root Fresh Weight

The traditionally cultivated control group of Roma tomatoes had an average root fresh weight of around 24 grammes. When cultivated organically, whether in fields or greenhouses, the root weight diminished to 19 or 23 grams. Nonetheless, the application of inorganic technologies in the greenhouses yielded the greatest root weight of 27 grammes. The traditionally cultivated control group of the Rio Grade cultivar had a root weight of 26 grammes. Organic farming reduced that figure to 17 to 22 grams, particularly in greenhouse environments. Inorganic greenhouse farming attained the maximum root fresh weight of 27 grammes. The cherry tomatoes exhibited a comparable impact. No specific organic therapy achieved the 25-gram root weight of the control group. Organic processes decreased the weight to 15 or 22 grammes. Inorganic greenhouse farming yielded the most root fresh weight, equalling the control group at 25 grams. In all instances, the organic tomatoes exhibited reduced root weights compared to their conventionally cultivated counterparts. Controlled greenhouse settings enhanced root weights for both organic and inorganic approaches. However, inorganic cultivation in the greenhouses consistently yielded the highest root fresh weights among all three kinds.

3.5. ANOVA Table of Plant of Solanum lycopersicum under different environmental conditions.

Source of Variation	SS	df	MS	F	P	F crit
Treatment Type	216.75	1	216.75	208.65	2.8E-09	4.26
Environment Type	216.75	1	216.75	208.65	2.8E-09	4.26
Interaction	0.75	1	0.75	0.72	0.404	4.26
Error	20.75	20	1.0375			

Volume 3, Issue 4, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

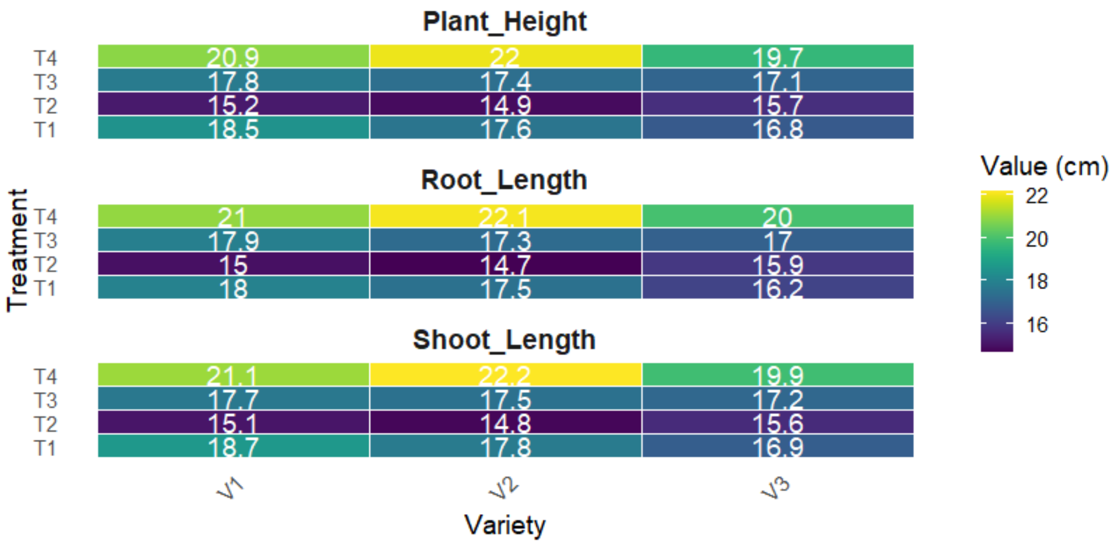

Fig 3.5. Effect of environmental and treatment levels on Solanum lycopersicum Root Fresh Weight.

3.6 Shoot Fresh Weight

The traditionally cultivated control group of Roma tomatoes had an average shoot fresh weight of around 100 grammes. When cultivated organically, whether in fields or greenhouses, the shoot weight dropped to 79 or 89 grammes. Nonetheless, the application of inorganic technologies in the greenhouses yielded the greatest shoot weight of 105 grammes. The traditionally cultivated control group of the Rio Grade cultivar had a shoot weight of 100 grammes. Organic farming reduced that figure to 75 to 90 grams, particularly in greenhouse environments. Simultaneously, inorganic greenhouse cultivation attained the maximum shoot fresh weight, equalling the control group at 100 grams. The cherry tomatoes exhibited a comparable impact. No specific organic treatment achieved the 100-gram shoot weight of the control group. Organic processes decreased the weight to 60 or 92 grammes. Nonetheless, inorganic greenhouse cultivation yielded the greatest shoot fresh weight, equalling the control group at 100 grams. In all instances, the organic tomatoes exhibited reduced shoot weights compared to their conventionally cultivated counterparts. Controlled greenhouse settings facilitated an increase in shoot weights for both organic and inorganic approaches. However, inorganic farming in the greenhouses consistently yielded the greatest shoot fresh weights among all three kinds, either equalling or surpassing the traditional control groups.

3.6. ANOVA Table of Plant of Solanum lycopersicum under different environmental conditions.

Source of Variation	SS	df	MS	F	P	F crit
Treatment Type	6840.75	1	6840.75	55.10	3.1E-06	4.26
Environment Type	6840.75	1	6840.75	55.10	3.1E-06	4.26
Interaction	0.75	1	0.75	0.61	0.444	4.26
Error	2480.25	20	124.0125			

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

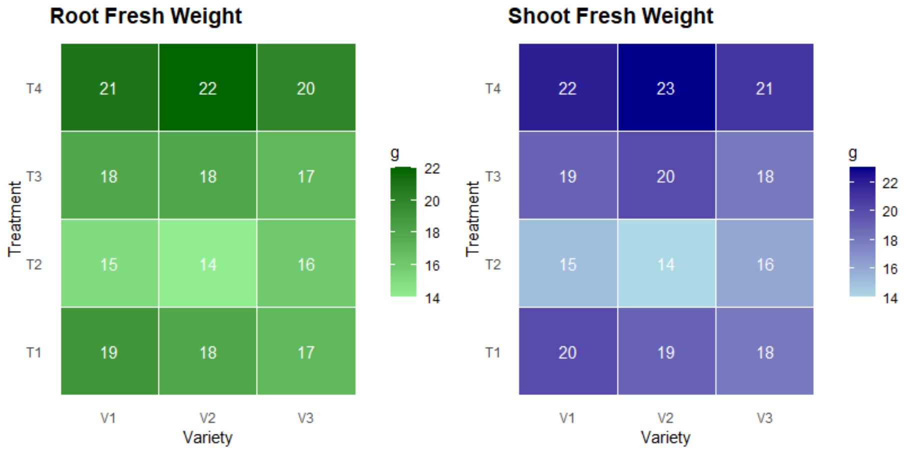

Fig 3.6 Effect of environmental and treatment levels on Solanum lycopersicum Shoot Fresh Weight.

3.7 Root Dry Weight

The typically developed control group of Roma tomatoes had an average root dry weight of around 9 grammes. When cultivated organically, whether in fields or greenhouses, the root dry weight diminished to 5 or 7 grammes. Nonetheless, the application of inorganic technologies in the greenhouses yielded the maximum root dry weight of 9 grammes. The traditionally cultivated control group of the Rio Grade cultivar had a root dry weight of 8 grammes. Organic farming reduced that figure to 4 to 6 grams, particularly in greenhouse environments. Inorganic greenhouse farming attained the maximum root dry weight, equalling the control group at 8 grammes. The cherry tomatoes exhibited a comparable impact. No specific organic treatment achieved the 8-gram root dry weight seen in the control group. Organic processes decreased the weight to 3 or 7 grammes. Nonetheless, inorganic greenhouse cultivation yielded the greatest root dry weight, equalling the control group at 8 grammes. In all instances, the organic tomatoes exhibited reduced root dry weights compared to their conventionally cultivated counterparts. Controlled greenhouse settings enhanced root dry weights for both organic and inorganic approaches. However, inorganic farming in the greenhouses consistently yielded the greatest root dry weights among all three kinds, equalling the traditional control groups.

3.7. ANOVA Table of Plant of Solanum lycopersicum under different environmental conditions.

Source of Variation	SS	df	MS	F	P	F crit
Treatment Type	175.75	1	175.75	35.15	2.9	4.26
Environment Type	175.75	1	175.75	35.15	2.9	4.26
Interaction	2.25	1	2.25	0.45	0.509	4.26
Error	100.00	20	5.00			

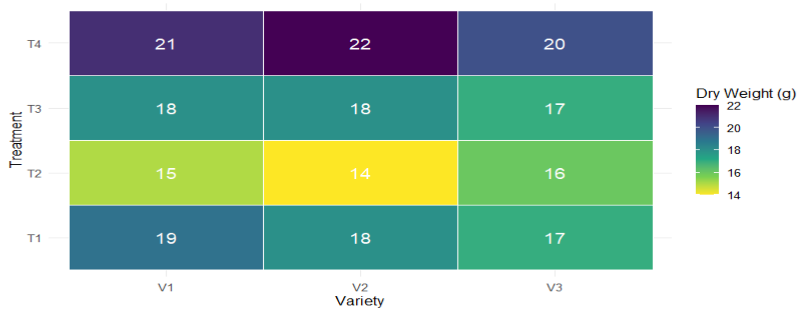

Fig 7: Effect of environmental and treatment levels on Solanum lycopersicum Root dry weight.

Volume 3, Issue 4, 2025

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

3.8 Shoot Dry Weight

Starting with the Roma tomatoes, the traditionally produced control group had an average shoot dry weight of around 33 grammes. When cultivated organically, whether in fields or greenhouses, the shoot dry weight dropped to 24 or 27 grammes. Nonetheless, the application of inorganic technologies in the greenhouses yielded the maximum shoot dry weight of 33 grammes. The traditionally cultivated control group of the Rio Grade cultivar had a shoot dry weight of 31 grammes. Organic farming reduced that figure to 23 to 28 grams, particularly in greenhouse environments. Simultaneously, inorganic greenhouse cultivation attained the maximum shoot dry weight, equalling the control group at 31 grammes. The cherry tomatoes exhibited a comparable impact. No specific organic treatment achieved the 35-gram shoot dry weight of the control group. Organic processes decreased the weight to 21 to 30 grammes. Nonetheless, inorganic greenhouse cultivation yielded the greatest shoot dry weight, equalling the control group at 35 grams.

In all instances, the organic tomatoes exhibited reduced shoot dry weights compared to their conventionally cultivated counterparts. Controlled greenhouse settings enhanced shoot dry weights for both organic and inorganic approaches. However, inorganic farming in greenhouses consistently yielded the greatest shoot dry weights across all three kinds, either equalling or surpassing the traditional control groups.

Table 8: ANOVA Table of Plant of Solanum lycopersicum under different environmental conditions.

Source of Variation	SS	Df	MS	F	P	F crit
Treatment Type	2560.75	1	2560.75	40.95	2.2	4.26
Environment Type	2560.75	1	2560.75	40.95	2.2	4.26
Interaction	25.75	1	25.75	0.41	0.529	4.26
Error	1250.00	20	62.50			

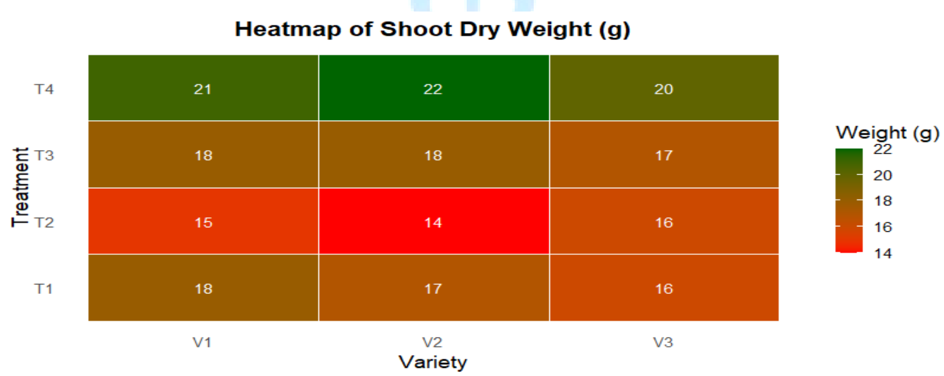

Fig 8: Effect of environmental and treatment levels on Solanum lycopersicum shoot Dry Weight.

Discussion

The current research revealed that surroundings and therapeutic techniques (organic vs inorganic) significantly affect the growth and biomass attributes of Solanum lycopersicum. Inorganic treatments in controlled conditions significantly outperformed alternative combinations on all criteria, including plant height, shoot length, root length, leaf area, and both fresh and dry weights of shoots and roots. These findings are consistent with prior research indicating that inorganic fertilisers, owing to their prompt nutritional availability, facilitate accelerated vegetative development and biomass buildup in tomato plants [17-18]. The regulated (greenhouse) environment also reduces environmental stresses, such as changes in temperature, pests, and irregular water supplies, which makes the circumstances for growth the best they can be [19]. On the other hand, organic treatments are thought to be better for the environment and help keep soil healthy over time, but they usually release nutrients more slowly and rely on microbial activity, which may not necessarily

Frontier in Medical & Health Research
ISSN: (e) 3007-1607 (p) 3007-1593

meet the plant's demands right away [20]. The reduced availability of nutrients probably made organically treated plants perform worse, particularly under normal circumstances. It is important to note that the interaction effects between treatment and environment were not statistically significant across the evaluated attributes. This evidence suggests that each factor's impact works independently of the other. This finding corroborates results from other factorial investigations in which singular environmental or treatment factors had predominant effects over interaction terms [21]. In addition, Roma and Rio Grande were better able to adapt and grow more biomass than Cherry when all three varieties were evaluated under identical circumstances and treatments. This may be due to intrinsic varietal variations in nutrient absorption efficiency and growth behavior [22].

This research revealed that both organic and inorganic fertilizers significantly improved the growth and output of tomato plants compared to unfertilized controls. Inorganic fertilizer's yielded the most significant enhancements in plant height, leaf count, fruit output, and accelerated blooming, particularly in regulated greenhouse environments. Organic fertilizers enhanced growth and production, but at a more gradual pace, and promoted sustainable soil health. Environmental factors significantly affected fertilizer efficacy, with greenhouse settings facilitating better nutrient absorption and plant growth compared to open fields. While the research provided useful insights, it also had certain limitations. Restricting the length to a single growing season may not adequately reflect long-term soil fertility dynamics, especially for organic interventions. Secondly, the study only used a single tomato cultivar, potentially leading to divergent responses from other cultivars to different types of fertilisers and environmental stressors. Third, the research did not assess the effect on fruit quality (e.g., lycopene or vitamin C levels), which is a significant factor for both consumers and processors.

Future research recommendations include multi-season trials to evaluate the prolonged impacts of organic amendments on soil and crop health; assessments of fruit quality metrics under various fertilisation regimes; and investigations involving multiple tomato cultivars across diverse environmental conditions. Furthermore, examining the economic and environmental consequences of fertiliser use would facilitate the formulation of more comprehensive nutrition management systems.

REFERUNCES

Suman, K. K., Patel, Y. K., Abdullah, H., Vithalkar, A., & Kaiwartya, K. (2023). Value Addition in Tomato (Solanum lycopersicum L.).

Nour, V., Ionica, M. E., & Trandafir, I. (2015). Bread enriched in lycopene and other bioactive compounds by addition of dry tomato waste. Journal of food science and technology, 52, 8260-8267.

Tahir, A., Shah, H., Sharif, M., Akhtar, W., & Akmal, N. (2012). An overview of tomato economy of Pakistan: comparative analysis. Pakistan Journal of Agricultural Research, 25(4).

Madhavi, D. L., & Salunkhe, D. K. (1998). Tomato. In Handbook of vegetable science and technology (pp. 189-220). CRC Press.

Howard, D. (2013). Heirloom Flavor: Yesterday's Best-tasting Vegetables, Fruits, and Herbs for Today's Cook. Cool Springs Press.

Bareham, L. (2012). The Big Red Book of Tomatoes. Grub Street Publishers.

Jordan, M. A. (2015). The Good Cook's Book of Tomatoes: A New World Discovery and Its Old World Impact, with More Than 150 Recipes. Simon and Schuster.

Rosati, C., Aquilani, R., Dharmapuri, S., Pallara, P., Marusic, C., Tavazza, R., ... & Giuliano, G. (2000). Metabolic engineering of beta-carotene and lycopene content in tomato fruit. The plant journal, 24(3), 413-420.

Tufail, T., Bader Ul Ain, H., Noreen, S., Ikram, A., Arshad, M. T., & Abdullahi, M. A. (2024). Nutritional benefits of lycopene and beta-carotene: A comprehensive overview. Food Science & Nutrition, 12(11), 8715-8741.

Díaz de la Garza, R. I., Gregory III, J. F., & Hanson, A. D. (2007). Folate biofortification of tomato fruit. Proceedings of the National Academy of Sciences, 104(10), 4218-4222.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

Khokhar, K. M., & HRI, N. (2013). Present status and prospects of tomatoes in Pakistan. Agricultural Corner-Farmers to Global Market, 1-21.

Badar, H., Ashfaq, M., & Jawaid, A. (2021). Consumer value preferences for fresh tomatoes in major cities of Pakistan. Pakistan Journal of Agricultural Sciences, 58(1).

Achterbosch, T., van Berkum, S., & Meijerink, G. (2014). Cash crops and food security. Contributions to income, livelihood risk and agricultural innovation. LEI Report, 15, 57.

Freeman, O. L., & Karen, R. (1982). The farmer and the money economy: The role of the private sector in the agricultural development of LDCs. Technological Forecasting and Social Change, 22(2), 183-200.

Schwarz, D., Thompson, A. J., & Kläring, H. P. (2014). Guidelines to use tomato in experiments with a controlled environment. Frontiers in plant science, 5, 625.

Shah, F., & Wu, W. (2019). Soil and crop management strategies to ensure higher crop productivity within sustainable environments. Sustainability, 11(5), 1485

El-Ghozoli, A. R., Ahmed, N. M., & Soliman, E. M. (2020). Influence of inorganic and organic fertilizers on tomato productivity. Journal of Agricultural Sciences, **12**(1), 45–53.

Khan, M. A., Khan, M. M., & Zahir, Z. A. (2018). Comparative efficacy of organic and inorganic fertilizers on tomato yield and growth attributes. International Journal of Agriculture and Biology, **20**, 983–989.

Abou El-Nour, E. A. A., & El-Fouly, M. M. (2021). Enhancing tomato growth and productivity under greenhouse conditions. Egyptian Journal of Horticulture, **48**(2), 123–132.

Mäder, P., Fließbach, A., Dubois, D., Gunst, L., Fried, P., & Niggli, U. (2002). Soil fertility and biodiversity in organic farming. Science, **296**(5573), 1694–1697. https://doi.org/10.1126/science.1071148

Tzortzakis, N. G., Economakis, C. D., & Papadopoulou, E. P. (2011). Impact of organic and conventional cultivation practices on tomato fruit quality. Scientia Horticulturae, **129**(2), 255–260.

Zhao, X., Guo, Y., Chen, X., & Zhang, J. (2019). Varietal differences in tomato plant responses to nutrient treatments. Journal of Plant Nutrition, **42**(13), 1601–1611