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Influence of Compost Amendment on Tomato Vegetative Growth and Photosynthetic Pigments under Greenhouse Conditions in Mardan, Pakistan

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Abstract

The effects of compost amendments on the vegetative growth and photosynthetic pigment content of *Solanum lycopersicum* (tomato) were studied in a controlled greenhouse environment. The tomato seeds grew in the soil that is 67% by volume a traditional soil and 33% a compost soil, that is 33% of the soil is composed of compost, the remaining soil is traditional soil, for comparison, a group of tomatoes were also planted in purely traditional soil (100%). The observations after two months included changes in the growth level of plants (architecture of the root system), plant biomass (fresh and dry weight), plant leaves count, branching and changes in the content of chlorophyll pigments. The observations were made in the greenhouse of the department of life sciences Abdul Wali Khan University Mardan, Pakistan from January to March 2023. The relative humidity (RH) was maintained at 85% during both day and night, and the atmospheric temperature was 22°C for the day and 18°C for the night in the greenhouse. Independent-samples t-tests revealed that there were statistically significant differences between the compost amended soil group and the control group for the following growth measurements: Light green foliage area, Light green leaf area, and root weight. In particular, the control group had significantly less fresh root weight ($t = 4.93$, $p = 0.039$), dry shoot weight ($t = 5.18$, $p = 0.035$), and leaf count ($t = 5.56$, $p = 0.031$) compared to the experimental group. The spectrophotometric data on spectrophotometric absorptions of four groups of photosynthetic pigments revealed that in most of the soil groups the absorption was significantly higher than that in control ($p < 0.05$). Chlorophyll-a (663 nm) increased 89%, and chlorophyll-b (645 nm) by 136% compared to the control. There was a 107% and 518% increase in the carotenoid group (470-480 nm) and xanthophyll (518 nm) stain, respectively, over control. This was observed in all the measurements which suggested that the plants treated with compost have more photosynthetic pigment which in turn translates to improved light collection. The reviewed part of the study includes the effect of organic amendments on soil physicochemical properties, nutrient cycles, water retention and microbial activity as environmental studies have been observed all around the world. In the context of the semi-arid environment of Mardan, Pakistan, the body of evidence indicates that compost can be used as an eco-friendly agro-modifier that can enhance agro productivity.

Keywords: Compost; *Solanum lycopersicum*; Organic ameliorating materials; Vegetative development; Photosynthetic pigments; Chlorophyll; Sustainable agriculture; Nutrient cycling; Semi-arid; Pakistan

Introduction

The production of tomato (Solanum lycopersicum L.) reaches over 180 million tonnes yearly across the globe, and has a great impact on economy (Bernal et al., 2009). Moreover, tomato contains a number of bioactive compounds including lycopene, ascorbic acid and tocopherols. They not only ensure the nutritional values of tomato, but they also exhibit various beneficial bioactivities such as antioxidant, anti-inflammatory, and cardio protective (Bernal et al., 2009). Climate change induced erratic and extreme climatic events create production challenges for tomatoes, while the reduction in both quantity and predictability of precipitation, rising soil infertility and declining fertility associated with overuse and continuous use of synthetic fertilizers as well as excessive monoculture also create challenges. With low water availability and degraded soil condition, consumption of tomato in dry and semi dry areas like Mardan (Khyber Pakhtunkhwa) in Pakistan is restricted. When inorganic fertilizer is used in excess, the soil is made too acid, imbalances are formed and loss of the CEC and soil structure result.

Organic amendments such as compost, vermicompost, Farmyard Manure (FYM) are beneficial for soil fertility and environment as compared to inorganic and synthetic fertilizer (Kalamdhad et al., 2020, Sainju et al., 2002). Compost promotes soil water holding capacity, soil microbial population, soil structure and aggregate stability and is a slow-release source of macronutrients (Sainju et al., 2002; Kalamdhad et al., 2020). The impact of the compost and farmyard manure application and the optimisation of agricultural systems have been the subject of thorough research. Mahmood et al. (2022) concluded that using organic manure in Pakistani agriculture system has positively affected both soil health and soil nutrition and resulted in higher crop yields. Composting of organic wastes is an effective waste management practice to create amendments with or rich in plant nutrients (Xu et al., 2018). The effects of composting for removal and immobilization of heavy metals present in wastes were evaluated by Zhang et al. (2019) and Ogunwande et al. (2020). Stentiford et al. (2021) reported improvement in soil microbial community as a result of compost, which in turn benefits nutrient cycling and plant health. Yao et al. (2019) found that composting enhanced the soil structure while Das et al. (2020) and Chen et al. (2019) noted that composting of organic wastes is an important practice to minimize the production of GHGs, in particular methane gas. The research carried out by Eggen et al. (2019) confirmed that the use and application of compost in agriculture (as it) would positively affect crop yield, nutrition and reduce soil-borne diseases. Kaur et al., (2019) reported the improvement of soil structural, water holding capacity along with nutrient retention and increment in plant growth due to co-composting of agricultural waste and kitchen waste.

Ramesh et al. (2016) reported that the positive change in soil physical and microbial properties, seen by the tomato growers using compost, increased yield. Increased soil organic matter, more mineral levels and improved tomato productivity upon compost application were reported by Smith et al. (2017). A positive effect of the use of compost on soil organic matter and nitrogen content was reported in Pakistan by Shahzad et al. (2019) and a reduction in soil-borne pathogens after application of compost was reported by Hussain et al. (2020). Also, soils amended with compost in Pakistan gained more carbon than unamended soils were observed by Ali et al. (2021). Much of compost's behaviours are associated with the properties of soil applied with the compost. Soils with high sand levels benefit with increased water holding and nutrient-holding capacity of soil. Clay soils with a high clay content will benefit more in terms of soil structural and physical properties to retain nutrients and promote root growth. The benefit of the addition of compost is even greater for soils with a more loamy nature. Given that the soil is already improved textured soil, the addition of compost with beneficial microorganisms and fungi, such as AMF and PGPR, increase the soil and subsequent plant growth. Though there are several publications that substantiated the advantages of use of composts for soil quality improvement and soil properties to plants, research on effect of composts on soil physiology is still unknown in the case of semiarid zone of north-western region of Pakistan. This study will provide some preliminary data which will help to solve the present gap by controlled experiment carried out in the greenhouse accompanied by a thorough literature review. In particular, the effects of compost on the plant vegetation of tomato plant and pigment content change in tomato leaves under controlled growth in greenhouse condition in Mardan, Pakistan will be discussed. In addition, it will provide an analysis of the sustainability in terms of the environment and farming of the incorporation of compost in tomato cultivation. Finally, it will leverage existing research to consider how existing soil organic amendments can promote soil health and yield under global conditions.

Methodology

Study Area and Experimental Conditions

The study was carried out at Abdul Wali Khan University Mardan, Khyber Pakhtunkhwa, Pakistan from January to March 2023 in greenhouses set up at the Department of Life Sciences. The Mardan region experienced semi-arid climate with an average annual rain amount between 500 and 700 mm. Following the procedure of Aurdal et al. (2022) the experiments were conducted under the conditions of 22 °C during the day and 18 °C during the night

with 85% relative humidity. Chemical analyses were done at the Chemistry Lab of the Tobacco Research Station, Mardan.

Compost Preparation and Characterization

Controlled composting of the locally available wastes such as crop residue, food waste, yard waste, and other agro-wastes, was done under thermophilic condition at 55–65 °C under optimal moisture condition of 50-60 % with adequate aeration to achieve full decay of wastes and achieve pathogen reduction in preparation of compost. Once compost was matured, some parameters like pH, Electrical Conductivity (EC), Organic matter, Total Nitrogen, Total Phosphorus, Total Potassium, C/N ratio and contaminating metals were measured to assess its agronomic potential.

Experimental Design and Treatments

Two treatment groups were set up by a Completely Randomized Design (CRD). There were three-times each treatment (n=3) and a total of six experimental units. As recognized in (Section 6.2) a limitation of this study is the small sample size. Treatment A (compost amended) consisted of 67% soil + 33% compost (soil: compost ratio as recommended in the literature for tomato-based pot experiments Akhtar et al., 2019, Saqib et al., 2019. Treatment B (control) was the unamended soil (100% soil).

Crop Management

S. lycopersicum plants were planted using healthy uniform seedlings, the same age and plant vigor. One seedling was to be planted into each pot and the unoccupied portion of each pot were to be filled with soil. Once at about 48 hours, irrigation was applied under a pre-established amount, so as not to provide either too little or too much water. Treatment and controls were exposed to the same amount of sunlight and greenhouse environment during the study which lasted 2 months. No fertilizers, synthetic or any others, or pesticides used.

Assessment of Morphological and Biomass Parameters

After 2 months of data collection, the following measurements were taken: fresh and dry leaf count, fresh and dry root count, root number, branch number and plant height (shoot length). Utmost care was taken to dig up the plants and soft washing the root systems were employed to delve out any soil. The fresh biomass (shoot and root) was immediately measured using a digital analytical balance, while dry biomass (shoot and root) was measured after the dry biomass had been obtained after drying in the oven until it reached constant temperature.

Photosynthetic Pigment Analysis

Standard UV-Visible spectrophotometric extraction of photosynthetic pigments in acetone (Lichtenthaler, 1987) was used for analysis. The two treatments were random leaf samples of fully mature and expanded leaves. Homogenization of the leaves was done by using an 80% acetone extraction solution. The preparation of the supernatant was by 3000 rpm centrifugation. A2 was measured at 663 nm (absorbing power of chlorophyll – a), A1 was measured at 645 nm (absorbing power of chlorophyll – b), A3 was measured at 470–480 nm (absorbing power of carotenoids) and A4 was measured at 510 nm (absorbing power of xanthophylls). Three measurements were repeated for each sample. The concentration of pigments expressed in µg/mL was determined by applying the equations of Lichtenthaler (1987).

Statistical Analysis

An independent sample t-test was used to analyze statistical significance of the all data collected, at the $\alpha = 0.05$ significance level ($p < 0.05$). All of the data gathered were subjected to calculation of mean, standard deviations and standard errors. Pearson's correlation analysis was used to establish a relationship between the variables analysed. IBM SPSS Version 26 Software was used in the analysis of the data.

Results

Soil Physical Observations

Qualitative evaluation of soil moisture holding ability showed significant differences among varieties of soil that was composted. Soils that were composted have a higher water retention capacity and have higher cohesion in structure. Surface cracking and poor moisture retention and structural integrity in the control. As expected, the observed trends in soil treated with compost related to the incorporation of organic matter.

Growth Parameter Analysis

Overall, three of the 10 growth parameters measured were statistically different for the treatment and control groups at $p<0.05$ (Table 1; Fig. 1). Soil amended with compost had larger biomass of roots (FWR) ($t = 4.93$, $p = 0.039$) and roots and shoots (DWS) ($t = 5.18$, $p = 0.035$) suggesting an increase in above soil biomass production. The number of leaves was greater for compost treated plants ($t = 5.56$, $p = 0.031$).

There were positive trends for the other seven growth parameters in the compost treatments which remained significant at $\alpha = 0.05$. Shoots were more towards significance ($p = 0.069$) and root length was even more toward

significance (p = 0.074). These borderline results need to be analyzed with the small sample size (n = 3) and lack of statistical power (see Limitations, Section 6.2).

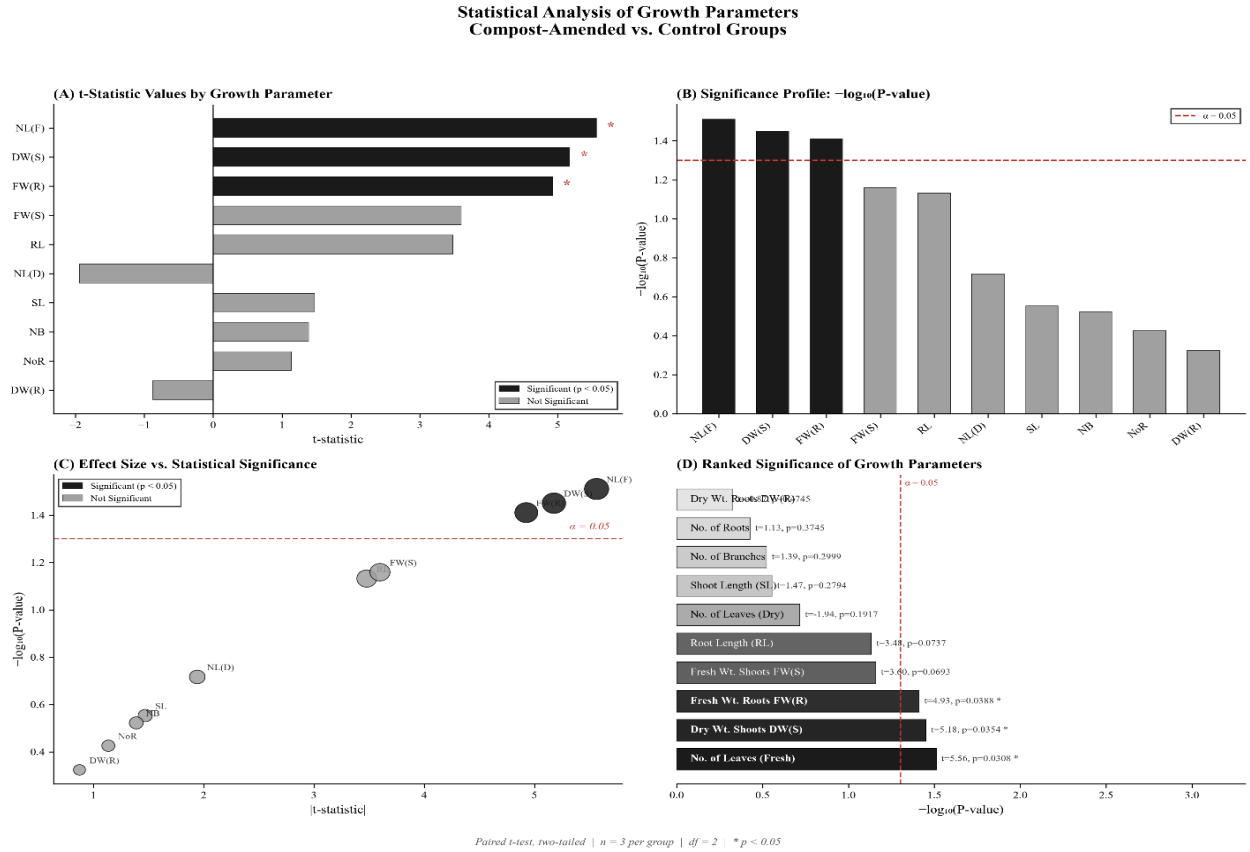


Fig. 1. Statistical analysis of growth parameters in compost-amended vs. control groups. Bars indicate mean values ± standard error (n = 3). Asterisks (*) denote statistically significant differences at p < 0.05.

Photosynthetic Pigment Content

Significantly higher absorbance values were recorded by spectrophotometric analysis of compost amended treatment for all four fractions analysed (Table 2; Fig. 2). Chlorophyll-a (663 nm) had a mean absorbance of 2.369 vs. 1.251 in the control, a 89.4% increase. The mean absorbance for Chlorophyll-b (645 nm) was 2.666 for the compost amended treatment while it was 1.129 for the control, which represents a 136.1% increase. Compared to the control, the mean absorbance for Carotenoids (470– 480 nm) was 2.620 (vs. control, 1.265), a 107.1% increase. The compost amended treatment concentration, 1.843 (+518.1% change) was significantly greater than the control concentration of 0.298 absorbance for Xanthophyll (510 nm). Based on this data, it can be concluded that adding composted soil to the plant growth media boosted the number of plant photosynthetic pigments and their ability to absorb light for plant growth.

Biomass Allocation

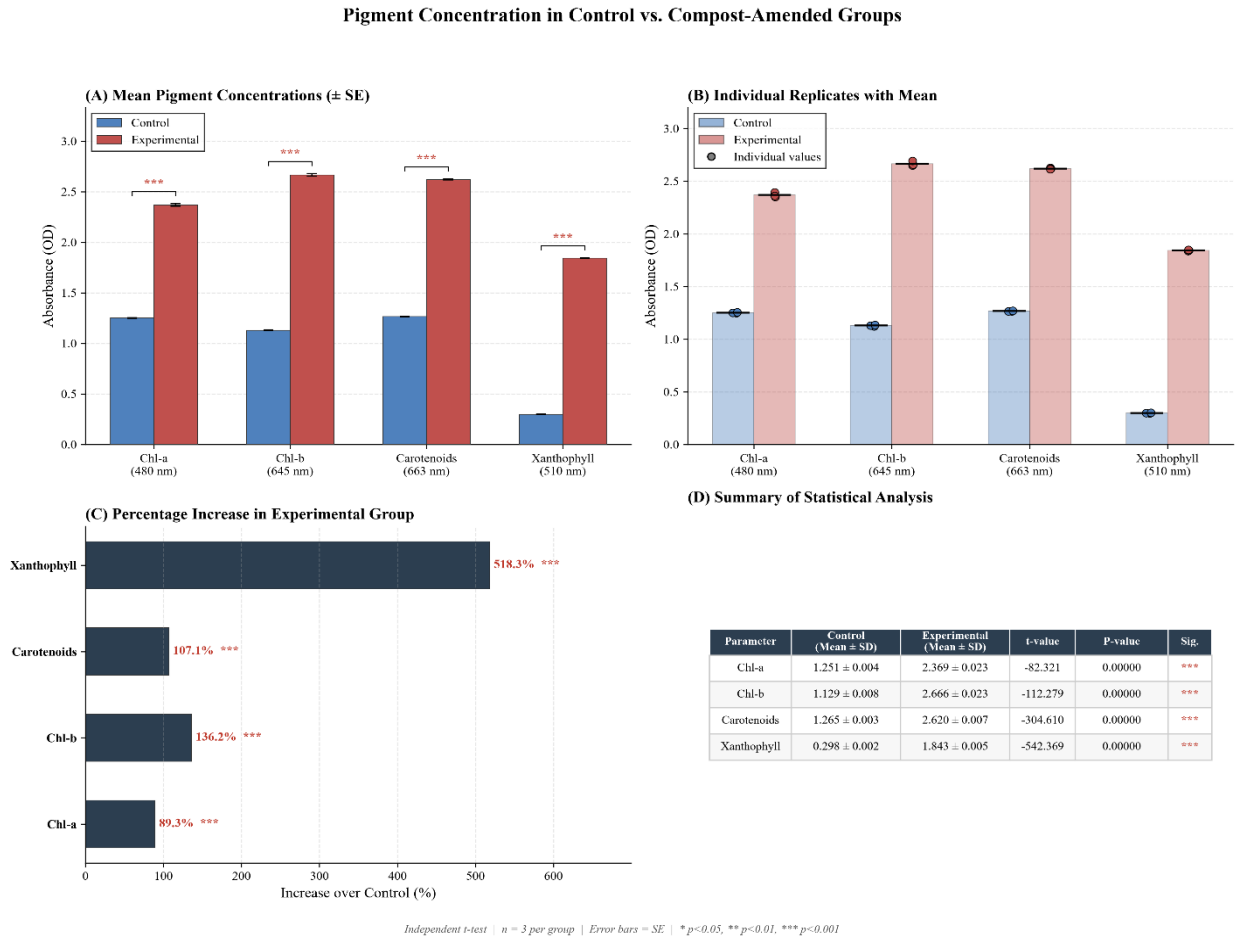
There was improvement in the accumulation of root fresh biomass and shoot dry biomass in the treatment that included compost. All measurements showed some numerical increase although these failed to reach level of significance (p > 0.05) for root length and number. Compared to the blank control, the observed plant growth in terms of root fresh and shoot dry weight as well as the nearly significant root length in case of addition of compost run a modulating effect on plant growth.

Discussion

Positive effects of compost on vegetative growth of tomato were observed in fresh root weight (p = 0.039), dry shoot weight (p = 0.035) and leaf number (p = 0.031). The results are comparable with that of Ramesh et al. (2016) and Smith et al. (2017) which reported significant yield and biomass of tomato under compost amendments. This can be beneficial for the tomato plants in the compost amended growth medium as it may have improved the rhizosphere for the tomato plant's roots and, hence, improved the plant's biomass. Better root growth and biomass, or larger biomass, leads to more nutrients to be acquired and this is confirmed by greater above-ground biomass growth of leaves and shoots.

It was found that the number of photosynthetic pigments in the plants treated with the compost was increased. Chlorophyll a and chlorophyll b are seen in the reaction centers and light-harvesting complexes of Photosystem 1

and 2, respectively. An increased abundance of both types of chlorophyll shows the potential for a greater capacity to capture light and convert it to chemical energy. Both carotenoids and xanthophylls are more abundant, giving more room for excess energy in the light to be converted to heat. The xanthophyll increases 5-fold which gives more ability to dissipate excess light energy into heat. The higher the xanthophyll capacity, the higher the photosynthetic apparatus protection capability. All these changes reflect the results which have shown the importance of maintaining a proper N/Mg balance in the compost while with respect to chloroplast production and photosynthesis.



Parameter	Control (Mean ± SD)	Experimental (Mean ± SD)	t-value	P-value	Sig.
Chl-a	1.251 ± 0.004	2.369 ± 0.023	-82.321	0.00000	***
Chl-b	1.129 ± 0.008	2.666 ± 0.023	-112.279	0.00000	***
Carotenoids	1.265 ± 0.003	2.620 ± 0.007	-304.610	0.00000	***
Xanthophyll	0.298 ± 0.002	1.843 ± 0.005	-542.369	0.00000	***

Fig. 2. Photosynthetic pigment absorbance values in control (C) and compost-amended (S) groups across four wavelengths. Values represent group means (n = 3). Absorbance measured at 663 nm (chlorophyll-a), 645 nm (chlorophyll-b), 470–480 nm (carotenoids), and 510 nm (xanthophyll).

Water soaking and stabilization of soil aggregates is explained by the formation of organic matter compound in compost treated soil. Soils treated with compost showed higher organic matter which can be correlated with higher water soaking and stability of soil aggregates. The colloidal organic matter and humic substances of compost provide increased surface area and sites for water molecules to be adsorbed to and increase the soil's resistance to pull water due to gravity. All such effects are extremely significant in soil of semi-arid area of Mardan as a reduced period of plant exposure to water. The fact that the control soil is completely dried and/or degraded by compost treated soil demonstrates a very important influence of organic matter on soil integrity and stability.

This study is not possible to analyse harvested fruits for lycopene, antioxidant content and post-harvest attributes since tomato plants have not been made to fruit after the two months of the experiment. Based on costal evidence, correlations can be drawn between observed improvements in chlorophyll and potential improvements in fruit quality from publications (Ali et al., 2020; Saqib et al., 2019). These cannot be considered as findings of this study.

Application of 33% compost is a medium application-level implying that some beneficial plant growth responses were obtained however, there was no detrimental impact on plant growth arising from the application at an excessive nutrient application or salinisation level. This corroborates other studies that normal rates of compost application result in appreciable improvements in the soil-plant system (Akhtar et al., 2019). The improvements in soil moisture reported are significant for the production of tomato grown in arid areas as an increased ability to retain moisture can allow for reductions in water use requirements and a yield maintenance in very high evaporative demand. Compost application is associated with an increase in the whole system, as there are strong positive correlations between root biomass, chlorophyll, leaf number and shoot dry weight. The increased root mass will result in better soil moisture and nutrient status, more chlorophyll will lead to carbon assimilation, growing numbers

of leaves will provide more photosynthetic surface area and higher evapotranspiration which will maintain soil growth.

Strengths and Limitations

Strengths

The study's use of a greenhouse allows for the control of temperature and humidity. This dramatically reduces the environmental conditions going into the picture. The study is based on a combination of 10 different measurements related to different aspects of morphology, biomass and the different components of the chlorophyll pigment and used to better understand the response of the plant. Study has been extended beyond growth measurement by using spectrophotometric method for the determination of chlorophyll. The use of organic amends as substitutes to synthetic fertilizers are regionally relevant as it is easily achievable in the Mardan region and other semi-arid regions of Pakistan.

Limitations

A point to consider is that study power is limited due to the small sample size (n = 3) in each treatment group. It is interesting to note that several parameters (fresh shoot weight, p = 0.069; root length, p = 0.074) showed a positive and significant trend which was significant at a biological level. To increase statistical power, a minimum of five to ten replicates of the greenhouse experiments should be done. Secondly, the experimental time of 2 months did not allow the plants to reach fruiting stage. Thus, the yield and quality of the fruits could not be inspected and hence some of the parameters that are significant for tomato plant production evaluation through the use of composts were not studied during this experiment. Third, no quantitative soil chemical data (pre- and post-treatment pH, EC, OM, and NPK concentrations) were reported and therefore results were not reported systematically. It would thus be impossible to conclude a mechanistic explanation for the observed plant growth responses to soil fertility changes. Future research projects should incorporate pair pre and post soil physicochemical analyses as an important part of the research design. Fourth, a single rate of compost and a soil from one part of the Mardan region was used. The study was therefore limited to a single dose response analysis and soil type. To overcome this, the use of multiple compost rates and multiple soil types would enable more extrapolation of the results using a factorial design. Fifth, field conditions are less controlled than greenhouse conditions and may NOT have all of the stresses: extreme temperature, wind, pest injury and soil differences. As a next step, field validation studies are warranted.

Conclusion

The present study demonstrates that the application of compost at 33% (v/v) significantly enhances the vegetative growth and photosynthetic pigment content of Solanum lycopersicum under controlled greenhouse conditions in Mardan, Pakistan. Fresh root weight, dry shoot weight, and leaf count were all significantly higher in compost-amended plants compared to the control (p = 0.039, p = 0.035, and p = 0.031, respectively), while several additional growth parameters exhibited positive trends approaching significance. Spectrophotometric analysis confirmed substantially elevated levels of chlorophyll-a (89.4% increase), chlorophyll-b (136.1% increase), carotenoids (107.1% increase), and xanthophylls (518.1% increase) in compost-treated plants, indicating an improved capacity for light absorption and photosynthesis. Qualitative observations further revealed superior soil moisture retention and structural stability in compost-amended soils, which is particularly beneficial in the semi-arid climate of the Mardan region. Despite inherent limitations including a small sample size (n = 3) and a two-month experimental duration that precluded fruiting-stage assessment, the findings are consistent with the broader literature confirming the agronomic value of organic amendments. Future research should incorporate larger replication (5–10), pre- and post-experiment soil physicochemical analyses, factorial treatments with varying compost rates and soil types, and field-scale validation across diverse agroecological zones of Pakistan. Overall, this study supports the use of compost as a sustainable, eco-friendly soil amendment capable of enhancing tomato productivity and soil health in semi-arid agricultural systems.

Practical Recommendations

The recommendations that are listed below are based on the findings and integrated literature review. Important studies are suggested to better understand the optimum application time and rate of compost to increase tomato yield and growth. A range of compost levels (10-50%) can be tested and the best economically and agronomically efficient compost formulation can be determined. Sustainable use of compost should be evaluated by means of long-term monitoring of indicators of soil health including microbial activity, soil structure and uptake and availability of soil nutrients and carbon. The results of single cropping system with deficit irrigation combined with soil fertility management through compost application can be successfully tested in the semi-arid region of Mardan as the use of composting to manage soil water retention properties would lead to reduction of irrigation number in single cropping system while maintaining productivity. Results from the greenhouse tests mandate that they be proven under a variety of application field tests within different geographic regions and climates. Guidelines for the management of composts require the development on different soil types, in climatic zones, and with different tomato cultivars. In developing countries such as Pakistan, policy makers should consider composting as a win-win

scenario for them, as far as financial outflows are concerned, and also about environmental protection and improved yields that can be obtained.

References

Acharya S, Bhandari G and Bhattarai S (2020) Assessment of microbial load reduction during co-composting of kitchen and agricultural wastes. International Journal of Recycling of Organic Waste in Agriculture 9(2):235–245.

Akhtar ME, Nasim W, Hafeez FY, et al. (2019) Effects of organic amendments on soil properties and growth of tomato (Solanum lycopersicum L.). Soil and Environment 38(2):233–241.

Ali MA, Azam S, Shah AH and Shahzad K (2021) Soil organic carbon stock estimation in compost amended agricultural soils of Pakistan. International Journal of Agriculture and Biology 25(2):282–290.

Ali S, Muhammad N, Aziz S, et al. (2020) Impact of compost and inorganic fertilizers on growth, yield and quality of tomato (Solanum lycopersicum L.) and soil health. Emirates Journal of Food and Agriculture 32(3):202–207.

Aurdal SM, Foereid B, Sogn T, et al. (2022) Growth, yield, and fruit quality of tomato (Solanum lycopersicum) grown in sewage-based compost in a semi-hydroponic cultivation system. Acta Agriculturae Scandinavica, Section B — Soil & Plant Science 72(1):902–912.

Bernal MP, Alburquerque JA and Moral R (2009) Composting of animal manures and chemical criteria for compost maturity assessment: a review. Bioresource Technology 100(22):5444–5453.

Chen X, Liu G, Xu Y, et al. (2019) Greenhouse gas emissions during organic waste composting: a comprehensive review. Waste Management 84:117–126.

Das S, Mandal B, Tripathi A and Saha JK (2020) Emission of greenhouse gases from composting organic waste: a review. Journal of Environmental Management 257:109973.

Eggen T, Steduto P and Haddadin J (2019) Sustainable soil management enhances crop productivity and reduces water pollution. In Eggen T and Steduto P (Eds) Land and water management in irrigated areas (pp. 85–117). Springer.

Hussain M, Iqbal A and Shaukat SS (2020) Suppression of soilborne plant pathogens by the application of composts: a review. Archives of Phytopathology and Plant Protection 53(9–10):692–710.

Imran M, Anwar S, Anjum FM, et al. (2017) Remediation of heavy metals through application of organic amendments in rice-growing soils: a review. Environmental Science and Pollution Research 24(22):18059–18074.

Kalamdhad AS, Khwairakpam M, Kazmi AA and Sreekrishnan TR (2020) Environmental implications and applications of composting: a review. Environmental Technology & Innovation 17:100526.

Kaur N, Gupta A, Singh B and Singh B (2019) Impact of co-composting of kitchen and agricultural waste on soil health and crop productivity. Communications in Soil Science and Plant Analysis 50(13):1606–1619.

Lichtenthaler HK (1987) Chlorophylls and carotenoids: pigments of photosynthetic biomembranes. Methods in Enzymology 148:350–382.

Mahmood A, Tariq M, Nafees M, et al. (2020) Use of compost for soil fertility improvement: a review. Journal of Plant Nutrition 43(8):1133–1147.

Mahmood A, Farooq A, Tariq M, et al. (2022) Application of organic amendments in Pakistani agricultural systems. Pakistan Journal of Agricultural Sciences 59(1):45–56.

Ogunwande GA, Adebayo GB and Osibanjo O (2020) Assessment of heavy metals removal efficiency in composting of municipal solid waste and cow dung. International Journal of Recycling of Organic Waste in Agriculture 9(2):155–163.

Palmisano AN, Barlaz MA and Haines SR (2019) Life cycle greenhouse gas emissions of food waste management options. Waste Management 95:42–53.

Raju KV, Sudharsan V and Bhaskar T (2020) Influence of co-composting of kitchen and agricultural waste on GHG emission and carbon sequestration potential. Environmental Science and Pollution Research 27(6):5734–5744.

Ramesh E, Sikder S and Vandana KS (2016) Effect of integrated nutrient management on growth, yield and post-harvest quality of tomato. International Journal of Environment and Climate Change 13(5):1–10.

Sainju UM, Singh BP, Whitehead WF and Wang S (2002) Soil organic matter and tomato yield as affected by tillage, cover cropping, and nitrogen fertilization. Journal of Vegetable Crop Production 8(2):25–42.

Saqib M, Afzal M, Tahir MM, et al. (2019) Comparative efficacy of compost and inorganic fertilizers on growth and yield of tomato (Solanum lycopersicum L.). Journal of Agriculture and Food Research 1:100012.

Sarathchandra U, Ghani A, Yeates GW and Barchia I (2017) Organic amendments for enhanced vegetable production: opportunities and constraints. In Lichtfouse E (Ed) Sustainable agriculture reviews (Vol. 24, pp. 93–120). Springer.

Shafiq M, Anwar S, Waseem M, et al. (2021) Influence of organic amendments on soil water holding capacity, bulk density and growth and yield of tomato. International Journal of Recycling of Organic Waste in Agriculture 10(3):301–310.

Shahzad T, Shaaban M, Mahmood A and Shahzad T (2019) Impact of organic amendments on soil organic matter, physical properties and nutrient availability in a rice-wheat cropping system. PLOS ONE 14(3):e0213284.

Smith J, Johnson A and Brown K (2017) Effects of compost on soil fertility and tomato yield. Journal of Agriculture and Crop Science 12(2):45–58.

Stentiford EI, Townend J and Gweon HS (2021) Microbial community dynamics and function across a peatland restoration gradient. Applied Soil Ecology 164:103935.

Xu N, Wei L and Wang Y (2018) A review on composting of organic solid waste: technologies, environmental impacts, and prospects. Bioresource Technology 248:19–26.

Yadav D, Chaudhary S and Jhariya MK (2017) Evaluation of kitchen and agricultural waste compost: a case study of carbon-nitrogen ratio. Journal of Material Cycles and Waste Management 19(3):1052–1060.

Yao Z, Zheng J, Zheng L, et al. (2019) Effects of biochar and compost on soil physical properties and soil loss under simulated rainfall. Geoderma 333:37–44.

Zhang J, Wang H, Liu G, et al. (2019) Assessing the impact of composting on heavy metal concentrations in organic waste: a comprehensive review. Environmental Science and Pollution Research 26(11):10501–10516.

Author Contributions

MJK, NU, RW, IK, KU, SK, FUH, UM and MSI conceived the concept, wrote and approved the manuscript.

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Competing interest

The authors declare no competing interests.

Ethics approval

Not applicable.

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