EFFECT OF COWDUNG SLURRY ON GROWTH, YIELD AND QUALITY OF TOMATO IN HYDROPONIC SYSTEM

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CERTIFICATE

*This is to certify that thesis entitled, "**EFFECT OF COWDUNG SLURRY ON GROWTH, YIELD AND QUALITY OF TOMATO IN HYDROPONIC SYSTEM**" submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of bonafide research work carried out by **MD. Mamun Mia**. **Registration no. 19-10169** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

Dated:

Place: Dhaka, Bangladesh

Dr. Md. Jahedur Rahman

Professor

Supervisor

Dedicated to

My

Beloved Parents

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EFFECT OF COWDUNG SLURRY ON GROWTH, YIELD AND QUALITY OF TOMATO IN HYDROPONIC SYSTEM

ABSTRACT

A pot experiment was conducted at the Sher-e-Bangla Agricultural University, Dhaka-1207, to investigate the effect of cowdung slurry on growth, yield and quality of tomato in hydroponic system. The experiment consisted of two factors, and followed completely randomized design (CRD) with three replications. Factor A: Tomato variety denoted as V, *viz*: V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5, V_4 = Tomato line 1885, Factor B: Cowdung slurry denoted as C, *viz:* C_0 = 0 ml L^{-1} + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution. Experimental results revealed that in case of different varieties cultivating of BARI toamto-10 in hydroponic system (V_2) had the highest number of flower clusters plant^{-1} (16.67), fruits cluster plant^{-1} (6.75), fruits plant^{-1} (54.25), fruit polar length (3.68 cm), fruit radial length (3.47 cm), individual fruit fresh weight (67.42 g), fruit dry weight (3.76 g), yield plant^{-1} (3.66 kg), volume (190.00 cc) and pH value (4.50) while V_3 treatment contained the highest total soluble solids (6.58 %). In case of different levels of cowdung slurry application with standard nutrient solution differences the plant yield ranges between (2.26-2.75 kg plant^{-1}). The highest yield plant^{-1} (2.75 kg) was recorded in C_3 (200 ml L^{-1} cowdung slurry + standard solution) treated pot which was due to enhanced yield attributes like flower clusters plant^{-1} (15.33), fruits cluster plant^{-1} (6.09), fruits plant^{-1} (39.75), fruit polar length (3.68 cm), fruit radial length (3.35 cm), individual fruit fresh weight (69.12 g), fruit dry weight (3.71 g).Cultivating of BARI toamto-10 (V_2) along with (C_3) 200 ml L^{-1} cowdung slurry + standard solution treated pot performed best for achieving higher yield (4.02 kg) and quality of tomato, comparable to others treatment combinations in hydroponic culture.

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ABBREVIATIONS

Abbreviations	Full word
Agr.	Agriculture
AEZ	Agro-Ecological Zone
BBS	Bangladesh Bureau of Statistics
Biol.	Biology
Biotechnol.	Biotechnology
Bot.	Botany
Cv.	Cultivar
DW	Dry weight
Eds.	Editors
EC	Emulsifiable concentrate
Entomol.	Entomology
Environ.	Environments
FAO	Food and Agriculture Organization
FW	Fresh weight
Intl.	International
J.	Journal
LSD	Least Significant Difference
L	Liter
TSP	Triple super phosphate
Sci.	Science
SRDI	Soil Resource Development Institute
Technol.	Technology
Sl.	Serial

CHAPTER I

INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill.) belongs to the family Solanaceae and is normally a self-pollinated annual crop. Tomato is a universally known vegetable and is one of the widest grown vegetables in the world and ranked third in respect of vegetable production in the world next to potato and sweet potato (Yasmin *et al*., 2022). According to (FAO, 2022) 180.76 million tons of fresh and processed tomatoes were produced worldwide in 2021. Among the vegetables tomato is important for vitamin A, C and minerals (Collins *et al*., 2022). Nutritive elements are almost double compared to apple which proved superiority in regard to food values (Ibrahim *et al*., 2017). Due to its phytonutrients mainly antioxidant elements such as lycopene and β carotene, it prevents cancer and many human diseases (Islam *et al*., 2021). It occupies an area of 0.15 million hectares with annual production of about 0.45 million tons in Bangladesh (BBS, 2021). Although the total cultivated area and production of tomato in our country have been increased gradually over the last few years, the productivity is still very low (9.4 t/ha) compared to the average yield (26.29 t ha^{-1}) of the world (Mazed *et al*., 2015).

The use of improved varieties, proper management, high-quality seed, knowledge of improved production technologies like hydroponics, and even conventional breeding techniques, which may increase production level and quality under the current environmental conditions, are just a few of the factors that affect tomato production.

The cultivation of hybrid tomato varieties has grown significantly around the world and offers numerous benefits over open pollinated species. There are many tomato cultivars with great yield potential and extended harvest times that have been released by BARI and other seed companies (Yasmin *et al*., 2022).

Hydroponic is a modern technology in Bangladesh to cultivate leafy vegetables (Alam, 2022). Hydroponic tomato are grown in a nutrient solution rather than soil, although they are typically placed in a non soil material that can support their roots and hold the nutrients. Growing tomatoes hydroponically allows the grower to raise them in a controlled environment with less changes of disease, faster growth and greater fruit yield (Cardoso *et al*., 2018).

Nutrient solution is one of the most important factor for determining the yield and quality in hydroponic cultivation. However the price of hydroponic nutrient are relatively expensive for the community (Alexopoulos *et al*., 2021). Therefore, it required alternative nutrients for hydroponic by utilizing multiple sources of nutrients that are relatively economical.

One potential source of organic nutrients for soilless cultivation is organic wastes produced by livestock animals. The annual world production of nitrogen (N) fertilizer as livestock animal manure is 125 billion tons, but 70% of it is left on pastures and cannot be collected. The remaining amount of this potential N-fertilizer could theoretically supplement the yearly consumption of mineral N-fertilizers in the world (11 million tons) (FAOSTAT, 2019).

The main challenges that currently hinder the application of organic waste-based fertilizer in tomato greenhouse systems are difficulties that arise in providing the proper level and balance of nutrients, and dealing with the presence of phytotoxic organic compounds, heavy metals, and salts (Kechasov *et al*., 2021). The effects of phytotoxic stress factors can be alleviated in part by oxygenation (Chandra and Keshavkant, 2021). However, little is known regarding the effects of organic waste-based fertilizer on the development of tomato plants and quality of tomato fruits. In other crops, organic fertilization may increase root development, for example, citrus trees grown in soil (Martinez- Alcantara *et al*., 2016), maize seedlings (Jindo *et al*., 2012) and lettuce in hydroponic culture (Shinohara *et al*., 2011). Generally, tomato plants cultivated organically (e.g., in organic waste or manure) have comparable or slightly lower yields than plants cultivated with conventional fertilizer (Antonious *et al*., 2019). However, reductions in fruit size have often been reported (Zhang *et al*., 2016). This suggests that the choice of organic material may be important to ensure efficient tomato production. Hydroponic cultivation of tomatoes in greenhouses could utilize many sources of liquid organic waste by-products, such as compost, cow dung slurry, biogas effluent, soluble fish waste, or corn steep liquor (Bergstrand, 2022). The liquid effluent from anaerobic digestion (digestate) also has the potential for use as a fertilizer in hydroponic cultures (Bergstrand *et al*., 2020). During anaerobic digestion, nutritionally interdependent communities of bacteria and Archaea convert biomass into energy-rich biogas and nutrient-rich liquid digestates slurry in the absence of oxygen (Sarker *et al*., 2019). The resulting digestate slurry has a high concentration of ammonium (NH_4^+) and potassium (K+) ions and can be readily generated from locally collected household wastes or livestock manure. However high levels of ammonium may reduce calcium uptake, thereby inducing disorders like blossom-end rot and subsequent losses in production (Hagassou *et al*., 2019). The low concentration of some macro and micro elements in slurry can be corrected by adding fertilizers (Melo *et al*., 2019) to form a complete nutrient solution (Upendri and Karunarathna, 2021). Liquid manures such as cow dung slurry also act as a source of water that plants can take along with the nutrients in nutrient solutions within a hydroponic system, preventing these wastes from polluting natural lake and river channels (Alam and Chong, 2010). This system for managing liquid manures is conducive to, in areas where water resources are scare, producing foods in small areas of land (Montes *et al*., 2013) and also, with balanced nutrition, achieving greater water use efficiency and increased biomass production and crop yield. Although many different types of organic waste can potentially be used to grow tomatoes in soilless culture, the long-term effects of organic waste-based fertilizers on plant growth, development, and fruit quality have not been sufficiently investigated. By considering the above facts, this study aimed to investigate the following objectives-

i. To investigate the performance of different tomato cultivars grown on different concentration of organic nutrient solution.

ii. To develop a protocol for making cowdung slurry for use in hydroponic solution additive

iii. To identify the effect of cowdung slurry in tomato production.

CHAPTER II

REVIEW OF LITERATURE

In order to gather information useful for carrying out the current study, an effort was made to compile and research pertinent material about the investigation of the effect of cowdung slurry on growth, yield and quality of tomato in hydroponic system.

2.1 Effect of variety

Shah *et al*. (2021) carried out a study to know the performance of tomato cultivars transplanted on various dates under the agro-climatic conditions of district Buner and reported that among different cultivars Anna resulted in tallest plant (258.37 cm), more branches plant^{-1} (41.73), fruits plant^{-1} (80.58), fruit weight (133.43 g), fruit diameter (5.00 cm), yield (95.16 tons ha^{-1}), lowest fruit drop (4.87 %) and disease incidence (2.30 %).

Hoque *at el.* (2020) reported that the combination of organic and inorganic fertilizers has a substantial impact on tomato growth and yield. The results indicated that the variety BARI-2 (Ratan) showed superior performance than BARI-15 tomato varieties on different fertilizer combination regarding growth and yield of tomato.

Sanjida *et al*. (2020) conducted a field research to examine the effect of different levels of boron (B) on physico-chemical quality of different summer tomato (*Lycopersicon esculentum* Mill.). Experimental results showed that the longest fruit length (41.87 mm) and maximum fruit width (48.0 mm) were recorded from V_2 (BARI hybrid tomato 8) while the shortest fruit length (33.07 mm) and minimum fruit width (34.60 mm) were observed from V_3(BARI hybrid tomato 10) variety. The marked differences in fruit length and fruit width might be due to the different genetic makeup of the summer tomato varieties. Significant variations ($p<0.05$) were observed in case of total soluble solids (TSS) and pH content of summer tomato varieties. The highest TSS (5.41%) was found from V_2 (BARI hybrid tomato 8) which was statistically similar with V_3 (BARI hybrid tomato 10) (5.23%) while the lowest TSS (4.97%) was obtained from V_1 (BARI hybrid tomato 4). The highest (3.88) and lowest (3.71) pH were found from V_3 (BARI hybrid tomato 10) and V_1 (BARI hybrid tomato 4), respectively. Varietal character might influence the variations of TSS and pH in summer tomato.

Das *et al.* (2019) reported that height of a plant is determined by genetical character and under a given set of environment different variety will acquire their height according to their genetic makeup.

Prakash *et al.* (2019) performed an experiment with twenty six genotypes of tomato and revealed that the genotype TOINDVAR-3 (4.91) recorded highest mean performance for fruit yield per plant, while, genotype TOINDVAR-5 showed lowest fruit yield.

Devkota *et al.* (2018) studied hybrid genotypes of tomato for fruit yield and fruit quality traits and revealed that the hybrids HRA-14× HRD-7, HRA-13× HRD-7, HRA-20× HRD-1 and HRA-20× HRD-6 were high yielder and with good quality as compared to check variety Srijana.

Rojalin *et al.* (2018) conducted an experiment to evaluate performance of eighteen genotypes of tomato at Bhubaneshwar during rabi season of 2017-18. The overall performance on vegetative parameters of eighteen diverse determinate tomato genotypes indicated superiority of 2016/TODVAR-12 and Pusa 120 as compared to other tested genotypes.

Kerketta *et al.* (2018) studied performance of twenty diverse genotypes of tomato for growth, yield and quality traits at Allahabad during Rabi season of 2015-16. On the basis of present research study they concluded that the genotype Arka Abha (165.66cm) is the highest the plant height, days to first flower open (29.15) and flower per cluster (9.66), lycopene (4.23mg/100g), shelf life (5.66 days) in Kashi Sharad. The heighest fruit set per cluster (5.33), number of fruits per plant (87.50), fruit index (1.43), TSS (7.61^0Brix) in Pusa Cherry and the average weight of fruit (84.50g), fruit yield per plant (4 kg) in genotype Kashi Aman.

Kiran *et al.* (2018) investigated twenty two genotypes of tomato for yield and quality attributes at Horticultural Research Farm, IGKV, Raipur (CG) during 2016-17. On the basis of the investigation they revealed that genotype 2014/TOLCVRES-3 was recorded maximum values for the traits number of flowers per cluster, pericarp thickness, number of fruits per cluster and TSS. The variety H-86 recorded as a high yielding variety with 4.06 kg per plant fruit yield, 659.72 quintal per hectare total yield, 107.33 g average fruit weight and 6.00 percent dry matter of fruit.

Biswas *et al.* (2017) reported that the genotype C-41 produced the highest number of fruits (48.00 plant^{-1}) but its corresponding individual fruit weight was the lowest (34.33 g). The lowest number of fruits plant^{-1} was harvested from the line WP-10 (22.33 plant^{-1}), and it had the highest individual fruit weight (66.67 g). Significant variation was observed in weight of fruit plant^{-1}. The highest fruit yield plant^{-1} was recorded from the genotype HT-025 (2.02 kg plant^{-1}) and the lowest was recorded from the line FP-5 (1.17 kg plant^{-1}). The variation in different characters of tomato might be due to difference in cultivars used.

Khondakar *et al.* (2017) reported that the differences in number of branches might be due to the different genetic makeup of the summer tomato varieties.

Spaldon and Hussain (2017) conducted an experiment to analyze the performance of the tomato genotypes for yield, quality and biotic reaction against biotic stress. Pusa Ruby recorded the highest fruits per plant (30.82), estimated maximum marketable yield in hybrid Tokita (5.07 kg/plot). With respect to the quality traits, maximum pericarp thickness (6.86mm) was found in genotype Anand. Arka Vikas reported highest fruit pH (4.49) and beta-carotene content (7.06mg/100g). They concluded that the genotypes Tokita, US-3383, Pusa Ruby were high yielding and good for fresh marketing purpose. Arka Vikas, Aditya, and Arka Meghali genotypes were classified as suitable for processing.

Ali *et al.* (2016) conducted an experiment to Evaluate various tomato (*Lycopersicon esculentum* Mill.) cultivars for quality, yield and yield component under agro-climatic condition of Peshawar and found significant variation in respect of total soluble solids in different genotypes of tomato and maximum TSS (4.98 %) and minimum TSS (3.70 %) were observed in Bambino and Money maker tomato varieties respectively.

Dunsin *et al.* (2016) performed an experiment to assess the Performance of five tomato cultivars under Controlled Environment Condition of the Southern Guinea Savannah. They found that the Nemoneta cultivar, performed better than rest of the cultivars with respect to plant height (8.3cm), highest shelf life of 14 days followed by Delicious with 7 days, while Small Cherry was better for number of fruits per plant with an average of 8.733/plant. But Delicious cultivar gave the highest values in terms of marketable fruit weight (9.33kg) and highest pH values (4.07). In terms of fruit quality, Large Cherry cultivar contains the highest values for lycopene (1467.30mg/100g), vitamin A & B (56.7mg/100g & 0.62 mg/100g, respectively) and potassium content (0.62%).

Kanaujia and Phom (2016) studied the performance of various tomato genotypes of tomato and revealed that the genotype 2013/TODVAR-1 recorded maximum fruit yield (32.59 t/ha) and vitamins C content (74.58 mg/ 100g of fruit). The maximum TSS content (6.45^{o} Brix) was recorded in genotype 2012/TODVAR-3.

Khan *et al.* (2016) carried out an experiment to know the effect of different mulching materials on weeds and yield of chili cultivars and reported that in production of branches the differences among the cultivars might be due to their hereditary composition.

Helal *et al.* (2016) reported that higher number of branches/plant is the result of genetic makeup of the crop and environmental conditions which play a remarkable role towards the final yield of the crop.

Biswas *et al.* (2015) investigated BARI tomato varieties to study growth and yield responses of tomato varieties and revealed that the variety BARI Tomato-7 recorded tallest plant, maximum number of leaves and branches. The maximum number of flowers, number of clusters and number of fruits were recorded in BARI Tomato-9 and Maximum fruit diameter, yield, number of locules, individual fruit weight were also recorded in BARI Tomato-7.

Bhati and Kanaujia (2014) evaluated the performance of nine tomato varieties for their growth, yield and quality characters in the experiment. TODVAR-8 was found superior variety and recorded maximum plant height, number of leaves per plant, branches per plant, fresh weight of fruit, fruit length, fruit diameter, fruits per plant, total soluble solids, yield per hectare ascorbic acid content.

Mehraj *et al.* (2014) conducted an experiment to evaluate the performance of twenty (V_1 -V_{20}) coded tomato cultivars grown in the summer. The cultivar Mini Anindyo Red (V8) and Hybrid Tomato US440 (V_{18}) showed maximum leaves and plant height. Cultivar BARI Tomato 6 (V_{19}) has observed maximum days to flower bud appearance chlorophyll content, and days to flowering. Maximum number of number of flower bud per plant, branches per plant, flowers per plant, bunch per plant, fruit weight, number of flower per bunch, number of fruits per plant, fruit length, fruit diameter, yield per plant, yield per plot and fruit yield per hectare were detected from Mini Chika (V_{10}) cultivar. Thus the cultivar Mini Chika (V_{10}) was found suitable for summer cultivation.

Ngullie and Biswas (2014) conducted an experiment at krishi vigyan Kendra, Mokokchung, Nagaland to evaluate five tomato cultivars for their growth and fruit yield. Observation were taken on growth parameters and yield components including plant height, number of branches, fruit length, fruit girth, fruit weight, and total fruit yield per hectare. They found that highest fruit yield per hectare was found in Megha-1 followed by Sel-1, Punjab Chhuhara and Sel-2. While, the lowest fruit yield was obtained in Pusa Ruby than rest of the cultivars.

Kiran (2014) studied the twelve qualitative and quantitative characters of forty-five genotypes at AICRP on vegetable crops at O.U.A.T. Bhubaneshwar. She found that the genotypes BT-22-4(V7), BT-442-2 (V1), BT-3 (V28), BT-17-2 (V18) and BT- 437-1-2 (V2) were good yielders among all the genotypes in Odisha conditions.

Aoun *et al*. (2013) reported that tomato quality parameters can be verified by both physical and chemical characteristics of the fruit.

Jilani *et al.* (2013) reported minimum stem diameter (9.11 mm) in tomato cultivar Nema-1200 while the maximum stem diameter (14.95 mm) in tomato cultivar Vegnesh during comparison. He also reported that cultivar Nandi and Vegnesh took least days to flowering.

Singh *et al.* (2013) studied the performance of different tomato hybrids under greenhouse conditions in 2008 to 2009 and 2009 to 2010 at Hissar and reported that Avinash-23 recorded maximum yield per plant of 2.90 kg followed by Richa with a yield of 2.88 kg.

Tyeb *et al.* (2013) reported that the variation in plant height is due to the effect of varietal differences. The variation of plant height is probably due to the genetic make-up of the cultivars.

According to Mehmood *et al.* (2012) the tomato germplasm BINA Tomato-6 took maximum time to first flower appearance when compared with the other twenty one germplasms.

Ali *et al.* (2012) found maximum fruit diameter (5.19 cm) and minimum fruit diameter (4.50 cm) in tomato hybrids T-7010 and PTM-1603 respectively during studying the performance of various tomato hybrids.

Islam *et al.* (2012) studied the genetic variability of eleven inbred lines of cherry tomato and reported that line CH155 (5.7%) had the highest total soluble solids followed by CLN1555A (4.9%).

Naz *et al.* (2012) found that number of flower clusters plant^{-1} had significant variation among the tomato varieties.

Chapagain *et al*. (2011) assessed the performance of tomato varieties under plastic house for two successive years from 2009 to 2010 in Nepal. The highest marketable yield was recorded from All Rounder (86.6 t ha-1) followed by Srijana (80.8 t ha^{-1}).

Olaniyi *et al*. (2010) carried out an experiment where the assessment of seven varieties of tomatoes was done. He evaluated the growth, fruit yield and quality of the varieties. The results showed that DT97/162A(R) gave the highest height compared to Ogbomoso local variety. This shows that the yield and the quality of tomato depend on the variety.

2.2 Effect of cowdung slurry

Ferdous *et al.* (2020) reported that application of biogas slurry from cowdung or poultry manure in combination with chemical fertilizer resulted in 20–24% higher grain yield along with 22–23% greater gross return and 52–53% more gross margin compared with the traditional farmer practice indicating the beneficial effect of integrated application of biogas slurry and chemical fertilizer on maize productivity and financial return. Integrated application of biogas slurry and chemical fertilizer has a good potential in maize production as it provides higher grain yield and economic profitability.

Zheng *et al.* (2020) conducted an experiment to study the effects of biogas slurry irrigation on tomato (*Solanum Lycopersicum* L.) physiological and ecological indexes, yield and quality as well as soil environment Three biogas slurry treatments (treatment 1, T_1; treatment 2, T_2; treatment 3, T_3) and a inorganic fertilizer treatment (CK) were set to explore the effects on tomato growth, yield, quality and root-zone soil environment. The volume concentrations of biogas slurry in T_1, T_2 and T_3 treatments were 20, 15 and 10%, respectively. Results showed that T1 and CK treatments maintained a high leaf area index (LAI), photosynthetic rate and chlorophyll (a+b) contents during the whole growing period. T_1 treatment can obtain an equivalent yield to CK, however, the yield of T_2 and T_3 treatments were inferior to that of CK. For the quality of tomato, T_1 treatment can improve the soluble sugar and titratable acid contents for about 19.07 and 4.17% when compared to CK, and T_2 treatment can improved about 7.55 and 4.17%. Furthermore, T_1 and T_2 treatment can get a better sugar-acid ratio and tastes. In comparison with inorganic fertilizer treatment, all biogas treatments could increase soil porosity and soil aggregate, decrease soil debris, in which the superior treatment is T_1 and can be considered as a good organic fertilizer.

Spehia *et al*. (2020) reported that cowdung in growing media has improved nutrient uptake and utilization throughout the growing phase to ensure better vegetative growth and photosynthetic activities for higher yield and fruit quality.

Debebe and Itana, (2019) observed maximum plant height (cm) in T_6 (recommended dose of inorganic fertilizer + biogas slurry compost @ 8ton/ha), while the lowest plant height (cm) was recorded in T_1 (control) in cabbage.

Hossain *et al.* (2019) conducted an experiment to study the potentiality of using bio-slurry as organic manure for cabbage production. There were seven treatments which includes T_1 (Control), T_2 (100% NPKS), T_3 (70% NK), T_4 (70 % NK+ PM bio-slurry), T_5 (70 % NK+CD bio-slurry), T_6 (70 % NK+PM) and T_7 (70% NK+CD). Treatment effects were examined on plant height; unfold leaves, length of breath, polar length, root length, head diameter, % marketable head, marketable head weight, head yield, and N, P, K & S uptake by the crops. There was a significant positive effect of the treatments on yield, yield components, and nutrient uptake of cabbage. Treatments T_4 (70%NK+poultry manure bioslurry) and T_6 (70%NK+poultry manure) produced significantly higher crop yield and nutrient uptake over sole chemical fertilizers (T_2: 100 % NPKS). Between the digested and fresh sources, digested sources gave better results.

Aina *et al.* (2018) conducted a pot experiment in April 2018 in faculty of Agriculture, Kogi state university, Anyigba to study the effect of organic (cow dung slurry) and inorganic (N: P: K 15:15:15) fertilizer on the growth and yield of tomato. Experimental result revealed that the organic and inorganic manure used increased the soil physical-chemical properties as well as the performance parameters of the test crop (Tomato). Recommendation was made at the rate of 6 t ha^{-1} of cow dung slurry + 50 kg of NPK 15:15:15 (T_4) for optimum yield and performance of tomato.

Ferdous *et al.* (2018) conducted a field experiments at Lahirirhat Farming System Research and Development site, Rangpur, Bangladesh, to assess effects of biogas slurry in combination with synthetic fertilizer on tomato (*Solanum lycopersicum* L.) yield and profitability. Treatments included: soil test-based fertilizer, synthetic fertilizer+cow dung manure @ 5 t ha^{-1}, synthetic fertilizer + cow dung bioslurry @ 5 t ha^{-1}, synthetic fertilizer + poultry manure @ 3 t ha^{-1},, synthetic fertilizer + poultry bioslurry @ 3 t ha^{-1}, and farmer practice. Fruit yield was higher for plants grown with synthetic fertilizer + cow dung bioslurry compared with other fertilizer treatments and the farmer practice. Application of synthetic fertilizer + poultry bioslurry resulted in the highest fruit yield; plants maintained with the farmer practice yielded the least. The highest gross return and gross margin were obtained from plants treated with synthetic fertilizer + cow dung bioslurry. Synthetic fertilizer + poultry bioslurry-treated plants returned the highest gross return and gross margin. Application of synthetic fertilizer in combination with bioslurry has potential in increasing tomato yield and economic return of farmers.

Meena *et al.* (2017) determined that application of 75% recommended dose of fertilizer along with 25% FYM + *Azospirillium* resulted maximum average fresh fruit weight (64.94 g), yield/ plant (0.85 kg) and yield/ha (370.1 t/ha) in tomato cv. Pusa Sheetal.

Nabel *et al.* (2017) carried out a comparative experiment of three years duration and showed that the application of biogas slurry as fertilizer could enhance carbon content, water holding capacity, pH and fertility of soils.

Singh *et al.* (2017) investigated that application of organic manures along with biofertilizers (*Azospirillium* and P-solubilizing bacteria @ 2.5 kg/ha each) resulted maximum plant height (125.52 cm), number of branches/plant (4.62), number of fruit clusters/plant (18.28), number of fruits/plant (29.08), fruit yield/ha (465.83 q) and TSS (4.94^0Brix).

Tekale *et al*. (2017) studied the effect of integrated nutrient management (INM) on availability of nutrients in soil, nutrient uptake and yield of tomato cv. Gujarat Tomato-2. The experiment was conducted with different INM treatments, FYM (Cow dung) 20 t/ha + 100% RDF had significantly recorded the highest fruit yield/plant (1.49, 1.58 and 1.54 kg) and fruit yield/plot (29.86, 31.56 and 30.71 kg) during 2011-12, 2012-13 and pooled analysis, respectively.

Muralidharan *et al.* (2016) carried out an experiment to evaluate the effect of organic and inorganic fertilizers on yield and economic of indeterminate tomato plants. They observed that yield and economic attributes of indeterminate tomato were significantly influenced by different treatment combinations. Among the treatment combinations on application, that of 50% recommended dose of fertilizer + 12 t/ha FYM was found superior giving maximum yield (147.61 t/ha) in indeterminate tomato.

Sahu *et al.* (2015) reported that treatment of 75% RDF+ Cowdung Slurry resulted significantly minimum number of days for flowering (33.51 days), maximum number of flowers per m^2 (17.62) and number of fruits per m^2 (14.50), fruit set per m^2(90.18%) and fruit retention (93.11%) in guava cv. Sardar.

Shaheb *et al.* (2015) reported that CD slurry @ five t ha^{-1} along with IPNS basis inorganic fertilizers produced the highest yield of radish and cabbage, respectively in AEZ 20 of Bangladesh.

Shinde and Malshe (2015) observed that the significantly highest seedling height (33.19 cm), number of leaves (17.23 $seedling^{-1}$), length of primary roots (15.71 cm) and number of tertiary roots (41 $seedling^{-1}$) of khirni were recorded in the treatment having 12 hrs soaking in cattle urine + 12 hrs keeping in cow dung slurry which influenced rapid growth of plant.

Kumar *et al*. (2013) conducted an experiment to study the effect of integrated nutrient management on growth and yield of broccoli (*Brassica oleracea* var. italica) under Jharkhand conditions and reported that the increase in plant height may be attributed to balance supply of nutrient through organic and inorganic fertilizers resulting in higher plant canopy which in turn increased photosynthetic processes during development.

Shaharia *et al*. (2013) found that marketable weights of cabbage was obtained from RDF + 5 t ha^{-1} digested PL bio-slurry.

Alburquerque *et al.* (2012) showed that the application of biogas slurry could effectively improve soil environment and obtain yield which was comparable with that obtained by traditional fertilizer application.

Ekwu and Nwokwu (2012) reported that higher yield response of crops due to organic manure application could be attributed to improved physical and biological properties of the soil resulting in better supply of nutrients to the plants.

Sarker *et al*. (2012) conducted an experiment with replication and 6 treatments *viz*., T0 - Control, T_1 - Recommended fertilizer Dose (RFD), T_2- 60% RFD + Poultry Manure (PM), T_3 - 60% RFD + Poultry slurry, T_4 - 60% RFD + Cow-dung (CD), T_5 - 60% RFD + Cow-dung slurry. Chemical analysis of cow dung, cow-dung slurry, poultry manure and poultry manure slurry showed that the organic matter, organic carbon, N, P, K and S varied from 32-69.5, 18.6-40.4, 1.51- 2.94, 0.51- 0.81, 0.45- 1.36, 0.39- 0.46%, respectively. Cow-dung and cow-dung slurry had the higher organic matter and organic carbon content while poultry manure and poultry manure slurry had the higher nutrient concentration. Nutrient concentration particularly nitrogen content of cow-dung, cowdung slurry, poultry manure, and poultry manure slurry was 1.44%, 1.08%, 2.10% and 1.52% respectively and potassium content in cow dung, cow dung slurry, poultry manure, and poultry manure slurry contain 0.82%, 0.32%, 0.97% and 0.75% of K, respectively on wet basis In all cases N and K content of cow-dung and poultry Biogas slurry was always found lower than the cow-dung and poultry manure. The growth and yield of tomato were significantly influenced by the application of different manures at 1% level of probability.

Duan *et al*. (2011) applied biogas slurry as liquid fertilizer on greenhouse cucumber production. They obtained high yield and good quality of cucumber compared with inorganic fertilizer treatment. Their experiment had also achieved a reduction of greenhouse gas emission.

Nasir *et al.* (2010) carried out to study comparative study of biogas slurry with farm yard manure as fertilizer on maize crop at Department of Structures and Environmental, University of Agriculture, Faisalabad, Pakistan. They revealed that increased growth, plant height was better where biogas slurry was applied.

Yu *et al.* (2010) reported that application of concentrated slurry could bring significant changes to tomato cultivation, including increases in organic matter, available N, P, and K, total N and P, electrical conductivity, and fruit contents of amino acids, protein, soluble sugar, β-carotene, tannins, and vitamin C, together with the R/S ratios and the culturable counts of bacteria, actinomycetes, and fungi in soils. It was concluded that the application is a practicable means in tomato production and will better service the-is area of sustainable agriculture.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka-1207, to investigate the effect of cowdung slurry on growth, yield, and quality of hydroponically grown tomatoes. Materials used and methodologies followed in the present investigation have been described in this chapter.

3.1 Experimental period

The experiment was conducted during the period from September-2019 to February-2020.

3.2.1 Geographical location

The experiment was carried out at the Horticulture farm, Sher-e-Bangla Agricultural University's (SAU). The experimental site is located 8.6 meters above sea level at a latitude and longitude of 23°77 N and 90°33 E, respectively. In Appendix I Map of Bangladesh's AEZ, the experimental site has been highlighted for easier understanding.

3.2.2 Climate and weather

The experimental area was subtropical, with the winter season lasting from November to February, the pre-monsoon period, also known as the hot season, lasting from March to April, and the monsoon season lasting from May to October (Farukh *et al*., 2019). Appendix-II contains meteorological information about the temperature, relative humidity, and rainfall during the experiment period that was gathered from the Bangladesh Meteorological Department's Climate Division in Sher-e-Bangla Nagar, Dhaka.

3.3 Experimental materials

As planting materials, BARI tomato-4, BARI tomato-10, BARI tomato-5 and Tomato line 1885 tomato variety was chosen. The seeds of BARI tomato-4, BARI tomato-10, and BARI tomato-5 were obtained from Krishibid Seed Limited. The Tomato line-1885 variety seeds were obtained from Afroza Seed Company. Other substrates were collected from Hatibandha upazilla Lalmonirhat, and (Khoa+ cocopeat) was collected from an Agargoan in Dhaka.

3.4 Experimental treatment

There were two factors in the experiment namely variety and cow dung slurry as mentioned below:

Factor A: Tomato variety denoted as V:

V_1 = BARI tomato-4
V_2 = BARI toamto-10
V_3 = BARI tomato -5
V_4 = Tomato line 1885

Factor B: Cowdung slurry denoted as C:

C_0 = 0 ml L^{-1} + standard solution
C_1 = 100 ml L^{-1} + standard solution
C_2 = 150 ml L^{-1} + standard solution
C_3= 200 ml L^{-1} + standard solution

3.5 Experimental design

The two factor experiment was conducted in completely randomized design (CRD) with three replication. The experiment employed a total of 48 unit pots with 16 treatments.

3.6 Detail of experimental preparation

3.6.1 Preparation of the substrate

Overnight, cocopeat as substrate was immersed in a plastic container. Then the wet substrate was spread out on a polythene sheet to remove excess moisture from it. After that the growing medium was prepared for use as hydroponic culture by adding a little amount of cocopeat, khoa, and a disinfection chemical like sevin powder.

3.6.2 Selection and preparation of the pot

The pots were made of plastic and had a hole in the center of the bottom and measured 12 inches in height and diameter. The pots' upper edge diameter was 30 cm (r= 15 cm). To appropriately provide irrigation and nutrient solution, the top inch of the pot was left empty while being filled with various substrates. As a result, the upper surface's radius was 15 cm and its area was (πr^2 = 3.14x 0.015x 0.015=0.07 m^2).

3.6.3 Standard solution

Rahman and Inden (2012) nutrient solution was used as standard solution for this experiment. The NO_3-N, P, K, Ca, Mg, and S ratios for the Rahman and Inden (2012) solutions were 17.05, 7.86, 8.94, 9.95, 6.0, and 6.0 meq/L, respectively. The 17 micronutrient rates were 3.0, 0.5, 0.1, 0.03, 0.025, and 1.0 mg/L for Fe, B, Zn, Cu, Mo, and Mn, respectively. Each pot was filled with the solution according with par treatment requirement.

3.6.4 Seed bed preparation for seedling raising

To prepare the seed bed for growing tomato seedlings, a mixture of cocopeat, broken bricks (khoa), and rice husk at a ratio of 60:30:10 (v/v) was utilized. Blocks of cocopeat were steeped for 24 hours in a large bowl. After drying and washing them, they were correctly combined with khoa and rice husk. This combination was used after being put in a box made of styrofoam sheets.

3.6.5 Seed sowing

The seeds were sown in styrofoam sheet box and covered with newspaper under normal temperature for raising seedling.

3.6.6 Transplanting of tomato seedling

15 days old tomato seedlings were transferred to small pot. 4 weeks after that seedlings were transferred to 12 inch plastic pots containing 70 % cocopeat substrate and 30 % Khoa. The plants were transplanted carefully to avoid the root damage. Little amount of water was applied soon after transplanting of seedling.

3.6.7 Imposed treatment for experiment

Different cowdung slurry treatment were imposed on 20 days-old seedlings. Throughout the study period, a group of plants was grown in a similar type of container without cowdung slurry nutrient solution for comparisons.

3.7 Intercultural operations

3.7.1 Pruning

After transplanting, the lowest yellow leaves were cut off as needed to give the plants time to establish a strong vegetative frame before bearing fruit.

3.7.2 Irrigation

A light irrigation was given to each individual pot to make up for the water shortage after transplanting. Each container received watering on alternate days after seedling establishment to maintain the substrate's moisture levels for the regular growth and development of plants. Irrigation was applied during the pre-flowering stage.

3.7.3 Weeding

No weeding was done in the experiment.

3.7.4 Stalking

Firstly, a bamboo stick was used to support tomato plant. Secondly, a small plastic pipe was cut roundly different pieces. Then it was used as a hook in plant base and plastic rope used for support the plant.

3.7.5 Insect management

Tomato plants were grown in controlled environment. So, no insecticides were applied in the experiment.

3.7.6 Diseases management

Tomato plants were grown in controlled environment in hydroponic culture and all nutrients required for plant were supplied artificially to the plants. The growing environment was clean and no disease attacked the plant.

3.8 Harvesting

Once the first bloom of red appears on the skin of the tomato then they were harvested.

3.9 Data collection

Plants per pot were tagged for recording various data. The data were recorded as described below.

i. Plant height

The plant height was recorded in centimeters from earlier selected plant from ground level to the growing tip of the main stem with the help of metalic strip tape.

ii. Number of branches plant^{-1}

The number of branches per plant counted for randomly selected five plants and average was recorded.

iii. Days of first flower initiation

Number of days required from the day of transplanting to the day on first flower initiation as recorded as days of recorded as first flower initiation.

iv. Number of flower clusters plant^{-1}

Number of flower clusters plant^{-1} were counted and averaged.

v. Number of fruits plant^{-1}

Fruits was counted to compute the average number of fruits per cluster.

vi. Number of fruits plant^{-1}

Number of fruits per plant was counted at every picking, which was finally added up to work out total and average number of fruits per plant.

vii. Fruit polar length

The individual fruit polar length was measured during harvesting with the help of a large scale in centimeter unit.

viii. Fruit radial length

The individual fruit radial length was measured during harvesting with the help of a large scale in centimeter unit.

ix. Fruit yield plant^{-1}

The crop was harvested when the fruit was halfway ripe. The yield was measured in grams at each picking and totaled across all pickings to determine the overall fruit production per plant. Finally, the fruit production from all the plants was combined, and the average output from plant-^{1} (kg) was recorded.

x. Average fresh weight of tomato

Total weight of five randomly harvested fruits at every picking was recorded to compute the average fresh fruit weight of tomato in grams.

xi. Average dry weight of tomato

Individual tomato fruit were collected for each treatment. The fruit was then cut into slices and dried in the sun for two days separately before being moved to the central laboratory oven at Sher-e-Bangla Agricultural University to finish drying. After 72 hours, it was collected and weighed using an electric balance.

xii. Individual fruit volume

The individual fruit volume was measured during harvesting by Archimidis method with the help of a 500 ml beaker in centimeter cube (cc) unit. Another name of cc unit is ml.

xiii. Total soluble solids (^{0}Brix)

The randomly taken ripe fruits of third harvest were crushed and their juice was passed through a double layer of fine mesh cheesecloth. A drop of juice was placed on the plate of hand refractometer (0-32%) ERMA, JAPAN) and the reading was recorded. A mean of five readings was taken in each treatment and every replication.

xiv. pH determination

The pH value of tomato was measured using a digital pH meter. The pH meter was first calibrated with different standard solutions for pH 4, 7 and 10. Then, the tomato was taken in a beaker and the pH meter immersed in the juice to record the value. The test was performed by triplicate per each treatment at normal temperature.

3.10 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program name Statistix 10 Data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

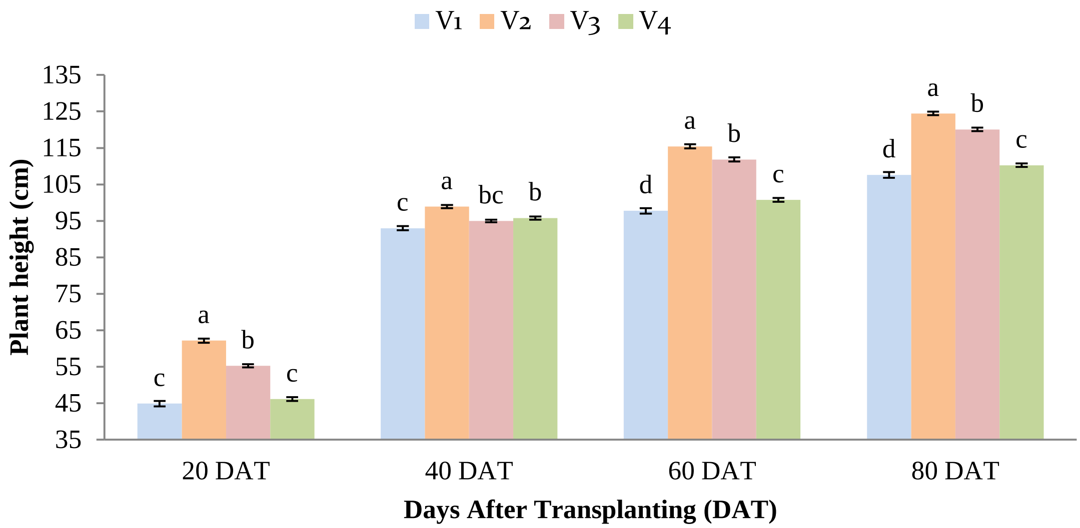
RESULTS AND DISCUSSION

The results of the study on the effect of cowdung slurry on tomato growth, yield, and quality in a hydroponic system were presented and discussed in this section. Tables and graphs were used to present the information. Under the headings listed below, possible interpretations of the findings had been considered.

4.1 Plant height

Effect of variety

Plant height is a crucial aspect of the vegetative stage of plants that indirectly affects crop plant yield. Different varieties had a substantial effect on tomato plant height at various days after transplanting (DAT). Height was observed to grow steadily as the crop aged up to harvest. At maturity, the plant's height achieved its peak value (Figure 1). Experimental result revealed that the highest plant height (62.16, 98.88, 115.43 and 124.43 cm) at 20, 40, 60 and 80 DAT was observed in V_2 (BARI toamto-10). Whereas the lowest plant height (44.90, 93.00, 97.76 and 107.58 cm) at 20, 40, 60 and 80 DAT was observed in V_1 (BARI tomato-4) which was statistically similar with V_4 (Tomato line 1885), (46.13 cm) at 20 DAT. The genetic makeup of the cultivar is likely to blame for the difference in plant height. Das *et al.* (2019) reported that height of a plant is determined by genetical character and under a given set of environment different variety will acquire their height according to their genetic makeup.

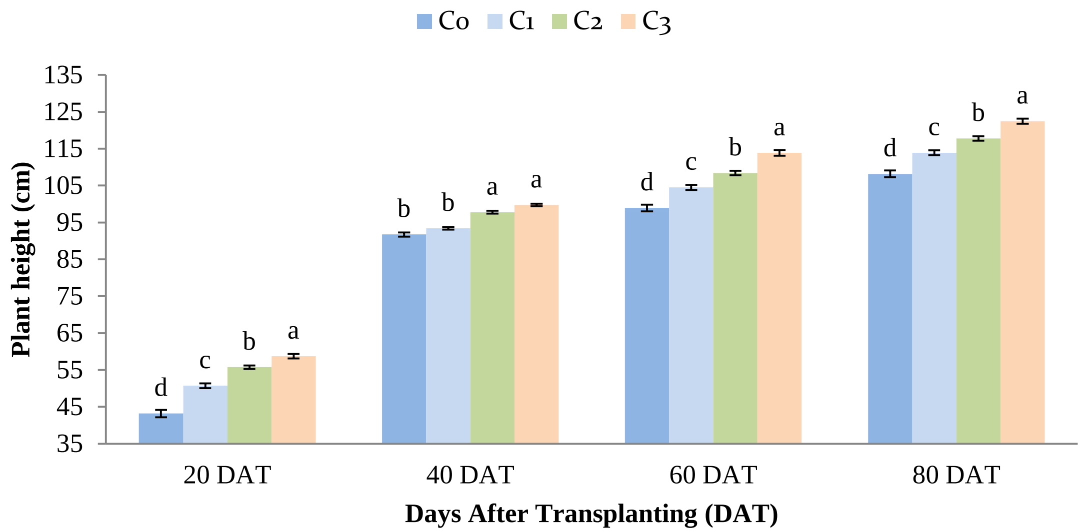


In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Vertical bars indicate standard error (SE). Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885

Figure 1. Effect of variety on plant height of tomato at different DAT

Effect of cowdung slurry

Plant height of tomato showed significant variation due to the effect of cowdung slurry treatment at different DAT (Figure 2). Experimental result showed that the lowest plant height (43.20, 91.74, 98.93 and 108.18 cm) at 20, 40, 60 and 80 DAT was observed in C_0 (0 ml L^{-1} cowdung slurry + standard solution/Control) treatment. Increasing cowdung slurry concentration increased plant height and the highest plant height (58.75, 99.73, 113.88 and 122.49 cm) was observed in C_3 (200 ml L^{-1} cowdung slurry + standard solution) treatment. Plants may gradually grow taller as a result of enhanced cell division or cell expansion, through improved food availability brought on by an increased cowdung slurry content. The result obtained from the present study was similar with the findings of Kumar *et al*. (2013) who reported that the increase in plant height of broccoli may be attributed to balance supply of nutrient through organic and inorganic fertilizers resulting in higher plant canopy which in turn increased photosynthetic processes during development.



In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Vertical bars indicate standard error (SE). Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 2. Effect of cowdung slurry on plant height of tomato at different DAT

Combined effect of variety and cowdung slurry

Different variety along with application of different concentration of cowdung slurry significantly influenced on plant height of tomato at different DAT (Table 1). Experimental result revealed that the highest plant (67.33, 104.03, 125.03 and 134.03 cm) at 20, 40, 60 and 80 DAT was observed in V_2C_3 treatment combination which was statistically similar with V_2C_2 (64.23 cm) at 20 DAT; with V_2C_2 (101.03 cm) and V_4C_2 (99.73 cm) treatment combination at 40 DAT. While V_1C_0 treatment combination had the lowest plant height (31.80, 88.55, 88.33 and 96.33 cm) at 20, 40, 60 and 80 DAT which was statistically similar with V_4C_0 (33.03 cm) treatment combination at 20 DAT; with V_1C_1 (89.85 cm), V_3C_0 (91.93 cm) and V_4C_1 (92.63) at 40 DAT; with V_1C_1 (96.03 cm) and V_4C_1 (99.03 cm) at 60 DAT.

Table 1. Combined effect of variety and different concentration of cowdung slurry on plant height of tomato at different DAT

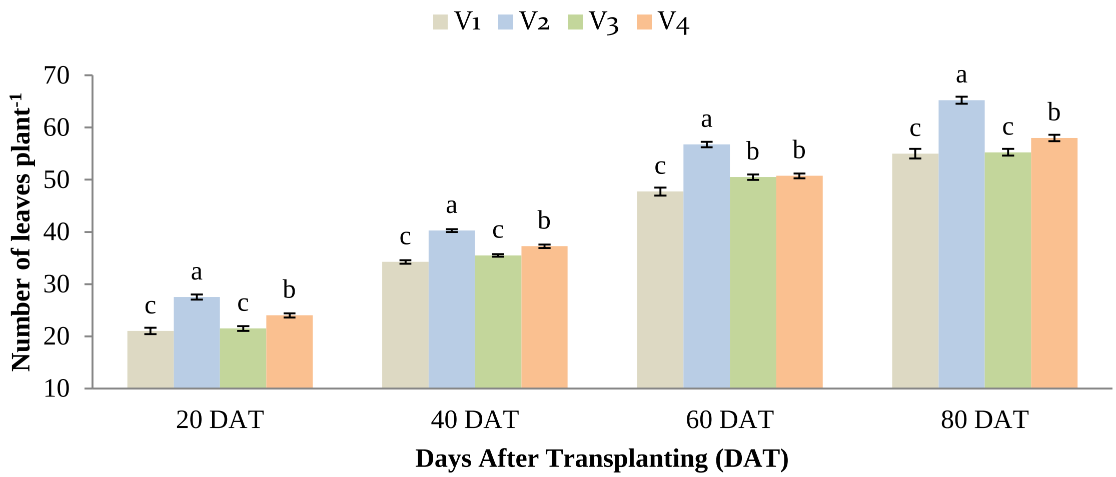
Treatment Combinations	Plant height (cm)			
	20 DAT	40 DAT	60 DAT	80 DAT
V_1C_0	31.80 h	88.55 h	88.33 j	96.33 i
V_1C_1	43.70 g	89.85 gh	96.03 i	106.47 g
V_1C_2	52.80 ef	96.95 b-e	100.83 gh	111.27 ef
V_1C_3	51.30 ef	96.65 b-e	105.83 ef	116.27 d
V_2C_0	57.03 cd	95.13 d-f	107.23 d-f	116.23 d
V_2C_1	60.03 c	95.33 c-f	113.33 bc	122.33 b
V_2C_2	64.23 ab	101.03 ab	116.13 b	125.13 b
V_2C_3	67.33 a	104.03 a	125.03 a	134.03 a
V_3C_0	50.93 f	91.93 f-h	108.83 de	117.83 d
V_3C_1	54.23 de	95.73 c-f	109.83 cd	118.83 cd
V_3C_2	51.93 ef	93.43 e-g	112.83 bc	121.83 bc
V_3C_3	63.83 b	98.83 b-d	115.83 b	121.83 bc
V_4C_0	33.03 h	91.33 f-h	91.33 j	102.33 h
V_4C_1	44.93 g	92.63 e-h	99.03 hi	108.03 fg
V_4C_2	54.03 d-f	99.73 a-c	103.83 fg	112.83 e
V_4C_3	52.53 ef	99.43 b-d	108.83 de	117.83 d
$LSD_{(0.05)}$	3.17	4.48	3.72	3.31
CV(%)	3.66	2.81	2.10	1.72

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5, V_4 = Tomato line 1885, C_0 = 0 ml L^{-1} + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

4.2 Number of leaves plant^{-1}

Effect of variety

A leaf is the principal lateral appendage of the vascular plant stem, usually borne above ground and specialized for photosynthesis. Different tomato varieties significantly influenced number of leaves plant^{-1} at different days after transplanting (Figure 3). Experimental result showed that the highest number of leaves plant^{-1} (27.50, 40.25, 56.75 and 65.25) at 20, 40, 60 and 80 DAT was observed in V_2 treatment. However V_1 treatment had the lowest number of leaves plant^{-1} (21.00, 34.25, 47.75 and 55.00) at 20, 40, 60 and 80 DAT which was statistically similar with V_3 treatment (21.50, 35.50 and 55.25) at 20, 40 and 80 DAT. The variation in number of leaves plant^{-1} was probably due to the genetic makeup of the cultivars. Similar results were discovered by Biswas *et al.* (2015). supporting the current finding, and reported that the changes in the number of leaves on plant^{-1} may be caused by the tomato variety's characteristics.

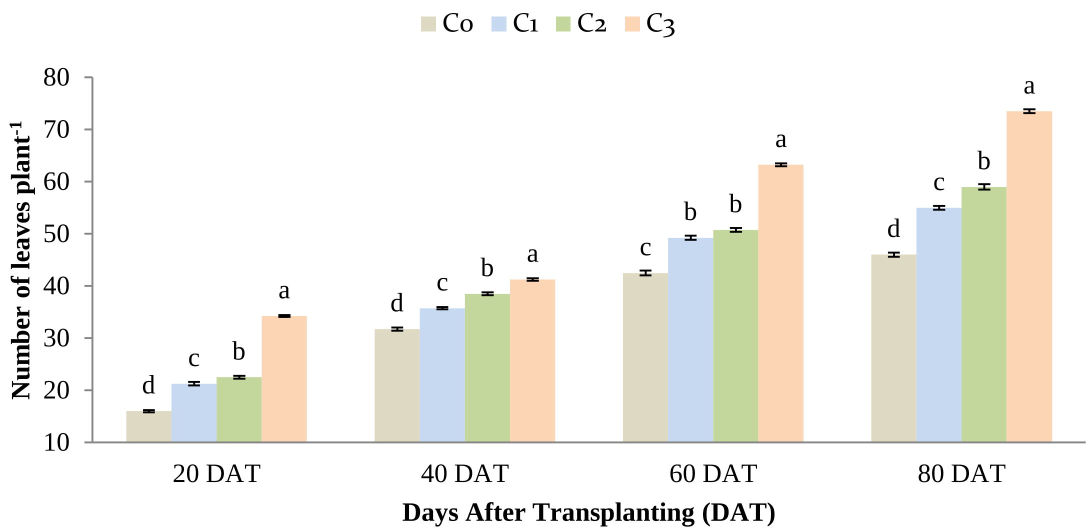


In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Vertical bars indicate standard error (SE). Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 3. Effect of variety on number of leaves plant^{-1}of tomato at different DAT

Effect of cowdung slurry

Different concentration of cowdung slurry application had shown significant effect on number of leaves plant^{-1} of tomato at different DAT (Figure 4). According to the experimental findings the C_0 treatment had the lowest number of leaves plant^{-1} (16.00, 31.75, 42.50 and 46.00) at 20, 40, 60 and 80 DAT. While the C_3 treatment had the highest number of leaves plant^{-1} (34.25, 41.25, 63.25 and 73.50) at 20, 40, 60 and 80 DAT. It was generally known that adding organic fertilizers enhanced the standard solution's organic matter content and made other plant nutrients more readily available in hydroponic growth systems. For this reason, adding various amounts of cowdung slurry to the normal solution considerably increased the number of leaves on plant^{-1}. Spehia *et al.* (2020) reported that cowdung has improved nutrient uptake and utilization throughout the growing phase to ensure better vegetative growth and photosynthetic activities for higher yield and fruit quality.



In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Vertical bars indicate standard error (SE). Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 4. Effect of cowdung slurry on number of leaves plant^{-1} of tomato at different DAT

Combined effect of variety and cowdung slurry

Combined effect of variety and different concentration of cowdung slurry had shown significant effect on the number of leaves plant^{-1} of tomato at different DAT (Table 2). The V_2C_3 treatment combination had the highest number leaves plant^{-1} (37.00, 45.00, 67.00 and 79.00) at 20, 40, 60, and 80 DAT. While V_1C_0 treatment combination had the lowest number of leaves plant^{-1} (13.00, 29.00, 38.00 and 42.00) at 20, 40, 60, and 80 DAT, and it was statistically similar with V_3C_0 (30.00) treatment combination at 40 DAT; with V_4C_0 (41.00) treatment combinations at 60 DAT and with V_3C_0 (44.00) treatment combination at 80 DAT.

Table 2. Combined effect of variety and cowdung slurry on number of leaves plant^{-1}of tomato at different DAT

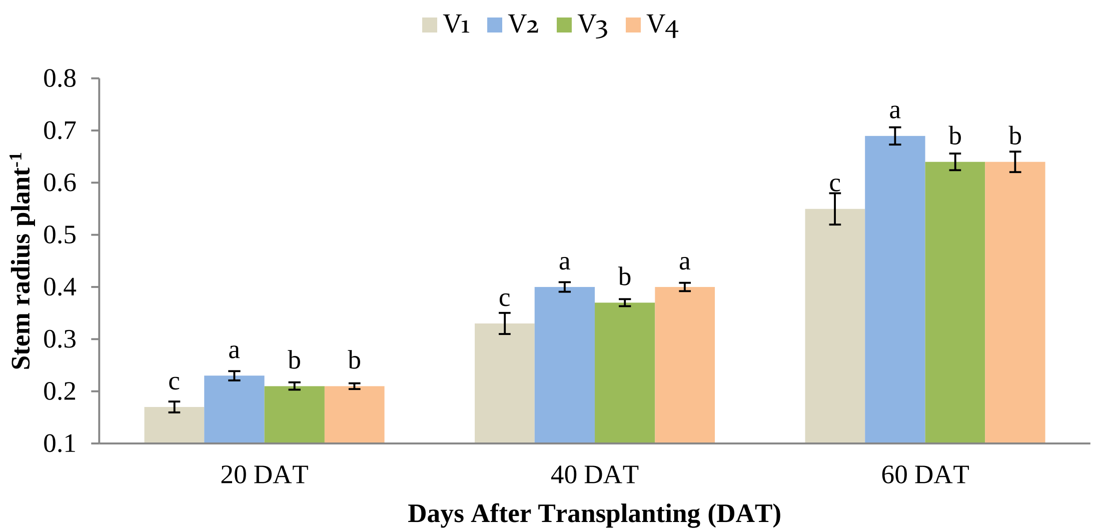
Treatment Combinations	Number of leaves plant^{-1}			
	20 DAT	40 DAT	60 DAT	80 DAT
V_1C_0	13.00 h	29.00 h	38.00 i	42.00 k
V_1C_1	19.00 f	34.00 fg	46.00 fg	53.00 h
V_1C_2	20.00 f	36.00 d-f	47.00 e-g	55.00 gh
V_1C_3	32.00 c	38.00 c-e	60.00 bc	70.00 cd
V_2C_0	19.00 f	36.00 d-f	47.00 e-g	53.00 h
V_2C_1	27.00 d	37.00 d-f	56.00 d	61.00 e
V_2C_2	27.00 d	43.00 ab	57.00 cd	68.00 d
V_2C_3	37.00 a	45.00 a	67.00 a	79.00 a
V_3C_0	16.00 g	30.00 h	44.00 gh	44.00 jk
V_3C_1	17.00 g	35.00 e-g	46.00 fg	50.00 i
V_3C_2	20.00 f	36.00 d-f	49.00 ef	55.00 gh
V_3C_3	33.00 c	41.00 bc	63.00 b	72.00 bc
V_4C_0	16.00 g	32.00 gh	41.00 hi	45.00 j
V_4C_1	22.00 e	37.00 d-f	49.00 ef	56.00 fg
V_4C_2	23.00 e	39.00 cd	50.00 e	58.00 f
V_4C_3	35.00 b	41.00 bc	63.00 b	73.00 b
$LSD_{(0.05)}$	1.20	3.10	3.79	2.52
CV(%)	3.07	5.06	4.42	2.59

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5, V_4 = tomato line 1885, C_0 = 0 ml L^{-1} + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

4.3 Stem radius plant^{-1}

Effect of variety

The results of the experiment showed that different varieties had had shown significant effect on stem radius plant^{-1} of tomato at different DAT (Figure 5).Experimental result revealed that the V_2 treatment had the highest stem radius plant^{-1} (0.23, 0.40 and 0.69 cm) at 20, 40 and 60 DAT. While the V_1 treatment showed the lowest stem radius plant^{-1} (0.17, 0.33 and 0.55 cm) at 20, 40 and 60 DAT. The diverse genetic make-up of the tomato cultivars may be the cause of the stem radius variations in plant^{-1}. The results obtained from the present study was similar with the findings of Jilani *et al.* (2013) who reported that the tomato cultivar Nema-1200 had the smallest stem diameter (9.11 mm), while tomato cultivar Vegnesh had the largest stem diameter (14.95 mm).

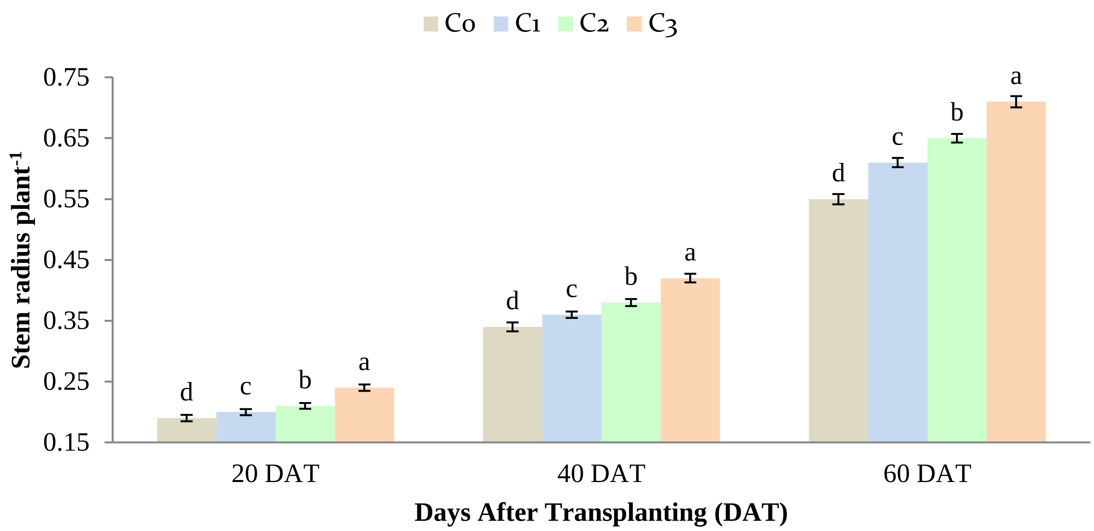


In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Vertical bars indicate standard error (SE). Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 5. Effect of variety on stem radius plant^{-1} of tomato at different DAT

Effect of cowdung slurry

The stem radius of tomato plant^{-1} at various DAT was significantly affected by the application of cowdung slurry at various concentrations (Figure 6). According to the experimental findings the C_0 treatment had the lowest stem radius plant^{-1} (0.19, 0.34 and 0.55) at 20, 40 and 60 DAT. While At 20, 40 and 60 DAT, the C_3 treatment exhibited the highest stem radius plant^{-1} (0.24, 0.42, and 0.71 cm). In a hydroponic cultivation system, the addition of fortified cowdung slurry with standard solution promotes the gradual breakdown of complex nitrogenous compounds and results in a steady supply of N. This may have contributed to greater N availability and subsequent uptake and, as a result, an increase in the stem radius of the tomato plant. Nabel *et al.* (2017) reported that the application of biogas slurry as fertilizer could enhance carbon content, water holding capacity and nutrient status of soils. Nasir *et al.* (2010) reported that maize stem radius increased when biogas slurry was used as fertilizer instead of farmyard manure.



In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Vertical bars indicate standard error (SE). Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 4. Effect of cowdung slurry on stem radius plant^{-1}of tomato at different DAT

Combined effect of variety and cowdung slurry

In hydroponic culture system different variety along with application of cowdung slurry at various concentrations had shown significant effect on the stem radius plant^{-1} of tomato at different DAT (Table 3). Experimental result revealed that the V_2C_3 treatment combination had the highest stem radius plant^{-1} (0.27, 0.48 and 0.80 cm) at 20, 40 and 60 DAT. However at 20, 40 and 60 DAT the lowest stem radius plant^{-1} (0.15, 0.28 and 0.46 cm) was recorded from the V_1C_0 treatment combination which was similar with V_1C_1 (0.16 cm) treatment combination at 20 DAT.

Table 3. Combined effect of variety and cowdung slurry on stem radius plant^{-1} of tomato at different DAT

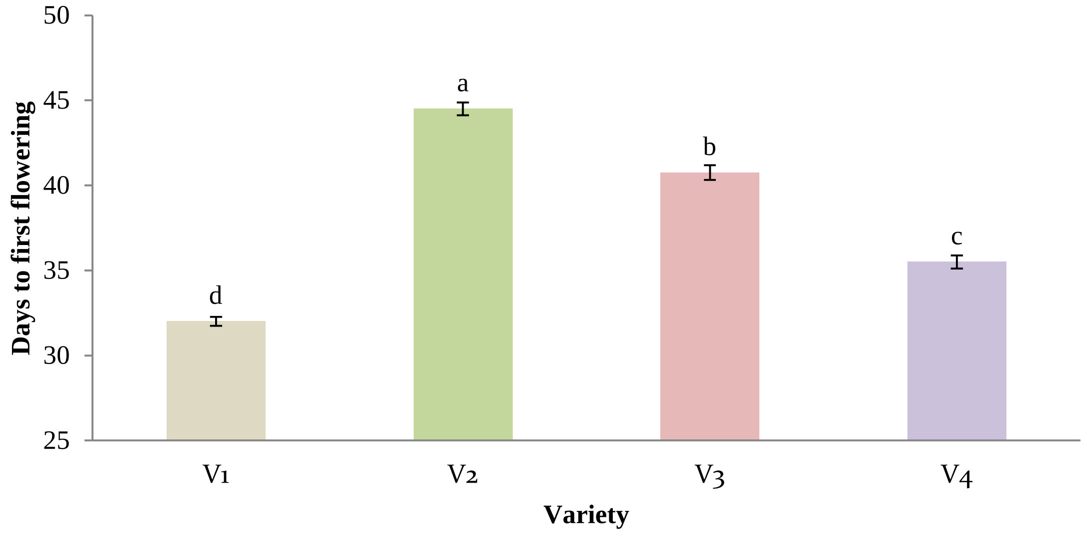
Treatment Combinations	Stem radius (cm) plant^{-1} at		
	20 DAT	40 DAT	60 DAT
V_1C_0	0.15 h	0.28 f	0.46 l
V_1C_1	0.16 h	0.32 e	0.54 k
V_1C_2	0.18 g	0.35 de	0.58 j
V_1C_3	0.20 ef	0.35 de	0.61 hi
V_2C_0	0.21 de	0.37 cd	0.59 ij
V_2C_1	0.22 cd	0.37 cd	0.66 ef
V_2C_2	0.23 bc	0.39 bc	0.69 cd
V_2C_3	0.27 a	0.48 a	0.80 a
V_3C_0	0.19 fg	0.34 de	0.59 ij
V_3C_1	0.20 ef	0.36 cd	0.61 hi
V_3C_2	0.21 de	0.36 cd	0.64 fg
V_3C_3	0.24 b	0.42 b	0.73 b
V_4C_0	0.19 fg	0.35 de	0.55 k
V_4C_1	0.20 ef	0.39 bc	0.63 gh
V_4C_2	0.22 cd	0.42 b	0.67 de
V_4C_3	0.23 bc	0.42 b	0.70 c
$LSD_{(0.05)}$	0.01	0.03	0.02
CV(%)	3.54	5.25	2.71

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BARI tomato-4, V_2 = BARI toamto-10, V_3 = BARI tomato-5, V_4 = Tomato line 1885, C_0 = 0 ml L^{-1} + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

4.4 Days to first flowering

Effect of variety

Days to first flowering differed significantly due to different varieties (Figure 7). The highest 44.50 days required for first flowering was found in V_2 treatment. While the lowest 32.00 days required for first flowering was found in V_1. The variation in production of flower was due to the variation in genetic makeup of the cultivars. Mehmood *et al.* (2012) reported that the tomato germplasm BINA Tomato-6 took maximum time to first flower appearance when compared with the other twenty one germplasms.

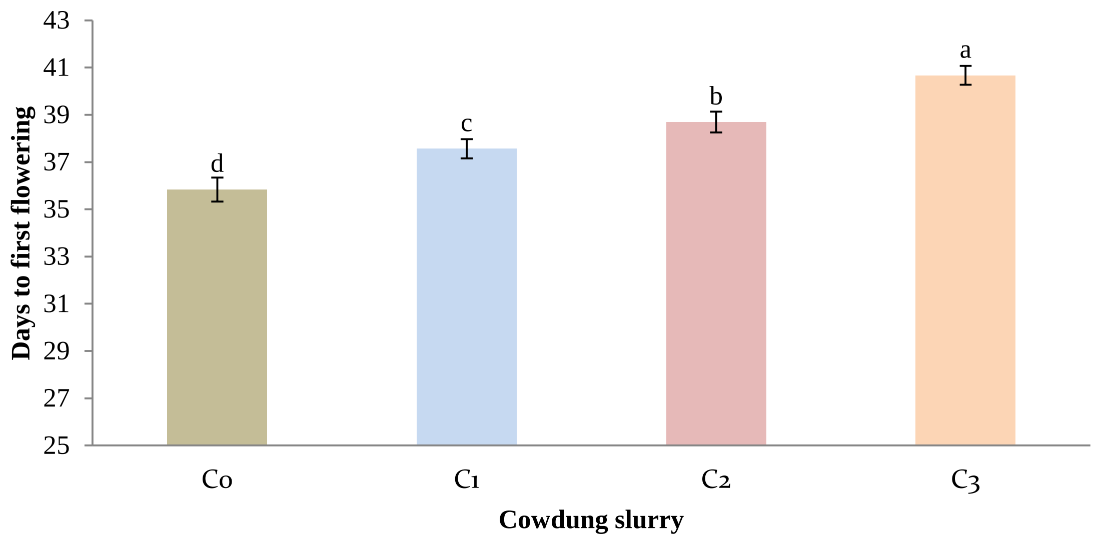


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 7. Effect of variety on days to first flowering of tomato

Effect of cowdung slurry

Days to first flowering of tomatoes produced in hydroponic culture at various cowdung slurry concentrations varied significantly (Figure 8). According to the experimental results the C_3 treatment required the maximum time(40.67 days) for initial blooming. While the C_0 treatment needed only 35.84 days to reach first flowering. Cowdung slurry increases macro- and micronutrients, as well as the physical and chemical characteristics of the growing medium. This results in a fast growth of vegetative development, which ultimately affects the number of days needed for the first tomato flowering. Ferdous *et al.* (2018) the use of synthetic fertilizer in conjunction with bioslurry has the potential to increase flowering number plant^{-1}, tomato yield qualities, yield, and farmer economic return.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 8. Effect of cowdung slurry on days to first flowering of tomato

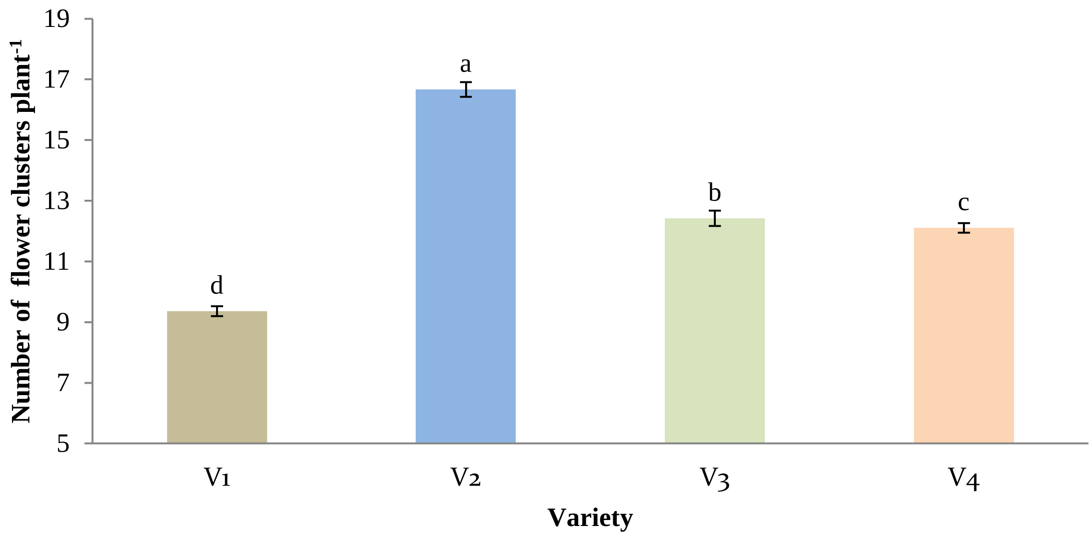
Combined effect of variety and cowdung slurry

Different varieties and the use of cowdung slurry at varying concentrations significantly affected the number of days needed for tomato flowering in a hydroponic system (Table 4). The V_2C_3 treatment combination was found to have the highest 46.33 days needed for first flowering based on the experimental findings. While the V_1C_0 treatment combination had the lowest 28.67 days required for first flowering.

4.5 Number of flower clusters plant^{-1}

Effect of variety

The number of flower clusters plant^{-1} at 60 DAT was significantly influenced by the tomato varieties grown in hydroponic culture system (Figure 9). Experimental result showed that the V_2 treatment had the highest number of flower clusters plant^{-1} (16.67) at 60 DAT. On the other hand the V_1 treatment, had the lowest flower clusters plant^{-1} (9.36) at 60 DAT. The varying genetic make-up of the tomato cultivars may be the cause of the variations in the number of flower clusters plant^{-1}. The findings of Naz *et al*. (2012), who indicated that there was significant variance in the number of flower clusters plant^{-1} among tomato varieties, were similar to the findings of the present study.

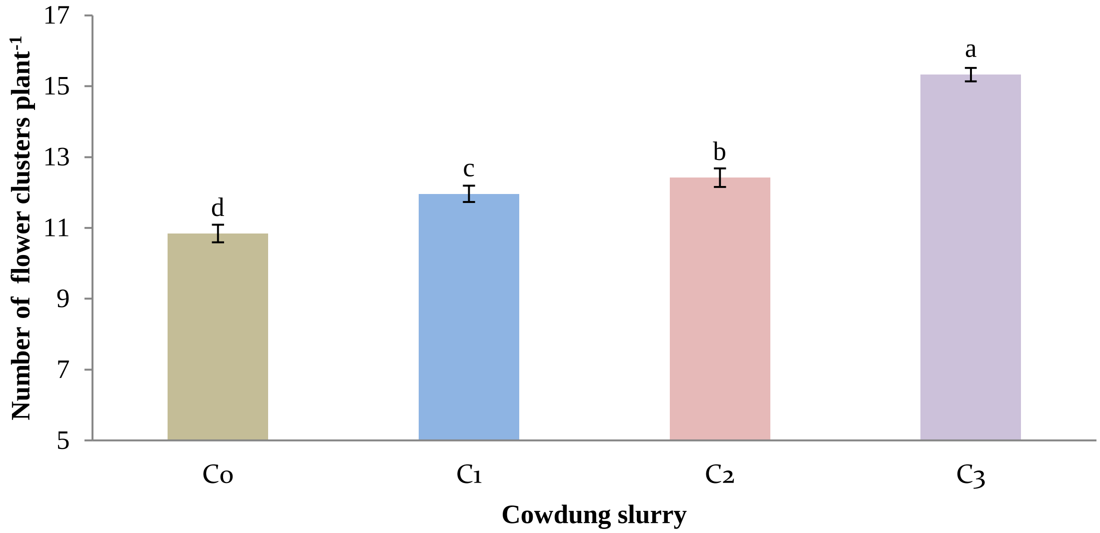


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 9. Effect of variety on number of flower clusters plant^{-1} at 60 DAT

Effect of cowdung slurry

The number of flower clusters plant^{-1} of tomato at 60 DAT was significantly affected by different concentrations cowdung slurry application (Figure 10). At 60 DAT, the C_0 treatment had the lowest number of flower clusters plant^{-1} (10.84). While the C_3 treatment had the highest number of flower clusters plant^{-1} (15.33) at 60 DAT. The differences in flower clusters plant^{-1} of tomato plants growing in the hydroponic culture system are most likely caused by the variations in nitrate and other nutrient levels between the conventional nutrient solution and the manure nutrient solution. The result obtained from the present study was similar with the findings of Sahu *et al*. (2015) who reported that the 75% RDF+ Cowdung Slurry treatment considerably improved the quantity of flowers per m^2 (17.62) in the guava cv. Sardar cultivation.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 10. Effect of cowdung slurry on number of flower clusters plant^{-1} at 60 DAT

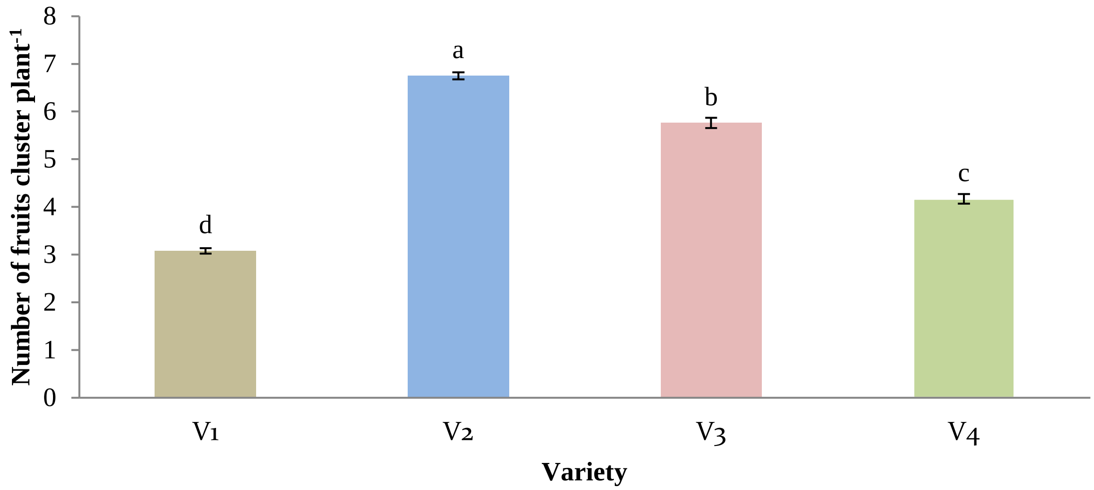
Combined effect of variety and cowdung slurry

In a hydroponic system, tomato varieties growing in various concentrations of cowdung slurry had shown significant effect on the number of flower clusters on plant^{-1} of tomato at 60 DAT (Table 4). Experimental results showed that the highest number of flower clusters plant^{-1} (18.33) at 60 DAT was found in V_2C_3 treatment combination. Whereas the lowest number of flower clusters plant^{-1} (7.67) at 60 DAT was found inV_1C_0 treatment combination.

4.6 Number of fruits cluster plant^{-1}

Effect of variety

The number of fruits clusters plant^{-1} at 80 DAT was significantly influenced by the tomato varieties grown in the hydroponic culture system (Figure 11). According to experimental findings, V_2(BARI tomato-10) had the highest fruit clusters plant^{-1} (6.75) at 80 DAT. While the V_1 cultivar had the lowest fruit clusters plant^{-1} (3.08) at 80 DAT. The diverse genetic make-up of the tomato varieties may be the cause of the variations in the number of fruit clusters on plant^{-1}. Kerketta *et al.* (2018) reported that the number of tomato fruit clusters per plant^{-1} varies depending on the genotype, and with genotype Kashi Aman having the highest fruit set per cluster (5.33) in comparison to other genotypes.

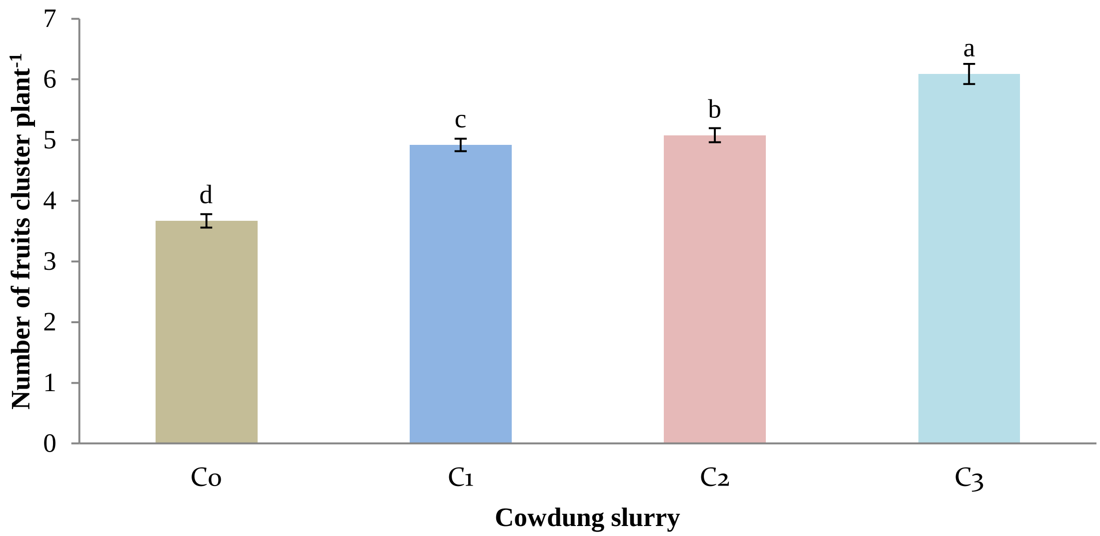


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 11. Effect of variety on number of fruits cluster plant^{-1} at 80 DAT

Effect of cowdung slurry

The number of fruits cluster plant^{-1} of the tomato was significantly influenced by the treatment of various cowdung slurry concentrations at 80 DAT (Figure 12). The results of the experiment showed that at 80 DAT, the C_3 treatment had the highest number fruit clusters (6.09). However, the C_0 treatment had the lowest fruit clusters plant^{-1} at 80 DAT (3.67). Increased cowdung slurry treatment had a substantial impact on the fruit cluster plant^{-1}, highlighting the importance of organic fertilizer in plant physiology and improving the number and quality of tomato plant development traits in hydroponic culture systems. Plants receive the essential components they require when cowdung slurry is added to a normal solution. This may enhance their capacity to absorb nutrients through their roots, resulting in greater vegetative growth and photosynthetic activities for higher yield and fruit quality. Singh *et al.* (2017) reported that application of organic manures along with biofertilizers (*Azospirillium* and P-solubilizing bacteria @ 2.5 kg/ha each) resulted maximum number of fruit clusters plant^{-1} (18.28) of tomato.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 12. Effect of cowdung slurry on number of fruits cluster plant^{-1} at 80 DAT

Combined effect of variety and cowdung slurry

The number of fruit clusters on tomato plant^{-1} at 80 DAT had significantly changed when different concentrations of cowdung slurry were used to cultivate different tomato varieties in a hydroponic culture system (Table 4). Experimental results showed that the V_2C_3 treatment combination had the highest number of fruit clusters plant^{-1} (8.67) at 80 DAT. However, at 80 DAT, the V_1C_0 treatment combination had the lowest fruit clusters plant^{-1} (2.00).

Table 4. Combined effect of variety and cowdung slurry on days to first flowering, number of flower clusters plant^{-1} and number of fruit cluster plant^{-1} of tomato

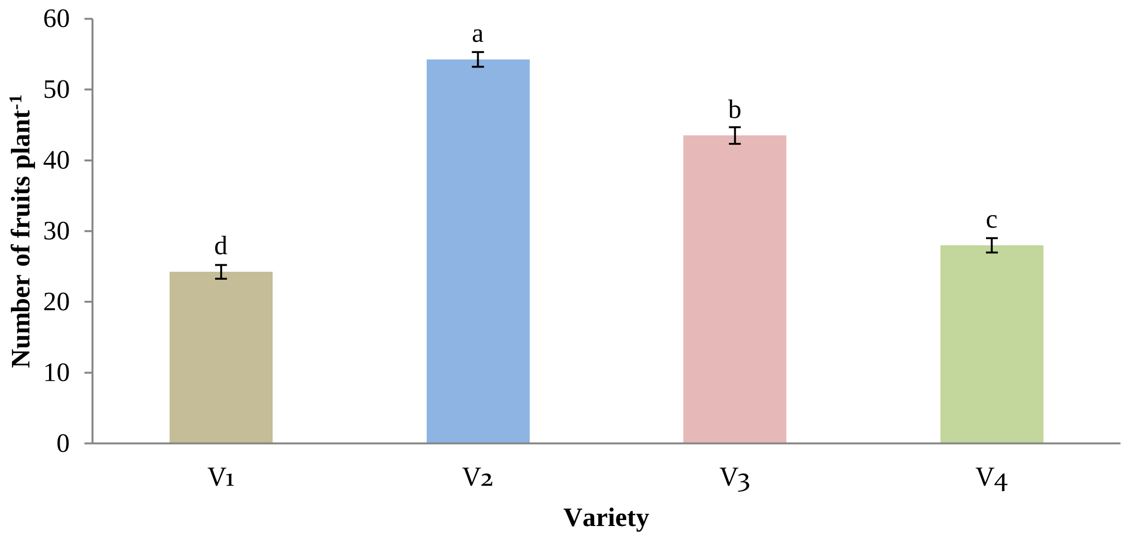
Treatment Combinations	Days to first flowering	No. flower clusters plant^{-1} (60 DAT)	No. fruits cluster plant^{-1} (80 DAT)
V_1C_0	28.67 i	7.67 k	2.00 m
V_1C_1	32.00 h	8.76 j	3.33 k
V_1C_2	32.67 h	8.67 j	3.33 k
V_1C_3	34.67 g	12.33 e	3.67 j
V_2C_0	42.34 cd	15.33 d	5.33 g
V_2C_1	43.89 bc	16.00 c	6.33 d
V_2C_2	45.45 ab	17.00 b	6.67 c
V_2C_3	46.33 a	18.33 a	8.67 a
V_3C_0	39.67 ef	10.67 h	4.36 i
V_3C_1	39.33 f	11.33 g	5.67 f
V_3C_2	41.00 de	12.33 e	6.00 e
V_3C_3	42.99 c	15.33 d	7.00 b
V_4C_0	32.67 h	9.67 i	3.00 l
V_4C_1	35.00 g	11.76 f	4.33 i
V_4C_2	35.67 g	11.67 fg	4.33 i
V_4C_3	38.67 f	15.33 d	5.00 h
$LSD_{(0.05)}$	1.61	0.42	0.15
CV(%)	2.54	2.03	1.94

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5, V_4 = Tomato line 1885, C_0 = 0 ml L^{-1} + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

4.7 Number of fruits plant^{-1}

Effect of variety

In hydroponic culture, tomato variety had shown significant effect on the number of fruits plant^{-1} (Figure 13). Experimental result revealed that the V_2 treatment contained the highest number of fruits plant^{-1} (54.25). In contrast, the V_1 treatment had the lowest number fruits plant^{-1} (24.25). The differences in number of fruits plant^{-1} might be due to the different genetic makeup of the tomato cultivars. Biswas *et al.* (2017) found similar results which supported the present finding and reported that the highest fruit yield plant^{-1} was recorded from the genotype HT-025 (2.02 kg plant^{-1}) and the lowest was recorded from the line FP-5 (1.17 kg plant^{-1}). The variation in different characters of tomato might be due to difference in cultivars used.

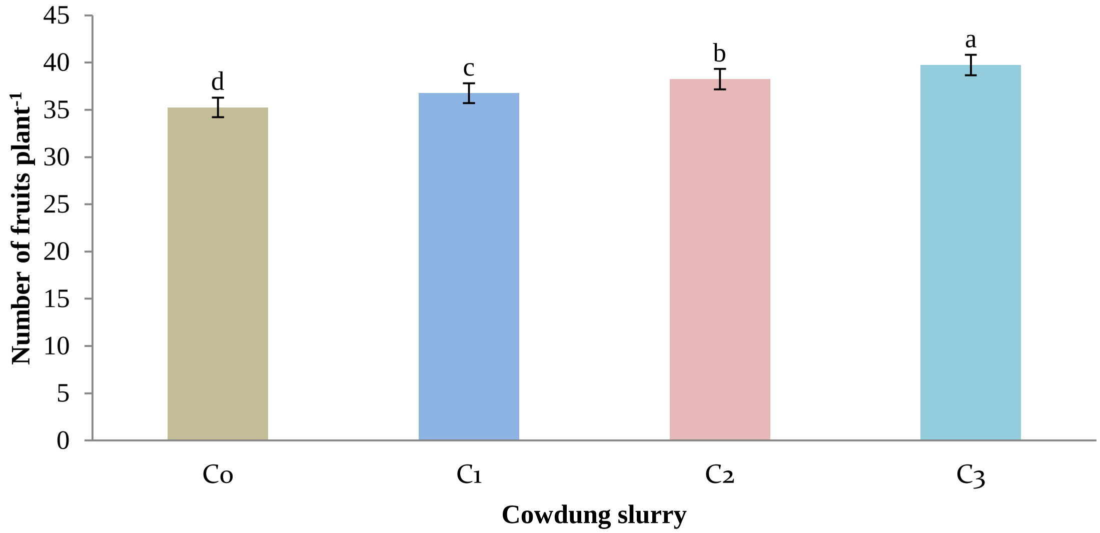


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 13. Effect of variety on number of fruits plant^{-1}

Effect of cowdung slurry

The number of fruits plant^{-1} of the tomato was significantly influenced by the treatment of various cowdung slurry concentrations (Figure 14). The results of the experiment showed that the highest number of fruits plant^{-1} (39.75) was found in C_3 treatment. While the C_0 treatment had the lowest number fruits plant^{-1} (35.25). The variation of number of fruits plant^{-1} of tomato was due to organic manure application could be attributed to improved physical and biological properties of the growing media resulting in better supply of nutrients to the plants.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 14. Effect of cowdung slurry on number of fruits plant^{-1}

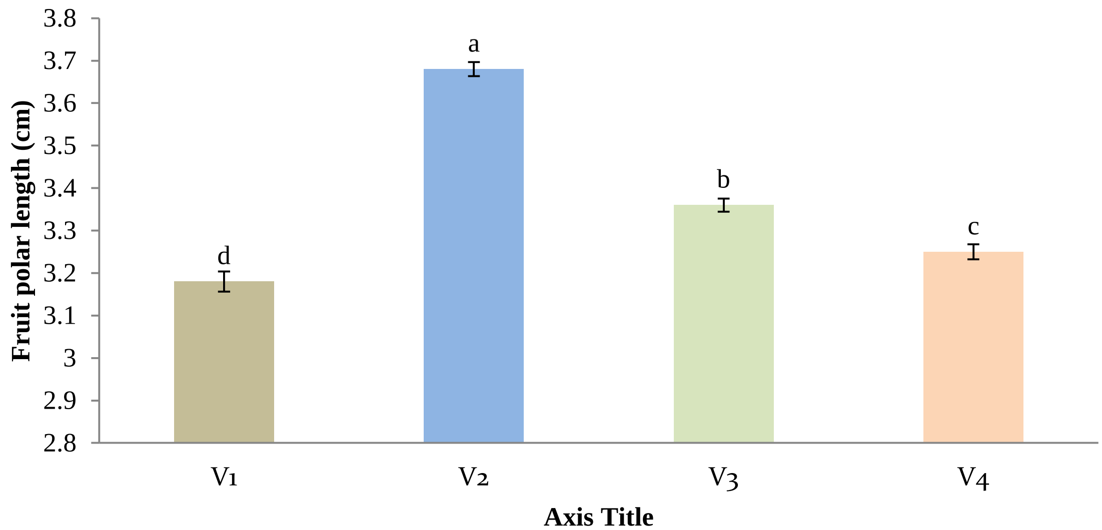
Combined effect of variety and cowdung slurry

The number of fruits plant^{-1} had shown significantly changed when different concentrations of cowdung slurry were used to cultivate different tomato varieties in a hydroponic culture system (Table 5). Experimental results showed that the V_2C_3 treatment combination had the highest number of fruit plant^{-1} (57.00) which was statistically similar with V_2C_2 (55.00) treatment combination. However, the V_1C_0 treatment combination had the lowest fruit clusters plant^{-1} (22.00) which was statistically similar with V_1C_1 (23.00) treatment combination.

4.8 Fruit polar length

Effect of variety

Tomato fruit polar length (cm) was significantly influenced by different varieties grown in a hydroponic culture system (Figure 15). Experimental result revealed that the V_2 treatment, had the highest fruit polar length (3.68 cm). While the shortest fruit polar length (3.18 cm) was found in V_1 treatment. Because of the genetic potential of the tomato varieties, there was a large differences in fruit polar length. Similar findings were obtained in Sanjida *et al*. (2020) investigation, and they suggested that the summer tomato varieties' varied genetic make-up may be the cause of the noticeable variances in fruit length and fruit breadth.

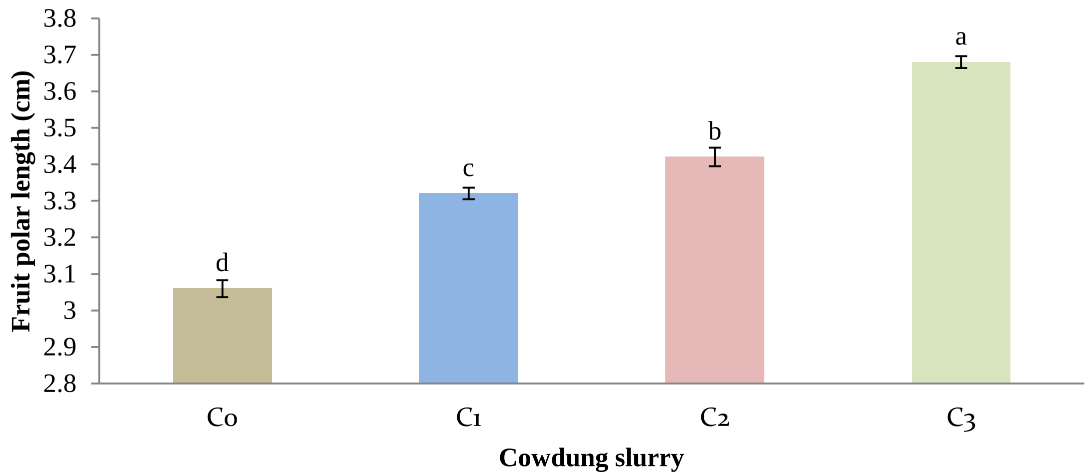


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 15. Effect of variety on fruit polar length of tomato

Effect of cowdung slurry

Different levels of cowdung slurry significantly influenced on the fruit polar length (cm) of tomato (Figure 16). The highest fruit polar length (3.68 cm) was found in C_3 treatment. While the lowest fruit polar length (3.06 cm) was found in C_0 treatment. This might be the case because the plants' vegetative growth was influenced by the presence of cowdung slurry in the growing medium when it was properly mixed with standard solution. A larger plant with more leaves was formed as a result of the higher cowdung slurry concentration, which may have increased photosynthetic activity and generated enough food for plant growth and fruit enlargement. The result was quite similar with the findings of Hossain *et al.* (2019) who founded that the treatments T_4 (70 % NK+poultry manure bioslurry) and T_6 (70%NK+poultry manure) had the highest plant height; unfold leaves, length of breath, polar length, root length, head diameter, % marketable head, marketable head weight, head yield, and N, P, K & S uptake by the crops significantly produced higher crop yield over sole chemical fertilizers (T_2: 100 % NPKS).



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 16. Effect of cowdung slurry on fruit polar length of tomato

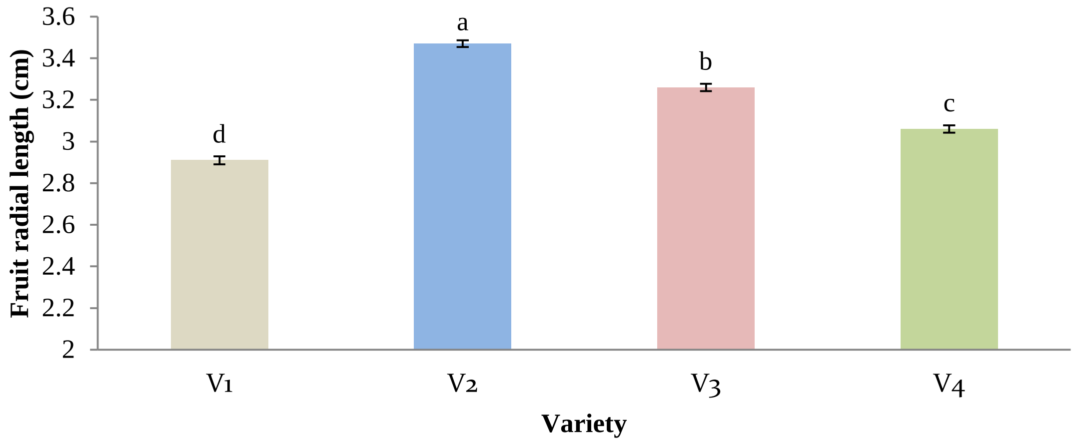
Combined effect of variety and cowdung slurry

Tomato plants grown in a hydroponic system at different varieties and varying levels of cowdung slurry concentrations had shown significant effect on the polar length of the fruit of tomato (Table 5). V_2C_3 treatment combination had the longest fruit polar length (3.89 cm), which was statistically similar to V_2C_2 treatment combination (3.86 cm). In contrast, the V_1C_0 treatment combination had the shortest fruit polar length (2.87 cm) which was statistically similar to V_4C_0 treatment combination (2.92 cm).

4.9 Fruit radial length

Effect of variety

Tomato varieties growing in hydroponic culture significantly varying fruit radial length (cm) of tomato (Figure 17). The highest fruit radial length (3.47 cm) was found in V_2 treatment. While the lowest fruit radial length (2.91 cm) was found in V_1 treatment. The significant variation in relation to fruit radial length was probably due to the genetic potentiality of the tomato cultivars. Ali *et al.* (2012) found maximum fruit diameter (5.19 cm) and minimum fruit diameter (4.50 cm) in tomato hybrids T-7010 and PTM-1603 respectively during studying the performance of various tomato hybrids.

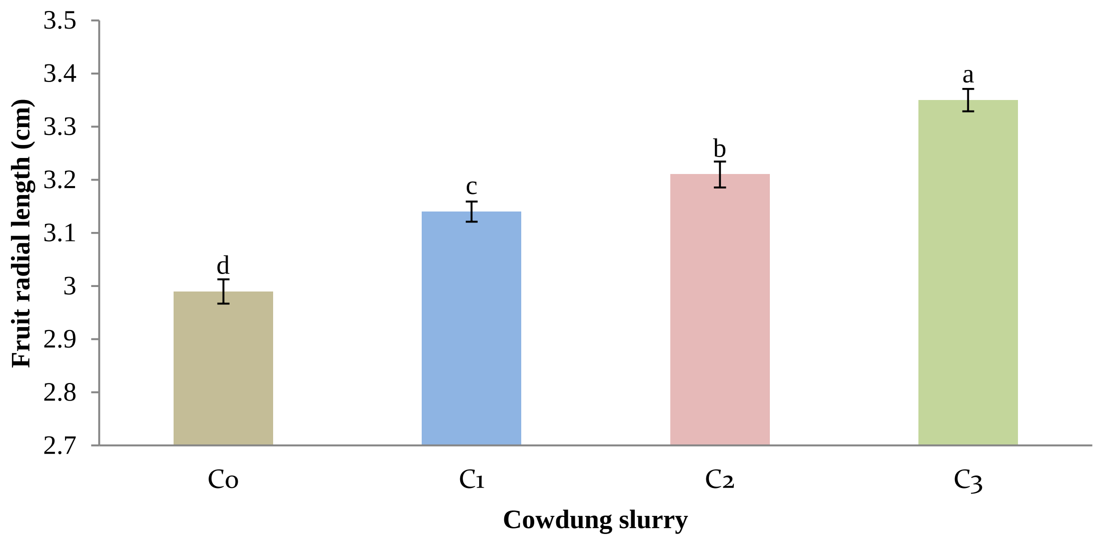


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 17. Effect of variety on fruit polar radial of tomato

Effect of cowdung slurry

The fruit radial length (cm) of tomato was significantly influenced by different amounts of cowdung slurry application (Figure 18). Experimental result showed that, the C_3 treatment yielded the longest fruit radial length (3.35 cm). While the C_0 treatment had the shortest fruit polar length (2.99 cm). These outcomes may be accounted for by the fact that high cowdung slurry application improved plant water potential and nutrient availability, both of which affect water flow into fruits and cause fruit enlargement. Nasir *et al.* (2010) revealed that in cob length of maize increased where biogas slurry was applied.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 18. Effect of cowdung slurry on fruit polar radial of tomato

Combined effect of variety and cowdung slurry

Tomato plants grown in a hydroponic system at different varieties along with different levels of cowdung slurry application had shown significant effect on the fruit radial length of tomato (Table 5). The V_2C_3 treatment combination had the longest fruit radial length (3.70 cm), which was statistically similar to V_2C_2 treatment combination (3.58 cm). The V_1C_0 treatment combination, on the other hand, had the smallest fruit radial length (2.77 cm), which was statistically equivalent to the V_1C_1 (2.84 cm), V_1C_2 (2.89 cm) and V_4C_0 (2.82 cm) treatment combination.

Table 5. Combined effect of variety and cowdung slurry levels on number of fruits plant^{-1}, fruit polar and radial length of tomato

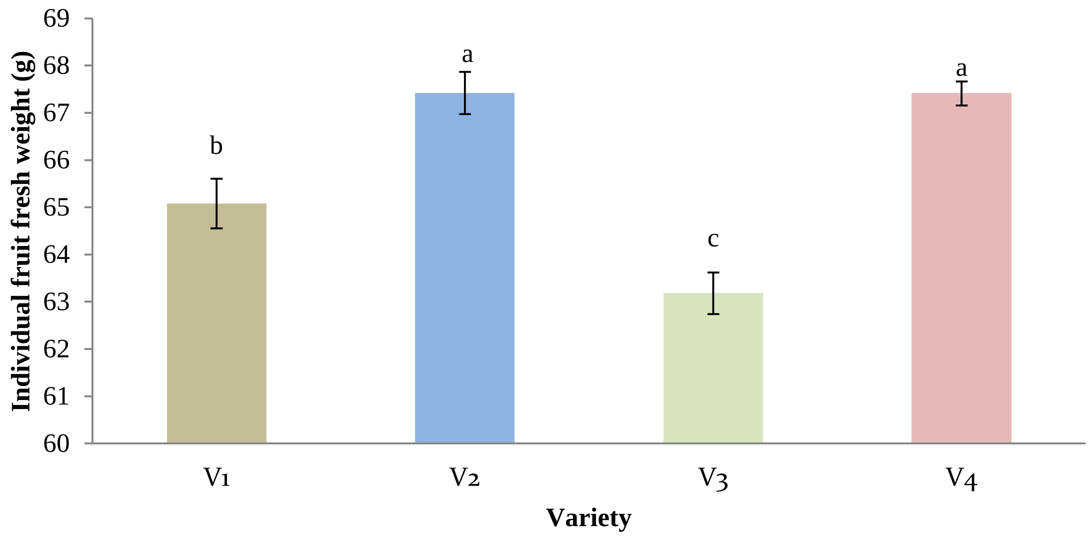
Treatment Combinations	No. of fruits plant^{-1}	Fruit polar length (cm)	Fruit radial length (cm)
V_1C_0	22.00 j	2.87 l	2.77 h
V_1C_1	23.00 ij	3.14 j	2.84 h
V_1C_2	25.00 hi	3.19 ij	2.89 h
V_1C_3	27.00 gh	3.51 de	3.13 e-g
V_2C_0	52.00 c	3.44 ef	3.22 d-f
V_2C_1	53.00 bc	3.54 cd	3.36 b
V_2C_2	55.00 ab	3.86 a	3.58 a
V_2C_3	57.00 a	3.89 a	3.70 a
V_3C_0	40.00 f	3.00 k	3.14 e-g
V_3C_1	43.00 e	3.34 gh	3.25 b-e
V_3C_2	45.00 de	3.41 fg	3.30 b-d
V_3C_3	46.00 d	3.69 b	3.35 bc
V_4C_0	27.00 gh	2.92 kl	2.82 h
V_4C_1	28.00 g	3.26 hi	3.11 fg
V_4C_2	28.00 g	3.21 ij	3.06 g
V_4C_3	29.00 g	3.61 bc	3.23 c-f
$LSD_{(0.05)}$	2.14	0.08	0.12
CV(%)	3.43	1.45	2.32

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5, V_4 = Tomato line 1885, C_0 = 0 ml L^{-1} + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

4.10 Individual fruit fresh weight

Effect of variety

Different tomato cultivars considerably altered the individual fruit weight (g) in a hydroponic growth system (Figure 19). Results of the experiment showed that the V_2 treatment, which was statistically equal to the V_4 (67.41 g). treatment, had the highest individual fresh fruit weight (67.42 g). The V_3 treatment had the lowest individual fresh fruit weight (63.18 g). The findings of Shah *et al*. (2021), who showed that tomato cultivars varied in fresh weight, were consistent with the findings of the current investigation.

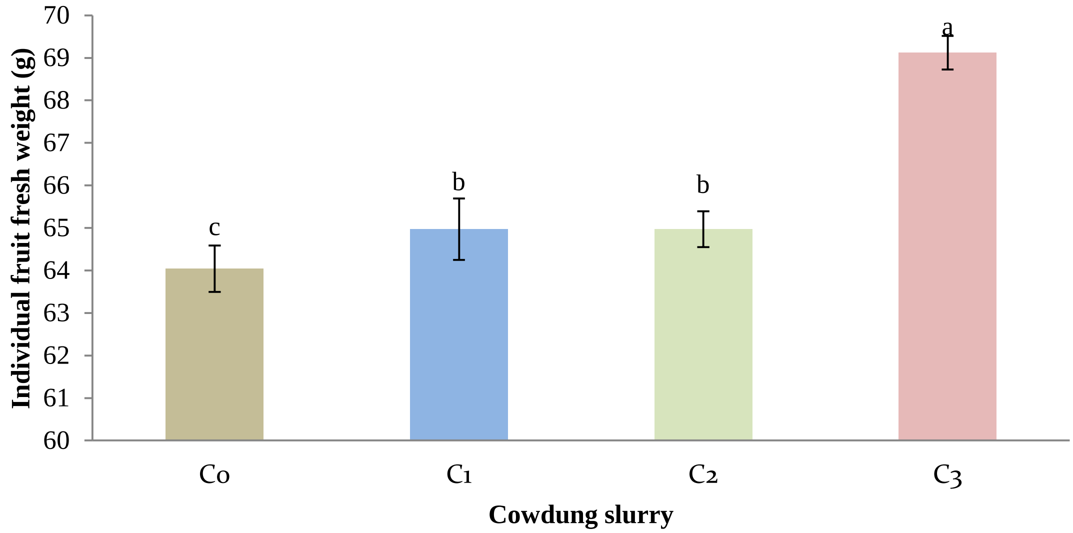


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 19. Effect of variety on individual fruit fresh weight of tomato

Effect of cowdung slurry

Different levels of cowdung slurry application significantly influenced individual tomato fruit fresh weight (g) in a hydroponic growing system (Figure 20). According to the experimental results, C_3 treatment had the highest individual fruit fresh weight of tomato (69.12 g). While C_0 had the lowest individual fruit fresh weight of tomato (64.04 g). Cowdung slurry was readily available and in the best form for easy absorption by the plant roots, hence there was a boost in the morphological growth of the plant result in increased individual fruit weight of tomato. Meena *et al.* (2017) reported that application of inorganic fertilizer along with organic fertilizer resulted maximum average fresh fruit weight (64.94 g) of tomato cv. Pusa Sheetal.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 20. Effect of cowdung slurry on individual fruit fresh weight of tomato

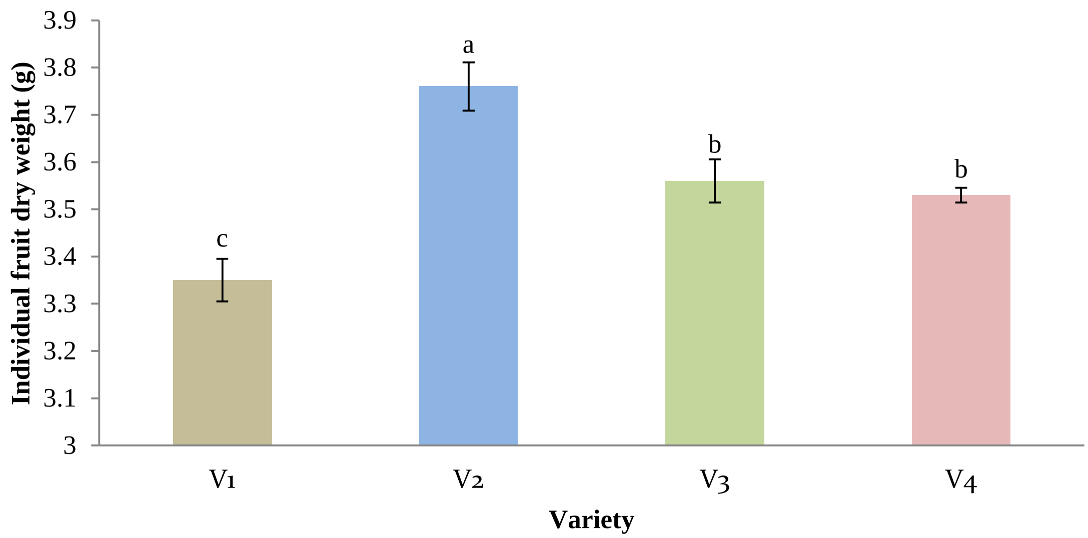
Combined effect of variety and cowdung slurry

Different varieties of tomato plants grown in a hydroponic system, together with various applications of cowdung slurry, had demonstrated significant effect on the individual fruit fresh weight of tomato (Table 6). The V_2C_3 treatment combination, which was statistically equal to the V_4C_3 (70.46 g) treatment combination, had the highest individual fruit fresh weight (70.47 g). Although the V_3C_0 treatment combination's had shown the lowest individual fruit fresh weight (60.98 g), which was statistically equivalent to the V_3C_1 treatment combination (61.23 g).

4.11 Individual fruit dry weight

Effect of variety

In a hydroponic growth system, various tomato varieties significantly influenced the individual fruit dry weight (g) of tomato (Figure 21). The experiment's findings revealed that the V_2 treatment had the highest weight of individual dry fruit (3.76 g). While the V_1 treatment had the lowest individual fruit dry weight of tomato (3.35 g).

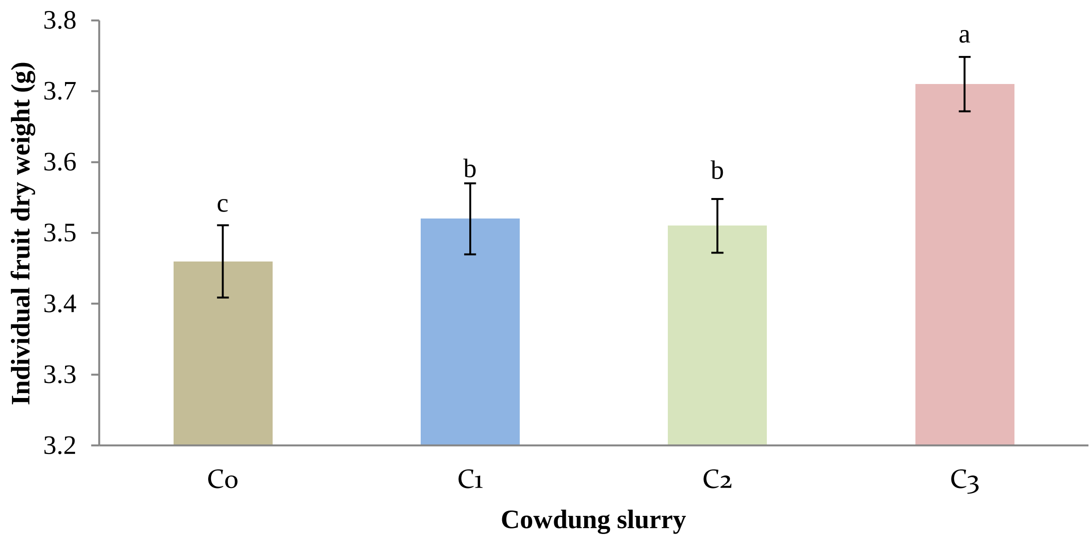


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 21. Effect of variety on individual fruit dry weight of tomato

Effect of cowdung slurry

Individual tomato fruit dry weight (g) was significantly influenced by different levels of cowdung slurry application in a hydroponic growing system (Figure 22). Experimental result revealed that, the C_3 treatment had the highest individual fruit dry weight of tomato, (3.71 g). While the C_0 treatment had the lowest individual fruit dry weight of tomato (3.46 g). This finding suggested that the application of cowdung slurry affected the dry weight of each tomato fruit and may have significantly contributed to healthy root growth and development through optimum nutrient uptake by the crop plants.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 22. Effect of cowdung slurry on individual fruit dry weight of tomato

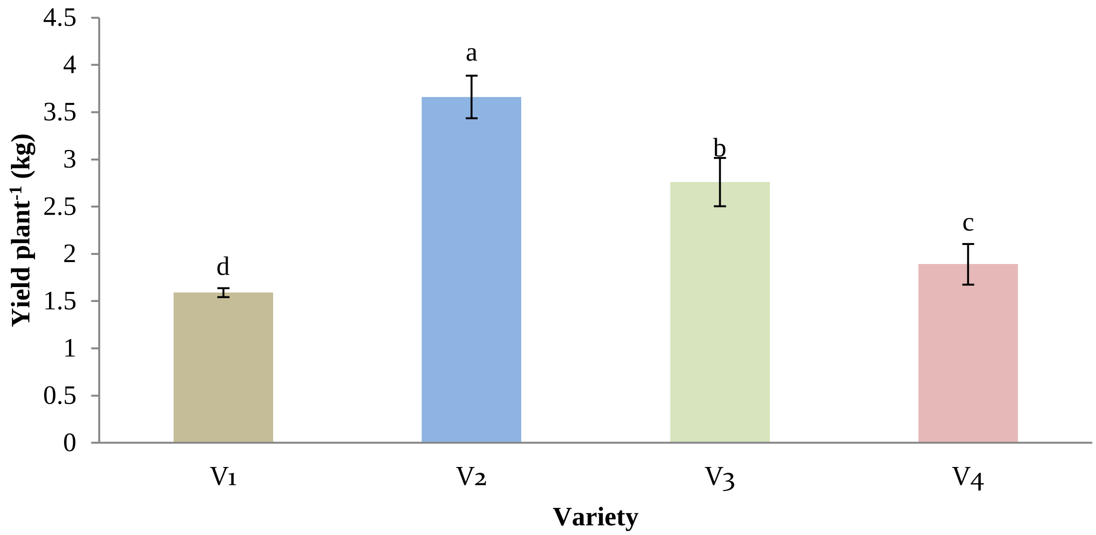
Combined effect of variety and cowdung slurry

Significant effect on the dry weight of individual fruits was seen in tomato varieties cultivated in a hydroponic system together with varied applications of cowdung slurry (Table 6). Experimental result showed that individual fruit dry weight was highest in the V_2C_3 treatment combination (3.93 g). While the V_1C_0 treatment combination had the lowest individual fruit dry weight (3.19 g), which was statistically equivalent to the V_1C_1 treatment combination (3.26 g).

4.12 Yield plant^{-1}

Effect of variety

The yield plant^{-1} (kg) of tomato varietals grown under hydroponic culture varied significantly (Figure 23). According to experimental findings, the V_2 treatment had the highest yield plant^{-1} (3.66 kg). While the V_1 treatment had the lowest yield plant^{-1} (1.59 kg), The genetic potential of the tomato varieties was likely the cause of the large difference in relation to yield plant^{-1}. The findings of Singh *et al*. (2013), who indicated that Avinash-23 recorded the highest yield per plant of 2.90 kg followed by Richa with a yield of 2.88 kg, were consistent with the results of the current study.

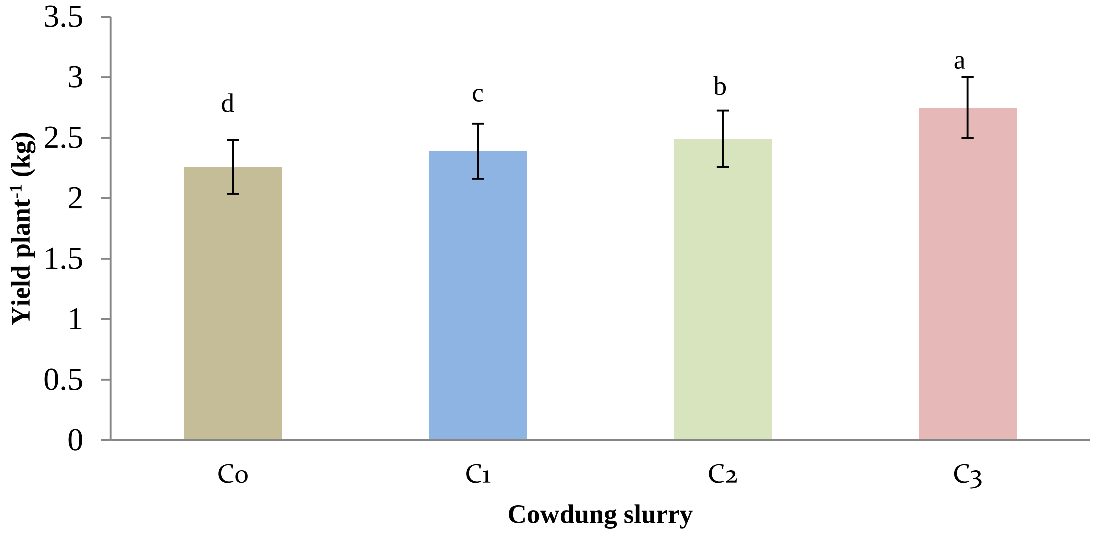


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 23. Effect of variety on yield plant^{-1} tomato

Effect of cowdung slurry

Different levels of cowdung slurry application had shown significant effect on yield plant^{-1} of tomato (kg) in a hydroponic growing system (Figure 24). The results of the experiment showed that the C_3 treatment had the highest yield plant^{-1} (2.75 kg). Yield plant^{-1} of tomato was lowest (2.26 kg) in the C_0 treatment. The tremendous increase in the yield and its components of the crop recorded as a result of cowdung slurry application as a source of manure could be attributed to the its beneficial role in improving growing media physical conditions and to its nutrients content. Spehia *et al.* (2020) reported that cowdung in growing media has improved nutrient uptake and utilization throughout the growing phase to ensure better vegetative growth and photosynthetic activities for higher yield and fruit quality of tomato.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 24. Effect of cowdung slurry on yield plant^{-1} tomato

Combined effect of variety and cowdung slurry

Combined effect of variety and cowdung slurry had shown significant effect on the yield plant^{-1} of tomato in a hydroponic growing system (Table 6). Experimental result showed that the V_2C_3 treatment combination had the highest yield plant^{-1} for tomatoes (4.02 kg). While plant^{-1}'s yield was lowest when in the V_1C_0 treatment combination was used (1.40 kg) which was statistically comparable with V_1C_1 (1.49 kg) treatment combination.

Table 6. Combined effect of variety and cowdung slurry on on individual fruit fresh weight, dry weight and yield plant^{-1} of tomato

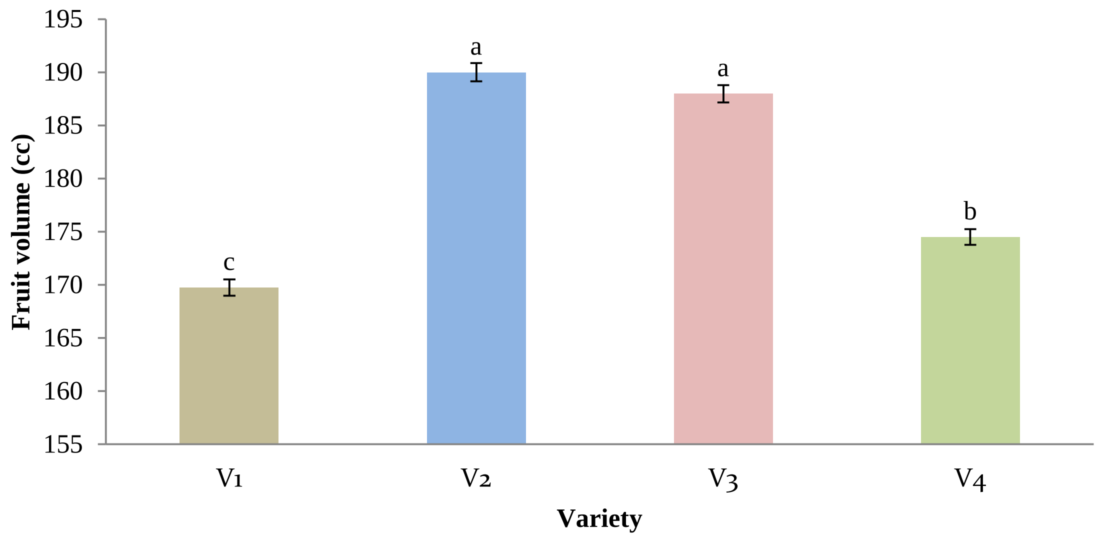
Treatment Combinations	Individual fruit fresh weight (g)	Individual fruit dry weight (g)	Yield plant^{-1} (kg)
V_1C_0	63.42 fg	3.19 i	1.40 k
V_1C_1	64.74 ef	3.26 hi	1.49 jk
V_1C_2	64.04 fg	3.33 h	1.62 ij
V_1C_3	68.13 b	3.60 de	1.84 h
V_2C_0	65.76 c-e	3.68 b-d	3.42 c
V_2C_1	67.08 b-d	3.75 b	3.56 bc
V_2C_2	66.38 c-e	3.66 cd	3.65 b
V_2C_3	70.47 a	3.93 a	4.02 a
V_3C_0	60.98 h	3.52 ef	2.45 f
V_3C_1	61.23 h	3.52 ef	2.63 f
V_3C_2	63.07 g	3.60 de	2.84 e
V_3C_3	67.42 bc	3.61 d	3.10 d
V_4C_0	65.75 de	3.45 fg	1.78 hi
V_4C_1	67.07 b-d	3.52 ef	1.88 gh
V_4C_2	66.37 c-e	3.43 g	1.86 gh
V_4C_3	70.46 a	3.70 bc	2.04 g
$LSD_{(0.05)}$	1.66	0.08	0.19
CV(%)	2.18	2.07	3.21

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5, V_4 = Tomato line 1885, C_0 = 0 ml L^{-1} + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

4.13 Fruit volume

Effect of variety

Hydroponically grown tomato cultivars had shown significant effect on tomato fruit volume (cc) (Figure 25). The maximal fruit volume (190.00 cc), which was discovered in the V_2, was statistically comparable to the V_3 (187.98 cc). While V_1, had the smallest fruit volume (169.75 cc). The genetic make-up of the crop and the environmental factors, which have a significant impact on how well the crop performs, were the causes of the variance in fruit volume.

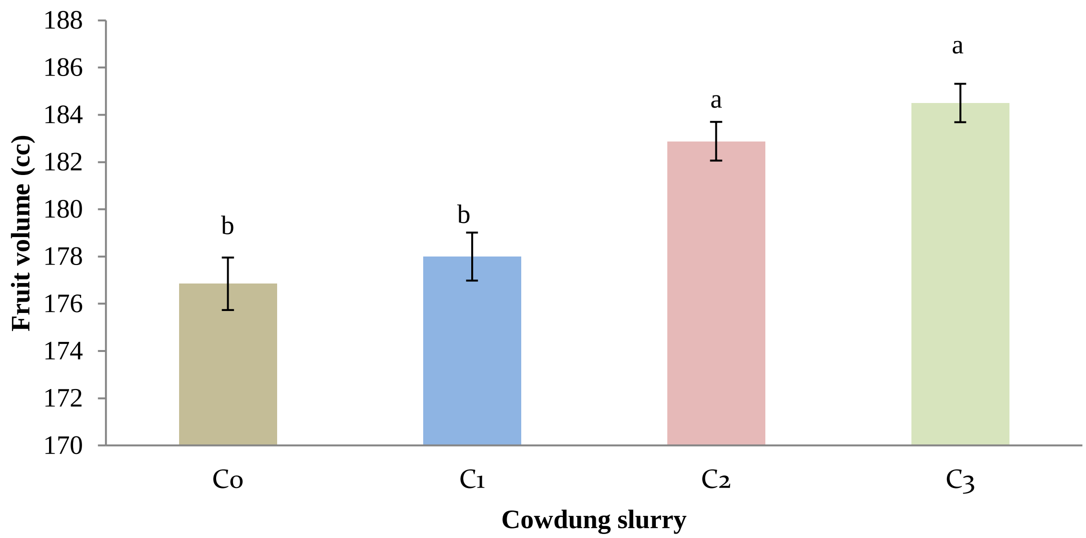


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 25. Effect of variety on fruit volume of tomato

Effect of cowdung slurry

The fruit volume (cc) of tomatoes produced by hydroponically grown tomatoes at various levels of cowdung slurry application was significantly differed (Figure 26). According to the experimental findings, the C_3 treatment had the highest fruit volume (184.50 cc) which was statistically comparable to the C_2 treatment (182.88 cc). The C_0 treatment on the other hand had the lowest fruit volume (176.85 cc) which was statistically comparable to the C_1 treatment (178.00 cc).



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 26. Effect of cowdung slurry on fruit volume of tomato

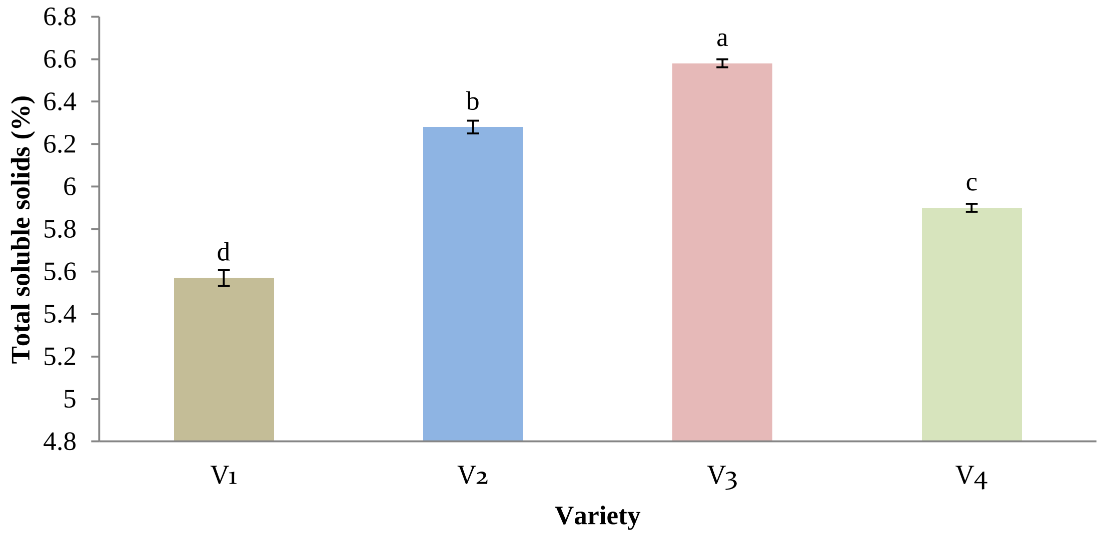
Combined effect of variety and cowdung slurry

Combined effect of variety and cowdung slurry had shown significant effect on the fruit volume of tomato in a hydroponic growing system (Table 7). Experimental result showed that the V_2C_3 treatment combination had the highest fruit volume (192.50 cc) which was statistically comparable with V_2C_0 (190.50 cc), V_2C_1 (188.50 cc), V_2C_0 (188.50 cc), V_3C_2 (189.00 cc) and V_3C_3 (190.50 cc) treatment combination. While fruit volume was lowest when in the V_1C_0 treatment combination was used (164.50 cc) which was statistically comparable with V_1C_1 (166.50 cc) treatment combination.

4.14 Total soluble solids (%)

Effect of variety

The total soluble solids (%) of tomatoes was significantly influenced by tomato varieties when grown in hydroponic culture (Figure 27). Results of the experiment showed that the V_3 treatment had the highest amount of total soluble solids (6.58%). While the V_1 treatment had the lowest total soluble solids (5.57%). The genetic make-up of the crop and the environmental factors, which have a significant impact on how well the crop performs, caused the variance in total soluble solids. Similar findings were made by Sanjida *et al.* (2020), who showed that for summer tomato varieties, V_2 (BARI hybrid tomato 8) had the highest total soluble solids (TSS) (5.41%), while V_1 had the lowest total soluble solids (4.97%) (BARI hybrid tomato 4). variation was due to the varietal effect of different cultivars.

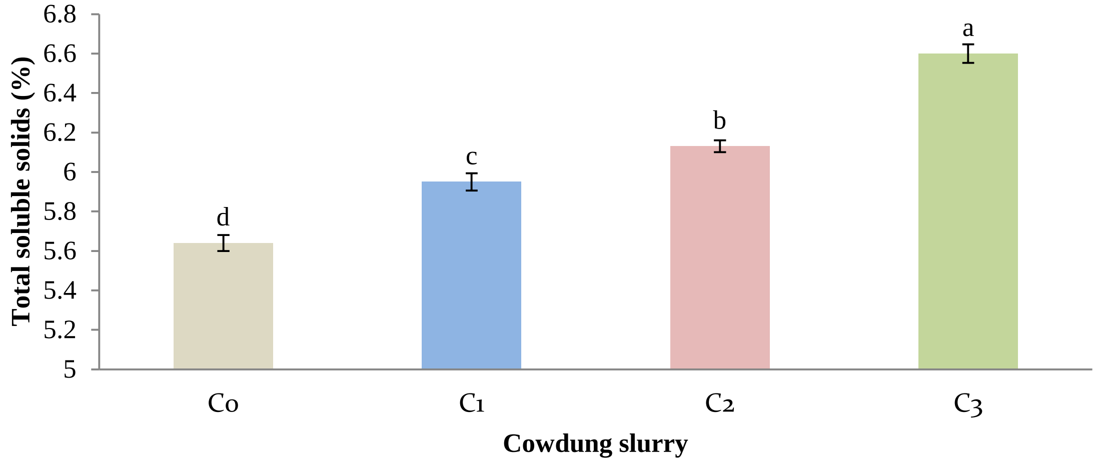


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 27. Effect of variety on total soluble solids of tomato

Effect of cowdung slurry

The total soluble solids of tomatoes produced by hydroponically grown tomatoes at various levels of cowdung slurry application was significantly differed (Figure 28). According to the experimental findings, the C_3 treatment had the highest total soluble solids (6.60 %). While the C_0 treatment had the lowest total soluble solids (5.64 %). The addition of cowdung slurry to a standard solution in a hydroponic growing system encourages the progressive breakdown of complex nitrogenous compounds and produces a consistent supply of N. The tomato plant may have produced more fruit as a result of increased N availability and subsequent uptake through the root system of the plant. Yu *et al.* (2010) also found similar result which supported the present finding and reported that application of concentrated slurry could bring significant changes to tomato cultivation, including increases in organic matter, available N, P, and K, total N and P, electrical conductivity, and fruit contents of amino acids, protein, soluble sugar, β-carotene, tannins, and vitamin C, together with the R/S ratios and the culturable counts of bacteria, actinomycetes, and fungi in soils.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 28. Effect of cowdung slurry on total soluble solids of tomato

Combined effect of variety and cowdung slurry

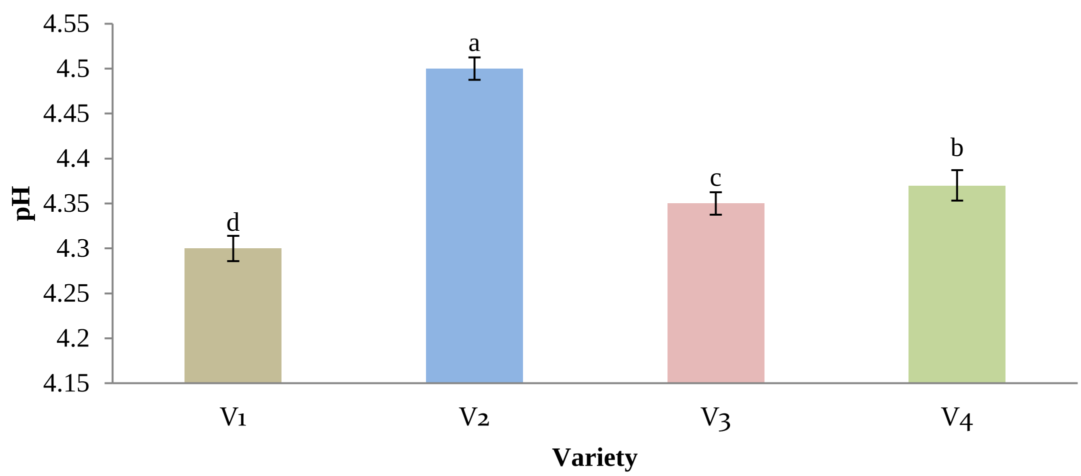
In a hydroponic growth system, the combination of variety and cowdung slurry had shown significant effect on the tomato's total soluble solids (Table 7). According to experimental findings the V_2C_3 treatment combination exhibited the highest levels of total soluble solids (192.50 cc). While using the V_1C_0 treatment combination resulted in the lowest total soluble solids (164.50 cc).

4.15 pH

Influence of variety

Different tomato cultivars growing in hydroponic culture system had shown significant effect on pH of tomato (Figure 29). Experimental results revealed that, the maximum pH (4.50) was found in V_2 treatment. While the lowest pH (4.30) was found in V_1 treatment.

Spaldon and Hussain (2017) found similar result with the present study and reported that varietal character might influence the variations of pH in tomato genotypes. With respect to the quality traits, Arka Vikas variety reported highest fruit pH (4.49) and beta-carotene content (7.06mg/100g).

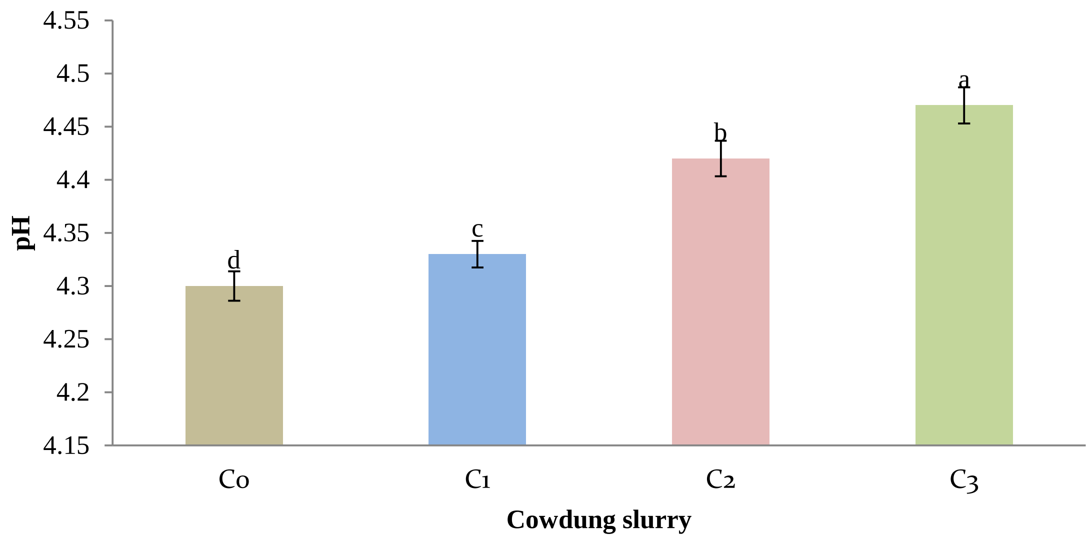


Here, V_1 = BARI tomato-4, V_2 = BARI toamto-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 29. Influence of variety on pH of tomato

Effect of cowdung slurry

In hydroponic culture system's tomato, pH was significantly influenced by the use of cowdung slurry (Figure 30). The experiment's findings showed that the C_3 treatment had the highest pH (4.47). While the pH was lowest in the C_0 treatment (4.30). This may be because organic residues from plants or animals introduced to the growth medium generate organic anions that balance the hydrogen ion of the acidic medium. Nabel *et al.* (2017) reported that the application of biogas slurry as fertilizer could enhance carbon content, water holding capacity, pH and fertility of soils.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 30. Effect of cowdung slurry on pH of tomato

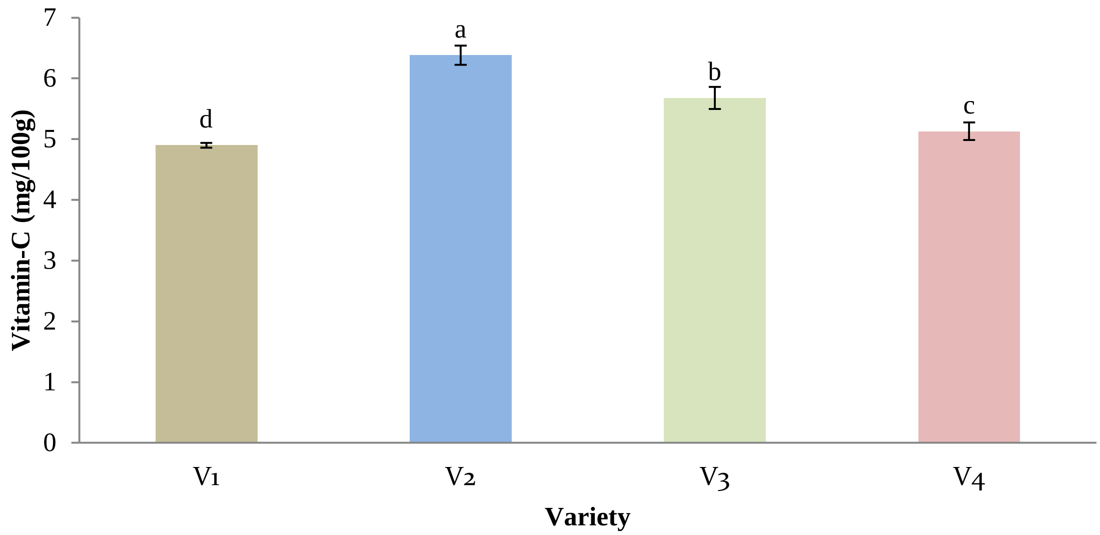
Combined effect of variety and cowdung slurry

The combination of variety and cowdung slurry had shown significant effect on the pH of the tomato in a hydroponic growth system (Table 7). Experimental results showed that the V_2C_3 treatment combination had the highest pH (4.68), which was statistically equivalent to the V_2C_2 treatment combination's (4.68). On the other hand the V_1C_0 treatment combination had the lowest pH, though (4.23).

4.16 Vitamin-C

Influence of variety

The vitamin-C content of tomatoes produced by various tomato varieties grown in a hydroponic cultivation technique varied significantly (Figure 31). The highest vitamin-C concentration (6.38 mg/100g), according to experimental findings, was discovered in the V_2 treatment. While the V_1 treatment had the lowest amount of vitamin C (4.90 mg/100g). The variation in vitamin c concentration was brought on by the crop's genetic makeup and environmental conditions, both of which have a big impact on how well the crop performs. Kanaujia and Phom (2016) revealed that different genotype of tomato varies vitamin-C concentration and the genotype 2013/TODVAR-1 recorded maximum fruit yield (32.59 t/ha) and vitamins C content (74.58 mg/ 100g of fruit).

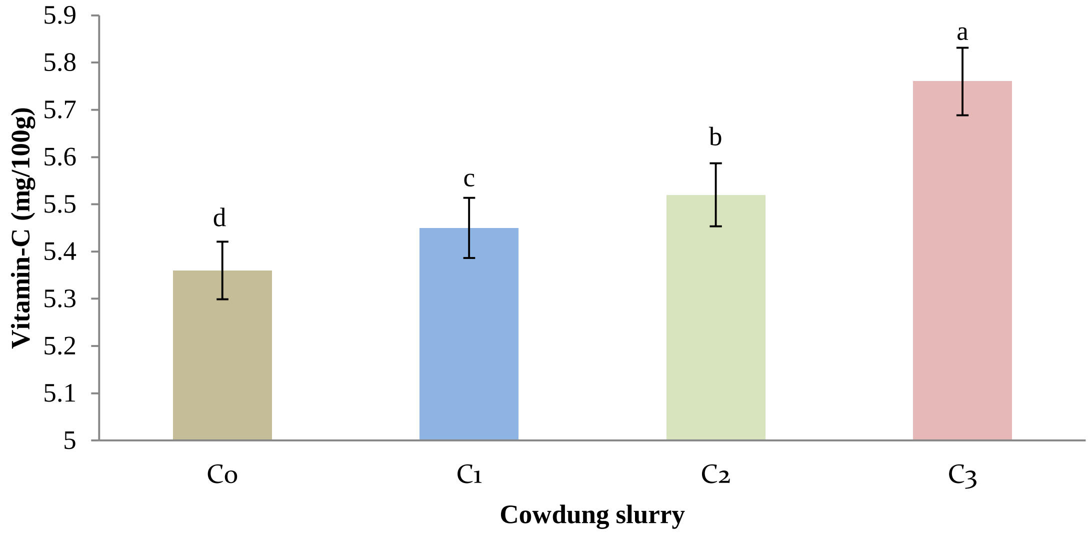


Here, V_1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5 and V_4 = Tomato line 1885.

Figure 31. Influence of variety on vitamin-c content of tomato

Effect of cowdung slurry

The use of cowdung slurry had shown significant effect on the tomato vitamins C concentration in the hydroponic growing system (Figure 32). The results of the trial revealed that the C_3 treatment had the highest vitamin C (5.76 mg/100g) content. While the C_0 treatment's vitamin C concentration was the lowest (5.36 mg/100g). Yu *et al.* (2010) reported that application of concentrated slurry could bring significant changes to tomato cultivation, including increases in organic matter, available N, P, and K, total N and P, electrical conductivity, and fruit contents of amino acids, protein, soluble sugar, β-carotene, tannins, and vitamin C, together with the R/S ratios and the culturable counts of bacteria, actinomycetes, and fungi in soils.



Here, C_0 = 0 ml L^{-1} cowdung slurry + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

Figure 32. Effect of cowdung slurry on vitamin-c content of tomato

Combined effect of variety and cowdung slurry

The combination of variety and cowdung slurry had shown significant effect on the vitamins C content of the tomato grown in a hydroponic system (Table 7). Experimental results showed that the V_2C_3 treatment combination had the highest vitamins C content (6.68 mg/100g). On the other hand the V_1C_0 treatment combination had the lowest vitamins C content (4.78 mg/100g) which was statistically similar with V_1C_1 (4.83 mg/100g) and V_1C_2 (4.87 mg/100g) treatment combination

Table 7. Combined effect of variety and cowdung slurry on volume, total soluble solids, pH and vitamin-c content of tomato

Treatment Combinations	Volume (cc)	Total soluble solids (%)	pH	Vitamin-C (mg/100g)
V_1C_0	164.50 h	5.10 i	4.23 f	4.78 j
V_1C_1	166.50 gh	5.40 h	4.29 e	4.83 j
V_1C_2	172.50 ef	5.83 fg	4.33 de	4.87 j
V_1C_3	175.50 de	5.96 ef	4.35 cd	5.13 i
V_2C_0	188.50 a-c	5.77 g	4.32 de	6.18 c
V_2C_1	188.50 a-c	6.01 e	4.35 cd	6.30 b
V_2C_2	190.50 ab	6.05 e	4.64 a	6.35 b
V_2C_3	192.50 a	7.27 a	4.68 a	6.68 a
V_3C_0	184.90 c	6.27 d	4.32 de	5.45 g
V_3C_1	187.50 bc	6.57 c	4.35 cd	5.56 f
V_3C_2	189.00 ab	6.59 c	4.35 cd	5.74 e
V_3C_3	190.50 ab	6.87 b	4.38 c	5.98 d
V_4C_0	169.50 fg	5.43 h	4.32 de	5.04 i
V_4C_1	169.50 fg	5.83 fg	4.34 cd	5.12 i
V_4C_2	179.50 d	6.03 e	4.35 cd	5.10 i
V_4C_3	179.50 d	6.31 d	4.48 b	5.26 h
$LSD_{(0.05)}$	4.07	0.16	0.04	0.09
CV(%)	1.35	1.63	1.56	1.00

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability. Here, In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability In the bar graph having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probabilityV1 = BARI tomato-4, V_2 = BARI tomato-10, V_3 = BARI tomato-5, V_4 = Tomato line 1885, C_0 = 0 ml L^{-1} + standard solution, C_1 = 100 ml L^{-1} + standard solution, C_2 = 150 ml L^{-1} + standard solution and C_3= 200 ml L^{-1} + standard solution.

CHAPTER V

SUMMARY AND CONCLUSION

The experimental results revealed that different varieties and cow dung slurry greatly influenced the growth, yield and quality parameters of tomato. In case of different variety the lowest yield plant^{-1} (1.59 kg) was obtained from V_1(BARI tomato-4). Whereas cultivating V_2(BARI tomato-10) had the highest number of flower clusters plant^{-1} (16.67), fruits cluster plant^{-1} (6.75), fruits plant^{-1} (54.25), fruit polar length (3.68 cm), fruit radial length (3.47 cm), individual fruit fresh weight (67.42 g), fruit dry weight (3.76 g), yield plant^{-1} (3.66 kg), volume (190.00 cc) and pH value (4.50) while V_3(BARI tomato-5)contained the highest total soluble solids (6.58 %). In case of different levels of cowdung slurry application with standard nutrient solution differences the plant yield ranges between (1.56 -1.96 kg plant^{-1}). The highest yield plant^{-1} (2.75 kg) was recorded in C_3 (200 ml L^{-1} cowdung slurry + standard solution) treated pot which was due to enhanced yield attributes like flower clusters plant^{-1} (15.33), fruits cluster plant^{-1} (6.09), fruits plant^{-1} (39.75), fruit polar length (3.68 cm), fruit radial length (3.35 cm), individual fruit fresh weight (69.12 g), fruit dry weight (3.71 g). In case of combination, cultivating of BARI tomato-10 (V_2) along with (C_3) 200 ml L^{-1} cowdung slurry + standard solution treated pot affected plant growth, yield and quality parameters, leading to the maximum plant yield (4.02 kg) than compared to other treatment combination.

Conclusions

According to the findings of the present experiment, the following conclusions were drawn.

i. Higher fruit yield and other vegetative growth parameters and physiological traits of tomato were found in BARI tomato-10 variety.

ii. In the 200 ml L^{-1} cowdung slurry + standard solution (C_3) treated pot, a higher fruit production as well as other vegetative growth parameters and physiological features of tomato were observed.

iii. In case of combination, cultivating of BARI toamto-10 (V_2) along with (C_3) 200 ml L^{-1} cowdung slurry + standard solution treated pot performed best for achieving higher yield (4.02 kg) and quality of tomato, comparable to others treatment combinations in hydroponic culture.

Therefore, it can be concluded that in a hydroponic system cultivation of BARI tomato-10 variety along with 200 ml L^{-1} cowdung slurry + standard solution (C_3) performed best for achieving higher yield and quality of tomato, comparable to others treatment combinations in hydroponic culture.

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APPENDICES

Appendix I. Map showing the experimental site under study

Appendix II. Monthly meteorological information during the period from October, 2019 to March 2020.

Year	Month	Air temperature (^0C)		Relative humidity (%)	Total rainfall (mm)
		Maximum	Minimum		
2019	September	32.4	25.7	80	86
	October	31.2	23.9	76	52
	November	29.6	19.8	53	00
	December	28.8	19.1	47	00
2020	January	25.5	13.1	41	00
	February	25.9	14	34	7.7
	March	31.9	20.1	38	71

(Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix III. Analysis of variance of the data of plant height of tomato at different DAT

Source	DF	Mean square of plant height at			
		20 DAT	40 DAT	60 DAT	80 DAT
Replication (R)	2	96.590	305.720	355.961	346.714
Variety (V)	3	793.523*	71.683*	870.482*	763.392*
Cow dung (C)	3	554.582*	166.810*	476.673*	440.217*
V×C	9	54.822*	11.797*	16.854*	28.509*
Error	30	3.636	7.228	4.984	3.949

*: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data of number of leaves plant^{-1} of tomato at different DAT

Source	DF	Mean square of number of leaves plant^{-1} at			
		20 DAT	40 DAT	60 DAT	80 DAT
Replication (R)	2	14.138	31.997	76.963	92.16
Variety (V)	3	106.000*	81.187*	172.688*	274.25*
Cow dung (C)	3	711.500*	197.188*	898.687*	1574.75*
V×C	9	5.500*	4.021*	6.854*	6.92*
Error	30	0.521	3.464	5.176	2.29

*: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data of stem radius plant^{-1} of tomato at different DAT

Source	DF	Mean square of stem radius at		
		20 DAT	40 DAT	60 DAT
Replication (R)	2	1.393E-03	0.00516	0.01338
Variety (V)	3	7.425E-03*	0.01467*	0.03987*
Cow dung (C)	3	5.675E-03*	0.01457*	0.05521*
V×C	9	9.167E-05*	0.00130*	0.00150*
Error	30	5.318E-05	0.00038	0.00029

*: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data of days to first flowering, number of flower clusters plant^{-1} and number of fruits cluster plant^{-1} of tomato

Source	DF	Mean square of		
		Days to first flower	No. flower clusters plant^{-1}	No. fruits cluster plant^{-1}
Replication (R)	2	44.445	4.656	0.6893
Variety (V)	3	367.585*	109.238*	31.9813*
Cow dung (C)	3	49.283*	44.010*	11.7540*
V×C	9	1.758*	0.992*	0.4811*
Error	30	0.943	0.066	0.0092

*: Significant at 0.05 level of probability

Appendix VII. Analysis of variance of the data of number of fruits plant^{-1}, fruit polar and radius perimeter of tomato

Source	DF	Mean square of		
		No. fruits plant^{-1}	Fruit polar length	Fruit radial length
Replication (R)	2	45.06	0.31975	0.30124
Variety (V)	3	2329.50*	0.59675*	0.70897*
Cow dung (C)	3	45.00*	0.78165*	0.27562*
V×C	9	2.50*	0.02010*	0.01675*
Error	30	1.65	0.00239	0.00541

*: Significant at 0.05 level of probability

Appendix VIII. Analysis of variance of the data of individual fruit fresh weight, dry weight and yield plant^{-1} of tomato

Source	DF	Mean square of		
		Individual fruit fresh weight (g)	Individual fruit dry weight (g)	Yield plant^{-1} (kg)
Replication (R)	2	61.9603	0.20224	0.10233
Variety (V)	3	50.5408*	0.33917*	5.17784*
Cow dung (C)	3	62.0296*	0.14837*	0.35259*
V×C	9	1.4561*	0.01534*	0.01484*
Error	30	0.9940	0.00277	0.00305

*: Significant at 0.05 level of probability

Appendix IX. Analysis of variance of the data of volume (cc), total soluble solids (%), pH and Vitamin-C of tomato

Source	DF	Mean square of			
		Volume (cc)	Total soluble solids (%)	pH	Vitamin-C
Replication (R)	2	913.05	1.05382	0.50927	61.9603
Variety (V)	3	1190.70*	2.29202*	0.08465*	50.5408*
Cow dung (C)	3	164.80*	1.93077*	0.07610*	62.0296*
V×C	9	14.02*	0.16524*	0.01895*	1.4561*
Error	30	5.97	0.00978	0.00061	0.9940

*: Significant at 0.05 level of probability