EFFECTS OF PLANT VITALIZER (HB-101) ON GROWTH, YIELD AND NUTRIENT CONTENT OF TOMATO

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECTS OF PLANT VITALIZER (HB-101) ON GROWTH, YIELD AND NUTRIENT CONTENT OF TOMATO"** submitted to the Department of Agricultural Chemistry, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **AGRICULTURAL CHEMISTRY**, embodies the result of a piece of bonafide research work carried out by **MD. SAHAN SHA BABU**, Registration No. 18-09282 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

December, 2020
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Dedicated to
My
Beloved Parents

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The Author

EFFECTS OF PLANT VITALIZER (HB-101) ON GROWTH, YIELD AND NUTRIENT CONTENT OF TOMATO

ABSTRACT

A field experiment was conducted during October 2019 to March 2020 in the farm of Sher-e-Bangla Agricultural University to study the effects of plant vitalizer (HB-101) on growth, yield and nutrient content of tomato. The experiment consisted of two factors: Factor A: two tomato varieties *viz*. V_1: BARI tomato-2 and V_2: BARI tomato-15 and Factor B: 5 levels of HB-101 plant vitalizer *viz*. PV_0: control (0 ml PV L^{-1}), PV_1: 1 ml PV L^{-1}, PV_2: 2 ml PV L^{-1}, PV_3: 3 ml PV L^{-1} and PV_4: 4 ml PV L^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. In case of different tomato varieties, the best performance for most of the parameters was obtained from V_2 (BARI tomato-15) and gave highest yield (59.47 t ha^{-1}) compared to V_1 (BARI tomato-2) (57.87 t ha^{-1}). In case of plant vitalizer, 3 ml PV L^{-1} (PV_3) treatment showed best performance and gave highest yield (62.10 t ha^{-1}) compared to other treatments. In case of combined treatments, V_2PV_3 (BARI tomato-16 with plant vitalizer @ 3 ml L^{-1}) gave highest number of fruits $plant^{-1}$ (28.80), single fruit weight (63.75 g), fruit weight $plant^{-1}$ (1836.00 g) and yield (62.95 t ha^{-1}) compared to other treatment combinations but in case of nutrients (N, P, K and S) content in tomato fruits V_2PV_3 showed non-significant variation compared to other treatments. Above all considerations, treatment combination of V_2PV_3 (BARI tomato-15 with plant vitalizer @ 3 ml L^{-1}) can be considered as the best then other treatments which can be recommended for different tomato varieties to achieve higher yield and nutrient content.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agricultural Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
Kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
mg	=	Miligram
P	=	Phosphorus
K	=	Potassium
Ca	=	Calcium
L	=	Litre
µg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization

CHAPTER I

INTRODUCTION

Tomato (*Solanum lycopersicum*) is one of the most obsessive vegetables in the world including Bangladesh and it plays an important role in the human diet. It is an important vegetable; grown in most home gardens and by market gardeners. Worldwide, it is the second most important vegetable crop next to potato (Kumar *et al*., 2015). In Bangladesh, it occupies second and third positions in case of production and area of the winter vegetables, respectively (BBS, 2017). It can be eaten either fresh or processed into different products. It is helpful in healing wounds because of antibiotic properties found in ripe fruits. It is good source of Vitamins A, B and C (Baloch, 1994). Tomato has long served as a model system for plant genetics, development, physiology and pathology, leading to substantial information regarding the biology of this economically important organism (Faurobert *et al*., 2007).

Tomato ranks next to potato and sweet potato in respect of vegetable production in the world (Hossain *et al*., 2010). It ranks fourth in respect of production and third in respect of area in Bangladesh (BBS 2016). Global production is estimated at 170.8 million metric tons with China and India as the leading producers in 2017. China accounted for 31% of the total production. India and the United States followed with the second and third highest production of tomatoes in the world (Worldatlas, 2019).

Tomato is one of the cost-effectively important vegetable crops in Bangladesh. Recent statistics shows that tomato production was approximately 414000 tons from 76000 acres of land in 2014-2015 and in 2015-2016 production of tomato was 368000 tons in an area of 67000 acres (BBS, 2016). But in 2016-17, total tomato production was 389000 tons from 68000 acres of land whereas in 2017-18

the total tomato production was 385000 tons from 66000 acres of land (BBS, 2018).

Tomato is a major component in the daily diet, having several nutrients. It contains many macro and micro nutrients, vitamins and minerals, especially potassium, folic acid, vitamin C and contains a mixture of different carotenoids (Wilcox *et al*., 2003). Nutritiously important tomatoes are widely used in fresh like salads, soups; and processed products like ketchup, sauce, marmalade, chutney, juice etc. Tomato contains a fair amount of vitamins A, C, minerals like Na, K, Fe, Ca, Mg and it provides antioxidant elements such as lycopen (Bhutani and Kallo, 1983). 100 grams of red, ripe and raw tomatoes contain 18 calories, 0.9 g proteins, 3.9 g carbohydrates, 2.6 g sugar and 1.2 g fiber (USDA, 2019). Ripe tomatoes having antioxidant-lycopene, which acts as an anti-carcinogen and prevents cancer (Agarwal and Rao, 2000) and also prevent so many diseases.

High yield is the ultimate goal in all crops with good qualities. Tomato is cultivated all over Bangladesh due to its adaptability to wide range of soil and climate (Ahmed *et al*., 2017). Varietal tomato line or cultivar shows significant response to yield and quality characters on tomato due to variability in genetic makeup. The types of antioxidants present in tomato are also used to differentiate tomato cultivars (Langlois *et al*., 1996). The overall antioxidant activity of tomatoes varies considerably according to the genetic variety, ripening stage and growing conditions (Leonardi *et al*., 2000).

Many factors should be considered in making management strategies, such as crop cultivars, local climate, soil nutrients, irrigation method and water management practices (Datta *et al*., 2015). Variety plays the most important role for higher yield of crop. Yield difference varied significantly due to varietal difference. Modern varieties shows higher yield compared to local cultivars of tomato (Hamid

et al., 2005). So, yield performance of tomato is mostly dependent on variety difference.

Bangladesh Agricultural Research Institute (BARI) has developed some HYV of tomato which performs higher yield than local cultivars however; improvement of their cultivation technique needs to be evolved. Improving growth and yield potential of tomato crop demands an adequate amount of manure and fertilizers including micronutrients, BARI has released a number of yield promising inbred as well as hybrid tomato varieties such as BARI Tomato-2, BARI Tomato-4, BARI Tomato-14, BARI Tomato-15, BARI Hybrid Tomato-5, BARI Hybrid Tomato-6 etc., but their performance in different growing seasons have not been well studied (Sanjida *et al*., 2020).

HB-101 is derived from extracts of cedar, pine, cypress and plantain grass and it is purely natural. Microbes live in the soil and on the surface of plants. HB-101 and microbes are good friends. When HB-101 ("HB-101" hereunder means "HB-101diluted solution) is sprayed on the leaves and the soil, microbes are very happy and become more beneficial for plants. HB- 101 is neither an agricultural chemical nor a plant fertilizer (Anon., 2019 and Loan and Hung, 2019).

The use of vitalizer has been started in European countries for the last few years and getting remarkable responses in regards of attained more yield. As vitalizer HB-101 is a purely natural extract derived from the portion of plant that is important growth nutrient for plants, flowers and crop production. It is 100% organic product, safe for plants and animals and designated to benefit the earth environment. It is an all-natural solution that supports healthy plants by strengthening the cells and increasing photosynthetic efficiency (Anon., 2019 and Loan and Hung, 2019).

HB-101 plant vitalizer, which itself contains ionized minerals that enhanced the activity of the micro-organisms, insuring that the necessary balance of plant

nutrients. Continuous application of HB-101 improves soil fertility and contributes to the higher marketable yield and superior corps in the upcoming and future years. Hence, HB-101 is referred to as a plant “vitalizer”, or plant growth enhancer (Anon., 2019).

The aim of this experiment was therefore undertaken to assess the effects of plant vitalizer on growth, yield and nutrients content of tomato with the following objectives:

1. To evaluate the effect of HB-101 plant vitalizer on growth and yield of tomato
2. To determine the nutrients content of tomato

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important vegetable crops grown under field and greenhouse condition, which received much attention of the researchers throughout the world. The response of tomato to different varieties and plant vitalizer levels for its successful cultivation has been investigated by numerous investigators in various parts of the world. In Bangladesh, there have not enough studies on the influence of variety and plant vitalizer (HB-101) application on the growth and yield of tomato. However, the available research findings in this connection over the world have been reviewed in this chapter under the following headings.

2.1 Effect of variety

Sanjida *et al*. (2020) conducted a study to investigate the effects of varieties and boron (B) levels on growth and yield of summer tomato (*Lycopersicon escuientum* Mill.) during the period from May, 2018 to September, 2018. Fifteen treatments were comprising (i) three summer tomato varieties (BARI hybrid tomato 4, 8 and 10) and (ii) five levels of boron as boric acid (0,1,2, 3 and 5 kg B ha^{-1}) in all combinations. Randomized complete block design with three replications was used in the earthen pot (0.79 ft^3) experimentation. The effects of varieties and boron levels showed significant variations ($p < 0.05$) on growth and yield of summer tomato at different days after transplanting. Among the varieties at final count $plant^{-1}$, delayed flowering (32.6 days), the highest plant height (93.8 cm), number of leaves (99.93), no. of branches (26.27), no. of flower clusters (18.53), no. of flowers (82.73), no. of fruits (51.87), longest fruit length (41.87 mm) and maximum fruit width (48.0 mm), weight of individual fruit (55.71 g) and total weight of fruits (2892.88 g) were observed in BARI hybrid tomato 8. In contrast, the lowest plant height (87.3 cm), no. of leaves (86.47), no. of branches (24.06),

no. of flower clusters (15.87), no. of flowers (66.07), no. of fruits (37.33), weight of individual fruit (43.60 g) and total weight of fruits (1630.57g) were found in BARI hybrid tomato 4; and early flowering (31.93 days), shortest fruit length (33.07 mm) and maximum fruit width (34.60 mm) were noticed in BARI hybrid tomato 10. Among the boron levels at final count plant^{-1}, early flowering (29.67 days), the maximum no. of flower clusters (18.44), no. of flowers (89.11), no. of fruits (46.22) and total weight of fruits (2364.29 g) were recorded in 2 kg B ha^{-1} treatment; the maximum plant height (96.50 cm), no. of leaves (102.89), no. of branches (28.11), longest fruit length (42.89 mm) and maximum fruit width (46.78 mm) and weight of individual fruit (51.74 g) were obtained in 3 kg B ha^{-1} treatment. Conversely, delayed flowering (34.67 days), minimum plant height (83.50 cm), no. of leaves (87.56), no. of branches (21.78), no. of flower clusters (15.89), no. of flowers (63.56), no. of fruits (40.33), shortest fruit length (31.78 mm) and minimum fruit width (34.67 mm), weight of individual fruit (47.47 g) and total weight of fruits (1936.00 g) were recorded in control (0 kg B ha^{-1}) treatment. Our results suggest that the inclusion of B (2-3 kg ha^{-1}) with the current fertilization practice will enhance the growth and yield of summer tomato grown at AEZ (agro-ecological zone) 13 while BARI hybrid tomato 8 could be recommended as one of the promising varieties.

Roy and Monir (2020) conducted an experiment at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during the period from October 2016 to April 2017. The experiment was conducted to assess the effect of two factors, for example; I, two levels of foliar spray of boron as:100 ppm boric acid (B1) and 200 ppm boric acid (B2) in relation to a control and II, three different tomato cultivars/lines as: L1: Exotic Tomato Line -1, L2: Exotic Tomato Line-2, L3: BARI Tomato-15. The two factorial experiments were laid out in Randomized Complete Block Design with three replications. Fruit setting (56.73%), yield (64.89 t/ha) and total soluble solid (TSS) (4.3%) were

considerably higher in B1 and low in B2. Whereas, significantly higher yield (79.87 t/ha) was recorded in L3 in in comparison to L1. Considering quality parameters, Vitamin C (20 mg) was the highest in L3 whereas TSS (4.58%) was the highest in L1. In interaction effect, the highest yield (85 t/ha) was obtained from B1L3 and the lowest (31.23 t/ha) in B2L1. The present study suggest to cultivate BARI Tomato-15, but other two exotic lines adapted well and showed good performance in terms of yield and quality parameters.

Kena (2018) conducted a field experiment at Meti and Kombolcha sub sites of KellemWollega, and Inango of West Wollega zones in Western Ethiopia, during the 2016/2017 and 2017/2018 cropping season under supplementary irrigation. A total of 11 tomato varieties collected from Melkasa Agricultural Research Center (MARC) of the Ethiopian Institute of Agricultural Research (EIAR) and one local check variety were used as planting materials. The combined analysis of variance (ANOVA) for fruit yield and other agronomic traits of 12 tomato varieties grown at five locations in 2016/2017 and 2017/2018 revealed significant varietal difference for all considered traits except for unmarketable yield and number of branches per plant. In the present experiment, Melka shola, Melka salsa, Fetene and Miya varieties were found superior in terms of economic yield (marketable yield) and other parameters and thus they are recommended for popularization and wider production in test locations and similar agro-ecologies in the Western Oromia in particular and tomato producing regions of Ethiopia under supplementary irrigation in general.

Parmar and Thakur (2018) conducted an experiment to study the performance of different tomato cultivars under organic regimes, at the experimental farm of the Himachal Pradesh Agricultural University, Hill Agricultural Research and Extension Centre, Kullu, India. Among different cultivars, Sioux variety took maximum days (74) from transplanting to first harvest and HeemSohna hybrid took minimum time of 67.2 days. The maximum plant height was observed in

hybrid RK 123 (100.6 cm) followed by Best of all (100.3 cm). The minimum height was recorded for Sioux (83.9 cm). The Red gold hybrid recorded significantly highest number of fruits per plant (25.9) followed by RK 123 (20.0). The Red Gold hybrid had greater fruit size (29.0 cm2) followed by RK 123 (26.4 cm2), HeemSohna (24.6 cm2), Palam Pink (23.3 cm2) and Mar Globe (22.9 cm2), whereas the fruit size of Best of All (18.8 cm2) and Naveen 2000 (19.2 cm2) was minimum. Some of the entries of tomato namely RK 123, Manisha, Best of all Yash, Naveen 2000, Red Gold hybrid recorded highest but similar TSS content as compared to rest of the hybrids/varieties. All hybrids had highest but statistically similar acidity ranging from 0.54-0.58 g/100 ml of juice but varieties recorded significantly lower value of acidity (0.41-0.46 g/100 ml of juice). The ascorbic acid contents within hybrids and varieties were identical, though hybrids recorded higher ascorbic acid values (18.53-22.08 g/100 ml of juice) than varieties (11.53-14.52 g/100ml of juice). The hybrids contained lower carotene and lycopene as compared to varieties. The hybrid Manisha recorded minimum carotene and lycopene content (5.25 mg/100 g of fruit and 3.90 mg/100 g of fruit) and highest was in Best of All variety (9.51 mg/100 g and 6.38 mg/100 g of fruit). Red Gold hybrid produced maximum tomato fruits (143.7 q/ha) and minimum fruit yield was recorded for Best of all (33.7 q/ha) and Marglobe (34.7 q/ha). Significantly higher profit and B: C was observed in case of Red Gold hybrid (rupees 259685/ha and 1.37) followed by RK 123 (rupees 186497/ha and 0.99), however, rest of the entries were found to be non-profitable.

Devkota (2018) conducted an experiment to evaluate hybrid genotypes of tomato for fruit yield and fruit quality in Horticulture Research Division, NARC, Khumaltar, Lalitpur, Nepal during March to August, 2014 in open field condition. Eleven hybrid genotypes developed from the crosses between HRA and HRD lines, selected as good performer under late blight condition and ‘Srijana’as a local check were taken for the evaluation. Design of experiment was single factorial

RCBD with three replications. Observation on traits related to plant morphology, maturity and yield component were recorded to develop, evaluate, identify and recommend high yielding hybrids of tomato. The fruit yield per hectare ranged from 80.83 t/ha (HRA 14 × HRD 7) to 45.89 ton/ha (HRA 15 × HRD 6). Fruit yields of the genotypes HRA 14 × HRD 7, HRA 13 × HRD 7, HRA 20 × HRD 1, HRA 20 × HRD 2, HRA 20 × HRD 6 and HRA 16 × HRD 1 had 80.83 ton/ha, 78.50 ton/ha, 73.75 ton/ha, 70.44 ton/ha, 68.72 ton/ha, 64.64 ton/ha were higher than the yield of 'Srijana' (62.33 ton/ha). Based on overall performance, genotypes HRA 14 × HRD 7, HRA 13 × HRD 7, HRA 20 × HRD 1 and HRA 20 × HRD 6 were observed as good performer than Srijana (Check) and selected as high yielder with good fruit quality.

Benti and Degefa (2017) conducted a field experiment to evaluate tomato varieties under irrigation water and recommend high fruit yielding variety to the area. The results revealed that there was significant ($P \leq 0.05$) differences among varieties for plant height, days to flowering, fruits per cluster, clusters per plant, average fruit weight and fruit yield per hectare, except primary branches per plant. 'Melkashola' and 'Bishola' out yielded among the varieties; 30.86 t ha-1 and 26.96 t ha-1, respectively over the two years. 'Melkashola' and 'Bishola' 'Melkashola' and 'Bishola' advanced fruit yield per hectare by about 40% and 35% over the 'Babile local', respectively. However, farmers preferred 'Melkashola' due to its fruit size and shape over 'Bishola' which is extreme in fruit size and was susceptible to sun scald. Therefore, 'Melkashola' was recommended to the area for its high fruit yield per hectare under irrigation during offseason cropping.

Sidhu and Nandwani (2017) conducted a field research trials from April to October in 2015 and 2016 growing seasons at the Tennessee State University organic farm. Differences occurred in number of marketable fruit, fruit weight and total soluble solids. 'Arbason F1' (28.67 Mt·ha^{-1}), 'Gold Nugget' (26.08 Mt·ha-1), 'Roma' (25.65 Mt·ha^{-1}) were the high yielding and 'Pink Bumblebee' (2.61 Mt·ha^{-}

^{1}), 'Hillbilly' (3.10 Mt ha^{-1}), 'Cherokee Green' (5.99 Mt ha^{-1}) had the lowest marketable yield. 'Mountain Prince' (57.68%), 'Pink Brandywine' (52.32%) and 'Black Prince' (44.74%) had the most culls and 'Pink Bumblebee' (1.80%), 'Rutgers VF' (4.98%), and 'Hillbilly' (5.02%) had the fewest cull fruit. 'Bing Cheery' and 'Cheery Sweetie' ranked highest in taste among cherry types. All twenty six cultivars did set fruits during the growing seasons in local climatic conditions. Results suggest that 'German Johnson' and 'Pink Brandywine' (beefsteak type), 'Gold Nugget', (cherry type), and 'Roma', (plum type) were top performers in higher yields and brix.

Dunsin (2016) conducted a study to evaluate the performance of five different varieties of tomatoes under controlled environment (screen house). The results revealed that the Nemoneta variety, performed better compared to other varieties in terms of plant height (8.3cm) and also have the highest shelf life of 14 days followed by Delicious with 7 days, while the number of fruits per plant was height in Small Cherry with an average of 8.733/plant, but Delicious variety 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 variety contains the highest values for lycopene (1467.30mg/100g), vitamin A & B (56.7mg/100g & 0.62 mg/100g, respectively) and potassium (0.62%).

Biswas and Sarkar (2015) conducted an experiment at Agronomy Farm of the Sher-e-Bangla Agricultural University, Dhaka to study growth and yield responses of tomato varieties. Experiment consisted of four varieties, *viz*. BARI Tomato-4 (V1), BARI Tomato-5 (V2), BARI Tomato-7 (V3) and BARI Tomato-9 (V4) using Randomized Complete Block Design with three replications. Tallest plant (101.3 cm), maximum number of leaves (114.1/plant) and maximum number of branches (10.0/plant) was found from BARI Tomato-7. While maximum number of flowers (6.1/cluster), number of fruits (5.0/cluster), number of clusters (17.9/plant) were found from BARI Tomato-9. However, maximum fruit diameter

(20.1 cm), individual fruit weight (115.9 g), yield (34.7 kg/plot and 95.9 t/ha), number of locule (4.4/fruit) were also found from BARI Tomato-7. Virus infestation, fruit length and Total soluble solid (TSS) were statistically identical among the varieties.

Khaled and Sikder (2015) conducted an experiment during the period of December 2013 to April 2014. The experiment was laid out in two factors randomized complete block design with three replications including three concentrations of Indole Acetic Acid (0, 100 and 200 ppm) and three tomato varieties (BARI tomato 7, Manik and Ratan). Plant height, number of leaves and number of branches, days required for first flower initiation, days required for 50% flowering, days required for fruit setting, fruit cluster plant-1, fruit plant-1, weight tomato-1, yield plant-1, yield plot-1 and yield hectare-1 were significant influenced by the combined application of IAA and varieties of tomato. BARI Tomato-7 had the highest fruit yield with 100 ppm IAA and the lowest yield was observed in Ratan with 0 ppm IAA. IAA treated plots showed better performance for growth parameters and yield compared to control condition and 100 ppm IAA was more suitable than the 200 ppm IAA for higher yield of tomato cultivation. Among the treatment combinations, BARI Tomato-7 with 100 ppm IAA was superior, Ratan with 0 ppm IAA was inferior and BARI Tomato-7 with 200 ppm IAA, Manik with 200 ppm IAA and Ratan with 200 ppm IAA treated plots showed the intermediate results for yield and yield components.

Noonar (2015) conducted the present study to assess the economic analysis of tomato production and changes in socio-economic status of the farmers. The tomato farmers in study area incurred that on an average per Farm spent a sum total fixed cost was 20900.00 Rs/acre in Hybrid tomato and total fixed cost was 20900.00 Rs/acre in Conventional tomato. Total fixed cost includes Land Rent, Land tax, and water charges and total variable costs for Hybrid tomato were (64420.00 Rs/Acre) while in conventional tomato the total variable costs ware

(61620.00 Rs/Acre). On an average higher yield was obtained in hybrid tomato 94.00 Mds /acre from Hybrid tomato while 76.00 Mds /acre average obtained by conventional tomato. As for pricesconcerned, the Hybrid and Conventional tomato growers received Rs. 1520.00/ Mds and Rs. 1480.00/ Mds respectively. Total revenue of tomato production was calculated and found that hybrid tomato growers received Rs. 142880.00/acre, while conventional tomato growers Rs. 112480.00 /acre. The tomato growers in selected study area who cultivates Hybrid tomato obtained higher gross revenue (Rs.142880.00Per/acre), whereas gross margin of conventional tomato growers who seem to be lower (Rs. 112480.00Per/acre). The Net Return of tomato production was calculated and found that Hybrid tomato growers received higher Net Return which was (57560.00 Rs/acre), where as Net Return of Conventional tomato grower who seem to be lower (29960.00 Rs/acre). Therefore they availed in hybrid farms input output ratio of 1:1.67, cost benefit ratio of 1:0.67while 1:1.36 input output ratio and 1:0.36 from conventional tomato farmers in the study area.

Ilupeju (2015) carried out a field experiments to assess the impact of 100% NPK fertilizer recommendation (300 kg NPK 20:10:10), 100% Tithonia compost (TC), 75% NPK + 25% TC, 50% NPK + 50% TC, 25% NPK + 75% TC and control (non-fertilized plant) on the growth, fruit yield, nutritional and lycopene contents of three tomato varieties (Raoma VF; Ogbomoso local and Califonia wonder). The experiment was a split plot fitted into a randomized complete block design replicated three times. Data were collected on growth and reproductive parameters, fruit and seed attributes, and fruit proximate and nutritional contents. Data collected were subjected to analysis of variance to determine significant means. Significant varietal differences were observed among the tomato varieties in terms of growth, fruit yield and nutritional attributes. The plant dry matter yield was highest in Ogbomoso local and least in Roma VF. Fruit yield obtained with Ogbomoso local was 45 and 56% higher than what was obtained for Roma VF and

Califonia wonder, respectively. In terms of vitamin C content, Roma VF fertilized with 50% NPK + 50% TC gave the highest value which is 23 to 67% higher than values obtained from the other treatment combinations. Again, irrespective of variety, organically grown tomato contains higher content of lycopene. It was also observed that the higher the proportion of TC compost in the treatments, the better the lycopene content. It could be concluded that the use of organic fertilizer has potential in improving the growth, fruit yield and nutritional contents of any of the three tomato varieties studied.

Isah and Amans (2014) conducted a field experiments in 2010-2011 and 2011-2012 dry seasons at the Research farm of the Institute for Agricultural Research, Samaru northern guinea savanna agro ecological zone of Nigeria to study growth rate and yield of tomato under green manure and NPK fertilizer rates. Treatment consisted of two tomato varieties (Roma VF and UC82B), four rates of NPK 15-15-15 fertilizer (0, 150, 300, and 450kgha−1), and three rates of green manure (0, 5, and 10 t ha−1), laid in a split-plot design with three replications. The variety and fertilizer constituted the main plot while green manure was allocated in subplot. Both varieties responded linearly ingrowth stages of 5 and7weeks after transplanting (WAT) onplantheight, relative growth rate, and crop growth rate (CGR). However, UC82B proves superior over Roma VF on growth indices CGR at 5–7WAT, net assimilation rate (NAR) at 7–9WAT, and total fruit yield with 10.6% higher. Application of NPK fertilizer significantly increased growth such as plant height, crop dry weight, crop growth rate, and yield. Application between 250 and 280 kg ha−1 NPK fertilizers was found efficient for total fruit yield.

Mehraj*et al*. (2014) conducted an experiment at Horticultural farm of Sher-e-Bangla Agricultural University, Bangladesh for performance evaluation of twenty tomato cultivar coded from V1-V20 cultivated in summer. Maximum plant height (116 cm) and number of leaves (147) were found from cultivar Mini Anindyo Red (V8) and Hybrid Tomato US440 (V18) respectively. Maximum chlorophyll

content, days to flower bud appearance and days to flowering were observed from cultivar BARI Tomato 6 (V19); 53.0% chlorophyll, 40.3 days to bud appearance and 46.7 days for flowering. Maximum number of flower bud/bunch (6.0) and fruit/bunch (1.2) were observed from cultivar BARI Tomato 11(V20) and Aran Chan Mini (V12) respectively. Maximum number of branch/plant (5.7), number of bunch/plant (15.3), number of flower bud/plant (129.7), number of flower/plant (108.3), number of flower/bunch (6.7), number of fruit/plant (6.7), fruit length (22.8 cm), fruit diameter (61.3 mm), fruit weight (100 gm), yield/plant (667.1 gm), yield/plot (6.7 kg) and calculated yield/ha (22.3) were found from cultivar Mini Chika (V10). Thus, cultivar Mini Chika (V10) was found to be suitable for cultivation in summer.

Ali (2014) carried out a study and thirteen local and exotic hybrid tomato varieties *viz*. BARI F_1Tomato-4, BARI F_1 Tomato-5, BARI F_1Tomato-6, BARI F_1Tomato-7, BARI F_1Tomato-8, Lali, Abhilash, Nayak, Moon, Delta, Mintoo super, Mintoo, and Sucsess were evaluated to see their performances during the winter season of 2012-2013. All the characters showed significant differences among the varieties. The variety Nayak required maximum days for 50% flowering (77.00) while BARI F_1tomato-4 and 8 required minimum days for 50% flowering (60.00). The highest plant height was found in Success variety (134.3cm) and the lowest was found in BARI F1Tomato-7 (103.3). The maximum number of fruits/cluster (5.83) was recorded from BARI F_1tomato-8 while minimum were recorded from Mintoo Super (4.40). BARI F1 tomato-4 variety produced the maximum number and weight of fruits/plant (87.6 and 2.30 kg) whereas BARI F_1tomato-6 and Delta produced minimum number and weight of fruits per plant (49.33 and 1.62 kg). The average fruit weight was maximum in BARI F_1tomato-5 (52.73 g) and minimum in Abhilash (41.97 g). The maximum fruit length and diameter (5.14 cm and 5.41 cm) were obtained from BARI tomato-7 and 5 whereas minimum fruit length and diameter (3.77 cm and 4.22 cm) were obtained from BARI F1tomato-4 and

Mintoo. The number of locule/fruit was found maximum in BARI F1 tomato-5 (4.33) while minimum no. of locule/fruit was found in Delta (2.13). The variety Nayak showed maximum thickness of pericarp (0.52cm) and BARI F_1tomato-8 showed minimum thickness of pericarp (0.34cm). The TSS percentage was found maximum (5.00) in BARI F_1tomato-8 and Mintoo while minimum TSS percentage (4.00) was found in BARI F_1tomato-8 and Mintoo Super. The shelf life of the fruits were maximum in Delta (18.00 days) and minimum in Abhilash (5.00 days). The variety Nayak required maximum days to 1stharvest (154.0) and BARI F_1tomato-4 and 8 required minimum days to 1stharvest (138.0). Yellow leaf curl virus was found maximum in the variety Lali (10.41%) and minimum (2.08%) in BARI F_1tomato-5 and Mintoo. No virus infected plants were found in the rest varieties. The yield ranged from 64.92 to 93.21 t/ha. The maximum yield (93.21t/ha) was obtained from BARI F_1tomato-4 while minimum yield was obtained from Delta (64.92 t/ha). Considering the results it can be concluded that most of the local varieties showed better performance compared to the exotic varieties.

Das *et al.* (2011) conducted a field experiment variation in growth and yield quality of tomato varieties under different showing time. Result found that BARI Tomato-2 (Ratan) performed the best in yield in association with November 09 planting.

Olaniyi and Akanbi (2010) conducted an experiments to evaluate the growth, fruit yield and quality of seven varieties of tomato in the Guinea Savannah zone of South West Nigeria. The varieties tested were, DT97/162A(R), DT97/215A, Tropical, Roma VF, UC82B, Ibadan local and Ogbomoso local. These were assigned randomly into three blocks each containing seven beds and fitted into randomized complete block design. Growth, yield, mineral content and quality attributes of tomato were assessed. The results showed that DT97/162A(R) gave the highest height whereas Ogbomoso local recorded the highest number of leaves

at 6 weeks after transplanting. Higher fruit yield was recorded from UC82B, closely followed by Ibadan and Ogbomoso local. Although, there is inconsistence in the results of the nutritional compositions of tomato fruits, the local varieties (Ogbomoso and Ibadan Local) closely followed by UC82B recorded most of the nutritional values more than the other varieties. Therefore UC82B, Ibadan and Ogbomoso local in that descending order are better in terms of fruit yield and quality, and can be successfully grown in Ogbomoso, the Guinea Savannah zone of south west Nigeria.

Kayum *et al*. (2008) evaluated three popular tomato varieties namely, Ratan, BARI tomato-3 and BARI tomato-6 experimentally to identify the potential mulch on growth and yield, where the experiment consisted of four mulching treatments viz. water hyacinth, straw, am-ada leaf and banana leaf with a control (no mulch). The experiment was conducted under rainfed condition. In the experiment, mulching showed significant effect on growth, yield components and thus on the yield of tomato. Yield contributing characters were significantly higher when water hyacinth mulch was used. The variety Ratan produced the highest (53.74 t/ha) fruit yield, while BARI tomato-3 showed the lowest (48.89 t/ha) fruit yield. The combination of mulching and variety exhibited significant variation in some yield components and yield. The combination of water hyacinth and Ratan produced the maximum yield (62.16 t/ha) and thus the experiment revealed that water hyacinth and straw mulches have potentiality to increase the yield of tomato.

Ahmad and Khan (2007) conducted an experiment to evaluate the comparative performance of 11 tomato cultivars in the Northern Areas of Pakistan during 2003. It was found that days to first picking, plant height, number of branches per plant, number and weight of fruits per plant, harvesting period, fresh and dry fruit yield showed significant differences among the various cultivars under the trial. Maximum days to first picking (96.40) were recorded in cultivar Local round followed by Shalkot (95.25 days) while Rio grande gave the earliest fruit maturity

(82.40 days). Cultivar Local round also showed maximum plant height (110.50 cm), number of branches per plant (10.77) and fruits per plant (98.30) followed by Shalkot, Nagina and Peto-mech-II with 58.47, 51.33 and 46.15 fruits per plant, respectively. The lowest number of fruits per plant (29.47) was found in Nemadina. Cultivar Shalkot attained maximum fruit weight per plant (3.03 kg), fresh fruit yield (68.36 t ha-1) and dry fruit yield (4.49 t ha-1) while cultivar Local round gave the lowest fruit weight per plant (0.83 kg), fresh fruit yield (20.30 t ha-1) and dry fruit yield (1.01 t ha^{-1}). Cultivars Peto-mech-II and Rio grande stood second and third in term of fresh and dry fruit yield, respectively. Longest harvesting period was recorded in Local round (137.67 days) while the cultivar Gala gave the shortest harvesting period (107.23 days). Considering the overall performance it was found that tomato cultivars Shalkot, Peto-mech-II, Rio grande, Red blast and Roma were promising with stable performance, for yield and other characters. However, potential of these cultivars is needed to be further tested under the climatic conditions of the Northern Areas of Pakistan to elicit substantial conclusions.

Pandey (2006) evaluated four tomato varieties namely LTH-61, Avinash-2, NSITH-162 and BL-410 in farmer's field with farmers participation under plastic house condition for yield potential and other yield characters at Hemja, Kaski (920 masl) during rainy seasons of two consecutive years 2002 and 2003. The experiment was arranged in randomized complete block design with 5 replications, farmer as a replication. NSITH-162 took the shortest period of days to flowering and first harvest with an average of 36 and 66 days after transplanting respectively. Fruit set after flowering was highest in NSITH-162 (93.9%) and the lowest in Avinash-2 (83.1%). NSITH-162 produced the highest marketable fruit yield (89.05 t/ha) and Avinash-2 produced the lowest (51.98 t/ha). The results of the experiment revealed that the hybrid varieties NSITH-162 and LTH-61 have more yield potentiality than open pollinated variety BL-410 and Avinash-2 an

Indian hybrid variety and therefore NSITH-162 variety could be recommended for commercial production under plastic house condition.

Hossain (2001) conducted an experiment at the Horticulture Farm, BAU, Mymensing with four tomato varieties namely BARI Tomato-4, BARI Tomato-5, BARI Tomato-7, BARI Tomato-8 and three planting dates (October -25, December-25, and February-24). Planting dates and varieties had significant influence on growth, yield contributing parameters and yield of tomato. The highest yield of tomato (86.40 t ha^{-1}) was obtained from October 25 planting compared to lowest in Tomato-7 gave the highest yield (100.13 t ha^{-1}) in October 25 planting.

Nessa *et al.* (2000) conducted an experiment to study the comparative performance of ten genotypes of tomato in late planting and reported that the genotype BAU/TM 0058 was the best in late planting. It was closely followed by BAU/TM 0041. They also state that, fruit number and fruit weight should be considered as important criteria for higher yield.

Islam (2000) conducted a field experiment with four dates of planting (16 October, 15 November and 14 January) and four varieties (BINA Tomato-2, BARI Tomato- 3, BARI Tomato- 4, BARI Tomato- 5 at the horticulture farm, BAU, Mymensingh during the period from September, 1999 to May, 2000, to extend the pocking period of tomato through selection of variety and adjustment of date of planting. He mentioned that, the highest yield of tomato (53.65 t ha^{-1}) was achieved from 16 October planting. The variety BARI tomato-3 produced the highest yield (50.65 t ha^{-1}) and BINA Tomato- 2 gave the lowest yield (34.80 t ha^{-1}).

Ajlouni *et al.* (1996) conducted a field trial in Jordan 1993 to study the yield of 13 local and introduced open pollinated tomato cultivars, and to compare the yields to that of 3 common hybrids (Maisara F1, 898 F1 and GS12F1) in relation to

seasonal distribution of marketable and unmarketable yield and fruit number. The cultivars varied in their marketable yield during the harvested period (10 weeks from 22 June 1993). The results indicated that the cultivars Rio Grande, Nagina and T2improved were superior to the hybrids

Singh and Tripathy (1995) conducted a field experiment at Regional Research Station, Orissa, India during the rainy season of 1992 to study the growth and yield of four tomato genotypes (Pusa Ruby, LE79, BT1 and ArkaAlok). The cultivars showed significant genotypic variation for vegetative growth, fruit characters and yield when sown on different dates (20 June, 5 and 20 July and 5 and 20 August). The line LE97 gave the highest fruit yield (12.2 t ha^{-1}) and ArkaAlok produced significantly larger fruits (20.3 cm in diameter and 136 g in weight).Sowing on 20 June was significantly favorable for fruit yield as well as its contributing characters, like fruits weight (60.8 g), length (9.8cm) and girth (16.2 cm)..

A field Experiment was conducted by Jamwal *et al.* (1995) at the Regional Research Station, Baj aura, India during the summer of 1990 with two tomato cultivars, Roma and Sioux. The varieties were planted on 20 April and 20 May. They reported that, yield per hectare was similar for both cultivars; Roma produced significantly more fruits per plant, but had lower individual fruit weight than Sioux. Planting on 20 April gave better result than later planting.

An experiment was carried out by Phookan and Shadeque (1995) at Jorhat, Assam, India in order to test different genotypes of tomato during 4 seasons, Viz. early spring, spring, summer and autumn. Out of 29 genotypes, 7 were common in all the 4 seasons. The authors reported that the crop planted in September gave the highest yield, being 91.10, 74.66 and 67.88% higher than that planted in May, July and March, respectively. Among the varieties, the highest yield was recorded in ArkaAbha (1.5 kg $plant^{-1}$) followed by ArkaAlok.

Taleb (1994) conducted an experiment to study the effect of planting time (15 November, 30 November and 15 December) growth and yield of tomato at the horticulture farm of Bangladesh Agricultural University, Singh. He found that November 15 planting produced the tallest plants (129 m) and maximum yield per plant (4.29 kg), which was statistically different from other dates of planting.

2.2 Effect of plant vitalizer

Flora Co., Ltd. developed the organic plant growth enhancer vitalizer HB-101, a unique blend of the essences of Japanese cedar, pine, Japanese cypress and plantain grass (Anonymous, 2019). HB-101 is a liquid plant growth enhancer formula, specially processed by blending the extracts of cedars, pines, cypress trees and plantains. Cedars, pines and cypresses are long-lived trees with powerful deodorizing power. The saps and secondary metabolites of these trees are responsible for maintaining the health and longevity of the trees. Plantains are known to have medicinal qualities and have long been used for various human medications. HB-101 plant vitalizer is a purely natural extract derived from the portion of a plant that is most important in its development process. HB-101 is a growth nutrient for plants, flowers and crop production and is not a chemical fertilizer. HB-101 is a 100% organic product, safe for plants and animals, and designed to benefit the earth's environment while reducing the demand for costly fertilizers. HB-101 is formulated and bottled in a ready-to- dilute solution for easy and immediate use. Highly concentrated, it's a cost- efficient way to achieve healthier, more vibrant plants (Anonymous, 2019).

Anonymous (2019) stated that HB-101 is an OMRI listed plant growth enhancer, which (i) Improves the efficiency of the plant's metabolism to induce increased yield and higher crop quality, (ii) Facilitates nutrient uptake, (iii) Enhances crop quality attributes including sugar content and color, (iv) Enhances soil fertility by fostering the development of soil microorganisms, (v) Enhances plant's vigor and

increase plant's tolerance to and recovery from abiotic stresses, and (vi) Decreases transplant shock.

HB-101 treated crops maintain longer shelf life and tolerate to long shipment, which reduces shipping markdowns and expands market to overseas. Continuous application of HB-101 improves soil fertility and contributes to the higher marketable yield and superior corps in the upcoming and future years (Anonymous, 2019).

Plants need the sunlight, air (carbon dioxide and oxygen), water and soil (minerals and micro-organisms) to grow. If the delicate balance of these elements is not maintained, growth is slowed or stopped. Sunlight and carbon dioxide are absorbed into the plant's system through its leaves, where photosynthesis produces glucose and other nutrients necessary for survival. When HB-101 solution is sprayed onto foliage and applied to the soil, the plant absorbs necessary nutrients from the soil. These plant nutrients are combined with ionized calcium and sodium from HB-101 and absorbed into the leaves' cells, thereby strengthening the cells and increasing photosynthetic efficiency. This results in greener leaves and stronger, healthier plants (Anonymous, 2019).

Water and nutrients, especially calcium, are necessary for the development of leaves and roots, but many minerals cannot be absorbed into the plant's system in their solid form. These minerals have to be converted to an ionic state in order to be easily absorbed through the roots, and this is done by micro-organisms living in the soil. By applying HB-101 plant vitalizer, which itself contains ionized minerals, the activity of these micro-organisms is enhanced, insuring that the necessary balance of plant nutrients is maintained. In addition, HB-101 contains significant quantities of saponin, a metabolite which replenishes microorganisms with oxygen. The stem is the pathway by which nutrients are transported to and from the leaves and roots, and it is also the backbone of the plant. Healthy cells

and sufficient nourishment result in the smooth distribution of carbohydrates, which are necessary for strengthening cell membranes. With the introduction of HB-101, nutrient flow from the leaves and roots is maximized, contributing to the development of the stem (Anonymous, 2019).

Soil should be soft and contain a good balance of water and air, and should allow good drainage after rain or irrigation. It should also maintain proper moisture even during sunny weather and should be neutral to mildly acidic. In such conditions, the balance of micro-organisms in the soil will be favorable. However, factors such as acidic rain, agricultural chemicals, and repeated cultivation can harm the soil and stunt the growth of the essential microorganisms. With HB-101 plant vitalizer, the propagation and proper balance of these micro-organisms can be maintained. It is ideal for both the home gardener and use in sustainable farming practices (Anonymous, 2019).

Loan and Hung (2019) conducted a field experiment with 4×3 factorial design in 2017 summer season using a randomized complete block design with 3 replications to study the effects of organic fertilizer and HB101 organic plant vitalizer on the growth and yield components of the BH9 rice variety. Organic fertilizer derived from chicken manure and peat was applied at 3 levels (0 ton ha^{-1}, 4 tons ha^{-1}, and 6 tons ha^{-1}) while the HB101 plant vitalizer was sprayed in 4 levels (0%, 0.015%, 0.025%, and 0.035%; the amount of water to dilute HB101 was 1000 litre ha^{-1}). The application of the organic fertilizer alone and the combination of organic fertilizer and HB101 positively increased the total tiller number, effective tiller number, leaf area index (LAI), SPAD value, dry matter accumulation, yield components, and grain yield of rice. There were also differences in the SPAD values (at flowering stage), dry matter weight (at active tillering stage), and 1000 grain weight under the influence of the HB101 solution. The combination of 6 tons ha^{-1} organic fertilizer and HB101 significantly increased the grain yield as compared to the other treatments, and the highest grain

yield (3.03 tons ha^{-1}) was obtained when organic fertilizer (6 tons ha^{-1}) was applied in combination with HB101 plant vitalizer (0.025%).

Salwa *et al*. (2018) conducted an experiment during October 2017 to February 2018 in the Horticultural farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207. The experiment consisted of two factors: Factor A: Vermicompost (3 levels) as- Vr_0: No vermicompost (control condition); Vr_1: 4 ton vermicompost/ha, Vr_2: 8 ton vermicompost/ha; and Factor B: Plant vitalizer (4 levels) as- Vi_0: No vitalizer (control condition), Vi_1: 2 ml vitalizer/L water, Vi_2: 4 ml vitalizer/L water and Vi_3: 6 ml vitalizer/L water. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Different levels of vermicompost and plant vitalizer influenced significantly on most of the recorded parameters. In case of different levels of vermicompost, the highest marketable yield (52.30 t/ha) was observed from Vr_2 treatment, while the lowest (38.47 t/ha) from Vr_0 treatment. For different levels of plant vitalizer, the highest marketable yield (51.62 t/ha) was found from Vi_3, whereas the lowest (39.62 t/ha) from Vi_0 treatment. The highest marketable yield (33.83 t/ha) was observed from Vr_2Vi_3, while the lowest (58.77 t/ha) from Vr_0Vi_0 treatment combination. The highest benefit cost ratio (2.64) was found from Vr_2Vi_3 and the lowest (1.67) was obtained from Vr_0Vi_0. So, combination of 8 ton vermicompost/ha and foliar application of 6 ml vitalizer/water can be used for red cabbage cultivation.

Mohammadi *et al.* (2013) conducted an experiment to investigate the effects of natural and chemical fertilizers on yield and quality of potato at the Agricultural Research Farm of Razi University, Kermanshah, Iran. The first factor was tuber inoculation with Nitraginbiofertilizer at two levels: non inoculated and inoculated. The second factor was HB-101 (a completely organic natural extract) with three levels: non sprayed, one time and two times sprayed onto the potato foliage during the growing season. The third factor was chemical urea fertilizer. The results showed that the factors had significant effects on tuber yield, tuber weight, and

number of tuber per plant, biological yield and harvest index. The highest tuber yield and the number of tuber per plant were obtained when the tubers were inoculated with nitragin; and HB-101 was sprayed two times. It is concluded that integrated application of natural and biological fertilizers along with urea can be useful to enhance potato yield and quality.

Above cited reviews revealed that the tomato variety and plant vitalizer greatly influences the growth as well as yield of crops. The literature revealed that the effects of variety of tomat is more or less conclusive but vitalizer in red tomato have not been yet studied well and have no definite conclusion for the production of tomato under the agro climatic condition of Bangladesh.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted at the Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from October 2019 to March 2020 to study the effects of plant vitalizer (HB-101) on growth, yield and nutrient content of tomato. The details of the materials and methods have been presented below:

3.1 Experimental location

The research work was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 9 0°33´ E longitude and 23°77´ N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.2 Soil

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28 and was dark grey terrace soil. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI, Khamarbari, Dhaka. The details of morphological and chemical properties of initial soil of the experiment plot were presented in Appendix III.

3.3 Climate

The climate of experimental site was subtropical, characterized by three distinct seasons, the winter from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October (Edris*et al*., 1979). Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was

collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix II.

3.4 Test crop and its characteristics

Seeds of BARI tomato-2 and BARI tomato-15 were collected from Bangladesh Agricultural Research Institute (BARI), Joydevpur, Gazipur and were used as plant materials for the present study.

3.5 Experimental details

3.5.1 Treatment

Factor A: Variety – two

1. V_1 = BARI tomato-2
2. V_2 = BARI tomato-15

Factor B: Plant vitalizer (PV) application – five

1. PV_0 = Control (0 ml PV L^{-1})
2. PV_1 = 1 ml PV L^{-1}
3. PV_2 = 2 ml PV L^{-1}
4. PV_3 = 3 ml PV L^{-1}
5. PV_4 = 4 ml PV L^{-1}

Treatment combinations – Ten (10) treatment combinations

V_1PV_0, V_1PV_1, V_1PV_2, V_1PV_3, V_1PV_4, V_2PV_0, V_2PV_1, V_2PV_2, V_2PV_3 and V_2PV_4.

3.5.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of variety and doses of plant vitalizer (PV). The 10 treatment combinations of the experiment were assigned at random into 30 plots. The size of each unit plot was 1.87 m × 1.45 m. The distance between blocks and plots were

0.5 m and 0.25 m respectively. The layout of the experiment field is presented in Appendix IV.

3.5.3 Variety used and seed collection

BARI tomato-2 and BARI tomato-15, high yielding variety of tomato (*Solanum lycopersicum* L.) developed by Bangladesh Agricultural Research Institute (BARI), Gazipur was used as test crop. Seeds were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur.

3.6 Raising of seedlings

The land selected for nursery beds were well drained. The area was well prepared and converted into loose friable and dried mass to obtain fine tilth. All weeds and dead roots were removed and the soil was mixed with well rotten cowdung at the rate of 5 kg/bed. Seed bed size was 3m × 1m raised above the ground level maintaining a spacing of 50 cm between the beds. One seed bed was prepared for raising the seedlings. Ten (10) grams of seeds were sown in each seed bed on 23 October, 2019. After sowing, the seeds were covered with light soil. Complete germination of the seeds took place with 5 days after seed sowing. Necessary shading was made by bamboo mat (chatai) from scorching sunshine or rain. No chemical fertilizer was used in the seed bed.

3.7 Preparation of the main field

The plot selected for the experiment was opened in the 27 October, 2019 with a power tiller, and was exposed to the sun for a few days, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth of soil for transplanting. The land operation was completed on 17 November 2019. The individual plots were made by making ridges (20 cm high) around each plot to restrict lateral runoff of irrigation water.

3.8 Fertilizers and manure application

The N, P, K, and S nutrients were applied through urea, Triple super phosphate (TSP), Muriate of potash (MoP) and Gypsum, respectively. Phosphorus (P) and Sulphur(S) were applied as per treatment where rest of the nutrients was applied according to KrishiProjukti Hat Boi, 2016. Name and doses of nutrients were as follows:

Plant nutrients	Manure and fertilizer	Doses ha^{-1}
--	Cowdung	10 t
N	Urea	550 kg
P	TSP	150 kg
K	MoP	250 kg
S	Gypsum	10 kg

One third (1/3) of whole amount of Urea and full amount of TSP, MoP and Gypsum were applied at the time of final land preparation. The remaining Urea was top dressed in two equal installments- at 20 days after transplanting (DAT) and 50 DAT respectively.

3.9 Application of plant vitalizer (HB-101)

Plant vitalizer (HB-101) was used as plant growth enhancer. It was sprayed to the tomato plants at 20, 40 and 60 DAT as per treatment. HB-101 is a liquid plant growth enhancer formula, specially processed by blending the extracts of cedars, pines, cypress trees and plantains. Cedars, pines and cypresses are long-lived trees with powerful deodorizing power. The saps and secondary metabolites of these trees are responsible for maintaining the health and longevity of the trees. Plantains are known to have medicinal qualities and have long been used for various human medications (Johnny, 2017). HB-101 plant vitalizer is a purely natural extract derived from the portion of a plant that is most important in its development process. HB-101 is a growth nutrient for plants, flowers and crop production and is not a chemical fertilizer. HB-101 is a 100% organic product,

safe for plants and animals, and designed to benefit the earth's environment while reducing the demand for costly fertilizers (Greencoast Hydroponics, 2020). HB-101 is formulated and bottled in a ready-to-dilute solution for easy and immediate use. Highly concentrated, it's a cost-efficient way to achieve healthier, more vibrant plants. HB-101 is neither an agricultural chemical nor a plant fertilizer. It is an all natural solution that supports healthy plants. Hence, HB-101 is referred to as a plant "vitalizer", or plant growth enhancer (Mission Hills Nursery, 2020).

3.10 Transplanting of seedlings

Healthy and uniform sized 35 days old seedlings were taken separately from the seed bed and were transplanted in the experimental field on 18 November, 2019 maintaining a spacing of 60 cm × 60 cm. The seed bed was watered before uprooting the seedlings so as to minimize the damage of the roots. This operation was carried out during late hours in the evening. The seedlings were watered after transplanting. Shading was provided by piece of banana leaf sheath for three days to protect the seedlings from the direct sun. A strip of the same crop was established around the experimental field as border crop to do gap filling and to check the border effect.

3.11 Intercultural Operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of the tomato.

3.11.1 Gap filling and weeding

When the seedlings were established, the soil around the base of each seedling was pulverized. A few gaps were filled by healthy plants from the border whenever it was required. Weeds of different types were controlled manually as and when necessary.

3.11.2 Irrigation

Irrigation was done at three times. The first irrigation was given in the field at 25 days after transplanting (DAT) through irrigation channel. The second irrigation was given at the stage of maximum vegetative growth stage (40 DAT). The final irrigation was given at the stage of fruit formation (60 DAT).

3.11.3 Plant protection

The crop was infested with cutworm, leaf hopper and others. The insects were controlled successfully by spraying Malathion 57 EC @ 2ml /L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting. During foggy weather precautionary measures against disease infestation especially late blight of tomato was taken by spraying Dithane M-45 fortnightly @ 2 g/L.

3.12 Harvesting

Fruits were harvested at 5 days intervals during maturity to ripening stage. The maturity of the crop was determined on the basis of red colouring of fruits. Harvesting was started from 5 February, 2020 and completed by 21 March, 2020.

3.13 Data collection and recording

Ten plants were selected randomly from each unit plot for recording data on crop parameters and the yield of grain and straw were taken plot wise. The following parameters were recorded during the study:

3.13.1 Growth parameters

1. Plant height (cm)
2. Number of branches plant^{-1}

3.13.2 Yield contributing parameters

1. Number of flower cluster plant^{-1}
2. Number of flowers plant^{-1}

3. Number of fruits cluster^{-1}
4. Fruit length (cm)
5. Fruit diameter (cm)

3.13.3 Yield parameters

1. Number of fruits plant^{-1}
1. Single fruit weight (g)
2. Fruit weight plant^{-1} (kg)
3. Fruit yield ha^{-1} (t)

3.13.4 Quality parameters

1. Nutrient content (N, P, K, and S) in fruit

3.14 Procedure of recording data

3.14.1 Plant height (cm)

The height of plant was recorded in centimeter (cm) at the time of harvest. Data were recorded as the average of 5 plants of each plot. The height was measured from the ground level to the tip of the leaves.

3.14.2 Number of branches plant^{-1}

The total number of branches was counted from 5 plants of each plot. The average branches number was calculated which is termed as number of branches plant^{-1}.

3.13.3 Number of flower cluster plant^{-1}

The number of flower clusters was counted from 5 plants of each plot and the average number of clusters produced per plant was calculated.

3.14.4 Number of flowers plant^{-1}

Total number of flowers was recorded from the five sample plants, and the average number of flowers plant^{-1} was calculated by the following procedure

$$\text{Number of flowers plant}^{-1} = \frac{\text{Total number of flowers}}{\text{Number of plants}}$$

3.14.5 Number of fruits cluster^{-1}

The number of fruits and clusters from first harvest to last harvest was recorded from the five plants, and the average number of fruits cluster^{-1} was recorded by the following calculation

$$\text{Number of fruits cluster}^{-1} = \frac{\text{Total number of fruits from 5 plants}}{\text{Total number of clusters from 5 plants}}$$

3.14.6 Fruit length (cm)

The length of fruit was measured with a slide calipers from the neck of the fruit to the bottom of 15 selected marketable fruits from each plot and their average was calculated in centimeter.

3.14.7 Fruit diameter (cm)

Diameter or fruit was measured at the middle portion of 15 selected marketable fruits from each plot with a slide calipers and their average was calculated in centimeter.

3.14.8 Number of fruits plant^{-1}

The total number of fruits was counted at first harvest to last harvest from 5 plants of each plot and then averaged to obtain number of fruits plant^{-1}.

3.14.9 Number of fruits plot^{-1}

Number of fruits was recorded at each harvest from 5 plants of each plot. Totaling of fruit was calculated till final harvest and expressed as number of fruits plot^{-1}.

3.14.10 Single fruit weight (g)

Randomly 10 fruits were selected from sample plants regarding each treatment and then average single fruit weight was calculated by the following formula:

$$\text{Single fruit weight (g)} = \frac{\text{Weight of randomly selected ten fruits (g)}}{\text{Number of sample fruits}}$$

3.14.11 Fruit weight plant^{-1} (kg)

At first the total weight of fruit was taken from the 5 selected plants harvested at different dates using an electric balance and then weight plant^{-1} (kg) was calculated by following formula:

$$\text{Yield plant}^{-1}\text{ (kg)} = \frac{\text{Total weight of fruits from selected 5 plants (kg)}}{\text{Number of sample plants}}$$

3.14.12 Fruit yield ha^{-1} (t)

After collection of per plot yield, it was converted to ton per hectare by the following formula:

$$\text{Fruit yield per hectare (ton)} = \frac{\text{Fruit yield per plot (kg)} \times 10000\ m^2}{\text{Plot size } (m^2) \times 1\ 000\ kg}$$

3.14.13 Chemical analysis

Chemical analysis was done in the laboratory following the procedure of nutrient content measurement regarding nitrogen (N), phosphorus (P), potassium (K) and sulphur (S). Nutrient content was measured in plant.

3.14.13.1 Determination of nitrogen (%)

Oven dried of plant samples were grined in a Mill passed through 40 mesh screen, mixed well and stored in plastic vials.

For the determination of N an amount of 1 g oven dry grined sample were taken in a micro Kjeldahl flask. One gram catalyst mixture (K_2SO_4; $CuSO_4.5H_2O$ in the ratio of 100:10:1) and 10 ml conc. H_2SO_4 were added. The flasks were heated at 160°C and added 2 ml H_2O_2 than heating was continued at 360°C until digests become clear and colorless.

After cooling the content was taken into a 100 ml volumetric flask and the volume was made up to the mark with de-ionized water. A reagent blank was prepared in a similar manner.

Nitrogen in the digest was estimated by distilling with 10N NaOH followed by titration of the distillate trapped in H_3BO_3 indicator solution with 0.01N H_2SO_4.

The amount of nitrogen was calculated using the following formula:

$$\% N = (T-B) \times N \times 0.014 \times 100/S$$

Where,

T = Sample titration (ml) value of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

S = Sample weight (g)

3.14.13.2 Determination of phosphorus and potassium (%)

Oven dried of plant samples were grined in a Mill passed through 40 mesh screen, mixed well and stored in plastic vials.

Exactly 1 g of grined plant sample was taken in a 250 ml conical flask. 20 ml Di-acid mixture was added (previously prepared by adding 60% HNO_3 and $HClO_4$ in 2:1 ration through wet oxidation method) to the plant sample.

Flask was stirred to moisten the entire mass of tissue and was placed on an electric hot plate. The content was heated at 180-200°C until white fume was evolved. 5

ml Di-acid mixture was added to the flask if the contents become dry before the end of the digestion. The flask was removed and was allowed to cool. Than 20-30 ml distilled water was added and shaken and after that the solution was filtered with Whatman Filter Paper No.1 in 100 ml volumetric flask. The conical flask was washed several times to ensure that all the minerals are transferred to the volumetric flask. The volume was made up to the mark with distilled water.

The contents of phosphorus (P) was measured by Spectophotometer HALO DB-20S at 660 ηm and potassium (K) was measured by flame photometer JENWAY PFP7.

3.14.13.3 Determination of sulphur (ppm)

Sulphur in plant samples was determined by Calcium chloride extraction method (Turbidimetric method) (Page *et al.,* 1982). The S content in the extract was determined turbidimetrically and the intensity of turbid was measured by spectrophotometer at 420 ηm wavelength by the following procedure:

In this method, $CaCl_2$ solution helps to accumulate SO_4^{2-} from plant extract. The available S as the sulphate form determined by the turbidity of suspended barium sulphate and hence this is known as turbidimetric method. The turbidity of suspended $BaSO_4$ is produced by treating the plant extract with $BaCl_2.2H_2O$ crystals.

$BaCl_2 + SO_4^{2-}$ ---------- $BaSO_4$ (insoluble, turbidity) + $2C1^-$

The intensity' of the turbidity is measured by a spectrophotometer at 420 ηm wavelengths. The procedure by which barium sulphate is precipitated must be carefully controlled as the properties of suspension are influenced by the velocity of reaction. The $BaCl_2$ was added to the sulphate solution in the solid state as crystals of definite size (20-26 mesh) and not as solution. The size of the crystals determine their rate of solution, which in turn, determines the rate of reaction with

sulphate.

Different equipments such as Erlenmeyer/conical flask (100ml), funnel, filter paper Whatman No. 42, volumetric flasks (100 and 50 ml), spectrophotometer, etc. were used to determine S in the plant samples. Different reagent like (i) Extracting reagent (solution): 1.5 g $CaCl_2$ is dissolved in 1 liter distilled water (0.15 w/v), (ii) Acid seed solution: 6 N HCI containing 20 ppm S as K_2SO_4 and (iii) Barium chloride ($BaCl_2.2H_2O$): 20 to 26 mesh crystals (Fine Particles) were used.

10 g of 20-mesh plant sample was taken in a 100 ml. Erlenmeyer flask. 50 ml of the extracting solution was added to it. The content was shaken for 30 minutes and after shaking the plant suspension was filtered through a sulphate free Whatman No. 42 filter paper. 20 ml of the filtrate was pipetted to a 100 ml volumetric flask. 2 ml acid seed solution and 1 g $BaCl_2$ crystals were added. The mixture was allowed to stand for 1 minute. The solution in the flask was swirled frequently until the crystals were dissolved and the volume was made up to the mark with distilled water. The light absorbance of this turbid solution was measured on a suitable spectrophotometer at a wavelength of 420 ηm within the time interval of 2 to 8 minutes after dissolving the crystals.

3.15 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Difference Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The study was conducted to find out the effects of plant vitalizer (HB-101) on growth, yield and nutrients content of tomato. Analyses of variance (ANOVA) of the data on different growth, yield parameters and yield of tomato are presented in Appendix V-IX. The results have been presented and discusses with the help of table and graphs and possible interpretations under the following headings:

4.1 Growth parameters

4.1.1 Plant height (cm)

Effect of variety

Significant variation was observed on plant height of tomato as influenced by different varieties (Figure 1 and Appendix V). The highest plant height (71.68 cm) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest plant height (69.60 cm) was recorded from the variety V_1 (BARI tomato-2). Similar result was also observed by Parmar and Thakur (2018) but Sanjida *et al*. (2020) and Benti and Degefa (2017) found significant variation on plant height of different tomato varieties.

Effect of plant vitalizer (PV)

Different levels of plant vitalizer treatments had significant influence on plant height of tomato (Figure 2 and Appendix V). Results showed that the highest plant height (81.73 cm) was recorded from the plant vitalizer treatment PV_4 (4 ml PV L^{-1}) which was statistically identical with PV_3 (3 ml PV L^{-1}) whereas the lowest plant height (59.83 cm) was recorded from the control treatment PV_0 (0 ml PV L^{-1}) which was statistically identical with PV_1 (1 ml PV L^{-1}).

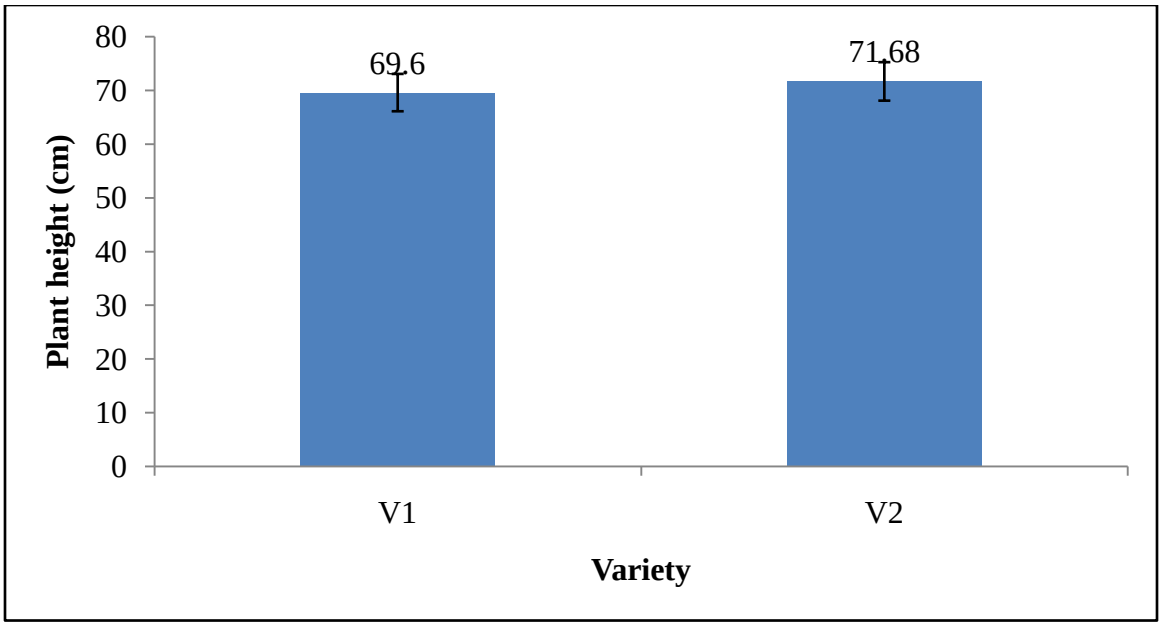

Figure 1. Plant height of tomato as influenced by variety

V_1 = BARI tomato-2, V_2 = BARI tomato-15

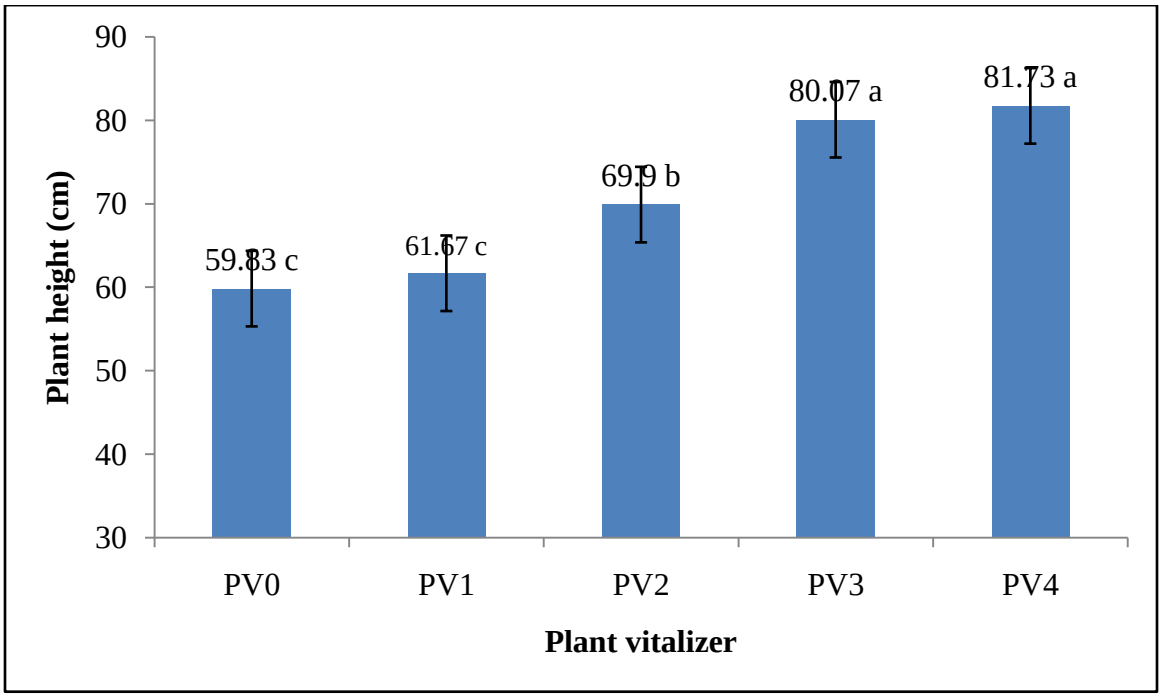

Figure 2. Plant height of tomato as influenced by plant vitalizer application

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

Combined effect of variety and plant vitalizer (PV)

Significant variation was observed on plant height of tomato as influenced by combined effect of variety and plant vitalizer (Figure 3 and Appendix V). It was found that the highest plant height (82.40 cm) was recorded from the treatment combination of V_2PV_4 which was statistically similar with the treatment combination of V_1PV_3, V_1PV_4 and V_2PV_3. On the other hand, the lowest plant height (59.07 cm) was recorded from the treatment combination of V_1PV_0which was statistically similar with the treatment combination of V_1PV_1, V_2PV_0 and V_2PV_1.

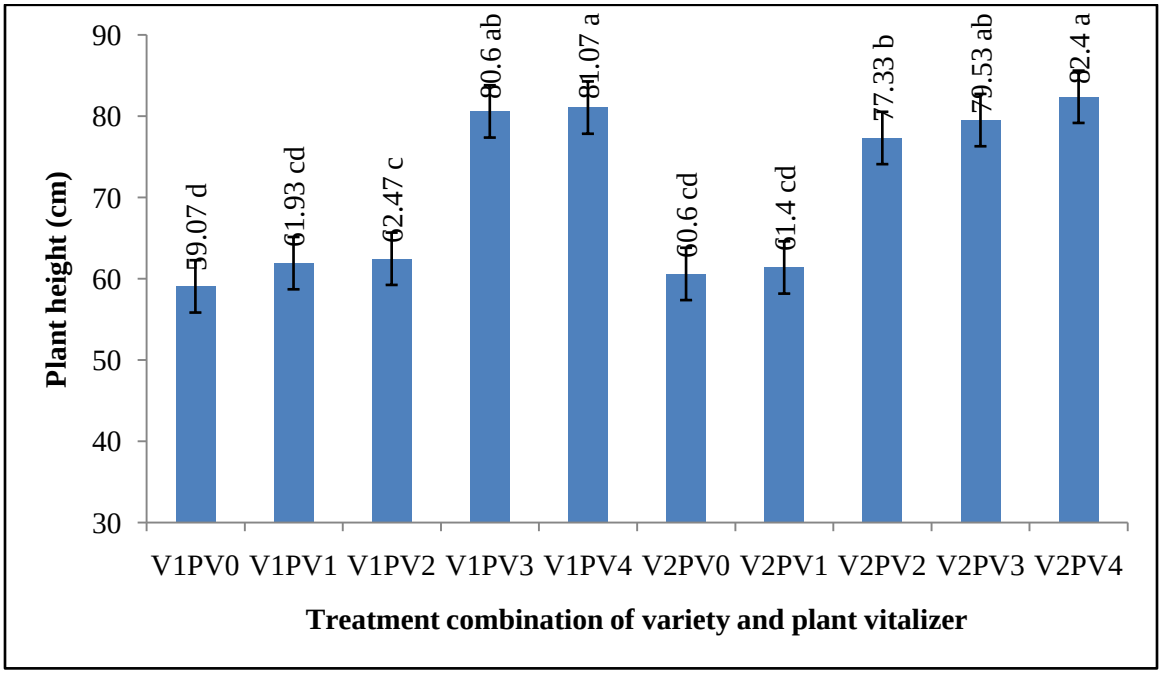

Figure 3. Plant height of tomato as influenced by combined effect of variety and plant vitalizer application

V_1 = BARI tomato-2, V_2 = BARI tomato-15

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

4.1.2 Number of branches plant^{-1}

Effect of variety

Number of branches plant^{-1} of tomato showed statistically significant variation due to different varieties (Figure 4 and Appendix V). It was found that the highest number of branches plant^{-1} (7.32 cm) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest number of branches plant^{-1} (6.91 cm) was recorded from the variety V_1 (BARI tomato-2). The result obtained from the present study was similar with the findings of Biswas *et al*. (2015), Kena (2018) and Sanjida *et al*. (2020) who found significant variation on number of branches plant^{-1} of tomato varieties.

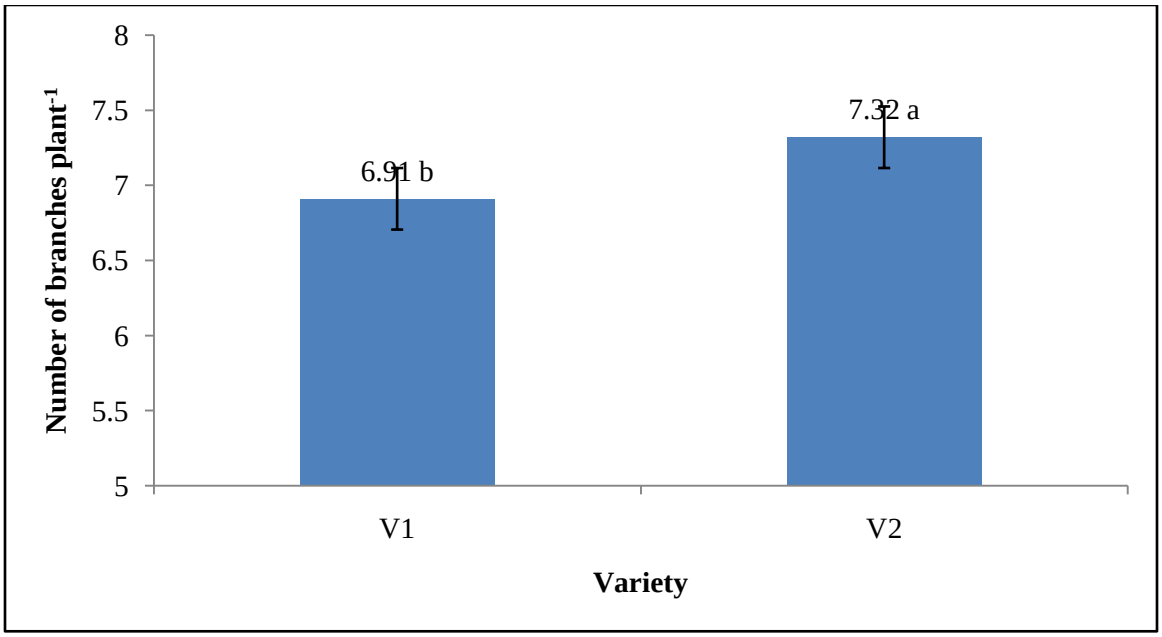

Figure 4. Number of branches plant^{-1} of tomato as influenced by variety

V_1 = BARI tomato-2, V_2 = BARI tomato-15

Effect of plant vitalizer (PV)

Statistically significant differences were recorded due to different levels of plant vitalizer on number of branches plant^{-1} of tomato (Figure 5 and Appendix V). Results indicated that the highest number of branches plant^{-1} (7.90 cm) was

recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) which was significantly same to PV_4 (4 ml PV L^{-1}). The lowest number of branches $plant^{-1}$ (6.23 cm) was recorded from the control treatment PV_0 (0 ml PV L^{-1}) which was statistically identical with PV_1 (1 ml PV L^{-1}).

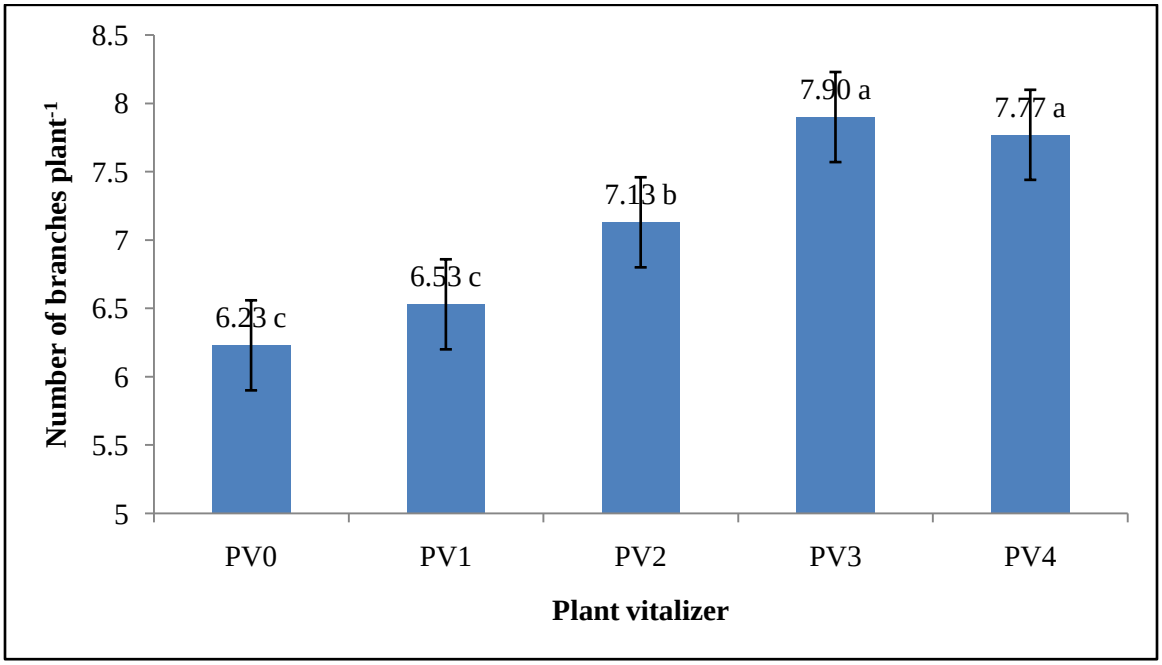

Figure 5. Number of branches $plant^{-1}$ of tomato as influenced by plant vitalizer application

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

Combined effect of variety and plant vitalizer (PV)

Combined effect of different variety and plant vitalizer showed statistically significant variation in terms of number of branches $plant^{-1}$ of tomato (Figure 6 and Appendix V). Results revealed that the highest number of branches $plant^{-1}$ (8.40 cm) was recorded from the treatment combination of V_2PV_3 which was statistically similar with the treatment combination of V_1PV_4 and V_2PV_4. The lowest number of branches $plant^{-1}$ (6.13 cm) was recorded from the treatment combination of V_1PV_0 which was statistically similar with the treatment combination of V_1PV_1 and V_1PV_2, V_2PV_0 and V_2PV_1.

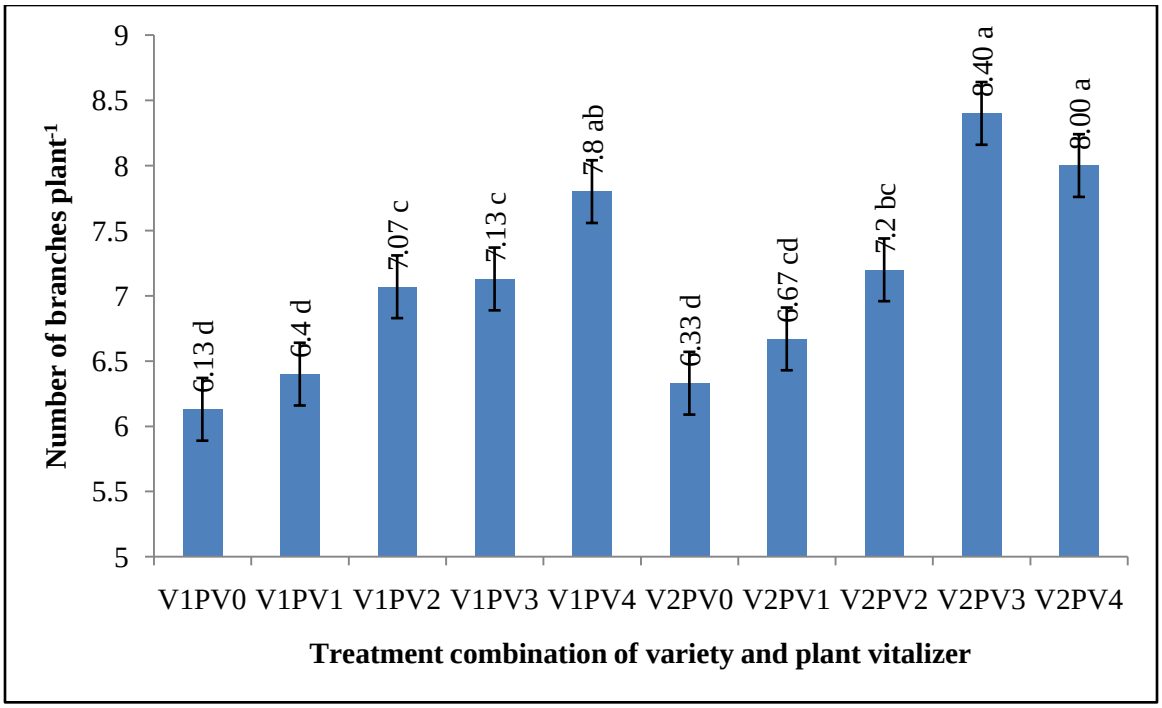

Figure 6. Number of branches plant^{-1} of tomato as influenced by combined effect of variety and plant vitalizer application

4.2 Yield contributing parameters

4.2.1 Number of flower clusters plant^{-1}

Effect of variety

There was no significant variation on number of flower clusters plant^{-1} influenced by different varieties of tomato (Figure 7 and Appendix VI). However, the highest number of flower clusters plant^{-1} (5.62) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest number of flower clusters plant^{-1} (5.54) was recorded from the variety V_1 (BARI tomato-2). Sanjida *et al*. (2020), Benti and Degefa (2017) and Biswas*et al*. (2015) found similar results which supported the present study.

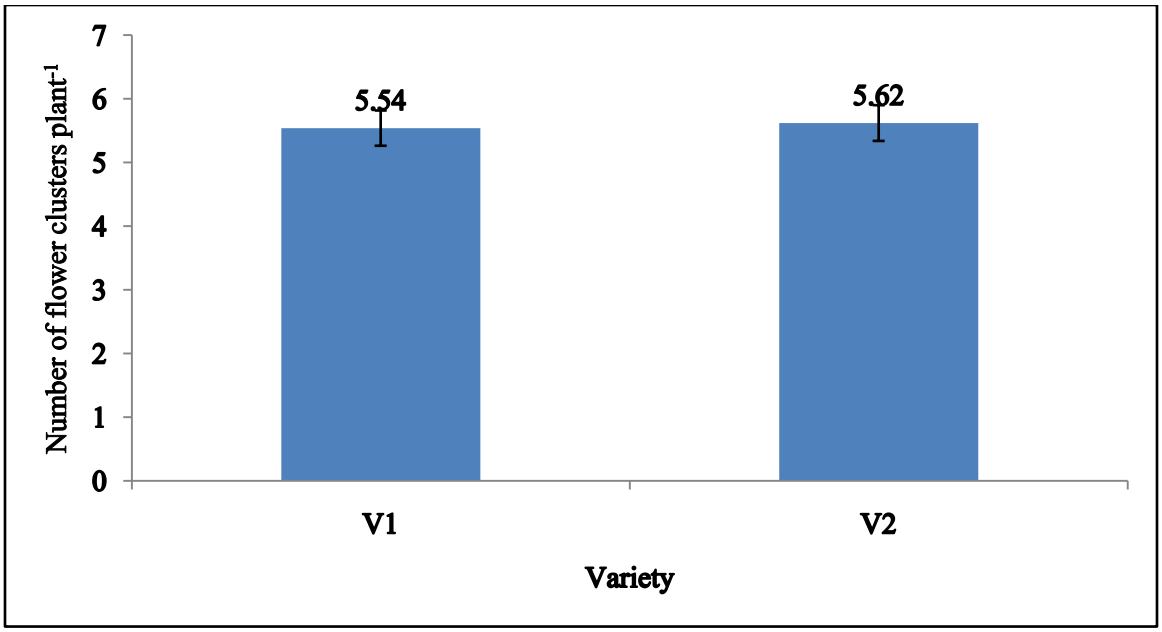

Figure 7. Number of flower clusters plant^{-1} of tomato as influenced by variety

V_1 = BARI tomato-2, V_2 = BARI tomato-15

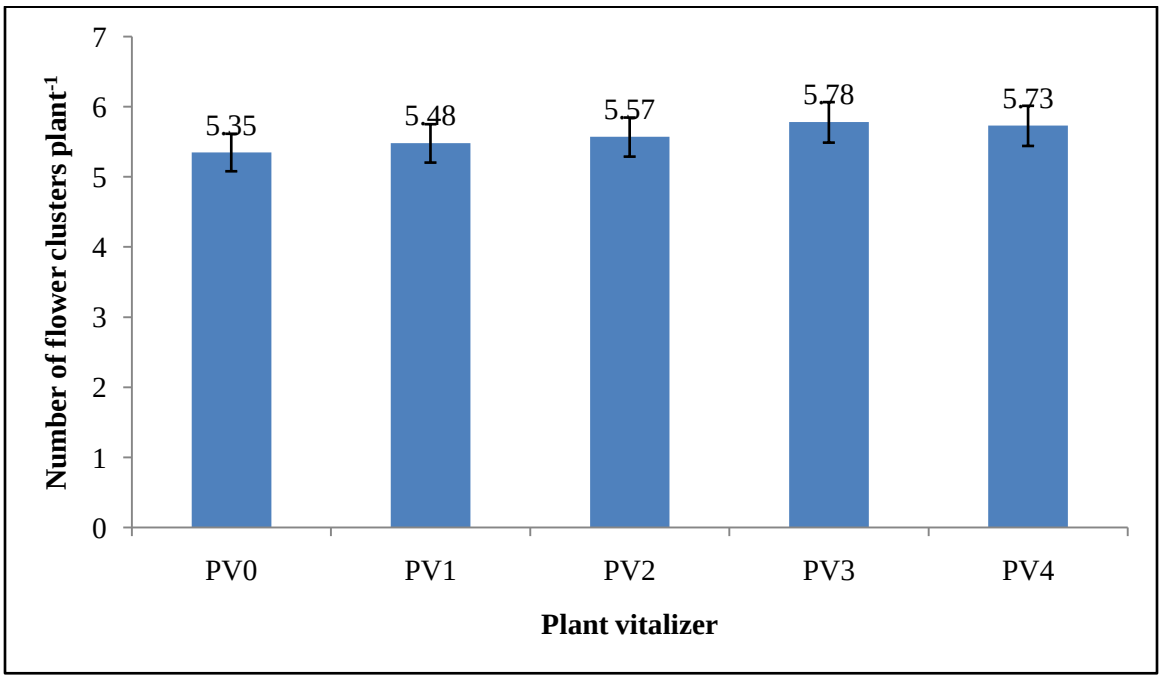

Figure 8. Number of flower clusters plant^{-1} of tomato as influenced by plant vitalizer application

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

Effect of plant vitalizer (PV)

Non-significant variation was found on number of flower clusters plant^{-1} of tomato as influenced by different levels of plant vitalizer (Figure 8 and Appendix VI). However, the highest number of flower clusters plant^{-1} (5.78) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) followed by PV_4 (4 ml PV L^{-1}) whereas the lowest number of flower clusters plant^{-1} (5.35) was recorded from the control treatment PV_0 (0 ml PV L^{-1}).

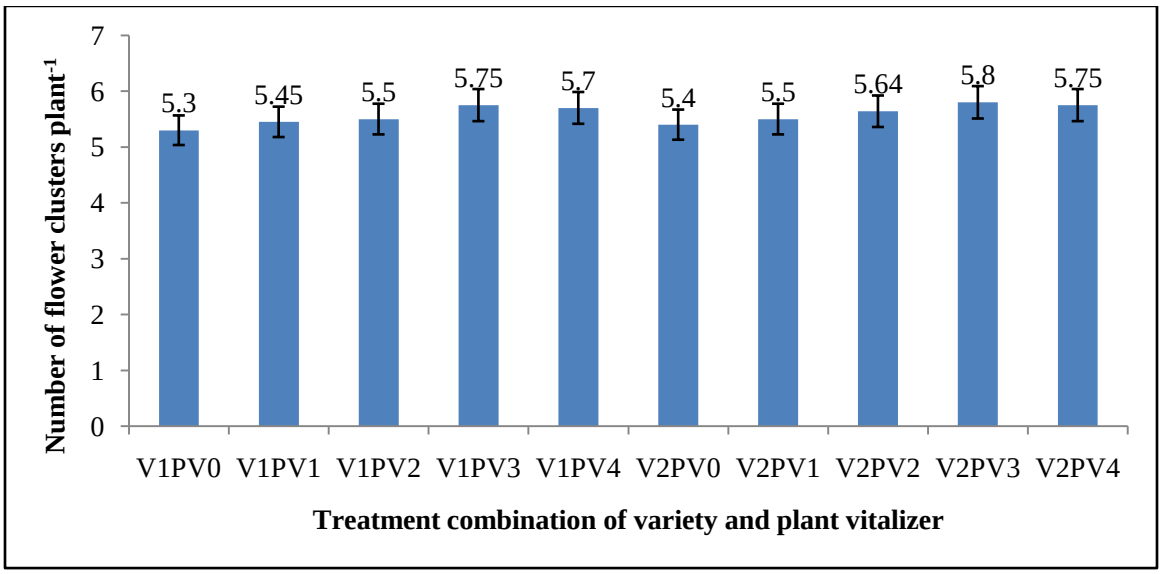

Figure 9. Number of flower clusters plant^{-1}of tomato as influenced by combined effect of variety and plant vitalizer application

V_1 = BARI tomato-2, V_2 = BARI tomato-15

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

Combined effect of variety and plant vitalizer (PV)

Number of flower clusters plant^{-1} was not significantly varied due to combined effect of different variety and plant vitalizer (Figure 9 and Appendix VI). However, results revealed that the highest number of flower clusters plant^{-1} (5.80) was recorded from the treatment combination of V_1PV_3 whereas the lowest number of flower clusters plant^{-1} (5.30) was recorded from the treatment combination of V_1PV_0.

4.2.2 Number of flowers plant^{-1}

Effect of variety

Number of flowers plant^{-1} was significantly influenced due to different varieties of tomato (Table 1 and Appendix VI). It was observed that the highest number of flowers plant^{-1} (35.90) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest number of flowers plant^{-1} (33.42) was recorded from the variety V_1 (BARI tomato-2). The results obtained from the present study was conformity with the findings of Sanjida *et al*. (2020) and Biswas *et al*. (2015).

Effect of plant vitalizer (PV)

Significant influence was noted on number of flowers plant^{-1} of tomato affected by different levels of plant vitalizer (Table 1 and Appendix VI). Results indicated that the highest number of flowers plant^{-1} (41.27) was recorded from the plant vitalizer treatment PV_4 (4 ml PV L^{-1} which was significantly different from other treatments followed by PV_3 (3 ml PV L^{-1}). The lowest number of flowers plant^{-1} (28.57) was recorded from the control treatment PV_0 (0 ml PV L^{-1}) which was statistically same with PV_1 (1 ml PV L^{-1}).

Combined effect of variety and plant vitalizer (PV)

Number of flowers plant^{-1} was significantly varied due to combined effect of different variety and plant vitalizer (Table 1 and Appendix VI). The highest number of flowers plant^{-1} (44.47) was recorded from the treatment combination of V_2PV_4 followed by the treatment combination of V_1PV_3, V_1PV_4 and V_2PV_3. The lowest number of flowers plant^{-1} (27.00) was recorded from the treatment combination of V_1PV_0 which was statistically similar with the treatment combination of V_1PV_1 and V_2PV_0.

4.2.3 Number of fruits cluster^{-1}

Effect of variety

Number of fruits cluster^{-1} between two varieties of tomato showed non-significant difference (Table 1 and Appendix VI). However, the highest number of fruits cluster^{-1} (4.90) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest number of fruits cluster^{-1} (4.87) was recorded from the variety V_1 (BARI tomato-2). Supported results was also observed by Benti and Degefa (2017) and Biswas *et al*. (2015).

Effect of plant vitalizer (PV)

Statistically non-significant difference was recorded due to different levels of plant vitalizer on number of fruits cluster^{-1} of tomato (Table 1 and Appendix VI). However, the highest number of fruits cluster^{-1} (4.95) was recorded from the plant vitalizer treatment PV_4 (4 ml PV L^{-1}) followed by PV_3 (3 ml PV L^{-1}). The lowest number of fruits cluster^{-1} (4.77) was recorded from the control treatment PV_1 (1 ml PV L^{-1}) followed by control treatment PV_0 (0 ml PV L^{-1}).

Combined effect of variety and plant vitalizer (PV)

Combined effect of different varieties and plant vitalizer showed statistically non-significant variation in terms of number of fruits cluster^{-1} of tomato (Table 1 and Appendix VI). However, the highest number of fruits cluster^{-1} (5.00) was recorded from the treatment combination of V_2PV_4 whereas the lowest number of fruits cluster^{-1} (4.76) was recorded from the treatment combination of V_1PV_0.

4.2.4 Fruit length (cm)

Effect of variety

Non-significant variation was observed on fruit length as influenced by different varieties of tomato (Table 1 and Appendix VI). However, the highest fruit length

(7.04 cm) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest fruit length (6.91 cm) was recorded from the variety V_1 (BARI tomato-2). Similar result was also observed by Mehraj *et al*. (2014), Ali (2014) and Ahmad and Khan (2007).

Effect of plant vitalizer (PV)

There was no significant variation on fruit length of tomato influenced by different levels of plant vitalizer (Table 1 and Appendix VI). However, the highest fruit length (7.14 cm) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) whereas the lowest fruit length (6.76 cm) was recorded from the control treatment PV_0 (0 ml PV L^{-1}).

Combined effect of variety and plant vitalizer (PV)

Combined effect of different variety and plant vitalizer had no significant influence on fruit length (Table 1 and Appendix VI). However, the highest fruit length (7.28 cm) was recorded from the treatment combination of V_2PV_3 whereas the lowest fruit length (6.73 cm) was recorded from the treatment combination of V_1PV_0.

4.2.5 Fruit diameter (cm)

Effect of variety

Fruit diameter was not significantly varied due to different varieties of tomato (Table 1 and Appendix VI). However, the highest fruit diameter (7.91 cm) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest fruit diameter (7.61 cm) was recorded from the variety V_1 (BARI tomato-2). The result obtained from the present study was conformity with the findings of Biswas *et al*. (2015), Mehraj *et al*. (2014) and Ali (2014).

Table 1. Yield contributing parameters of tomato as influenced by variety and plant vitalizer application

Treatments	Yield contributing parameters				
	Number of flower clusters plant^{-1}	Number of flowers plant^{-1}	Number of fruits cluster^{-1}	Fruit length (cm)	Fruit diameter (cm)
Effect of variety					
V_1	5.54	33.42 b	4.87	6.91	7.61
V_2	5.62	35.90 a	4.90	7.04	7.91
$LSD_{0.05}$	0.309^{NS}	0.411	0.207^{NS}	0.403^{NS}	0.385^{NS}
CV(%)	6.52	7.48	5.89	6.21	7.13
Effect of plant vitalizer (PV)					
PV_0	5.35	28.57 d	4.77	6.76	7.09 c
PV_1	5.48	29.45 d	4.89	6.83	7.48 b
PV_2	5.57	34.73 c	4.9	7.00	7.88 a
PV_3	5.78	39.27 b	4.94	7.14	8.22 a
PV_4	5.73	41.27 a	4.95	7.13	8.14 a
$LSD_{0.05}$	0.808^{NS}	2.003	0.769^{NS}	0.469^{NS}	0.389
CV(%)	6.52	7.48	5.89	6.21	7.13
Combined effect of variety and plant vitalizer (PV)					
V_1PV_0	5.30	27.00 e	4.76	6.73	7.04 f
V_1PV_1	5.45	29.50 de	4.90	6.79	7.38 ef
V_1PV_2	5.50	31.93 d	4.91	6.95	7.71 cde
V_1PV_3	5.75	40.60 b	4.90	7.00	7.77 cd
V_1PV_4	5.70	38.07 bc	4.89	7.08	8.13 b
V_2PV_0	5.40	29.40 de	4.77	6.78	7.13 f
V_2PV_1	5.50	30.13 d	4.87	6.87	7.58 de
V_2PV_2	5.64	37.53 c	4.88	7.05	8.05 bc
V_2PV_3	5.80	37.93 bc	4.97	7.28	8.50 a
V_2PV_4	5.75	44.47 a	5.00	7.20	8.30 ab
$LSD_{0.05}$	1.112^{NS}	2.833	0.949^{NS}	1.63^{NS}	0.356
CV(%)	6.52	7.48	5.89	6.21	7.13

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI tomato-2, V_2 = BARI tomato-16

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

Effect of plant vitalizer (PV)

There was a significant variation on fruit diameter of tomato influenced by different levels of plant vitalizer (Table 1 and Appendix VI). The highest fruit diameter (8.32 cm) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) which was statistically identical with PV_4 (4 ml PV L^{-1}) and PV_2 (2 ml PV L^{-1}). The lowest fruit diameter (7.09 cm) was recorded from the control treatment PV_0 (0 ml PV L^{-1}) which was significantly different from other treatments.

Combined effect of variety and plant vitalizer (PV)

Combined effect of different variety and plant vitalizer had significant influence on fruit diameter of tomato (Table 1 and Appendix VI). The highest fruit diameter (8.50 cm) was recorded from the treatment combination of V_2PV_3 which was statistically similar with the treatment combination of V_2PV_4. The lowest fruit diameter (7.04 cm) was recorded from the treatment combination of V_1PV_0 which was statistically similar with V_2PV_0 and V_1PV_1.

4.3 Yield parameters

4.3.1 Number of fruits plant^{-1}

Effect of variety

There was no significant variation on number of fruits plant^{-1} influenced by different varieties of tomato (Table 2 and Appendix VII). However, results indicated that the highest number of fruits plant^{-1} (27.51) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest number of fruits plant^{-1} (27.01) was recorded from the variety V_1 (BARI tomato-2). The results obtained from the present study was conformity with the findings of Sanjida*et al*. (2020), Parmar and Thakur (2018), Dunsin (2016), Khaled and Sikder (2015) and Mehraj *et al*. (2014) who observed significant variation on number of fruits plant^{-1} due to varietal difference.

Effect of plant vitalizer (PV)

Significant variation was found on number of fruits plant^{-1} of tomato as influenced by different levels of plant vitalizer (Table 2 and Appendix VII). It was found that the highest number of fruits plant^{-1} (28.50) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) which was statistically identical with PV_4 (4 ml PV L^{-1}) whereas the lowest number of fruits plant^{-1} (25.50) was recorded from the control treatment PV_0 (0 ml PV L^{-1}) which was significantly different from other treatments.

Combined effect of variety and plant vitalizer (PV)

Number of fruits plant^{-1} was significantly varied due to combined effect of different variety and plant vitalizer (Table 2 and Appendix VII). Results indicated that the highest number of fruits plant^{-1} (28.80) was recorded from the treatment combination of V_2PV_3 which was statistically identical with the treatment combination V_2PV_4. On the other hand, the lowest number of fruits plant^{-1} (25.25) was recorded from the treatment combination of V_1PV_0 which was statistically identical with the treatment combination of V_2PV_0.

4.3.2 Single fruit weight (g)

Effect of variety

Single fruit weight was not significantly influenced due to different varieties of tomato (Table 2 and Appendix VII). However, the highest single fruit weight (63.03 g) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest single fruit weight (62.47 g) was recorded from the variety V_1 (BARI tomato-2). Similar result was also observed by Sanjida *et al*. (2020), Biswas *et al*. (2015) and Jamwal *et al.* (1995).

Effect of plant vitalizer (PV)

Significant influence was noted on single fruit weight of tomato affected by different levels of plant vitalizer (Table 2 and Appendix VII). Results showed that the highest single fruit weight (63.70 g) was recorded from the plant vitalizer treatment PV_4 (4 ml PV L^{-1}) which was statistically identical with PV_3 (3 ml PV L^{-1}). The lowest single fruit weight (62.25 g) was recorded from the control treatment PV_0 (0 ml PV L^{-1}) which was statistically identical with PV_1 (1 ml PV L^{-1}).

Combined effect of variety and plant vitalizer (PV)

Single fruit weight was significantly varied due to combined effect of different variety and plant vitalizer (Table 2 and Appendix VII). Results revealed that the highest single fruit weight (63.75 g) was recorded from the treatment combination of V_2PV_3 which was statistically identical with the treatment combination of V_1PV_3, V_1PV_4, V_2PV_2 and V_2PV_4. The lowest single fruit weight (62.02 g) was recorded from the treatment combination of V_1PV_0 which was statistically similar with the treatment combination of V_1PV_1 and V_2PV_1.

4.3.4 Fruit weight plant^{-1} (g)

Effect of variety

Fruit weight plant^{-1} between two varieties of tomato varied significantly (Table 2 and Appendix VII). It was found that the highest fruit weight plant^{-1} (1735.00 g) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest fruit weight plant^{-1} (1688.00 g) was recorded from the variety V_1 (BARI tomato-2). Sanjida *et al*. (2020), Khaled and Sikder (2015) and Mehraj *et al*. (2014) also found similar results which supported the present study.

Table 2. Yield parameters of tomato as influenced by variety and plant vitalizer application

Treatments	Yield parameters			
	Number of fruits plant^{-1}	Single fruit weight (g)	Fruit weight plant^{-1} (g)	Yield (kg plot^{-1})
Effect of variety				
V_1	27.01	62.47	1688.00 b	20.26 b
V_2	27.51	63.03	1735.00 a	20.82 a
$LSD_{0.05}$	0.804^{NS}	1.514^{NS}	7.362	0.314
CV(%)	7.86	7.48	9.54	6.21
Effect of plant vitalizer (PV)				
PV_0	25.50 d	62.25 c	1587.00 e	19.05 d
PV_1	26.75 c	61.51 c	1645.00 d	19.75 c
PV_2	27.25 b	62.74 b	1710.00 c	20.52 b
PV_3	28.50 a	63.55 a	1811.00 a	21.74 a
PV_4	28.30 a	63.70 a	1803.00 b	21.64 a
$LSD_{0.05}$	0.3986	0.5637	8.019	0.399
CV(%)	7.86	7.48	9.54	6.21
Combined effect of variety and plant vitalizer (PV)				
V_1PV_0	25.25 e	62.02 c	1566.00 i	18.79 g
V_1PV_1	26.70 d	61.16 c	1633.00 g	19.60 ef
V_1PV_2	27.00 d	62.16 b	1678.00 e	20.14 d
V_1PV_3	28.20 b	63.35 a	1787.00 b	21.44 b
V_1PV_4	27.90 bc	63.66 a	1776.00 c	21.32 b
V_2PV_0	25.75 e	62.48 b	1609.00 h	19.31 f
V_2PV_1	26.80 d	61.85 bc	1658.00 f	19.89 de
V_2PV_2	27.50 c	63.32 a	1741.00 d	20.90 c
V_2PV_3	28.80 a	63.75 a	1836.00 a	22.03 a
V_2PV_4	28.70 a	63.74 a	1829.00 a	21.95 a
$LSD_{0.05}$	0.4603	0.9489	7.579	0.3255
CV(%)	7.86	7.48	9.54	6.21

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI tomato-2, V_2 = BARI tomato-16

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

Effect of plant vitalizer (PV)

Statistically significant difference was recorded due to different levels of plant vitalizer on fruit weight plant^{-1} of tomato (Table 2 and Appendix VII). The highest fruit weight plant^{-1} (1811.00 g) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) which was significantly different from other treatments followed by PV_4 (4 ml PV L^{-1}) whereas the lowest fruit weight plant^{-1} (1587.00 g) was recorded from the control treatment PV_0 (0 ml PV L^{-1}).

Combined effect of variety and plant vitalizer (PV)

Combined effect of different varieties and plant vitalizer showed statistically significant variation in terms of fruit weight plant^{-1} of tomato (Table 2 and Appendix VII). The highest fruit weight plant^{-1} (1836.00 g) was recorded from the treatment combination of V_2PV_3 which was statistically identical with the treatment combination of V_2PV_4. Reversely, the lowest fruit weight plant^{-1} (1566.00 g) was recorded from the treatment combination of V_1PV_0 which was significantly different from other treatment combinations.

4.3.5 Yield plot^{-1} (kg)

Effect of variety

There was a significant variation on yield plot^{-1} influenced by different varieties of tomato (Table 2 and Appendix VII). Results showed that the highest yield plot^{-1} (20.82 kg) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest yield plot^{-1} (20.06 kg) was recorded from the variety V_1 (BARI tomato-2). Similar result was also observed by Dunsin (2016).

Effect of plant vitalizer (PV)

Significant variation was found on yield plot^{-1} of tomato as influenced by different levels of plant vitalizer (Table 2 and Appendix VII). The highest yield plot^{-1} (21.74 kg) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) which was statistically identical with PV_4 (4 ml PV L^{-1}). The lowest yield plot^{-1} (19.05 kg)

was recorded from the control treatment PV_0 (0 ml PV L^{-1}) which was significantly different from other treatments.

Combined effect of variety and plant vitalizer (PV)

Yield $plot^{-1}$ was significantly varied due to combined effect of different variety and plant vitalizer (Table 2 and Appendix VII). It was found that the highest yield $plot^{-1}$ (22.03 kg) was recorded from the treatment combination of V_2PV_3 which was statistically identical with the treatment combination of V_1PV_4. The lowest yield $plot^{-1}$ (18.79 kg) was recorded from the treatment combination of V_1PV_0 which was significantly different from other treatment combinations.

4.3.6 Yield (t ha^{-1})

Effect of variety

Yield of tomato was significantly influenced due to different varieties of tomato (Figure 10 and Appendix VII). Results revealed that the highest yield (59.47 t ha^{-1}) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest yield (57.87 t ha^{-1}) was recorded from the variety V_1 (BARI tomato-2). The results obtained from the present study was conformity with the findings of Sanjida *et al*. (2020), Parmar and Thakur (2018), Kena (2018), Benti and Degefa (2017), Biswas *et al*. (2015), Khaled and Sikder (2015), Mehraj *et al*. (2014) and Ali (2014).

Effect of plant vitalizer (PV)

Significant influence was noted on yield of tomato affected by different levels of plant vitalizer (Figure 11 and Appendix VII). Results indicated that the highest yield (62.10 t ha^{-1}) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) which was statistically identical with PV_4 (4 ml PV L^{-1}). On the other hand, the lowest yield (54.43 t ha^{-1}) was recorded from the control treatment PV_0 (0 ml PV L^{-1}).

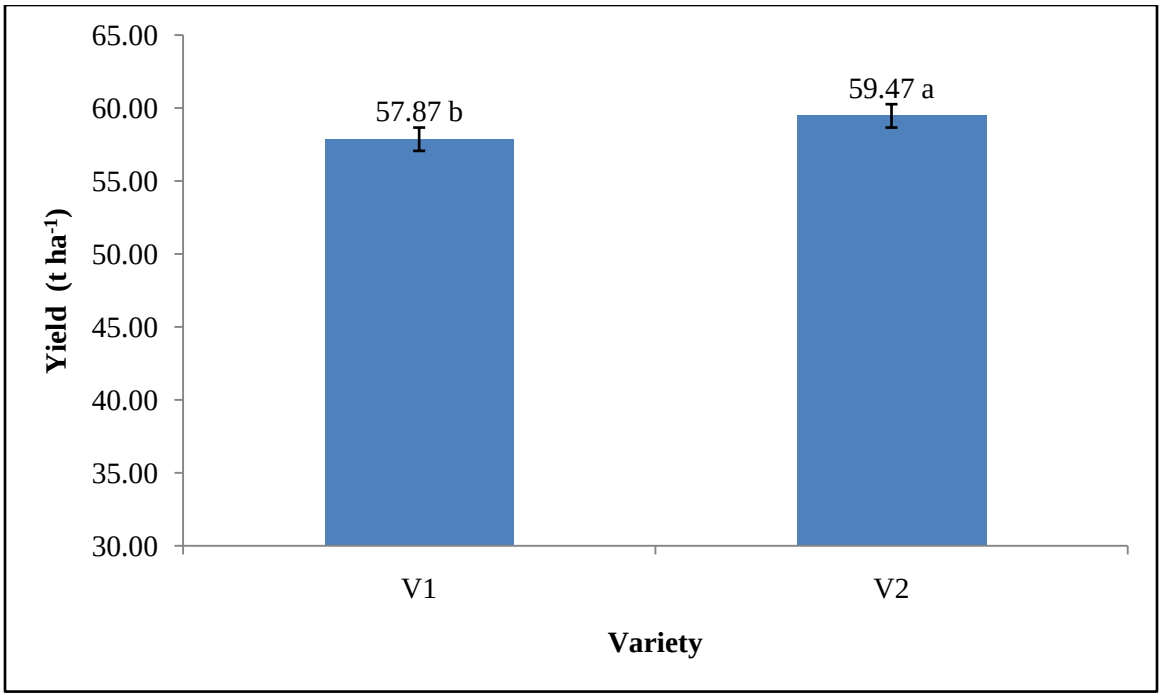

Figure 10. Yield of tomato as influenced by variety

V_1 = BARI tomato-2, V_2 = BARI tomato-15

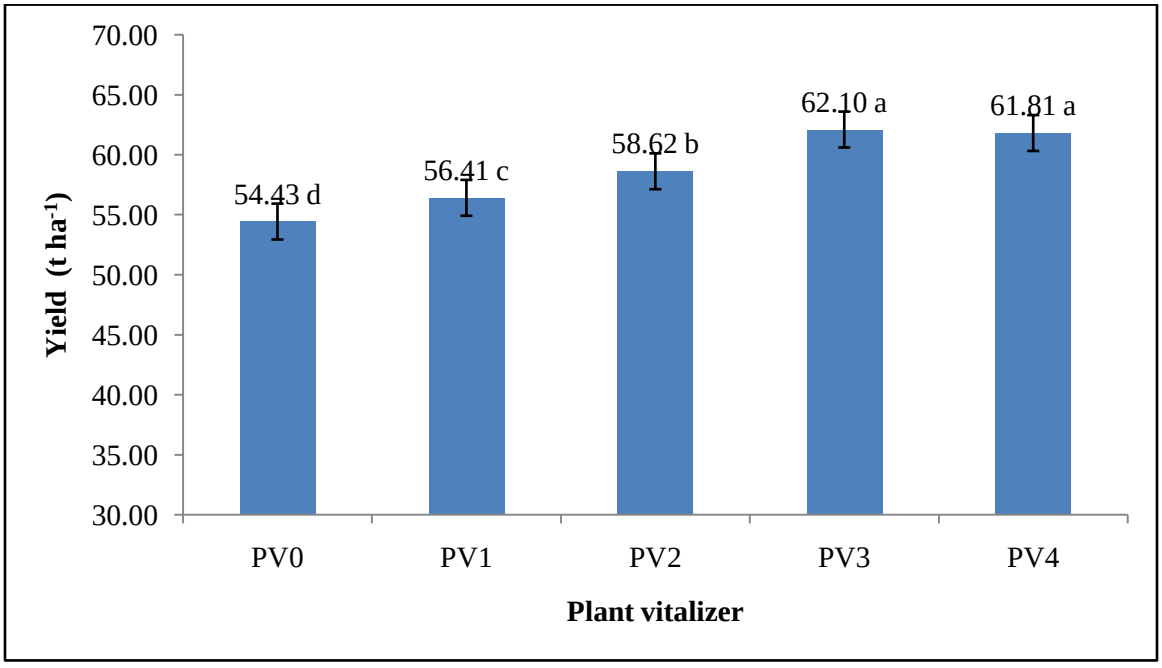

Figure 11. Yield of tomato as influenced by plant vitalizer (HB101) application

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

Combined effect of variety and plant vitalizer (PV)

Yield of tomato was significantly varied due to combined effect of different variety and plant vitalizer (Figure 12 and Appendix VII). Results revealed that the highest yield (62.95 t ha^{-1}) was recorded from the treatment combination of V_2PV_3 which was statistically identical with the treatment combination of V_2PV_4. On the other hand, the lowest yield (53.69 t ha^{-1}) was recorded from the treatment combination of V_1PV_0 which was significantly different from other treatment combinations.

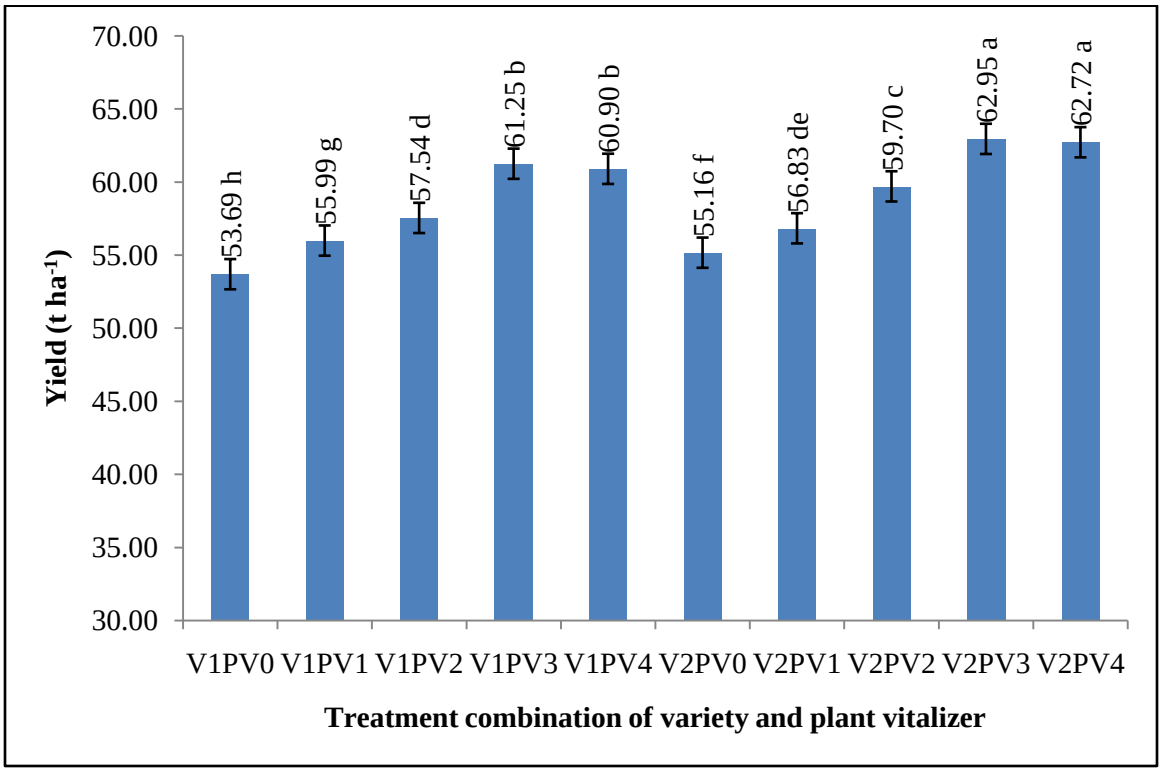

Figure 12. Yield of tomato as influenced by combined effect of variety and plant vitalizer (HB101) application

V_1 = BARI tomato-2, V_2 = BARI tomato-15

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

4.4 Nutrient contents

4.4.1 Nitrogen (N) (%)

Effect of variety

There was no significant variation on nitrogen content of fruit as influenced by different varieties of tomato (Table 3 and Appendix VIII). However, results indicated that the highest nitrogen content (0.120%) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest nitrogen content (0.113%) was recorded from the variety V_1 (BARI tomato-2).

Effect of plant vitalizer (PV)

Significant variation was not found on nitrogen content of tomato as influenced by different levels of plant vitalizer (Table 3 and Appendix VIII). However, the highest nitrogen content (0.165%) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) whereas the lowest nitrogen content (0.081%) was recorded from the control treatment PV_0 (0 ml PV L^{-1}). Here, it was also observed that nitrogen content was decreased with the application of plant vitalizer decreased and as a result control treatment showed lowest N content in tomato.

Combined effect of variety and plant vitalizer (PV)

Nitrogen content of tomato was not significantly varied due to combined effect of different variety and plant vitalizer (Table 3 and Appendix VIII). However, the highest nitrogen content (0.172%) was recorded from the treatment combination of V_2PV_3 whereas the lowest nitrogen content (0.080%) was recorded from the treatment combination of V_1PV_0.

4.4.2 Phosphorus (P) (%)

Effect of variety

Phosphorus content of tomato was not significantly influenced due to different varieties of tomato (Table 3 and Appendix VIII). However, the highest phosphorus

content (0.126%) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest phosphorus content (0.119%) was recorded from the variety V_1 (BARI tomato-2).

Effect of plant vitalizer (PV)

Significant influence was not observed on phosphorus content of tomato affected by different levels of plant vitalizer (Table 3 and Appendix VIII). However, the highest phosphorus content (0.133%) was recorded from the plant vitalizer treatment PV_3 (3 ml PV L^{-1}) whereas the lowest phosphorus content (0.108%) was recorded from the control treatment PV_0 (0 ml PV L^{-1}).

Combined effect of variety and plant vitalizer (PV)

Phosphorus content of tomato was not significantly varied due to combined effect of different variety and plant vitalizer (Table 3 and Appendix VIII). However, the highest phosphorus content (0.14%) was recorded from the treatment combination of V_2PV_3 whereas the lowest phosphorus content (0.11%) was recorded from the treatment combination of V_1PV_0.

4.4.3 Potassium content (K) (%)

Effect of variety

Potassium content between two varieties of tomato showed non-significant variation (Table 3 and Appendix VIII). However, the highest potassium content (0.349%) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest potassium content (0.340%) was recorded from the variety V_1 (BARI tomato-2). Similar result was also observed by Dunsin (2016).

Effect of plant vitalizer (PV)

Statistically significant differences was not found due to different levels of plant vitalizer on potassium content of tomato (Table 3 and Appendix VIII). However, the highest potassium content (0.358%) was recorded from the plant vitalizer

treatment PV_4 (4 ml PV L^{-1}) whereas the lowest potassium content (0.323%) was recorded from the control treatment PV_0 (0 ml PV L^{-1}).

Combined effect of variety and plant vitalizer (PV)

Combined effect of different varieties and plant vitalizer showed statistically non-significant variation in terms of potassium content of tomato (Table 3 and Appendix VIII). However, the highest potassium content (0.367%) was recorded from the treatment combination of V_2PV_4 whereas the lowest potassium content (0.323%) was recorded from the treatment combination of V_1PV_0.

4.4.4 Sulphur (S) (ppm)

Effect of variety

Sulphur content of tomato between two varieties showed non-significant variation (Table 3 and Appendix VIII). However, the highest sulphur content (0.160 ppm) was recorded from the variety V_1 (BARI tomato-2) whereas the lowest sulphur content (0.149 ppm) was recorded from the variety V_2 (BARI tomato-15).

Effect of plant vitalizer (PV)

Statistically non-significant difference was recorded on sulphur content of tomato due to different levels of plant vitalizer (Table 3 and Appendix VIII). However, the highest sulphur content (0.172 ppm) was recorded from the plant vitalizer treatment PV_3 (4 ml PV L^{-1}) whereas the lowest sulphur content (0.142 ppm) was recorded from the control treatment PV_0 (0 ml PV L^{-1}).

Combined effect of variety and plant vitalizer (PV)

Combined effect of different varieties and plant vitalizer showed statistically non-significant variation in terms of sulphur content of tomato (Table 3 and Appendix VIII). However, the highest sulphur content (0.172 ppm) was recorded from the

treatment combination of V_1PV_3 whereas the lowest sulphur content (0.134 ppm) was recorded from the treatment combination of V_2PV_0.

Table 3. Nutrient contents of tomato as influenced by variety and plant vitalizer application

Treatments	Nutrient contents			
	Nitrogen (N) (%)	Phosphorus (P) (%)	Potassium (K) (%)	Sulphur (S) (ppm)
Effect of variety				
V_1	0.113	0.119	0.340	0.160
V_2	0.120	0.126	0.349	0.149
$LSD_{0.05}$	0.043^{NS}	0.063^{NS}	0.064^{NS}	0.064^{NS}
CV(%)	6.56	5.93	5.34	4.73
Effect of plant vitalizer (PV)				
PV_0	0.081	0.108	0.327	0.142
PV_1	0.091	0.117	0.338	0.147
PV_2	0.116	0.125	0.343	0.157
PV_3	0.165	0.133	0.357	0.167
PV_4	0.130	0.130	0.358	0.159
$LSD_{0.05}$	0.087^{NS}	0.033^{NS}	0.038^{NS}	0.038^{NS}
CV(%)	6.56	5.93	5.34	4.73
Combined effect of variety and plant vitalizer (PV)				
V_1PV_0	0.080	0.110	0.323	0.149
V_1PV_1	0.088	0.117	0.333	0.151
V_1PV_2	0.116	0.120	0.340	0.165
V_1PV_3	0.158	0.127	0.347	0.172
V_1PV_4	0.123	0.123	0.357	0.162
V_2PV_0	0.081	0.107	0.330	0.134
V_2PV_1	0.095	0.117	0.343	0.142
V_2PV_2	0.117	0.130	0.347	0.149
V_2PV_3	0.172	0.140	0.360	0.162
V_2PV_4	0.137	0.137	0.367	0.157
$LSD_{0.05}$	0.189^{NS}	0.052^{NS}	0.054^{NS}	0.053^{NS}
CV(%)	6.56	5.93	5.34	4.73

In a column means having similar letters) arc statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI tomato-2, V_2 = BARI tomato-16

PV_0 = Control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1}, PV_4 = 4 ml PV L^{-1}

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was carried out during the period of October 2019 to March 2020 at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka-1207 to find out the effects of plant vitalizer (HB-101) on growth, yield and nutrient content of tomato. The experiment consisted of two factors: Factor A: variety (two) as – V_1 = BARI tomato-2 and V_2 = BARI tomato-15 and Factor B: Plant vitalizer (5 levels) as - PV_0 = control (0 ml PV L^{-1}), PV_1 = 1 ml PV L^{-1}, PV_2 = 2 ml PV L^{-1}, PV_3 = 3 ml PV L^{-1} and PV_4 = 4 ml PV L^{-1}. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. Data on different growth, yield contributing parameters, yield and nutrient content of tomato were recorded and analyzed statistically. Data on different parameters *viz*. plant height, number of branches $plant^{-1}$, number of flower clusters $plant^{-1}$, number of flowers $plant^{-1}$, number of fruits $cluster^{-1}$, fruit length, fruit diameter, number of fruits $plant^{-1}$, single fruit weight, fruit weight $plant^{-1}$, yield $plot^{-1}$, yield ha^{-1} and nutrient contents (N, P, K and S) were recorded.

In case of varietal performance, plant height, number of branches $plant^{-1}$ number of flowers $plant^{-1}$, fruit weight $plant^{-1}$, yield $plot^{-1}$ and yield ha^{-1} was affected significantly but other studied parameters showed non-significant variation. Regarding growth parameters, the highest plant height (71.68 cm) and number of branches $plant^{-1}$ (7.32) was recorded from the variety V_2 (BARI tomato-15) whereas the lowest (69.60 cm and 6.91, respectively) were found from V_1 (BARI tomato-2). Regarding yield contributing parameters and yield, the highest number of flower clusters $plant^{-1}$ (5.62), number of flowers $plant^{-1}$ (35.90), number of fruits $cluster^{-1}$ (4.90), fruit length (7.04 cm), fruit diameter (7.91 cm), number of fruits $plant^{-1}$ (27.51), single fruit weight (63.03 g), fruit weight $plant^{-1}$ (1735.00 g), yield $plot^{-1}$ (20.82 kg) and yield ha^{-1} (59.47 t) were recorded from V_2 (BARI tomato-15).

On the other hand, the lowest number of flower clusters plant^{-1} (5.54), number of flowers plant^{-1} (33.42), number of fruits cluster^{-1} (4.87), fruit length (6.91 cm), fruit diameter (7.61 cm), number of fruits plant^{-1} (27.01), single fruit weight (62.47g), fruit weight plant^{-1} (1688.00 g), yield plot^{-1} (20.26 kg) and yield ha^{-1} (57.87 t) were recorded from the variety V_1 (BARI tomato-2). Regarding nutrients (N, P, K and S) content in fruits showed non-significant variation due to varietal performance; however, the highest nitrogen content (0.120%), phosphorus content (0.126%) and potassium content (0.349%) were found from V_2 (BARI tomato-15) but the highest sulphur content (0.160 ppm) was recorded from V_1 (BARI tomato-2) whereas the lowest nitrogen content (0.113%), phosphorus content (0.119%) and potassium content (0.34%) were recorded from V_1 (BARI tomato-2) but the lowest sulphur content (0.149 ppm) was recorded from V_2 (BARI tomato-15).

In terms of plant vitalizer treatments, most of the studied parameters affected significantly except number of flower clusters plant^{-1}, number of fruits cluster^{-1} and fruit length. However, regarding growth parameters, the highest plant height (81.73 cm) was observed from PV_4 (4 ml PV L^{-1}) and highest number of branches plant^{-1} (7.90) was observed from PV_3 (3 ml PV L^{-1}) whereas the lowest plant height (59.83 cm) and number of branches plant^{-1} (6.23 cm) were recorded from the control treatment PV_0 (0 ml PV L^{-1}). Regarding yield contributing parameters and yield, the highest number of flower clusters plant^{-1} (5.78), fruit length (7.14 cm), fruit diameter (8.22 cm), number of fruits plant^{-1} (28.50), fruit weight plant^{-1} (1811.00 g), yield plot^{-1} (21.74 kg) and yield ha^{-1} (62.10 t) were recorded from PV_3 (3 ml PV L^{-1}) but the highest number of flowers plant^{-1} (41.27), number of fruits cluster^{-1} (4.95) and single fruit weight (63.70 g) were recorded from PV_4 (4 ml PV L^{-1}). On the other hand, the lowest number of flower clusters plant^{-1} (5.35), number of flowers plant^{-1} (28.57), number of fruits cluster^{-1} (4.77), fruit length (6.76 cm), fruit diameter (7.09 cm), number of fruits plant^{-1} (25.50), single fruit weight (62.25 g), fruit weight plant^{-1} (1587.00 g), yield plot^{-1} (19.05 kg) and yield

ha^{-1} (54.43 t) were recorded from the control treatment PV_0. Regarding nutrients (N, P, K and S) content in fruits; plant vitalizer treatments showed non-significant variation. However, the highest nitrogen content (0.165%), phosphorus content (0.133%) and sulphur content (0.167 ppm) were recorded from PV_3 (3 ml PV L^{-1}) but the highest potassium content (0.358%) was recorded from PV_4 (4 ml PV L^{-1}) whereas the lowest nitrogen content (0.081%), phosphorus content (0.108%), potassium content (0.327%) and sulphur content (0.142 ppm) were recorded from the control treatment PV_0.

In terms of combined effect of variety and plant vitalizer, most of the studied parameters affected significantly except number of flower clusters $plant^{-1}$, number of fruits $cluster^{-1}$ and fruit length. Regarding growth parameters, the highest plant height (82.40 cm) was recorded from the treatment combination of V_2PV_4 and the highest number of branches $plant^{-1}$ (8.40 cm) was recorded from V_2PV_3 whereas the lowest plant height (59.07 cm) and number of branches $plant^{-1}$ (6.13) were recorded from the treatment combination of V_1PV_0. Regarding yield contributing parameters and yield, the highest number of flowers $plant^{-1}$ (44.47) and number of fruits $cluster^{-1}$ (5.00) were recorded from V_2PV_4 but the highest number of flower clusters $plant^{-1}$ (5.80), fruit length (7.28 cm), fruit diameter (8.50 cm), number of fruits $plant^{-1}$ (28.80), single fruit weight (63.75 g), fruit weight $plant^{-1}$ (1836.00 g), yield $plot^{-1}$ (22.03 kg) and yield ha^{-1} (62.95 ton) were recorded from the treatment combination of V_2PV_3. On the other hand, the lowest number of number of flower clusters $plant^{-1}$ (5.30), flowers $plant^{-1}$ (27.00), fruit length (6.73 cm), fruit diameter (7.04 cm), number of fruits $cluster^{-1}$ (4.76), number of fruits $plant^{-1}$ (25.25), single fruit weight (62.02 g), fruit weight $plant^{-1}$ (1566.00 g), yield $plot^{-1}$ (18.79 kg) and yield ha^{-1} (53.69 ton) were recorded from V_1PV_0. Regarding nutrients (N, P, K and S) content in fruits showed non-significant variation due to combined effect of variety and plant vitalizer. However, the highest nitrogen content (0.172%), phosphorus content (0.140%) and sulphur content (0.162 ppm) were recorded

from V_2PV_3 but the highest potassium content (0.367%) was recorded from V_2PV_4. On the other hand, the lowest nitrogen content (0.080%) and potassium content (0.323%) were recorded from V_1PV_0 whereas the lowest phosphorus content (0.107%) and sulphur content (0.134 ppm) were recorded from V_2PV_0.

From the above results, it can be concluded that

1. The variety BARI tomato-16 (V_2) gave best results on different parameters and showed highest yield compared to BARI tomato-2 (V_1).
2. In terms of plant vitalizer, 3 ml PV L^{-1} (PV_3) treatment showed best performance and gave highest yield compared to other treatments.
3. In case of combined effect, the variety BARI tomato-16 with plant vitalizer @ 3 ml PV L^{-1} combination (V_2PV_3) gave best results in respect of maximum studied parameters and gave highest yield compared to other treatment combinations.
4. So, the treatment combination, V_2PV_3 (BARI tomato-16 with 3 ml PV L^{-1}) can be considered as best compared to other treatment combinations.

Therefore, plant vitalizer (HB101) might be important for plant growth, yield and nutrients content of different tomato varieties which might also be considered as safe food (100% organic).

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

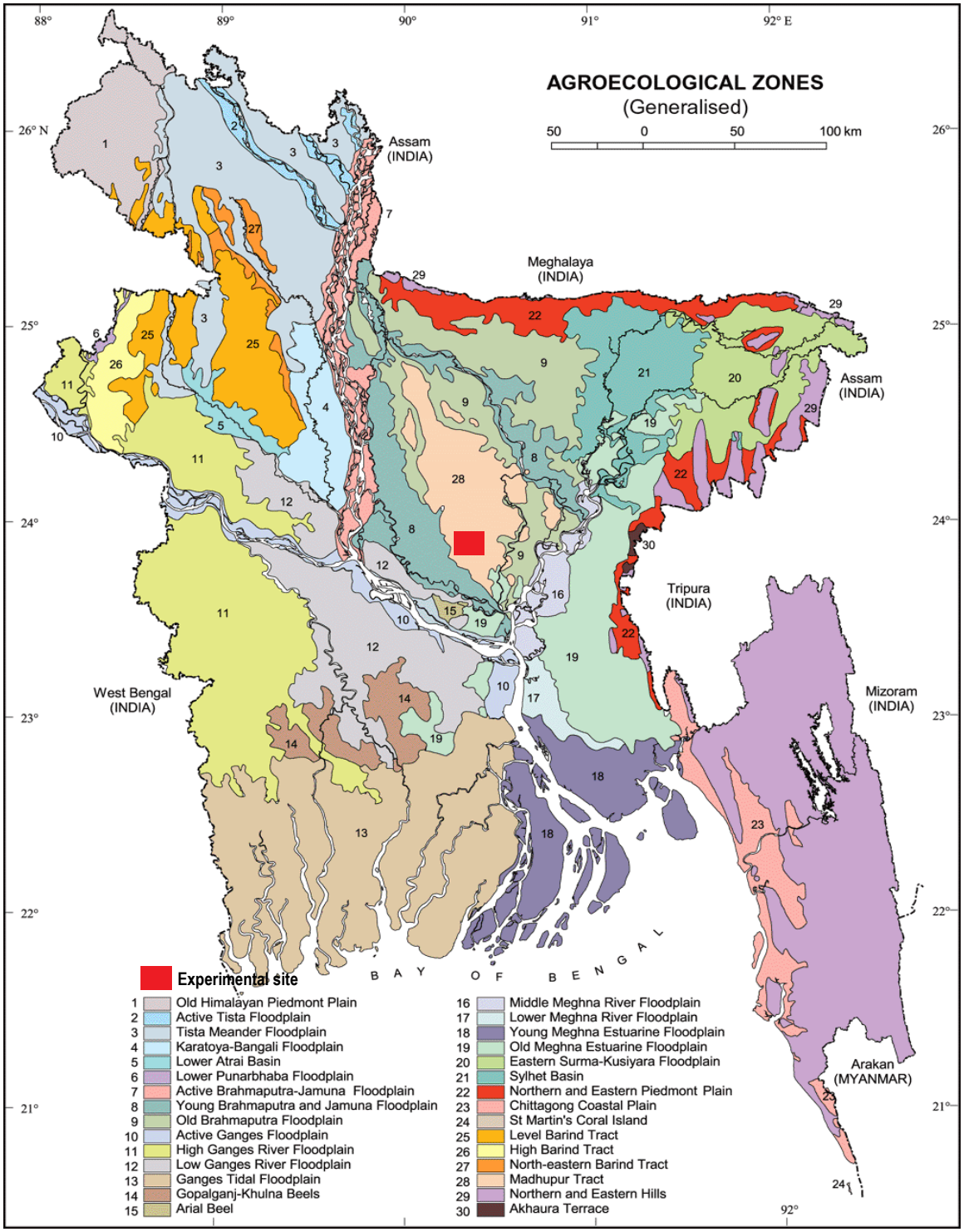


Figure13. Experimental site

Appendix II. Monthly records of air temperature, relative humidity and rainfall during the period from October 2019 to March 2020.

Year	Month	Air temperature (°C)			Relative humidity (%)	Rainfall (mm)
		Max	*Min*	*Mean*		
2019	October	30.42	16.24	23.33	68.48	52.60
2019	November	28.60	8.52	18.56	56.75	14.40
2019	December	25.50	6.70	16.10	54.80	0.0
2020	January	23.80	11.70	17.75	46.20	0.0
2020	February	22.75	14.26	18.51	37.90	0.0
2020	March	35.20	21.00	28.10	52.44	20.4

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix III. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

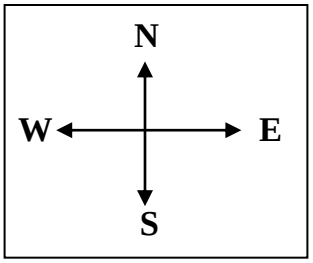
Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix IV. Layout of the experiment field



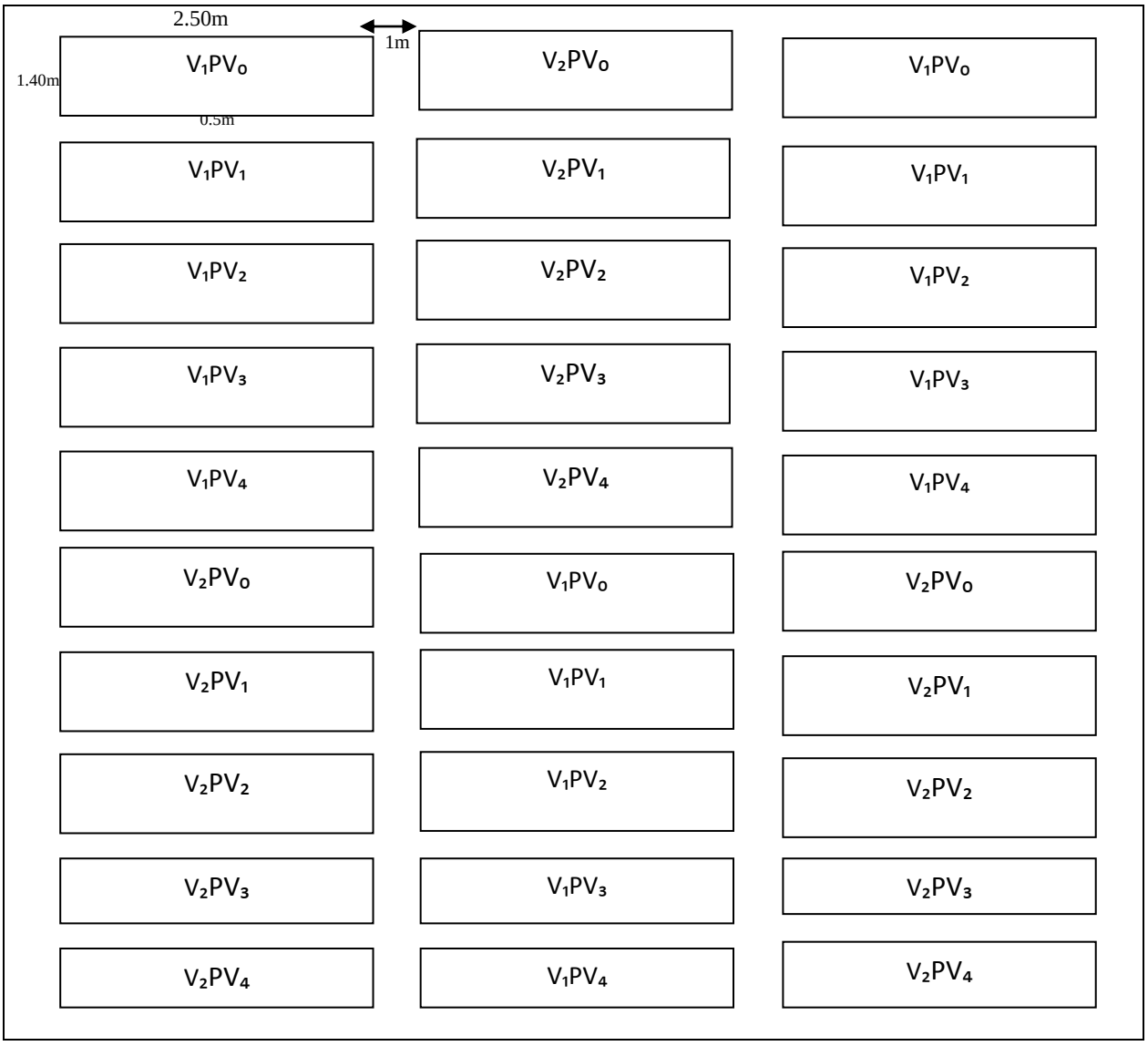


Figure14. Layout of the experimental plot

Appendix V. Growth parameters of tomato as influenced by variety and plant vitalizer application

Sources of variation	Degrees of freedom	Mean square of growth parameters	
		Plant height (cm)	Number of branches plant^{-1}
Replication	2	5.316	4.569
Factor A	1	2.436*	1.281*
Factor B	4	614.66*	3.435*
AB	4	76.851*	0.145**
Error	18	6.747	0.731

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Yield contributing parameters of tomato as influenced by variety and plant vitalizer application

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters				
		Number of flower clusters plant^{-1}	Number of flowers plant^{-1}	Number of fruits cluster^{-1}	Fruit length (cm)	Fruit diameter (cm)
Replication	2	6.085	5.366	1.650	0.016	0.010
Factor A	1	3.333^{NS}	45.930*	0.177^{NS}	0.104^{NS}	0.457^{NS}
Factor B	4	5.325^{NS}	193.78*	0.415^{NS}	0.192^{NS}	1.398**
AB	4	1.160^{NS}	22.022*	0.994^{NS}	0.007^{NS}	0.040*
Error	18	2.684	6.727	1.828	0.050	0.103

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Yield parameters of tomato as influenced by variety and plant vitalizer application

Sources of variation	Degrees of freedom	Mean square of yield parameters				
		Number of fruits plant^{-1}	Single fruit weight (g)	Fruit weight plant^{-1} (kg)	Yield (kg plot^{-1})	Yield (t ha^{-1})
Replication	2	0.734	1.237	25.927	1.336	10.916
Factor A	1	52.325^{NS}	7.174^{NS}	2198.27*	31.662*	258.36*
Factor B	4	200.22*	112.40*	1586.71*	84.526*	689.43*
AB	4	14.537*	64.710*	107.652*	1.543**	12.626**
Error	18	4.660	4.200	59.205	20.389	6.438

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Nutrient contents of tomato as influenced by variety and plant vitalizer application

Sources of variation	Degrees of freedom	Mean square of nutrient contents			
		Potassium (K) (%)	Phosphorus (P) (%)	Nitrogen (N) (%)	Sulphur (S) (ppm)
Replication	2	0.002	0.001	0.002	0.001
Factor A	1	0.001^{NS}	0.002^{NS}	0.001^{NS}	0.001^{NS}
Factor B	4	0.001^{NS}	0.004^{NS}	0.001^{NS}	0.002^{NS}
AB	4	0.001^{NS}	0.001^{NS}	0.001^{NS}	0.001^{NS}
Error	18	0.001	0.001	0.001	0.001

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level