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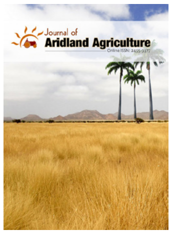

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Impact of combined cow dung and zinc on growth traits and yield of tomato

Mst. Bilkiss Akter Banu[1], A. K. M. Mosharof Hossain[1], Md. Mizanur Rahman[2], Md. Mahedy Alam[1]*

[1]Department of Soil Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh, [2]Independent Consultant, Risk Reduction, Resilience and Livelihoods, Bangladesh

ABSTRACT

In the present study, the combined effects of cow dung (CD) and zinc (Zn) fertilizers on tomato growth and yield was studied. Seven (7) treatments as T_0=CD_0Zn_0 (Control), T_1=CD_5Zn_0, T_2=CD_0Zn_1, T_3=$CD_0Zn_{1.5}$, T_4=CD_5Zn_2, T_5=$CD_5Zn_{2.5}$, T_6=CD_5Zn_3 were used in a RCBD with three replications using two factors like cow dung (0 and 5 t ha^{-1}) and zinc fertilizers (0, 1, 1.5, 2.0, 2.5, and 3.0 kg ha^{-1}).The use of CD and Zn fertilizers had a substantial impact on all of the assessed growth, yield contributing attributes, and yield. The result revealed that the highest yield and yield contributing characters such as plant height (51.33, 73.00 and 105.00 cm at 35, 50 and 65 DAT, respectively), number of leaves plant^{-1} (17.00, 19.33 and 24.00 at 35, 50 and 65 DAT, respectively), number of branches plant^{-1} (11.00, 12.00 and 14.00 at 35, 50 and 65 DAT, respectively), maximum number of flower clusters plant^{-1} (7.00 and 15.60 at 50 and 65 DAT, respectively), number of fruits plant^{-1} (8.00 and 46.09 at 50 and 65 DAT, respectively), the highest individual fruit weight (73.00 g), weight of fruit plant^{-1} (4.83 kg), fruit length (7.50 cm), fruit diameter (4.17 cm) and yield (55.00 t ha^{-1}) were produced at T_6 (5 t CD ha^{-1} and 3 kg Zn ha^{-1}) but lowest in T_0 (control) in all parameters. The results of the study suggest that combining CD and Zn fertilizers is an excellent source of tomato fertilization, with T6 treatment (5 t CD ha^{-1} and 3 kg Zn ha^{-1}) being found to be the most suitable due to the use of fewer treatment factors than recommended doses for obtaining economically viable yield.

KEYWORDS: Cow dung, Zinc, Growth, Yield, Tomato

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***Corresponding author:**
Md. Mahedy Alam
koushikmahedy1201104@gmail.com

INTRODUCTION

Tomatoes (*Solanum lycopersicum*) are one of Bangladesh's most popular and healthy vegetable crops, having originated in tropical America. In Bangladesh, it is grown in both the winter and summer seasons in all regions of the nation (Haque *et al.*, 1999). Tomatoes are grown in practically all household gardens and in the field because of their tolerance to a wide variety of soils and climates (Ahmed, 1976), having ranked next to potato in Bangladesh (BBS, 2016). Tomatoes are grown on 27518.62 hectares in Bangladesh, with a total production of 3, 89,000 metric tons and an average yield of 14.05 t ha^{-1} (BBS, 2018) where global tomato output is 200.95 million tons from 4.8 million hectares (FAO, 2018). In comparison to many field crops, tomato would be an effective source of vegetable worldwide and require appropriate fertilizer for development and yield (Pandey & Chandra, 2013). It also has a lower risk, a shorter production season, and requires less work (Islam, 2005).

Fertilizer application is one of the most important factors in increasing tomato yield, and micronutrients like zinc (Zn) improved the dry biomass, fruit yield, fruit fresh weight, and number of fruits per plant significantly (Gurmani *et al.*, 2012). Zinc (Zn) is an important essential micronutrient that aids in the formation of tryptophan, a precursor of IAA that promotes growth (Mallick & Muthukrishnan, 1980), synthesis of carbonic anhydrase enzyme and transport of carbon dioxide during photosynthesis (Alloway, 2008). Zn insufficiency can result from a lack of Zn in the soil, competition with Ca, Mn, Fe, P, and, to a lesser extent, K, and soil factors that impact Zn availability (Srivastava & Singh, 2003) and requires external treatment to guarantee that adequate zinc is accessible prior to tomato flowering. Supplementing the soil with Zn might be done by using a mix of Zn-containing fertilizer and an organic source like cow dung, which includes macro and micronutrients to some level and slowly releases nutrients to the soil. Cow dung improves soil's physical and physiological qualities by supplying all required macro and micronutrients in accessible forms during mineralization, which aids plant development.

In Bangladesh, careful use of organic fertilizers such as cow dung has the potential to increase tomato output per unit area. The combined use of cow dung and zinc might be a potential strategy for increasing tomato output and improving soil fertility. The current concern about global environmental contamination could be greatly alleviated by either using chemical fertilizers sparingly or increasing the use of manures, particularly cow dung. As a result, research into management strategies, notably the control of cow dung and zinc, might aid in enhancing tomato yields. As a result, an attempt was made to investigate the combined effects of cow dung and zinc on tomato development and yield, and to determine the integrated dose of cow dung and zinc for increased tomato yield.

MATERIALS AND METHODOLOGY

Location of the Experimental Site

Experimentation was performed during the "Rabi" season having scarce rainfall, low humidity, low temperature and short day period, from November 2019 to April 2020, at Hajee Mohammad Danesh Science and Technology University's soil science research area, with an average height of 37.5 m above mean sea level. The site belongs to AEZ-1 (Old Himalayan Piedmont Plain), which has a medium elevation (Table 1).

Description and Attributes of Experimental Initial Soil

The experimental land was well-drained sandy loam textured with a medium-high elevation (Table 2). Through proper extraction methods, different chemical attributes such as pH, organic matter, total nitrogen, phosphorus, exchangeable potassium, available sulphur, and available zinc of the initial experimental soil (1-15 cm depth) were 5.85, 1.40 percent, 0.035 percent, 30.15 ppm, 0.57 meq.100 g^{-1}, 9.05 ppm, and 0.05 ppm, respectively (Table 3).

Collection of Planting Material and Land Preparation

The planting material was BARI Tomato-16, a good-producing indeterminate type cultivar. Twenty eight (28) days aged healthy and uniform sized seedlings were collected from Bangladesh Agricultural Development Corporation (BADC). The land was ploughed three (3) times and then laddered to achieve the desired tilth quality for commercial crop production.

Treatments and Experimental Design

Two components, cow dung (CD) and zinc (Zn), were used in the experiment, with two (2) and six (6) values, respectively. $T_0=CD_0Zn_0$ (Control), $T_1=CD_5Zn_0$, $T_2=CD_0Zn_1$, $T_3=CD_0Zn_{1.5}$, $T_4=CD_5Zn_2$, $T_5=CD_5Zn_{2.5}$ and $T_6=CD_5Zn_3$, were the seven (7) treatments indicated by alphabetic symbols by combining the factors. Every treatment received prescribed quantities of nitrogen, phosphorus, potassium, and sulphur from urea, TSP, MoP, and gypsum, respectively (FRG, 2012) (Table 4). The two-factor experiment was laid out in the Randomized Complete Block Design (RCBD) with 3 replications forming 21 unit plots having a size of 5 m_2 (2.5 m × 2 m). In both situations, the space between the unit plots and blocks was kept at 20 cm.

Table 1: Morphological description of research area initial soil

Morphological Description	Characteristics
Location	Soil Science Research field, HSTU, Dinajpur
AEZ	Old Himalayan Piedmont Plain (AEZ-1)
General soil type	Non-calcareous brown floodplain soil
Parent material	Piedmont alluvium
Soil series	Ranishankail
Drainage	Moderately well drained
Flood level	Above flood level
Topography	High land

Table 2: Physical properties of the initial soil sample

Characteristics	Value
Sand (%)	53.2
Silt (%)	29.6
Clay (%)	17.2
Textural class	Sandy loam

Application of Fertilizer

CD typically comprises 10-15% dry matter of fresh manure, 14.6% organic material, 0.30-0.45% total nitrogen, 0.15-0.25% total phosphorus, 0.05-0.15% total potassium, and biological oxygen needed for five days (Miner & Smith, 1975). Just after opening the land, a base dosage of well-decomposed cow dung @ 5 t ha^{-1} was administered, followed by TSP at final land preparation. The urea and MoP were administered in two equal installments by band placement, with the first band applied after two weeks of transplanting and the second band applied two weeks later. According to the experiment's design, the treatments of Zn as zinc sulphate were distributed properly to each experimental unit.

Data Collection and Analysis

A total of five (5) plants were chosen at random in order to prevent the boundary effect. At 15-day intervals, data from the sample plants was collected.

Plant Height

A measuring tape was used to measure the plant height at 15-day intervals from the ground level to the tallest stem in cm from 35 days of planting to the final harvest (65 days), and a mean value was determined.

Number of Leaves Plant^{-1} and Number of Branches Plant^{-1}

At 35, 50, and 65 days following planting, the sample plants were counted for the number of leaves and branches per plant, and a mean value was computed.

Number of Flower Clusters and Number of Fruits Plant^{-1}

At 50 and 65 DAT, the number of flower clusters generated per plant was counted from the sample plants, and the average number of flower clusters produced per plant was computed.

Table 3: Chemical characteristics of the initial soil sample

Characteristics	Contents	Extraction Procedure
pH	5.85	Glass-electrode pH meter with 1:1.25 soil-water ratios (Page *et al.,* 1982)
Organic matter (%)	1.40	Wet oxidation method (Black *et al.,* 1965). Calculated by van Bemmelen factor 1.73 (Piper, 1966)
Total N (%)	0.035	Micro-Kjeldahl method (Bremner & Mulvaney, 1982)
Available *P* (ppm)	30.15	Molybdate blue ascorbic acid (Bray & Kurtz, 1945)
Exchangeable K (meq. 100 g^{-1} soil)	0.57	Determined by Flame photometer
Available S (ppm)	9.05	Turbidity method using $BaCl_2$ (Fox *et al.,* 1964)
Available Zn (ppm)	0.05	Atomic Absorption Spectrophotometer (Lindsay & Norvell, 1978)

Table 4: Rates and sources of fertilizers used in the experiment

Nutrient element	Sources	Rate (ha^{-1}) (FRG, 2012)
Cow dung	Cow dung	5 t
Zinc	Zinc sulphate	3 kg
Nitrogen	Urea	500 kg
Phosphorus	TSP	400 kg
Potassium	MoP	200 kg
Sulphur	Gypsum	120 kg

The number of fruits per plant was calculated by following formula,

Number of fruits per plant =

$$\frac{\text{Total number of fruits in 5 plants}}{5}$$

Fruit Length and Fruit Diameter

The length (from the fruit's neck to the bottom) and diameter (at the center region) of five marketable fruits from each plot were measured with slide calipers, and the average was obtained in cm.

Weight of Individual Fruit

Individual fruit weight was calculated by the following formula:

$$\text{Weight of individual fruit} = \frac{\text{Total weight of fruits}}{\text{Total number of fruits}}$$

Weight of Fruits Plant^{-1}

Electric balance was used to obtain the weight of fruits of 5 selected sample plants from each plot, and their average was calculated in gram.

$$\text{Weight of fruits per plant} = \frac{\text{Total weight of fruits in 5 plants}}{5}$$

Yield

Yield was measured by the following formula:

Fruit yield per hectare =

$$\frac{\text{Fruit yield per plot kg} \times 10000 \text{ m}}{\text{Area of plot in square meter}(m^2) \times 1000 \text{ kg}}$$

R software was used to statistically evaluate all of the acquired data and correlation studies, and the mean differences were compared using Duncun's Multiple Range Test (DMRT) at a 5% level of significance (Gomez & Gomez, 1984).

RESULTS AND DISCUSSION

Plant Height

One of the main parameters that is strongly connected with tomato output is plant height. Plant height exhibited statistically significant change due to the combined action of cow dung and zinc (Figure 1). Plant height grew as the number of days following transplanting increased (DAT). T_6 produced the longest plant (51.33 cm), which was followed by T_5, while T_0 produced the smallest plant (31.00 cm) at 35 DAT. T_6 produced the longest plant (73.00 cm, 105.00 cm) at 50 and 65 DAT, whereas T_0 produced the smallest plant (45.00 cm, 84.00 cm). Johura *et al.* (2021) discovered that increasing the zinc content boosted tomato plant height.

Number of Leaves Plant^{-1}

The more leaves there are, the more photosynthetic area there is, which might lead to better fruit production (Figure 2). The treatment of cow dung and zinc at 35, 50, and final harvests had a substantial impact on the number of leaves per plant^{-1} of tomato (65 DAT). T_6 had the highest and best number of plant^{-1} leaves (17.00, 19.33) at 35 and 50 DAT, whereas T_0 had the lowest number of plant^{-1} leaves (9.00, 14.00). At 65 DAT, T_6 had the highest number of plant^{-1} leaves (24.00), while T_0 had the lowest number of plant^{-1} leaves (18.00), both of which are statistically similar to T_1. Almost similar result was reported by Ahammad *et al.* (1999).

Number of Branches Plant^{-1}

At 35, 50, and 65 DAT, there were statistically significant changes in the number of branches per plant (Figure 3). With each passing day after transplantation, the number of branches rose. At 35, 50, and 65 DAT, it varies from 6.33 to 11.00, 7.33 to 12.00, and 9.33 to 14.00, respectively. T_6 therapy yielded the best results, whereas T_0 yielded the worst. T_6 was the most popular treatment in terms of yield, followed by T_5. Zinc and CD spraying greatly enhanced the number of leaves on tomato plants, according to Yadav *et al.* (2001).

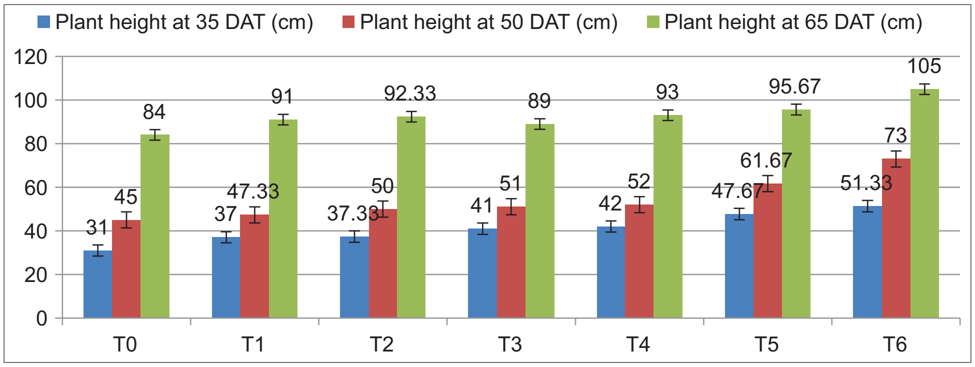

Figure 1: Combined effect of different levels of CD and Zn on tomato plant height at 35, 50, and 65 DAT, respectively ($T_0=CD_0Zn_0$ (Control), $T_1=CD_5Zn_0$, $T_2=CD_0Zn_1$, $T_3=CD_0Zn_{1.5}$, $T_4=CD_5Zn_2$, $T_5=CD_5Zn_{2.5}$ and $T_6=CD_5Zn_3$)

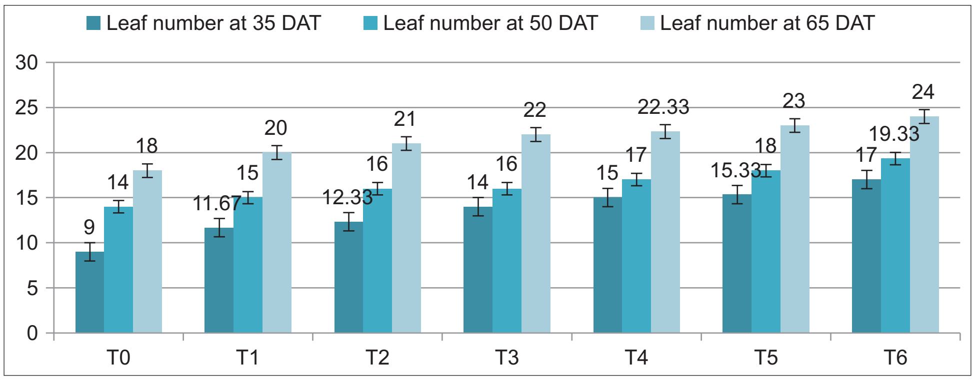

Figure 2: Combined effect of different levels of CD and Zn on number of leaves per plant at 35, 50, and 65 DAT, respectively ($T_0=CD_0Zn_0$ (Control), $T_1=CD_5Zn_0$, $T_2=CD_0Zn_1$, $T_3=CD_0Zn_{1.5}$, $T_4=CD_5Zn_2$, $T_5=CD_5Zn_{2.5}$ and $T_6=CD_5Zn_3$)

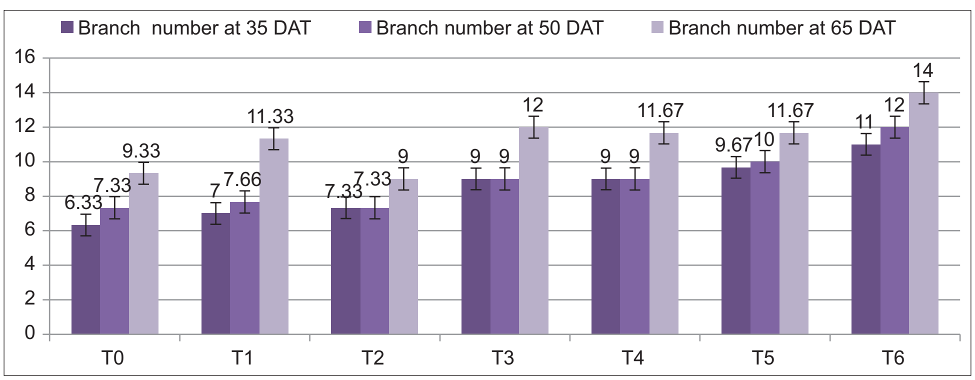

Figure 3: Combined effect of different levels of CD and Zn on number of branches per plant at 35, 50, and 65 DAT, respectively ($T_0=CD_0Zn_0$ (Control), $T_1=CD_5Zn_0$, $T_2=CD_0Zn_1$, $T_3=CD_0Zn_{1.5}$, $T_4=CD_5Zn_2$, $T_5=CD_5Zn_{2.5}$ and $T_6=CD_5Zn_3$)

Number of Flower Clusters and Number of Fruits Plant^{-1}

The administration of different amounts of CD and Zn at 50 and 65 DAT resulted in a considerable variation in the number of flower clusters per plant (Figure 4). T_6 had the highest and best number of flower cluster plants (7.60 and 15.00), whereas T_0 had the lowest number (2.00 and 7.60). As a consequence of the findings, it was discovered that the rate of CD and Zinc had a substantial impact on the quantity of fruits produced by tomato plant^{-1}. In all dosages of CD and Zn, the number of fruit plant^{-1} rose steadily over time until the final harvest (Figure 4). T_6 produced the largest number of fruits plant^{-1} (8.00) and T_0 produced the least number of fruits plant^{-1} (3.00) at 50 DAT. T_6 produced the highest number of fruits plant^{-1} (46.09) and T_0 gave the lowest number of fruits per plant (26.72) at 65 DAT. Yadav *et al.* (2001) reported a similar result.

Fruit Length and Fruit Diameter

The usage of CD and Zn fertilizers has a significant influence on the fruit's length and diameter (Table 5). T_6 exhibited the longest and statistically superior fruit length (7.50 cm) and

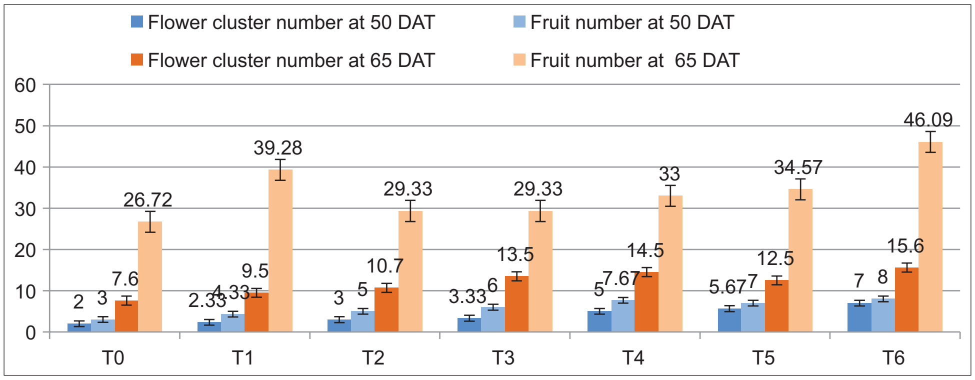

Figure 4: Combined effects of different levels of CD and Zn on number of flower clusters and number of fruits plant^{-1} at 50 and 65 DAT, respectively (T_0=CD_0Zn_0 (Control), T_1=CD_5Zn_0, T_2=CD_0Zn_1, T_3=$CD_0Zn_{1.5}$, T_4=CD_5Zn_2, T_5=$CD_5Zn_{2.5}$ and T_6=CD_5Zn_3)

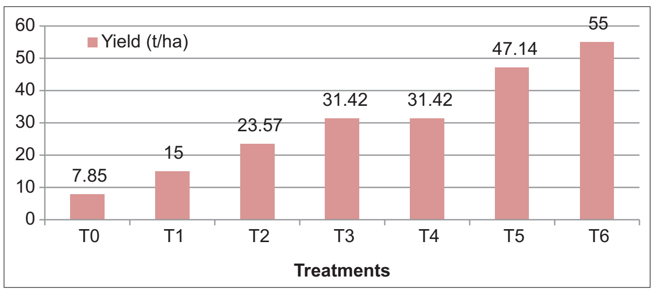

Figure 5: Combined effect of different levels of CD and Zn on the yield of tomato (T_0=CD_0Zn_0 (Control), T_1=CD_5Zn_0, T_2=CD_0Zn_1, T_3=$CD_0Zn_{1.5}$, T_4=CD_5Zn_2, T_5=$CD_5Zn_{2.5}$ and T_6=CD_5Zn_3)

diameter (4.17 cm). On the other side, the control treatment T_0 had the smallest fruit length (4.16 cm) and diameter (2.33 cm). This was attributable to the enhanced nutrient availability provided by CD and Zn fertilizers throughout the growing season. Atefe *et al.* (2012) found similar results.

Weight of Fruits Plant^{-1} and Individual Fruit Weight

The weight of tomato fruits per plant and individual fruits was considerably impacted by CD and Zn fertilizers (Table 6). In both cases (weight of tomato fruits per plant and individual fruit), T_6 had the maximum result (4.83 kg and 73.00 g, respectively), whereas the control treatment T_0 had the least one (0.74 kg and 26.00 g, respectively). These findings imply that using the same amount of CD and Zn fertilizers together generated higher fruit weight than using the same dose of CD and Zn fertilizers separately. The findings were similar to those reported by Osman *et al.* (2019).

Yield of Tomato

The use of CD and various amounts of Zn fertilizers resulted in yield variations (Figure 5). The treatment T_6 produced the highest output (55 t ha^{-1}) whereas the treatment T_0 produced the lowest yield (7.85 t ha^{-1}). The results revealed that using CD and Zn fertilizers together may considerably boost tomato growth and production. According to Ali *et al.* (2015), using organic and inorganic fertilizers boosted fruit output.

Table 5: Effect of CD and Zn on fruit length and fruit diameter of tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)
T_0	4.16^{d}	2.33^{bc}
T_1	5.66^{bc}	2.50^{bc}
T_2	4.70^{cd}	1.90^{c}
T_3	5.50^{bc}	2.53^{bc}
T_4	5.83^{bc}	2.90^{b}
T_5	6.30^{b}	2.67^{bc}
T_6	7.50^{a}	4.17^{a}
LSD	1.124	0.673
CV %	11.14	15.80

T_0=CD_0Zn_0 (Control), T_1=CD_5Zn_0, T_2=CD_0Zn_1, T_3=$CD_0Zn_{1.5}$, T_4=CD_5Zn_2, T_5=$CD_5Zn_{2.5}$ and T_6=CD_5Zn_3

Table 6: Effect of CD and Zn on weight of fruit plant^{-1} and the individual fruit weight of tomato

Treatments	Fruit weight (kg plant^{-1})	Individual fruit weight (g plant^{-1})
T_0	0.74^{d}	26.00^{f}
T_1	1.43^{cd}	28.00^{e}
T_2	1.73^{bcd}	29.00^{e}
T_3	2.47^{bc}	31.00^{d}
T_4	2.71^{bc}	44.00^{c}
T_5	3.31^{b}	65.33^{b}
T_6	4. 83^{a}	73.00^{a}
LSD	1.02	1.09
CV %	34.55	1.46

T_0=CD_0Zn_0 (Control), T_1=CD_5Zn_0, T_2=CD_0Zn_1, T_3=$CD_0Zn_{1.5}$, T_4=CD_5Zn_2, T_5=$CD_5Zn_{2.5}$ and T_6=CD_5Zn_3

Relationship between Growth Related Attributes and Yield of Tomato

All of the analyzed growth-related parameters (Plant height, number of leaves per plant, branch number per plant, and flower cluster number per plant at 65 DAT in all cases) were found to have a substantial positive connection with tomato output (Figure 6). By expressing the R_2 value in each scenario, this research shows that increasing the combined application of cow dung and zinc fertilizer raises the growth characteristics and consequently increases the tomato yield to a significant level.

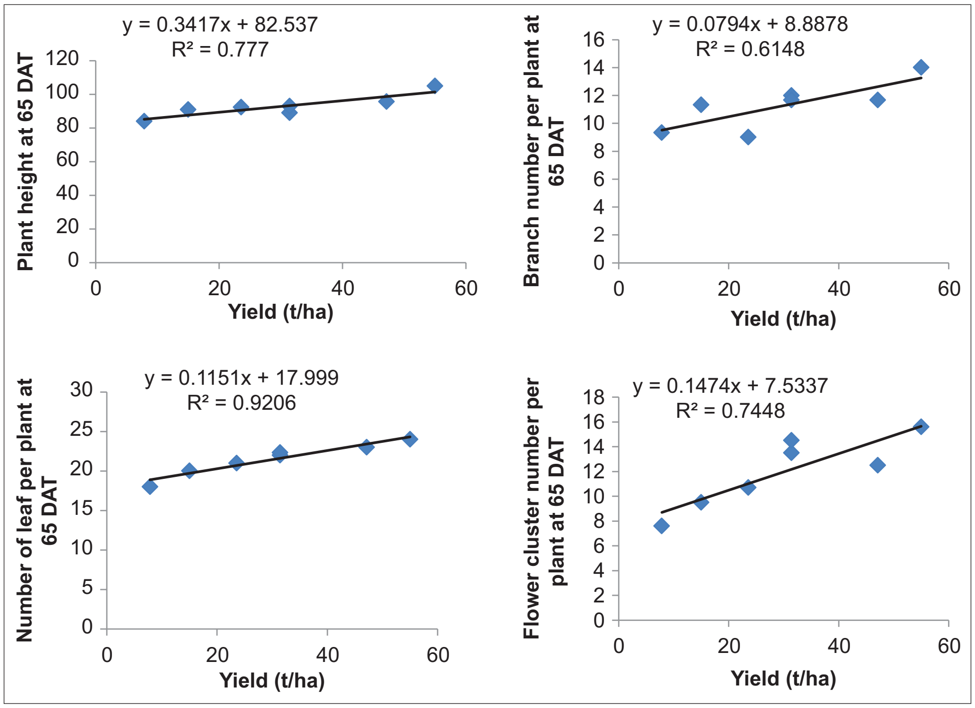

Figure 6: Relationship between growth related attributes (Plant height, number of leaves per plant, branch number per plant, and flower cluster number per plant at 65 DAT) and tomato yield

CONCLUSIONS

The study's findings suggest that applying higher levels of CD_5Zn_3 (cow dung 5 t ha^{-1} and Zn 3 kg ha^{-1}) together increased growth-related characteristics such as plant height, number of leaves per plant, number of branches per plant, number of flower clusters per plant, number of fruits per plant, fruit length and diameter, and so on, resulting in increased tomato yield. The yield of tomato was maximized by a higher integrated application dosage of cow dung at a rate of 5 t ha^{-1} and Zn 3 kg ha^{-1} (CD_5Zn_3), and the doses may be raised to produce more yield without exceeding the toxicity threshold of nutrients or economic unreliability.

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