IUBAT Review—A Multidisciplinary Academic Journal, 8(1): 85-95
https://doi.org/10.3329/iubatr.v8i1.83655

Growth and Yield Performance of Some Tomato Varieties During Winter Season in Uttara, Dhaka

Mohammad Rezaul karim[1*], Ismail Hossain[1], Md. Mahfuzul Hoque[1,2], Md Mosiur Rahman[1,3]

1. College of Agricultural Sciences, International University of Business Agriculture and Technology, Dhaka-1230, Bangladesh

2. Department of Soil, Water & Environment, University of Dhaka, Dhaka-1000, Bangladesh

3. Department of Soil Science, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200, Bangladesh

Keywords:

Tomato; Winter season; growth; Yield

Abstract

An experiment was conducted on "growth and yield performance of some tomato varieties during winter season in Uttara, Dhaka" at the IUBAT Agricultural Research Field, Uttara, Dhaka, Bangladesh, from October 2021 to January 2022. This study was conducted following Randomized Complete Block Design (RCBD). For this experiment, 4 (Four) tomato varieties viz., BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, and KUSUM (Hybrid) were used as planting material, and plant height, number of branches, number of leaves, and different yield parameters were recorded. Results indicated that the most prevalent diseases were recorded in V_1 (BARI Tomato-14), followed by V_3 (BARI Tomato-16), and V_4 (KUSUM). The affected rates of V_3 and V_4 were statistically similar. Additionally, it was observed that BARI Tomato-15 exhibited significant resistance to these diseases. The tallest plant height (110.40 cm) and highest number of leaves per plant (35.67) were observed in V_4 (KUSUM), while the shortest plant height (90.57 cm) and number of leaves per plant (24.33) were found in V_1 (BARI Tomato-14). The highest fruit yield per plant (3.05 kg) was achieved with V_3 (BARI Tomato-16). The variety V_1 (BARI Tomato-14) produced the lowest fruit yield per plant (1.78kg). So, by considering better yield performances, it can be concluded that BARI Tomato-16 is the best variety for commercial cultivation.

1. Introduction

Tomato (*Solanum lycopersicum*) is very important vegetable crop, and it is grown and consumed in many parts of the world (Laily *et al.*, 2021). Tomato, belonging to the Solanaceae family, is a widely grown vegetable that is positioned third in global vegetable production (Javaria *et al.*, 2012). In Bangladesh, approximately 4,69,204 MT of tomatoes are harvested from an area covering around 76,743 hectares (BBS, 2023). Bangladesh is among the 144 countries from which tomato production has been reported (Hossain *et al.*, 2017). Tomato is an essential source of minerals, vitamins, and antioxidants, and is a staple food in many countries. Vitamins A, B, and C, as well as calcium and beta-carotene, give it a high nutritional value (Bose & Som, 1990). The tomato can be eaten raw or cooked and to be used in a variety of foods, including soups, juices, ketchup, sauces, preserved purees, pastes,

*Corresponding author's E-mail address: rezaul.ag@iubat.edu
Article received: September 2024 Revised and accepted: April 2025 Published: June 2025

powders, and other goods. The tomato's flavor, color, and taste have made it a popular food around the world (Hossain *et al.*, 2017).

In Bangladesh, tomatoes are commonly produced throughout the winter months since the climate is generally favorable for their best development and productivity. Due to population growth, there is a daily rise in demand for tomatoes (Ali *et al.*, 2014). Producing and exporting high-quality tomatoes presents an opportunity to generate substantial foreign currency. The only way to meet the growing demand is to increase production per unit area. The climate tolerance of tomato plants differs between hybrid and inbred types, as they are thermosensitive plants (Hossain *et al.*, 2017). Temperature, soil moisture content, and light are environmental elements that impact tomato production (Wu *et al.*, 2015).

So far, the Bangladesh Agricultural Research Institute (BARI) has released 11 hybrid and 21 open-pollinated (OP) tomato cultivars (Islam *et al.*, 2021). BARI Tomato-14, BARI Tomato-15, and BARI Tomato-16 are open-pollinated tomato varieties developed by BARI-Bangladesh Agricultural Research Institute, and KUSUM is a hybrid Indian variety. BARI varieties usually produced 30-53 fruit/plant, average fruit weight of 65-95g/plant, and yielded 80-95 t/ha (BARI Handbook, 2020). KUSUM tomato is a high-yielding variety. The average fruit weight is 80-90 g, and the fruit shape is round and dark red at maturity. Good storability and suitable for long-distance transportation (*Signet Crop Sciences India Pvt. Ltd)*. Considering these, it is also important to understand the related growth and yield performance of BARI released tomato varieties with a popular hybrid Indian variety, KUSUM.

Tomato yields are quite promising, but during the growing season, farmers have several challenges, such as unfavorable weather, managing pests, and a shortage of acceptable tomato varieties (Uddin *et al.*, 2023). Moreover, the studied tomato varieties are known for tolerance to common tomato diseases such as bacterial wilt, late blight, and viral disease, which also significantly contribute to the yield performance. In addition, different tomato varieties perform differently under different climatic and agro-ecological conditions. Furthermore, depending on the variety utilized, there are substantial differences in tomato yield and quality. To find the best tomato variety for a given growing environment, it is therefore required to assess the various tomato varieties. Considering this, the investigation was undertaken to understand the growth and yield performance of studied tomato cultivars under given environmental conditions during the winter period in Bangladesh.

2. Materials and Methods

The research was conducted at the Agricultural Research Field of IUBAT-International University of Business Agriculture and Technology in Dhaka, Bangladesh, during the winter months from October 2021 to February 2022. The experimental field is located geographically at latitude 23.8883° N and longitude 90.3907° E. The soil of the plot was sandy loam, with a pH 6.5.

The experiment was laid out following Randomized Complete Block Design (RCBD), including four different varieties, and replicated three times. The varieties were BARI Tomato-14, BARI Tomato-15, BARI Tomato-16, and KUSUM. The experimental plot covered a total area of 18.9 square meters (7m x 2.70m), divided evenly into three replications. Each replication was subdivided into 4 plots, with each of the 4 different tomato cultivars randomly assigned. This arrangement resulted in a total of 12 plots for the experiment. Each plot measured 125 cm x 125 cm in size.

2.1 The Cultivar Name and Source of Seeds

The tomato seeds were sourced from BARI (Bangladesh Agricultural Research Institute), located in Gazipur, Bangladesh, as well as KUSUM variety was collected from the local market in Tongi, Gazipur. BARI Tomato-14, BARI Tomato-15, and BARI Tomato-16 are familiar for their adaptability to grow across different soil types and climatic conditions, and the varieties have good market demand for fruit quality, better shelf life, and consumer acceptability, therefore, the following varieties were included in the present study, as shown in Table 1.

Table 1. The cultivar name and source of seeds

SL	Name of Cultivars	Source
01	BARI Tomato -14	BARI
02	BARI Tomato-15	BARI
03	BARI Tomato -16	BARI
04	KUSUM	Local market

2.2 Land Preparation

The land was repeatedly plowed and cross-plowed, followed by laddering for leveling of the land surface. Large clods were broken up into little bits as much as possible, and the plot corners were trimmed using a spade. After removing all the trash and weeds, the ground was finally ready. Manure and fertilizer were applied during the final land preparation according to the fertilizer dose. After completing the final stage of land preparation, the experimental plots were arranged according to the experimental design.

2.3 Manure and Fertilizers Application

The manure and fertilizer were applied according to the guidelines provided by the Bangladesh Agricultural Research Institute (BARI).

Table 2. Manure & fertilizers were applied in the field

SL.	Manure and fertilizers	Dose of fertilizer per ha.
01	Cowdung	10 ton
02	Urea	180 kg
03	Triple Super Phosphate (TSP)	150kg

04	Muriate of potash (MoP)	80kg
05	Gypsum	90kg
06	Zinc sulphate	5kg
07	Boric acid	5kg

2.4 Seed Sowing and Seedling Transplanting

Disease free and healthy seeds were collected and placed in the well prepared seedbed. Seedlings germinated within one week, and one-month old seedlings were transplanted in the well-prepared main field following spacing 60 cm× 60 cm.

2.5 Intercultural Operations

For improved plant growth and development, several intercultural procedures, including irrigation, weeding, top dressing of fertilizer, and disease management were carried out as and when the seedlings were transplanted. The newly emerged weeds were diligently uprooted from the field once sprouts had fully emerged, and subsequently as required. Throughout the growing season, irrigation was applied as needed based on observations of the soil moisture content. In this experiment, the drip irrigation method was used. Pruning was executed at multiple intervals to eliminate superfluous branches, leaves, flowers, and fruits, thereby enhancing both growth and yield across the duration of the experiment. Garlic paste was sprayed in the field to protect plants from attacking insects and vectors of viral diseases.

2.6 Disease Infestation

It was found that tomato plants suffered from diseases (particularly yellow leaf curl) during the experimental investigation. Disease infestation data recorded at the different stages of growth, i.e., 20, 40, 60, and 70 DAT. At the seedling stage, no virus-infected plant was in the experiment plot. With the increase of days, the infestation of the leaf curl virus became higher. As for Disease Incidence (%), the calculation was followed by the formula which was used by Anik *et al.,* (2020).

$$\text{Disease Incidence (\%)} = \frac{\text{Number of diseased infected plants/leaves}}{\text{Total number of plants/leaves observed}} \times 100$$

The notation "0=No, 1=Less, 2=Medium, 3=High" in the context of the experiment indicates a category scale used to evaluate the degree of disease impact seen in the tomato plants. A rating of "0" indicates the absence of disease symptoms, while a rating of "1" signifies minimal disease presence or low level of infestation (1-25%). When a disease is rated as "2", it means that the symptoms are noticeable but the impact on plant health is still under control (26-50%). A rating of "3" indicates the significant effects of the disease (51%+), with severe symptoms seriously impairing the tomato plants' health and yield.

2.7 Harvesting

The fruits were harvested when they reached maturity, with the timing determined by closely observing their color. It was done at an interval of 5 days.

2.8 Collection of Data

Throughout the experiment, data was collected from the sample plants on various parameters, including plant height (cm), number of leaves per plant, number of branches per plant, date of initial flowering, total number of flowers per plant, number of fruits per plant, weight of each fruit (grams), and the percentage of plants affected by disease.

2.9 Statistical Analysis

The parameters collected were subjected to statistical analysis using the STAR software package (Statistical Tool for Agricultural Research, http://bbi.irri.org/products) to determine the significance of the experiment. The LSD test was used to assess the significance of mean differences at 0.05 level of significance.

3. Results and Discussion

3.1 Morphological Parameters

Plant height, number of leaves, and branches per plant were recorded at various growth stages. The plant height was found to be significantly affected by various tomato cultivars. Plant height showed a consistent daily increase (Table 3). There was a gradual growth in plant height across all varieties as the dates progressed. However, KUSUM exhibited the tallest plant height (110.40 cm) at 80 DAT, while BARI Tomato-14 had the shortest plant height (90.57 cm). The plant height of BARI Tomato-15 and BARI Tomato-16 showed statistical similarities with the KUSUM variety. Based on the findings regarding plant height at various DAT, it can be concluded that all varieties exhibited a fluctuating yet generally normal growth pattern. It's evident that the variety of plants significantly influences the rate of growth, with notable differences observed among them. Islam *et al.*, (2021), Hossain *et al.*, (2017), Mehraj *et al.*, (2014), and Biswas *et al.*, (2015) have documented statistical differences in plant height among various tomato varieties at different DAT. A previous investigation conducted by Saha *et al.*, (2019) revealed that the plant height of BARI Tomato-14 and BARI Tomato-15 ranged from 64.53 cm to 76.07 cm and 71.33 cm to 84.93 cm, respectively. This variability was attributed to the application of various organic and inorganic fertilizers. BARI Tomato-14 and BARI Tomato-15 plant height varied from 62.98 cm to 86.05 cm and 67.24 cm to 97.80 cm, respectively, according to a previous study by Akand *et al.*, (2015). Different manures were used, which was the reason for this diversity.

The total number of leaves per plant varied significantly throughout tomato varieties. Leaf numbers per plant were recorded on various days after transplanting

(DAT). A continuous rise in leaf numbers was observed as the days progressed, regardless of the variety. The KUSUM variety exhibited the highest leaf count (35.67), while the BARI Tomato-14 variety had the fewest leaves per plant (24.33) at the 80 DAT. The branches' number per plant was also evaluated on various days after transplanting. It was found that different tomato varieties significantly influenced the number of branches per plant (Table 3). Over time, there was a gradual increase of branches per plant. BARI Tomato-16 exhibited the highest branch number per plant (5.67), whereas BARI Tomato-14 showed the lowest number (3) at the 80 DAT.

Table 3. Morphological parameters of the different studied tomato varieties

Variety	Plant Height (cm)				Number of Leaves/Plant				Number of Branches/Plant			
	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT	20 DAT	40 DAT	60 DAT	80 DAT
BARI Tomato-14	26.25	59.50	73.75b	90.57b	8.67	16.33	19.00b	24.33b	1.00	2.67	3.00b	3.00b
BARI Tomato-15	21.42	61.83	93.83a	106.75a	6.67	16.33	26.33a	30.67ab	1.00	2.67	3.67b	4.67ab
BARI Tomato-16	26.92	67.58	97.25a	108.35a	8.67	19.00	26.67a	32.67a	1.33	3.67	5.00a	5.67a
KUSUM	25.00	65.42	94.83a	110.40a	8.00	17.33	28.33a	35.67a	1.00	2.67	4.00ab	5.00a
$LSD_{(0.05)}$	NS	NS	16.18	12.90	NS	NS	6.06	7.31	NS	NS	1.15	1.76
CV (%)	15.81	8.36	9.01	6.21	26.76	13.07	12.11	11.88	26.65	22.13	14.74	19.24

3.2 Disease Infestation Rate of Different Tomato Cultivars

The various tomato cultivars' rates of disease infestation varied noticeably, according to an analysis of the collected data. BARI Tomato-15 exhibited higher resistance to specific diseases (Figure 1), while BARI Tomato-14 was more susceptible. The affected rates of BARI Tomato-16 and KUSUM were statistically similar. The statistical significance of these variations highlights the significance of cultivar selection in disease management strategies. Tomato cultivars differ in their rates of disease infestation, which can be explained by genetic variances and characteristics that are exclusive to each cultivar. Hossain & Ali, (2009) reported that BARI Tomato-14 is moderately susceptible to various diseases among 12 BARI tomato varieties. Amin *et al.,* (2016) also reported that BARI Tomato-14 is moderately resistant, while BARI Tomato-15 is resistant to pests and diseases.

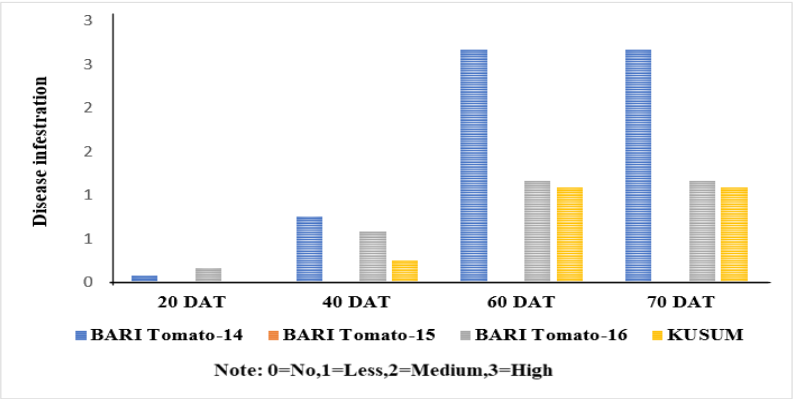

Figure 1. Disease infestation rate of different tomato cultivars

3.3 Date of Germination and Flowering of Different Cultivars of Tomato

During the experiment's germination stage, it was found that the tomato cultivars BARI Tomato-14, BARI Tomato-15, and BARI Tomato-16 consistently showed (Table 4) a germination period of three days, whereas the cultivar KUSUM took one (1) day more to germinate compared to the other three varieties. There are inherent varietal differences across the examined cultivars, as seen by the divergence in germination timing. These differences may be due to variations in physiological or genetic factors that influence the germination process. Such understanding of germination dynamics advances our knowledge of cultivar-specific characteristics and could influence agricultural techniques to improve tomato cultivation's early growth stages and seedling establishment.

Different dates for the start of blooming were noted in the developmental process of the tomato cultivars. In particular, BARI Tomato-14 showed (Table 4) the earliest signs of flowering—the first blossom appeared at 41 DAT. On the other hand, BARI Tomato-15 and BARI Tomato-16 both showed a slightly delayed start to bloom, with the first blooms appearing at 44 and 49 DAT, respectively. Surprisingly, the cultivar KUSUM showed a faster response to flowering; the first blossom appeared at 40 DAT. These differences in the time at which the studied cultivars begin to flower highlight the genetic diversity present in the tomato species, which can affect important developmental milestones as well as total output and fruit production.

Table 4: Days of seed germination and flowering

Cultivars	DAS to first germination	DAT to first flowering
V_1 (BARI Tomato-14)	03	41
V_2 (BARI Tomato-15)	03	44
V_3 (BARI Tomato-16)	03	49
V_4 (KUSUM)	04	40

3.4 Yield and Yield Contributing Characters of Different Varieties of Tomato

Various tomato varieties significantly influenced both the yield and yield-contributing characteristics of the tomato plants (Table 5). The variety BARI Tomato-16 yielded the highest number of fruits per plant (45.83), a statistically significant difference compared to other varieties. In contrast, the variety BARI Tomato-14 had the lowest number of fruits per plant (23.83). The findings also indicated no significant difference between BARI Tomato-15 and BARI Tomato-16 tomatoes in terms of the number of fruits per plant. The BARI Tomato-14 variety has the lowest fruit-per-plant value. The variety's ability to yield the largest fruits was the reason given for this (Hossain *et al.*, 2017).

Table 5. Performance of different tomato Varieties and yield contributing characteristics of tomato

Variety	No. of fruit/plant	Single fruit weight (g)	Yield per plant (kg)	Yield per plot(1.575m^2) (kg)	Yield ton/ha
BARI Tomato- 14	23.83c	75.20a	1.78c	7.13c	45.28c
BARI Tomato-15	36.58b	58.07b	2.12bc	8.47bc	53.84bc
BARI Tomato-16	45.83a	66.43ab	3.05a	12.19a	77.45a
KUSUM	37.17b	70.43a	2.64ab	10.54ab	66.99ab
LSD$_{(0.05)}$	8.2363	10.7597	0.7279	2.9118	18.4976
CV (%)	11.5	7.97	15.21	15.21	15.21

The finding of Figure 1 also indicates another reason for producing the lowest number of fruits per plant in BARI Tomato-14. Regarding crop damage, severity, and prevalence across all tomato-growing regions worldwide, TYLCV (Tomato yellow leaf curl virus) is the most significant. By alone, it can result in a 100% yield loss (Anik *et al.*, 2020). A statistically significant negative relation was observed between tomato yield and the incidence of TYLCV (%). When the incidence of TYLCV (%) was increased, the yield of tomatoes was decreased. The result in (Figure 1) showed that maximum disease infection was recorded on BARI Tomato-14 among other varieties. Disease infestation obtained from the current study agreed with the previous report of Anik *et al., (2020),* who reported that BARI Tomato-14 is more disease-susceptible than BARI Tomato-15.

The highest fruit weight value (75.20g) was observed in BARI Tomato-14, which was statistically higher than the other tomato varieties except for KUSUM, as it also produced fruits of statistically similar size. The smallest fruit weight (58.07g) was noted in BARI Tomato-15, showing statistical variation from the other varieties. The individual fruit weight significantly varied in different tomato varieties, and the same phenomenon has been reported by Biswas *et al.*, (2015). The varietal characteristics were responsible for the wide variance in fruit weight among

the varieties. There have also been reports of varietal influences on the weight of individual fruits (Islam *et al*., 2021; Hossain *et al.*,2017). BARI Tomato-16 attained the highest yield of fruits per plant (3.05 kg), followed by KUSUM tomatoes (2.64 kg). Conversely, the lowest fruit yield per plant (1.78 kg) was observed with BARI Tomato-14, which differed significantly from the other varieties. This difference in yield can be explained by variations in both the quantity of fruits per plant and the average weight of the fruits. Although BARI Tomato-14 produced the largest size of fruits (75.20g), the number of fruits was the lowest (23.83). On the other hand, BARI Tomato-16 produced a moderate size of fruits (66.43g), but the number of fruits per plant was the highest (45.83) which consequently lead the maximum yield per plant from BARI Tomato-16. The results concerning the number of fruits per plant, individual fruit weight, and fruit yield per plant in this study are consistent with those documented by Islam *et al*., (2021). Their study documented a range of 11.7 to 71.3 fruits per plant, individual fruit weights varying from 16.4 to 186.6 g, and fruit yields per plant ranging from 0.47 to 4.56 kg across 75 tomato germplasms in Bangladesh during the winter season.

4 Conclusion

The study investigates the growth and yield performance of some tomato varieties in the winter season in Uttara, Dhaka and observed a wide range of variation across different tomato varieties in terms of their different parameters. As per the obtained results, BARI Tomato-16 performed better irrespective of the number of branches, number of fruits, and yield per plant, which consequently lead the BARI Tomato-16 produced maximum yield of 77.45 t/ha. However, the variety showed a bit delayed in terms of first flowering and was moderately resistant to disease infestation. Moreover, others studied varieties also performed well following KUSUM, BARI Tomato-15, and BARI Tomato-14 and produced 66.99 t/ha, 53.84 t/ha, and 45.28 t/ha, respectively. Based on the given conditions, the BARI Tomato-16 performed better and can be recommended for farmers; however, further investigation is recommended in different agro-ecological zones in Bangladesh to validate the results.

Author's contribution

The study conceptualization, methodology, writing, review, and editing were performed by M. R. Karim; Review and editing by I. Hossain; Numerical analysis, writing, review, editing, and initial draft were written by M. M. Hoque. M. M. Rahman conducted the experiment and writing the initial draft.

Conflict of interest

The authors state that they have no conflicts of interest related to the publication of this work. They also affirm that they have conscientiously addressed ethical considerations, including plagiarism, informed consent, misconduct, data fabrication or falsification, duplicate publication or submission, and redundancy.

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