European Journal of Nutrition & Food Safety

14(11): 94-105, 2022; Article no.EJNFS.93359
ISSN: 2347-5641

Growth and Yield of Tomatillo as Influenced by Planting Time and Macronutrients

Abdullah Salfe Al Shamim [a], Tahmina Mostarin [a], Khaleda Khatun [a], Shamsun Nahar [a], Tahira Begum [a], Md. Khokon Uzzaman [b*], Asif Ahmed [a], Abdullah All Imtiaz [c], Md. Anisur Rahaman [d] and Md. Abdus Samad [a]

[a] Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, Bangladesh.
[b] Department of Agricultural Extension, Dhaka, Bangladesh.
[c] Institute of Economics and Social Sciences, Estonian University of Life Sciences, Estonia.
[d] State Plant Breeding Institute, University of Hohenheim Stuttgart, Germany.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/EJNFS/2022/v14i111268

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/93359

Original Research Article

Received 05 September 2022
Accepted 08 November 2022
Published 14 November 2022

ABSTRACT

With the use of a strategic pairing of planting time and macronutrients, tomatillo growth and yield can be boosted. Due to their complementing effects, the ideal combination of different planting times and macronutrients may significantly boost tomatillo growth and yield. The experiment was set by taking two treatment factors. Our treatment factors were: (1) Planting time (three time's viz. T_1 = 02 November, T_2 = 12 November, and T_3 = 22 November); and (2) Macro nutrients (four levels viz. F_0 = $N_0P_0K_0$ Kg/ha, F_1 = $N_{200}P_{60}K_{100}$ Kg/ha, F_2= $N_{250}P_{90}K_{120}$Kg/ha, F_3 = $N_{300}P_{120}K_{140}$ Kg/ha). The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. In case of planting time, the sharp increase of fruits per plant (37.06), fruit weight (42.7 g), yield per plant (2.04 kg) and per hectare (85.06 t) were obtained from T_3 (22 November). In case of macronutrients, the maximum number of fruits per plant (47.26), fruit weight (48.47 g), yield per plant (2.75 kg) and per hectare (114.59 t) were obtained from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha). Combined effect (T_3F_1) had improved the number of fruits per plant (49.66), fruit weight (55.64 g), yield per plant (2.94 kg) and per hectare (122.84 t), vitamin C content (25.92 mg) and noted from T_1F_0 (02 November with $N_0P_0K_0$Kg/ha) treatment combination that minimum number of fruits per plant (14.0), fruit weight (24.69 g), yield per plant (0.5 kg) and per hectare (20.85 t),

**Corresponding author: Email: mk.uzzaman84@gmail.com;*

vitamin C content (16.63 mg). So, the T_3F_1 treatment combination appeared to be the best for achieving the higher growth and yield of tomatillo.

Keywords: Growth; yield; tomatillo; planting time; macro nutrients.

1. INTRODUCTION

Tomatillo (*Physalis ixocarpa* brot.) produce a fleshy bearing round to spherical and green or green– purple fruit and its chromosome number is basically n=_24 and maximum species are diploid. Tomatillo fruit is surrounded by an inedible, paper-like basket developed Physalis from calyx and from outside it looks like a common weed present in Bangladesh which is known as "Foshka Begun"(*Physalis heterophylla* Nees) [1]. The tomatillo fruits are slightly acidic true berries with many tiny seeds and are typically green, yellow, or purple in color when mature. At the time of maturity, the fruit fills the husk and after separating this, the berry botanical fruit looks like a tomato, it appears a little sticky as it contains a pectin-like substance. Tomatillos make a great addition to a high-antioxidant eating plan focused on cancer prevention [2]. Production of a crop depends on many factors such as quality of seeds, proper management practices including time of planting, plant spacing, fertilizer management, intercultural operations. But as tomatillo is a relatively new and minor vegetable crop, information on its cultivation is very low in Bangladesh. Planting time is responsible for reduced growth and lower yield of fruit vegetables. An appropriate planting date helps reduce damage from cold, heat, pest disease and weeds competetion. Growers often manipulate planting times for better growth and maximum yield [3]. Therefore, late plant decrease the most important traits like days to flowering, duration of flowering, plant height and yield plant^{-1} [4]. In Bangladesh, production in the early and late growing season is difficult because the prevailing high temperature. Maintenance of optimum plant and planting time offers ample scope for increasing the flowering; fruiting and seed yield [5]. Among the macronutrients, NPK are showed deficit in our soil to grow crops. Nitrogen is an essential and important determinant for growth and development of crop plants [6]. Deficiency of nitrogen results in slow growth and stunting of plants [7] and consequently reduction in crop yields [8]. The vegetative growth is increased by nitrogen and also delayed maturity of plants. After nitrogen, phosphorus occupies the most significant input for increasing tomatillo production. Optimum level of P application increases the vegetative growth, yield and yield attributes and each nutrient element had a positive effect on vegetative growth as well as yields [9]. Potassium plays a balancing role on the effects of both the nitrogen and the phosphorus. The application of potassium increases the plant height, flower number, peduncle length, fruit size, fruit set and fruit number. Growth and yield of tomatillo can be increased through application of judicial combination of planting time and macronutrients. Optimum combination of different planting time and macronutrients may bring about considerable increase the growth and yield of tomatillo due to their complementary effects.

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Framework

This study was conducted in the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh. The location of the experimental site is 23°74′ N latitude and 90°35′ E longitude at an altitude of 8.6 meter above the sea level. The soil of the experimental area belongs to the Madhupur Tract under AEZ No. 28. The characteristics of the soil under the experiment were analyzed in the Laboratory of Soil Resources Development Institute (SRDI), Dhaka. The research experiment consists of two factors: Factor A: Planting time (Three times) T_1 = 02 November, T_2 = 12 November, T_3= 22 November. Factor B: Macronutrients (Four levels) F_0 = $N_0P_0K_0$Kg/ha , F_1 = N_{200} $P_{60}K_{100}$ Kg/ha , F_2 = $N_{250}P_{90}K_{120}$ Kg/ha , F_3 =$N_{300}P_{120}K_{140}$ Kg/ha. The two-factor experiment was laid out the following Randomized Complete Block Design (RCBD) with three replications. There were 12 treatment combinations. In total 36 plots for 3 blocks and each block consisted of 12-unit plots. The size of each unit plot was (1.8 m x 1.2 m) or 2.16 m^2. The distance between two replications was 1 m and two plots was 0.5 m.

2.2 Planting Materials Collection and Germination Test

Tomatillo variety named SAU tomatillo-1 was released by the Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka-1207. Collected seeds were checked by germination test. Seeds were allowed to germinate in moist blotting paper in the petri-dish for 10 days and counted the number of seeds that germinated then the percentage of germination was calculated.

2.3 Manure and Fertilizer Application

Full amount of well rotten cow dung (10 t ha^{-1}) was applied and mixed with soil during the final land preparation in all plots. For the source of macronutrients (NPK), Urea, Triple Super Phosphate (TSP), and Muriate of Potash (MOP) were used. The fertilizer dose followed by the treatment was calculated. Total amount of TSP and half of MOP were applied during the plot preparation. The rest amount of MOP was applied in two split of time on 25 days after transplanting (DAT) and 40 days after transplanting which was divided equally. As a source of nitrogen, urea was calculated as per the treatment for the plot and applied in three split of time i.e. 1/3rd amount of urea applied in 10 DAT, 1/3rd amount of urea applied in 25 DAT and the rest amount on 40 DAT.

Table 1. The calculation of fertilizer doses

Factor: B Fertilizer	Source of Macro-nutrients (NPK)			Cow dung (t ha^{-1})
	Urea (Kg ha^{-1})	TSP (Kg ha^{-1})	MOP (Kg ha^{-1})	
F_0	-	-	-	10
F_1	434.78	300	200	10
F_2	543.47	450	240	10
F_3	652.17	600	280	10

2.4 Statistical Analysis

The collected data were compiled and tabulated. Statistical analysis was done on various plant characters to find out the significance of variance resulting from the experimental treatments. Data were analyzed using analysis of variance (ANOVA) technique with the help of computer package program Statistics 10 (software) and the mean differences were adjudged by least significant difference test (LSD) as laid out by [10].

Table 2. Recommended fertilizers and manure doses

Sl no.	Fertilizers/ manure	Dose (quantity ha^{-1})
1	Urea	550 Kg
2	TSP	450 Kg
3	MOP	250 Kg
4	Cow dung	10 ton

[Source: A Hand Book of Agricultural Technology, BARI]

3. RESULTS AND DISCUSSION

3.1 Growth Parameters

3.1.1 Plant height (cm)

Plant height is a central part of plant ecological strategy. It is strongly correlated with life span, seed mass and times to maturity, and is a major determinant of a species' ability to compete for light. Plant height is also related to critical ecosystem variables such as animal diversity and carbon storage capacity [11]. Plant height at 10, 30, 45 and 60days after transplanting (DAT) was significantly influenced by planting time (Fig. 1). At 60 DAT, the maximum plant height (94.28 cm) was obtained from T_3 (22 November) treatment and minimum plant height (88.71 cm) was observed from T_1 (02 November) treatment. The similar pattern of plant height was reported by [12] and [13]. Plant height was significantly influenced by macronutrients (Fig. 2) at 10, 30, 45 and 60 DAT. At 60 DAT, the maximum plant height (105.53 cm) was noted from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment and minimum plant height (77.19 cm) was identified from F_0 ($N_0P_0K_0$ Kg/ha) treatment. The similar pattern of plant height was reported by [13]. Combined effect of planting times and macronutrients significantly was influenced by plant height at different days after transplanting (Table 3). At 60 DAT, the tallest plant height (109.13 cm) was recorded from T_3F_3 (22 November with $N_{300}P_{120}K_{140}$ Kg/ha) treatment combination and the shortest plant height (73.22 cm) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

3.1.2 Number of leaves per plant

The main function of a leaf is to produce food for the plant by photosynthesis. Number of leaves per plant was significantly influenced by planting time (Table 4) at 15, 30, 45, and 60 DAT. At 60 DAT, the maximum number of leaves per plant (242.83) was noted from T_3 (22 November) treatment and minimum number of leaves per plant (229.52) was obtained from T_1 (02 November) treatment. Number of leaves per plant at 15, 30, 45, and 60 DAT was significantly affected by macronutrients (Table 4). At 60 DAT, the maximum number of leaves per plant (301.80) was obtained from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment and minimum number of leaves per plant (175.80) was recorded from F_0 ($N_0P_0K_0$ Kg/ha) treatment. Combined effect of planting times and macronutrients was significantly influenced number of leaves per plant at different days after transplanting (Table 3).From the experiment at 60 DAT, the highest number of leaves per plant (310.73) was recorded from T_3F_3 (22 November with $N_{300}P_{120}K_{140}$ Kg/ha) treatment combination and the lowest number of leaves per plant (170.73) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

3.1.3 Canopy size (cm)

Plant canopy structure can strongly affect crop functions such as yield and stress tolerance, and canopy size is an important aspect of canopy structure. Canopy size at 15, 30, 45 and 60 DAT exerted significant difference due to transplanting times (Table 4). At 60 DAT, the maximum canopy size (97.68 cm) was obtained from T_3 (22 November) treatment and minimum canopy size (92.01 cm) was obtained from T_1 (02 November) treatment. Canopy size was significantly influenced by macronutrients (Table 4) at different days after transplanting. Results from the experiment showed that the maximum canopy size (106.84 cm) was revealed from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment at 60 DAT whereas the minimum canopy size (75.52 cm) was noticed from F_0 ($N_0P_0K_0$ Kg/ha) treatment. Combined effect of planting times and macronutrients was significantly influenced by canopy size of tomatillo plant at different days after transplanting (Table 5). It was showed from the experiment that the maximum canopy size (109.75 cm) was observed from T_3F_3 (22 November with $N_{300}P_{120}K_{140}$ Kg/ha) treatment combination at 60 DAT and the smaller canopy size (70.8 cm) was noted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

3.1.4 Chlorophyll content (SPAD unit)

Chlorophyll is an important photosynthetic pigment to the plant, largely determining photosynthetic capacity and hence plant growth. When considering on the importance of chlorophyll for photosynthesis, plants in the natural community should optimize light absorption and photosynthesis by adjusting the content and ratios of chlorophyll to enhance growth and survival at the long-term evolutionary scale. Certain factors might influence chlorophyll levels. From the perspective of phylogeny, stable traits are the results of long-term adaption and evolution to the external environments [14].

Chlorophyll content exerted significant influence due to different transplanting times (Table 4). From the experimental result it was showed that the maximum chlorophyll content (74.60 SPAD Unit) was noted from T_3 (22 November) treatment and minimum chlorophyll content (69.72 SPAD Unit) was observed from T_1 (02 November) treatment. Marked variation on Chlorophyll content was revealed by macronutrients (Table 4). Result from the experiment showed that the maximum chlorophyll content (84.22 SPAD Unit) was recorded from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment. On the other hand the minimum chlorophyll content (59.66 SPAD Unit) was noted from F_0 ($N_0P_0K_0$ Kg/ha) treatment. Statistically significant variation was noticed on leaf chlorophyll content due to the combined effect of planting times and macronutrients during this experiment (Table 5).From the experiment, the maximum leaf chlorophyll content (85.48 SPAD Unit) was recorded from T_3F_3 (22 November with $N_{300}P_{120}K_{140}$ Kg/ha) treatment combination and the minimum leaf chlorophyll content (54.71 SPAD Unit) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

3.2 Yield Parameters

3.2.1 Days to first flowering

Days to first flowering was showed significant variation due to transplanting times (Table 6). Result from the experiment showed that the maximum days to first flowering (31.89) was noticed from T_3 (22 November) treatment whereas minimum days to first flowering (28.18)

was observed from T_1 (02 November) treatment. There was marked variation noticed on days to first flowering of tomatillo due to different levels of macronutrients (Table 6). It was revealed that the maximum days to first flowering (33.03) was observed from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment. On the other hand, the minimum days to first flowering (25.33) was noted from F_0 ($N_0P_0K_0$ Kg/ha) treatment. Combined effect of planting times and macronutrients was significantly influenced by tomatillo on days to first flowering (Table 6).From the experimental results, it was showed that the maximum days to first flowering (35.8) was recorded from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination whereas the minimum days to first flowering (24.07) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

3.2.2 Number of flowers per plant

Number of flowers per plant was significantly influenced by transplanting times of tomatillo (Table 6) at15, 30, 45 and 60 DAT. It was revealed that the maximum number of flowers per plant (21.7) was exerted from T_3 (22 November) treatment and minimum number of flowers per plant (15.98) was observed from T_1 (02 November) treatment. Significant difference on number of flowers per plant at 15, 30, 45 and 60 DAT was noticed due to macronutrients (Table 6).The experimental results was exerted that at 60 DAT, the maximum number of flowers per plant (29.2) was observed from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha) treatment. On the other hand, the minimum number of flowers per plant (9.16) was noted from F_0 ($N_0P_0K_0$ Kg/ha) treatment. Statistically significant variation at 15, 30, 45 and 60 DAT was noticed on number flowers per plant due to the combined effect of planting times and macronutrients (Table 6). From the experimental results, at 60 DAT the highest number of flowers per plant (35.4) was recorded from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination and the lowest number of flowers per plant (6.27) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

3.2.3 Number of fruits per plant

Tomatillo plants can be extremely productive. An individual plant may produce 64 to 200 fruits in a season. Number of fruits per plant was significantly influenced by transplanting times (Table 7) at different days after transplanting. It was exerted that the maximum number of fruits per plant (37.07) was noted from T_3 (22 November) treatment at 60 DAT and minimum number of fruits per plant (32.6) was obtained from T_1 (02 November) treatment. Statistical significant variation was noticed on maximum number of fruits per plant of tomatillo due to macronutrients (Table 7) at 15, 30, 45 and 60 DAT. At 60 DAT, the maximum number of fruits per plant (47.27) was observed from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha) treatment and minimum number of fruits per plant (15.82) was revealed from F_0 ($N_0P_0K_0$ Kg/ha) treatment.

Marked variation on number of fruits per plant of tomatillo was observed due to the combined effect of planting times and macronutrients (Table 7) at different days after transplanting. At 60 DAT, the highest number of fruits per plant (49.67) was recorded from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination and the lowest number of fruits per plant (14.0) was noted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

3.2.4 Yield per Plant (kg)

Yield per plant was significantly influenced by planting time (Table 7). From the result of the experiment it was revealed that the maximum yield per plant (2.04 Kg) was observed from T_3 (22 November) treatment and minimum yield per plant (1.73 Kg) was noted from T_1 (02 November) treatment. Significant influence was revealed on yield per plant by macronutrients during the present experiment (Table 7). It was exerted that the maximum yield per plant (2.75 Kg) was noted from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha) treatment while minimum yield per plant (0.58 Kg) was obtained from F_0 ($N_0P_0K_0$ Kg/ha) treatment. Statistical variation was showed on yield per plant due to combined effect of planting times and macronutrients (Table 7).From the experimental result, it was revealed that the maximum yield per plant (2.95 kg) was recorded from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination and the minimum yield per plant (0.5 Kg) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

Table 3. Combined effect of planting time and macronutrients on plant height and number of leaves at different days after transplanting of tomatillo (*Physalis ixocarpa*)

Treatment Combinations	Plant height (cm)				Number of leaves per plant			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**	**15 DAT**	**30 DAT**	**45 DAT**	**60 DAT**
T_1F_0	21.64 h	44.05 i	63.07 h	73.22 h	13.61 i	76.8 g	115.8 i	170.73 j
T_1F_1	29.72 e	54.89 f	71.95 f	84.79 f	19.73 fg	97.83 e	190.90 g	214.53 h
T_1F_2	34.16 c	62.99 d	82.01 d	94.06 d	24.93 e	114.8 d	218.53 d	238.87 f
T_1F_3	36.71 b	65.92 c	86.61 c	102.77 b	37.73 b	138.76 b	242.73 b	293.93 c
T_2F_0	22.40 h	47.01 h	67.84 g	77.66 g	14.67 hi	82.73 f	121.73 h	177.93 i
T_2F_1	28.28 f	56.80 f	72.84 ef	86.98 ef	18.73 g	99.07 e	205.93 f	215.33 h
T_2F_2	33.52 c	64.64 cd	83.51 d	97.11 cd	32.80 c	132.93 c	219.67 d	247.03 e
T_2F_3	38.84 a	72.15 b	90.73 b	104.67 b	29.87 d	158.8 a	245.80 b	300.73 b
T_3F_0	25.10 g	49.95 g	70.68 f	80.70 g	15.73 h	86.87 f	126.53 h	178.73 i
T_3F_1	31.12 d	59.80 e	74.98 e	88.44 e	20.62 f	115.53 d	212.15 e	229.07 g
T_3F_2	35.57 b	69.77 b	89.00 b	98.87 c	33.16 c	134.17 bc	226.93 c	252.80 d
T_3F_3	39.64 a	74.98 a	93.78 a	109.13 a	44.60 a	162.73 a	252.8 a	310.73 a
$LSD_{(0.05)}$	1.24	2.39	2.37	3.51	1.5301	5.5185	5.298	5.5958
CV%	2.34	2.35	3.78	2.27	2.9	2.79	3.58	4.2

Here, T_1 = 02 November, T_2 = 12 November, T_3= 22 November, $F_0 = N_0P_0K_0$ Kg/ha, $F_1 = N_{200}P_{60}K_{100}$ Kg/ha, $F_2 = N_{250}P_{90}K_{120}$ Kg/ha, $F_3 = N_{300}P_{120}K_{140}$ Kg/ha

Table 4. Effects of planting time and macronutrients on number of leaves at different days after transplanting, canopy size (cm) and chlorophyll content (SPAD Unit) of tomatillo (*Physalis ixocarpa)*

Treatment	Number of leaves per plant				Canopy Size (cm)				chlorophyll content (SPAD Unit)
	15 DAT	30 DAT	45 DAT	60 DAT	15 DAT	30 DAT	45 DAT	60 DAT	
Planting time									
T_1	24.27 b	107.05 c	191.99 c	229.52 c	21.34 b	57.81 b	78.00 c	92.01 c	69.72 c
T_2	23.75 b	118.38 b	198.28 b	235.26 b	21.86 b	58.67 ab	79.67 b	95.43 b	71.66 b
T_3	28.53 a	124.83 a	204.60 a	242.83 a	22.91 a	59.48 a	81.85 a	97.68 a	74.60 a
$LSD_{(0.05)}$	0.76	2.75	2.64	2.79	0.74	1.42	1.52	1.2	1.25
CV%	2.9	2.79	3.58	4.20	3.32	3.14	2.26	2.5	4.83
Macro-nutrients									
F_0	14.67 c	82.13 d	121.36 d	175.80d	15.88 c	41.37 d	66.316 d	75.52 d	59.66 d
F_1	19.70 b	104.14 c	202.99 c	219.64 c	20.38 b	55.48 c	77.87 c	96.08 c	70.30 c
F_2	33.59 a	127.30 b	221.71 b	246.23 b	25.78 a	67.07 b	83.72 b	101.74 b	73.79 b
F_3	34.11 a	153.43 a	247.11 a	301.80 a	26.11 a	70.70 a	91.45 a	106.84 a	84.22 a
$LSD_{(0.05)}$	0.8834	3.18	3.05	3.23	0.86	1.64	1.76	1.39	1.44
CV%	2.9	2.79	3.58	4.20	3.32	3.14	2.26	2.5	4.83

Here, T_1 = 02 November, T_2 = 12 November, T_3= 22 November, $F_0 = N_0P_0K_0$ Kg/ha, $F_1 = N_{200}P_{60}K_{100}$ Kg/ha, $F_2 = N_{250}P_{90}K_{120}$ Kg/ha, $F_3 = N_{300}P_{120}K_{140}$ Kg/ha

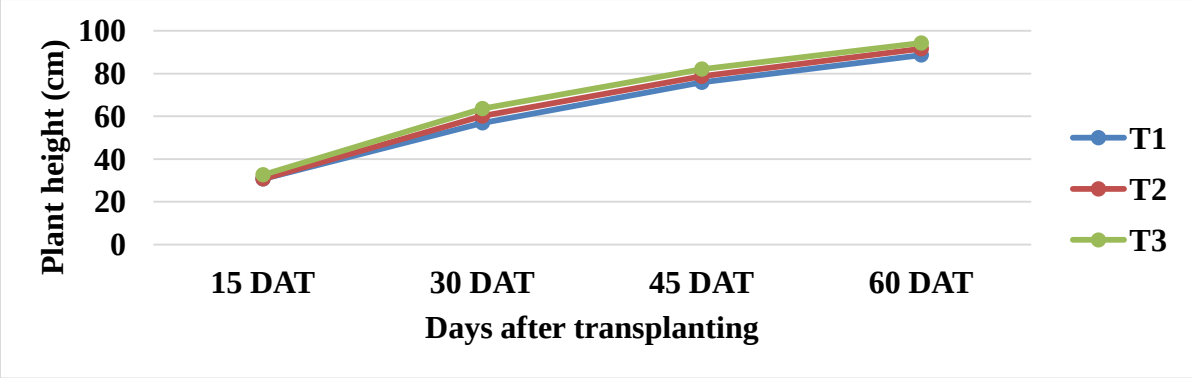

Fig. 1. Effect of planting time on plant height at different days after transplanting of tomatillo (*Physalis ixocarpa*)

Here, T_1 = 02 November, T_2 = 12 November, T_3= 22 November

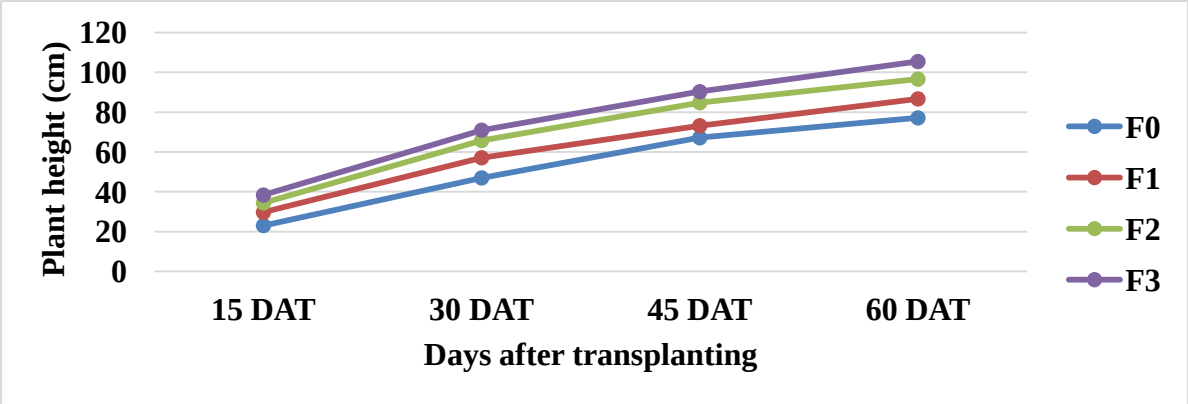

Fig. 2. Effect of macronutrients on plant height at different days after transplanting of tomatillo (*Physalis ixocarpa*)

Here, $F_0 = N_0P_0K_0$ Kg/ha, $F_1 = N_{200}P_{60}K_{100}$ Kg/ha, $F_2 = N_{250}P_{90}K_{120}$ Kg/ha, $F_3 = N_{300}P_{120}K_{140}$ Kg/ha

Table 5. Combined effect of planting time and macronutrients on number of leaves at different days after transplanting, canopy size (cm) and chlorophyll content (SPAD Unit) of tomatillo (*Physalis ixocarpa*)

Treatment	Canopy Size (cm)				Chlorophyll content (SPAD Unit)
	15 DAT	30 DAT	45 DAT	60 DAT	
Combinations					
T_1F_0	15.34 i	38.81 h	63.48 f	70.8 j	54.71 i
T_1F_1	18.95 gh	57.73 e	76.793 d	92.79 h	68.63 fg
T_1F_2	26.35 bc	70.36 b	82.66 c	100.33 ef	72.75 cde
T_1F_3	24.71 de	64.35 cd	89.087b	104.14 c	82.79 b
T_2F_0	17.53 h	40.48 h	66.533 ef	76.93 i	57.95 h
T_2F_1	22.19 f	55.72 ef	77.867 d	96.55 g	70.32 ef
T_2F_2	23.39 ef	66.85 c	83.947 c	101.62 de	73.99 cd
T_2F_3	28.55 a	74.85 a	90.333b	106.61b	84.38 ab
T_3F_0	14.77 i	44.81 g	68.933 e	78.83 i	66.32 g
T_3F_1	20.01 g	52.98 f	78.953 d	98.9 fg	71.95 de
T_3F_2	27.60 ab	63.99 d	84.567 c	103.27 cd	74.64 c
T_3F_3	25.07 cd	72.89 ab	94.953a	109.75a	85.48 a
LSD(0.05)	1.4993	2.8549	3.0588	2.4113	2.5018
CV%	3.32	3.14	2.26	2.5	4.83

Here, T_1 = 02 November, T_2 = 12 November, T_3= 22 November, $F_0 = N_0P_0K_0$ Kg/ha, $F_1 = N_{200}P_{60}K_{100}$ Kg/ha, $F_2 = N_{250}P_{90}K_{120}$ Kg/ha, $F_3 = N_{300}P_{120}K_{140}$ Kg/ha

Table 6. Effects of planting time, macronutrients and combined effect of planting time and macronutrients on days to first flowering, number of flowers per plant at different says after transplanting of tomatillo (*Physalis ixocarpa)*

Treatment	Days to first flowering	Number of flowers per plant			
		15 DAT	30 DAT	45 DAT	60 DAT
Different sowing date					
T_1	28.18 c	1.98 c	15.68 c	25.12 c	15.98 c
T_2	29.25 b	2.68 b	17.99 b	28.69 b	18.93 b
T_3	31.89 a	3.40 a	19.80 a	31.43 a	21.70 a
LSD(0.05)	0.5879	0.2775	1.5351	1.7519	0.9049
CV%	2.33	12.19	10.17	7.28	5.66
Different level of phosphorus					
F_0	25.33 d	0.87 d	10.37 d	14.67 d	9.16 d
F_1	30.71 b	5.27 a	27.67a	41.71 a	29.20 a
F_2	30.02 c	2.84 b	18.42 b	32.69 b	20.14 b
F_3	33.03 a	1.78 c	14.84 c	24.59 c	16.98 c
LSD(0.05)	0.6789	0.3204	1.7726	2.0229	1.0449
CV%	2.33	12.19	10.17	7.28	5.66
Combinations					
T_1F_0	24.07 h	0.53 j	8.07 j	10.80 h	6.27 i
T_1F_1	27.73 f	3.60 c	23.80 c	36.73 c	23.13 c
T_1F_2	29.07 e	2.47 ef	17.27 def	31.20 de	18.80 de
T_1F_3	31.87 c	1.33 hi	13.60 ghi	21.73 f	15.73 f
T_2F_0	25.40 g	0.93 ij	11.31 i	15.27 g	9.53 h
T_2F_1	28.60 ef	5.13 b	27.67 b	41.40 b	29.07 b
T_2F_2	30.33 d	2.93 de	18.20 de	34.53 cd	19.90 d
T_2F_3	32.67 c	1.73 gh	14.80 fgh	23.57 f	17.20 ef
T_3F_0	26.53 g	1.13 i	11.73 hi	17.93 g	11.67 g
T_3F_1	35.80 a	7.07 a	31.53 a	47.00 a	35.40 a
T_3F_2	30.67 d	3.13 cd	19.80 d	32.33 d	21.73 c
T_3F_3	34.57 b	2.27 fg	16.13 efg	28.47 e	18.00 e
LSD(0.05)	1.1759	0.5549	3.0702	3.5038	1.8099
CV%	2.33	12.19	10.17	7.28	5.66

Here, T_1 = 02 November, T_2 = 12 November, T_3= 22 November, F_0 = $N_0P_0K_0$ Kg/ha, F_1 = $N_{200}P_{60}K_{100}$ Kg/ha, F_2 = $N_{250}P_{90}K_{120}$ Kg/ha, F_3 = $N_{300}P_{120}K_{140}$ Kg/ha

3.2.5 Yield (t ha^{-1})

Freyre and Brent [15] conducted an experiment using five tomatillo varieties and showed that tomatillos are extremely productive ranging from 29.7 to 63.7 t ha^{-1}. Total yield of tomatillo was significantly influenced by planting time during the present experiment (Table 7). The experimental result was showed that the maximum yield (85.06 t ha^{-1}) was recorded from T_3 (22 November) treatment and minimum yield (72.15 t ha^{-1}) was noted from T_1 (02 November) treatment. Significant influence was exerted on total yield by macronutrients (Table 7). It was showed that the maximum yield (114.59 t ha^{-1}) was observed from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha) treatment where the minimum yield (24.34 t ha^{-1}) was revealed from F_0 ($N_0P_0K_0$ Kg/ha) treatment. Combined effect of planting time and macronutrients was significantly influenced by total yield of tomatillo (Table 7). The highest yield (122.84 t ha^{-1}) was recorded from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination and the lowest yield (20.85 t ha^{-1}) was exerted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

Table 7. Effects of planting time and macronutrients on number of fruits per plant at different days after transplanting, yield per plant, yield per ha, brix percentage and vitamin C content of tomatillo (*Physalis ixocarpa*)

Treatment	Number of Fruits per Plant				Yield per Plant (kg)	Yield per ha (ton)	Brix Percentage (%)	Vitamin C content (mg)
	15 DAT	30 DAT	45 DAT	60 DAT				
Different sowing date								
T_1	2.86 c	13.42 c	24.75 c	32.60 c	1.732 c	72.15 c	4.31 b	18.693 c
T_2	3.20 b	14.71 b	27.87 b	34.45 b	1.95 b	81.24 b	4.58 ab	19.887b
T_3	3.67 a	16.27a	30.76 a	37.07 a	2.042 a	85.06 a	4.81 a	20.785a
LSD(0.05)	0.2234	0.4933	1.1118	0.5968	0.0516	2.1483	0.2991	0.8365
CV%	8.14	3.94	4.72	2.03	3.19	3.19	7.73	4.99
Different level of phosphorus								
F_0	1.96 d	8.42 d	15.31 d	15.82 d	0.58 d	24.34 d	3.93 c	14.367 d
F_1	4.87 a	20.42 a	39.76 a	47.27 a	2.75 a	114.59 a	4.41 b	24.186 a
F_2	3.72 b	16.51 b	32.80 b	40.87 b	2.39 b	99.51 b	4.58 b	21.722 b
F_3	2.42 c	13.83 c	23.31 c	34.87 c	1.91 c	79.50 c	5.36 a	18.88 c
LSD(0.05)	0.2580	0.5697	1.2838	0.6891	0.0595	2.4807	0.3454	0.9659
CV%	8.14	3.94	4.72	2.03	3.19	3.19	7.73	4.99
Combinations								
T_1F_0	1.67 i	5.93 j	13.07 i	14.00 j	0.50 j	20.85 j	3.61 f	12.63 g
T_1F_1	4.47 bc	19.20 c	36.07 c	44.67 c	2.49 cd	103.70 cd	4.49 cde	22.82 bc
T_1F_2	3.43 e	15.53 e	31.27 d	39.13 d	2.19 e	91.10 e	4.39 cde	21.18 cd
T_1F_3	1.87 hi	13.00 g	18.60 g	32.60 g	1.75 h	72.93 h	4.76 bcd	18.137 e
T_2F_0	1.93 hi	8.00 i	15.96 h	15.87 i	0.65 i	27.01 i	4.05 ef	15.38 f
T_2F_1	4.73 b	20.27 b	39.53 b	47.47 b	2.81 b	117.24 b	4.53 cde	23.807b
T_2F_2	3.67 de	16.73 d	32.27 d	39.80 d	2.40 d	100.32 d	4.44 cde	21.603 c
T_2F_3	2.47 g	13.83 fg	23.73 f	34.67 f	1.93 g	80.40 g	5.31 b	18.76 e
T_3F_0	2.27 gh	11.33 h	16.90 gh	17.60 h	0.60 i	25.16 i	4.13 ef	15.09 f
T_3F_1	5.40 a	21.80 a	43.67 a	49.67 a	2.95 a	122.81 a	4.20 def	25.927a
T_3F_2	4.07 cd	17.27 d	34.87 c	43.67 c	2.57 c	107.11 c	4.91 bc	22.38 bc
T_3F_3	2.93 f	14.67 ef	27.60 e	37.33 e	2.04 f	85.18 f	6.01 a	19.743 de
LSD(0.05)	0.4468	0.9867	2.2235	1.1936	0.1031	4.2966	0.5983	1.6731
CV%	8.14	3.94	4.72	2.03	3.19	3.19	7.73	4.99

Here, T_1 = 02 November, T_2 = 12 November, T_3= 22 November, $F_0 = N_0P_0K_0$ Kg/ha, $F_1 = N_{200}P_{60}K_{100}$ Kg/ha, $F_2 = N_{250}P_{90}K_{120}$ Kg/ha, $F_3 = N_{300}P_{120}K_{140}$ Kg/ha

3.3 Quality Parameters

3.3.1 Brix percentage (%)

Degrees Brix (symbol °Bx) is the sugar content of an aqueous solution. One-degree Brix is 1 gram of sucrose in 100 grams of solution and represents the strength of the solution as percentage by mass. If the solution contains dissolved solids other than pure sucrose, then the °Bx only approximates thedissolved solid content. The highest and the lowest amount of brix percentages reported by [12] were 3.33% and 10.21%, respectively.

Brix percentage of tomatillo revealed statistical significant variation by transplanting times (Table 7). The experimental result was showed that the maximum brix (4.81%) was noted from T_3 (22 November) treatment and minimum °Bx (4.31%) was observed from T_1 (02 November) treatment. Significantly influence was exerted on °Bx percentage of tomatillo by macronutrients (Table 7).From the result of the experiment, it was showed that the maximum brix (5.36%) was noted from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha)) treatment where the minimum brix (3.93%) was observed from F_0 ($N_0P_0K_0$ Kg/ha) treatment. Combined effect of planting times and macronutrients was significantly influenced by brix percentage (Table 7). From the experimental results, it was revealed that the highest brix (6.01%) was recorded from T_3F_3 (22 November with $N_{300}P_{120}K_{140}$ Kg/ha) treatment combination and the lowest brix (3.61%) was noted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

3.3.2 Vitamin C content (mg)

Vitamin C is a water-soluble vitamin. It is needed for normal growth and development. Vitamin C, also known as ascorbic acid, has several important functions. These include: helping to protect cells and keeping them healthy, maintaining healthy skin, blood vessels, bones and cartilage. Tomatillos have plenty of vitamin C. They actually contain 20% of the daily recommended value. The Vitamin C found in tomatillos stimulates the production of white blood cells to help boost the immune system.

Vitamin C content of tomatillo was significantly influenced by planting time during the experiment (Table 7). From the result of the experiment, the maximum vitamin C content (20.78 mg) was observed from T_3 (22 November) treatment and minimum vitamin C content (18.69 mg) was noted from T_1 (02 November) treatment. Statistical variation on vitamin C content of tomatillo was significantly influenced by macronutrients (Table 7). From the experimental result it was revealed that the maximum vitamin C content (24.18 mg) was observed from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha) treatment. On the other hand, minimum vitamin C content (14.36 mg) was revealed from F_0 ($CN_0P_0K_0$ Kg/ha) treatment. Combined effect of planting time and macronutrients was significantly influenced by vitamin C content of tomatillo (Table 7). It was revealed that the highest vitamin C content (25.92 mg) was exerted from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination and the lowest vitamin C content (12.63 mg) was noted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

4. CONCLUSION

From the above findings, it can be concluded:

- For obtaining maximum yield of tomatillo, seedlings planted on 22 November was found the best among the planting times because growth and yield attributes decreased gradually with the early planting.
- For macronutrient doses, $N_{300}P_{120}K_{140}$ Kg/ha (F_3) was found to be superior for plant growth parameters and $N_{200}P_{60}K_{100}$ Kg/ha (F_1) was recorded to be the pre-eminent for yield attributing parameters.
- Considering yield contributing characters, combined effect of T_3F_1 (planting time: 22 November;macronutrients $N_{200}P_{60}K_{100}$ Kg/ha) was found to provide the best results of tomatillo.

The experiment was however, conducted in one season only and hence the results should be considered as a tentative. It is imperative that similar experiment should be carried out with more variables to reconfirm the recommendation of tomatillo.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Karim R. Estimation of genetic variability, heritability and genetic advance in agro

morphogenetic traits of tomatillo genotype. MS thesis, SAU, Dhaka,Bangladesh; 2016.
2. Dolson L. Tomatillo nutrition facts and health benefits; 2020.
Available: https://cutt.ly/CPelQ1q
3. Alam KS, Ishrat E, Zaman MY and Habib MA. Comparative karyotype and RAPD analysis for characterizing three varieties of (*Solanum lycopersicum* L.). Bangladesh J. Bot. 2012;4(2):149-154.
4. Rameeh V. Evaluation of the planting date effects on yield and yield associated traits in rap seed advanced lines. Int. J. Agri. Innovation Res. 2012;1(1):7-11.
5. Kumar R, Sharma R, Gupta RK and Singh M. Determination of genetic variability and divergence for root yield and quality characters in temperate radish. Int. J. Veg. Sci. 2012;8(4): 307-3018.
6. Tanaka A, Yamaguchi J, Miura S and Tamaru H. Comparison of fertilizer nitrogen efficiency among field crops. Soil Sci. Plant Nutrition. 1984;30(2):199- 208.
7. Makasheva RKH. The pea Oxonion Press Pvt. Ltd. New Delhi. 1983;267.
8. Meetha S and Techawongstien S. Influence of planting dates on growth, yield and seed quality of tomato grown in plastic house. Khon Kaen Agric. J. 2009; 217-222.
9. Shil IC, Haider J, Karim AJMS, Ali M and Hossain MM. Optimizing fertilizer requirement for grafted tomato cultivation. Ann. Bangladesh Agric. 1997;7(1):9-14.
10. Gomez K A and Gomez AA. Statistical procedures for agricultural research.2nd edn. John Wiley and Sons. New York. 1984;680.
11. Moles AT, Warton DI, Warman L, Swenson NG, Laffan SW, Zanne AE and Leishman MR. Global patterns in plant height. J. Ecol. 2009;97(5):923–932.
12. Narzis N. Interaction effect of genotype and salinity levels on agromorpho-genetic, physiological and nutritional traits of tomatillo.MS thesis, SAU, Dhaka, Bangladesh; 2018.
13. Ahammad K, Siddiky M, Ali Z, and Ahmed R. Effects of planting time on the growth and yield of tomato varieties in late season, Progress. Agric. 2013;20(1-2):73–78.
14. Li Y, He N, Hou J, Xu L, Liu C, Zhang J and Wu X. Factors Influencing Leaf Chlorophyll Content in Natural Forests at the Biome Scale. Front. Ecol. Evol. 2018; 6(64):1-10.
15. Freyre R. and Brent LJ. Evaluation and yield trials of tomatillo in new hemisphere. Hort. Technol. 2000;10(2):374-377.

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/93359