GROWTH AND YIELD OF TOMATILLO AS INFLUENCED BY PLANTING TIME AND MACRONUTRIENTS

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CERTIFICATE

This is to certify that the thesis entitled, ***"GROWTH AND YIELD OF TOMATILLO AS INFLUENCED BY PLANTING TIME AND MACRONUTRIENTS"*** *submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of* ***MASTER OF SCIENCE (MS) in HORTICULTURE****, embodies the result of a piece of bonafide research work carried out by Abdullah Salfe Al Shamim, Registration No. 14-06205 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

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TO

MY BELOVED PARENTS

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ABSTRACT

The experiment was carried out at the "Horticulture Farm" in Sher-e-Bangla Agricultural University, Dhaka during October 2019 to February 2020 to examine growth and yield of tomatillo as influenced by planting time and macronutrients. The experiment was set by taking two treatment factors. The treatment factors are: (A) Planting time (three times) viz. T_1 = 02 November, T_2 = 12 November, and T_3 = 22 November; and (B) Macronutrients (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. There were 12 treatment combinations such as T_1F_0, T_1F_1, T_1F_2, T_1F_3, T_2F_0, T_2F_1, T_2F_2, T_2F_3, T_3F_0, T_3F_1, T_3F_2, T_3F_3. The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Seeds of SAU tomatillo-1 were collected from department of Genetics and plant breeding, SAU, Dhaka-1207. In case of planting time, the maximum number 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 F1 ($N_{200}P_{60}K_{100}$ Kg/ha). Due to combined effect, the maximum 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) were identified from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination and 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), vitamin C content (16.63 mg) were noted from T_1F_0 (02 November with $N_0P_0K_0$Kg/ha) treatment combination. So, the T_3F_1 treatment combination appeared to be the best for achieving the higher growth and yield of tomatillo.

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SOME COMMONLY USED ABBREVIATIONS

Abbreviations	Full meaning	Abbreviations	Full meaning
%	Percentage	K	Potassium
AEZ	Agro- Ecological Zone	Kg	Kilogram (s)
BARI	Bangladesh Agricultural Research Institute	LSD	Least Significant Difference
RARS	Regional Agricultural Research Station	m	Meter
Ca	Calcium	mg	Milligram
Cl	Chlorine	pH	Negative Logarithm of hydrogen ion concentration
cm	Centimeter	Na	Sodium
cm^2	Centimeter square	mm	Millimeter
CO_2	Carbon-di-oxide	No.	Number
CV	Coefficient of Variance	PH	Plant height
cv.	Cultivar (s)	RCBD	Randomized complete block design
DAT	Days after Transplanting	SAU	Sher-e- Bangla Agricultural University
df	Degrees of freedom	S	Sulphur
et al.	et alia (And others)	var.	Variety
Ft	Fruit	N	Nitrogen
gm	Gram (s)	m^2	Meter squares
hr	Hour(s)	Mg	Magnesium
NBP	Number of branch plant per plant	P	Phosphorus
SRDI	Soil Resources Development Institute	t ha^{-1}	Ton per hectare
Wt.	Weight	^0C	Degree Celsius
FAO	Food and Agricultural Organization	ml	Milliliter

LIST OF ABBREVIATIONS (CONT'D)

Abbreviations	Full meaning	Abbreviations	Full meaning
EM	Effective Microorganisms	Fig.	Figure
FA	Foliar application	KCl	Potassium Chloride
Fe	Ferrous	Cu	Copper
Mn	Manganese	B	Boron
SPAD	Soil plant analysis development	ANOVA	Analysis of variance
Zn	Zinc	DW	Dry weight

CHAPTER I
INTRODUCTION

Tomatillo (*Physalis ixocarpa* brot.) is a fleshy fruit vegetable which belongs to the genus *Physalis* and family Solanaceae bearing round to spherical and green or green–purple fruit and its chromosome number is basically n=24 and maximum species are diploid(Menzel,1951).Tomatillos is originated in Mexico and distributed in India, Australia, South Africa and Kenya. About 10 years ago the crop began to be industrialized in Mexico and agro-industries are currently estimated to process 600t/year (FAO, 2015). Recently it was also introduced in Bangladesh by the Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University in 2013.

Tomatillo fruit is surrounded by an inedible, paper-like husk developed from calyx (Waterfall, 1967) and from outside it looks like a common weed of our country “Foshka Begun” (Karim, 2016).Tomatillo plants are weedy or cultivated annual of humid tropics and subtropics and its height is about 1 meter. It grows well in drained, fertile soil with a pH between 5.5 and 7.3 (Masabni, 2016).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, it is filled by the husk and may or may not split it open, but turns brown and leathery in texture and harvested when the fruits fill the calyx. After separating the husk, the fruit seems a little sticky as it contains a pectin-like substance. Tomatillo contains 100 g of edible tomatillo (raw) fruit contains energy 32 Kcal, carbohydrates 5.84 g, protein 0.96 g, total fat 1.02 g, dietary fiber 1.9 g, vitamins (Folates 7 µg, Niacin 1.85 mg, Pyridoxine 0.056 mg, Thiamin 0.044 mg, Riboflavin 0.035 mg, Vit-A 114 IU, Vit-C 11.7 mg, Vit-E 0.38 mg, Vit-K 10.1 µg), Na 1 mg, K 268 mg, Ca 7 mg, Cu 0.079 mg, Fe 0.62 mg, Mg 20 mg, Mn 0.153 mg, P 39 mg, Se 0.5 µg, Zn 0.22 mg, beta-carotene 63 µg, alpha-carotene 10 µg and Lutein-zeaxanthin 467 µg per unit (Yamaguchi, 1983).Tomatillos make a great addition to a high-antioxidant eating plan focused on cancer prevention (Dolson, 2020).

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. Its wide range of adaptation and versatile use as table purpose and processing form and increasing demand in exotic food market gives good prospect for the expansion of husk tomato as a new cash crop in tropical region. But as tomatillo is a relatively new and minor vegetable crop, information on its cultivation is very meagre in Bangladesh. Planting time is responsible for reduced growth and lower yield of fruit vegetables. The scientific vegetable production reveals the importance of planting time to be used for raising vegetables crops in order to get higher production of good quality vegetable crops including the vegetative and reproductive growth periods as well as balance between both of them, which affects yield. An appropriate planting date helps reduce damage from cold, heat, Pest disease and weeds. Growers often manipulate planting times for better growth and maximum yield (Alam *et al.*, 2010).Therefore, late plant decrease the most important traits like days to flowering, duration of flowering, plant height and yield plant^{-1}(Rameeh, 2012). 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 (Kumar *et al.*, 2012).

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 (Tanaka *et al*., 1984). Nitrogen is a structural part of proteins, the basis of life, the nucleic acids (RNA, DNA), chlorophyll, phosphamide and other organic compounds. Deficiency of nitrogen results in slow growth and stunting of plants (Makasheva, 1983) and consequently reduction in crop yields (Radin *et al.*, 1988).The vegetative growth is increased by nitrogen and also delayed maturity of plants. Excessive use may produce too much of vegetative growth, so production of fruit may be impaired (Maini *et al.*, 1959; Singh *et al.*, 1972). After nitrogen, phosphorus occupies the most significant input for increasing tomatillo production. Phosphorus has enormous effect on vegetative growth and the flower number that increase the yields insignificantly (Topcuoglu and Yacin, 1994; Razia and Islam, 1980) and marketable yield (Candilo, 1993).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 (Rahman *et al.,* 1996 and Shil *et al.,* 1997). Potassium plays a balancing role on the effects of both the nitrogen and the phosphorus. Consequently, it is especially important in a multi-nutrient fertilizer application (Brady, 1995). The application of potassium increases the plant height, flower number, peduncle length, fruit size, fruit set and fruit number (Bestford and Maw, 1975).

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. Considering all of the above factors, the present study was undertaken with the following objectives:

- To study the effect of planting time on the growth and yield performance of tomatillo,
- To find out the optimum level of macronutrients for ensuring higher growth and yield of tomatillo and
- To determine the best combination of planting time and macronutrients level for growth and yield of tomatillo.

CHAPTER II

REVIEW OF LITERATURE

Tomatillo is a nutritious and minor vegetable crop in Bangladesh. Like many fruits and vegetables, tomatillo fit perfectly into a heart healthy dietary pattern. A little information is available on effect of planting time and macronutrients of tomatillo under Bangladesh condition. The current research was designed to find the effect of these two factors on the growth and yield of tomatillo. The available literatures that talk about tomatillo directly and indirectly in terms of planting time and fertilization effect on growth and yield will be reviewed in this chapter.

Effect of planting time

The characterization of a plant development requires knowledge of the phenological cycle and may help in choosing the ideal time for cultivation, especially in the production of fruit that is considered annual, such as *physalis*. The transplanting season are important factors, and should allow the cultivation in the most favorable period, in terms of water availability, heat and light, and the growth and development of the plants, thus ensuring lower risk to producers and financial agents who invest in crop cultivation (Peixoto *et al.*, 2000). Knowledge of flowering and maturation seasons is also important, as they may vary by year and place (Smolarz, 2006).

The *Physalis* genus is composed of species with economic and medicinal importance; its cultivation is expanding in Brazil, and is needed research on the performance of species in different regions of the country. Thus, the objective was to characterize the growth, development and yield of *Physalis angulata* and *Physalis ixocarpa* species cultivated in three transplantingtimes in Bahia's semiarid region. The days after sowing were determined for the occurrence of vegetative and reproductive stages, and the length and diameter of the main branch were evaluated weekly. At the end of cultivation, the number and total weight of fruits per plant were determined. The plants sown in April showed the best results, as flowering precocity, higher productivity and growth close to other producing regions, which is the best period for the cultivation of species. *P. angulata* is a more tolerant species and can be sown at different periods without compromising yield. High temperatures combined with scarcity of rainfall compromise the development of plants of both species of *Physalis* (Tamara *et al*., 2021).

Plants sown in April and June got their development completed, while plants sown in December did not survive. The reasons were found out as high temperatures, higher than 30 °C, and low rainfall, factors that together with oxygen are the most limiting to the initial development of the plant (Marcos Filho, 2015).

Physalis angulata and *Physalis ixocarpa* plants have a cultivation cycle between 80 and 94 days. Sowing of these species should preferably be done in the fall, favoring the development and yield of the species. *P. angulata* is a more tolerant species and can be sown at multiple periods without compromising yield. However, high temperatures (± 30 °C) combined with rainfall shortages compromise plant development of both species, planting in these conditions is not recommended (Tamara *et al*., 2021).

Tomatillos grow similar to a tomato. Tomatillos grow similar to a tomato. They like full sun and frequent watering. Tomatillos cannot withstand frost, so if a late spring frost is forecasted, be sure to cover the seedlings with newspaper (Urban Farmer, n.d.).

An experiment was conducted at Jessore to observe the effect of planting date and variety on the yield of late planting tomato. The potentiality of fruiting in the late season were evaluated for BARI tomato 4, 5, 6 and 12 by planting December 01, December 16, January 01, January 16 and February 01. A combination of December 01 planting with BARI Tomato 5 variety performed better in respect of yield (57.07 t ha^{-1}). The variety BARI Tomato 5 also showed potential fruiting capability during late winter season and February 01 planting produced 11 t ha^{-1} of potential yield. All the four varieties showed potential fruiting capability during late winter season and February 01 planting produced 46 tons of potential yield during late season (Ahammad *et al.*, 2013).

The present study was carried out to examine the effect of different planting dates on growth, flowering and fruit yield of tomato during November 2013 to April 2014. Three transplanting were done at an interval of 10 days. The different transplanting dates were; December 10, December 20 and December 30. The experimental results showed that different planting dates showed significant influence on growth and reproductive characters of tomato including fruit yield. The first transplanting date, December 10 resulted in improvement of all the attributes including increased plant height (63.54 cm), leaf number (33.3), flower number (71.15 days), fruit number (41.98 days), number of flowers plant^{-1} (150), number of fruit plant^{-1} (86.08) and yield per hectare (85 t) compared to 2nd transplanting date, December 20 and 3rd transplanting date, December 30.Therfore, it is suggesting that earlier transplating produced higher friut yield of tomato (Islam *et al.*, 2017).

A study was conducted by Meetha and Techawongstien (2009) to investigate the effect of planting dates on tomato production under plastic house for seed production and continuous tomato production. Tomato variety TBRY was planted, one and half month interval during June 2008 and January 2009, under plastic-house at the vegetable-experimental fields, Khon Kaen University. A Completely Randomized Design with three replications was used. Data were recorded for growth, yield and seed quality. The results showed that growth of tomato grown in rainy season was better than in winter season, but yield in rainy season was low. The yield on October planting gave the highest fresh fruit weight of 1,861.9 kg plant^{-1}. Planting date on December and October gave the highest seed per plant of 2,536.6 and 2,156.8 seeds plant^{-1}, respectively. Planting date on December, October and September gave the highest seed dry weight of 8.2590, 7.0361 and 6.2365g plant^{-1}, respectively. Percentage of seed germination from October, December, July and September plantings were highest (98.65, 96.66, 93.22 and 91.55 %, respectively). Germination index of seed from October and December planting were highest (24.683 and 23.683, respectively).

Planting time is an important factor which directly related to crop production in a specific area. Different planting time may affect crop yield and quality due to varying climatic conditions at different stages of crop growth and development. An experiment was laid out to investigate the effect of planting date at an interval of 15 days during winter season of 2019-20 on the yield and quality of cherry tomato. The potentiality of fruiting in the winter season was evaluated by planting on November 15, November 30, December 15, December 30 and January 14. Data on yield and quality attributes of cherry tomato like plant height, number of fruits per plant, fruit yield per plant (g), yield (t ha^{-1}), TSS (%), pH and vitamin C contents (mg 100 g^{-1})

were recorded. Results revealed that planting time had significant effects on the yield and quality parameters of cherry tomato. Cherry tomato performed better on 30 November planting date in respect of yield and vitamin C content due to favourable climatic conditions at different growing stages as per requirements that may lead to higher yield and quality of fruits (Hossain, 2021).

An experiment was conducted to study the influence of planting date and fertilizer management on the growth and yield of tomato cv Ratan. The experiment consisted of two factors; Factor A: three planting dates, *viz*. 20 October, 5 November, 20 November and Factor B: four different doses of fertilizer, viz., control; 100 kg urea + 75 kg TSP + 100 kg MOP/ha; 200 kg urea + 150 kg TSP + 200 kg MOP/ha and 300 kg urea +225 kg TSP + 300 kg MOP/ha were used in 12 treatment combinations. The experiment was laid out in randomized complete block design with three replications. Combined effects of planting date and fertilizer management exhibited significant variation on plant height at 30 DAT, 45 DAT, and 60 DAT, number of flowers per plant, number of mature fruits per plant, fruit diameter, weight of individual fruit, weight of fruits per plant, fruit yield per plot and fruit per hectare. The highest fruit yields per plot (23.94 kg) as well as per hectare (73.89 t) were achieved from the treatment combination of planting at 5 November with 200 kg urea + 150 kg TSP + 200 kg MOP/ha (Ali *et al.*, 2020).

A study was carried out to examine the effect of transplanting date on growth and fruit yield of tomato during *rabi*, 2016. The field experiment was conducted at Ponnaniyar, Trichy, Tamil Nadu. The experimental setup included a factorial randomized block design with three replications. The treatments comprised of four transplanting (01 November, 15 November, 01 December and 15 December), and three N doses [RDN-75kg ha^{-1}, RDN (-25%) and RDN (+25%)]. The experimental results showed that different planting dates showed significant influence on growth and reproductive characters of tomato including fruit yield. The first transplanting date, resulted in improvement of all the attributes including fruit yield per hectare compared to 2nd transplanting date. Therefore, it is suggested that earlier transplanting produced higher fruit yield of tomato (Bhuvanaswri *et al.*, 2018).

Below optimal temperatures can restrict growth of autumn planted tomato (*Solanumlycopersicum* L.) resulting in delayed fruiting and decreased fruit yield under field conditions.Technology for growing tomato under protected structures needs to be standardized. A studywas conducted to determine effects of culture condition, planting date, and application of mulchon plant growth and fruit yield of tomato. To determine if time of establishment affected resultsplants were established in the 1st and 3rd week of October and the 1st week of November of2010 and 2011 in a polyhouse, or open field, using the mulch treatments black polyethylene,clear polyethylene, paddy straw or no-mulch. Root-zone and air temperatures and net radiationwere measured. Treatments affected plant height, fruit number, fruit weight, early yield,marketable yield and total yield. Except for early yield, results were consistent between years.Black polyethylene mulch increased fruit number under the polyhouse and in the open field.Fruit weight was improved by mulch treatments only in the open field. Highest early,marketable, and total yields were from planting in the polyhouse in the 3rd week of October using black polyethylene mulch and this is attributed to increased root-zone temperature, airtemperature and net radiation. Use of polyhouse and black plastic mulch combined withappropriate planting time improves early and total yields of tomato in areas where the productionis constrained by sub-optimal temperature conditions (Dhaliwal *et al.,* 2016).

A study was conducted by Madhumati and Sadarunnisa (2013) taking six different transplanting times (D1- September 5th, D2- September 15th, D3- October 5th, D4- October 15th, D5- November 5th and D6- November 15th) into consideration. Transplanting of tomato during 15th of October recorded significantly higher number of fruits per plant (33.31), yield per plant (1.25kg), fruit size (length, diameter and volume), fruit weight (42.63 g), pulp content (54.01%), ascorbic acid (20.81 mg/100 g pulp) and number of seeds per fruit (192.21) over other dates of planting. Among the varieties, maximum number of fruits per plant, yield per plant, titrable acidity, ascorbic acid content, number of seeds per fruit and seed weight per fruit were recorded in Pusa Ruby, whereas Pusa Early Dwarf recorded maximum fruit size, fruit weight, pulp content, TSS and 1000 – seed weight. Among the treatment combinations Pusa Ruby planted on October 15th emerged as the best combination with regard to fruit quality and seed characters.

An experiment was conducted at the RARS, Jamalpur during rabi 2019-2020 to find out the suitable planting time and increase production and economic return. Tomato variety *viz.* V1 = BARI Tomato-14, V2 = Udyan were considered as factor A and five planting dates dates viz. S1 = 25 August, S2 = 15 September, S3 = 05 October, S4 = 25 October, S5 = 15 November considered as factor B. The experiment was laid out in RCBD (Factorial) with three replications. The yield of tomato was significantly affected by different planting dates and tomato verities. Udyan and BARI Tomato-14 with 25 October combination and 05 October combination were suitable combinations for maximum yield of tomato. These combinations may be profitable in case of early growing, proper market price, seeds were available for planting, less infestation of virus and bacterial wilt (Rahman *et al.,* 2020).

Effect of macro-nutrients:

Physalis cultivation can be an alternative of extra income for small and medium producers, mainly with the use of materials available on the property that can replace chemical fertilizer. This study aimed to evaluate agronomic parameters of *Physalis peruviana* and *P. pubescens* submitted two different sources of fertilization – chemical (NPK) and organic (poultry litter). We evaluated plant height, shoot dry mass, production/plant, fruits diameter and weight and productivity. The organic fertilization provided better results for vegetative parameters. Regarding production, fertilization resulted in increase in mass, with no significant difference between sources. In the production of fruits/plant we obtained 156.2 g, 274.6 and 355.5 g for unfertilized, chemical and organic fertilizers, respectively, without significant differences between species. The productivity estimates were 2,370, 1,831 and 1,041 kg ha^{-1}, for organic, mineral and unfertilized treatments, respectively. These results demonstrate that organic fertilizer with poultry manure is the best alternative as a source of nutrients, which may result in gains to the producer by the use of originated waste from other activities, as well as lower environmental contamination, either by improper disposal of waste or the use of chemical fertilizers (Ariati *et al.,* 2017).

Organic and inorganic sources of macronutrients have significant effect on the growth and yield of tomatillo. In the experiment conducted by Ariati *et al.* (2017) it was found thatthere was a significant difference between the nutritional sources. Fertilization providing higher height was organic, with an average of 180.90 cm main branch height, against 167.7 of mineral fertilizer.

Opposite of the above mentioned finding was stated by Borges *et al.* (2013). They said that unlike that was observed for *Physalis*, some studies comparing organic and chemical fertilizers, such as jambu, the authors had greater heights when plants were treated with urea, and organic resulted in lower plants than the considered for the specie (Borges *et al*., 2013).

Peixoto *et al.* (2010), using two doses of cattle manure, 30 and 60 tha^{1}, *Physalis (P. peruviana),* found no significant difference between them in plant height parameter, showing that although there is no influence of dose, probably the source was important. In tomato plants, the application of the effluent derived from the bio-digestion of cattle manure resulted in higher plants (10.5%) compared to treatment with NPK (Campos, 2007). Freitas *et al.* (2012) also observed a better response in the rate of growth of sorghum plants when received organic manure (cattle manure). These authors suggest that plants under the organic fertilizer respond gradually over the growing cycle of the crop, once the nutrient release rate is not as fast as in the chemical fertilizer, supplying therefore their nutritional needs for a longer period chemicals, which could be observed in the same *Physalis* plants fertilized with poultry litter.

Fruits of *physalis* are rich in vitamin A, B, C, iron, phosphorus and zinc. In recent years, growing *Physalis peruviana* L. is a new tendency in Turkey. However, there isn't any trial for nutritional demand of *physalis* inTurkey also. The main purpose of this trial is determining nitrogen demand of *physalis*. Furthermore determineto effect of nitrogen fertilization on some fruit quality. For this purpose six different nitrogen levels were used, 0kg da^{-1}, 4 kg da^{-1}, 8 kg da^{-1}, 12 kg da^{-1}, 16 kg da^{-1} and 20 kg da^{-1}. In addition, yield, fruit diameter and plant high were affected from differentnitrogen levels significantly also. The trial was carried out in 2013 in Yalova (Albayrak *et al.,* 2014).

Increasing nitrogenous manure studies havegenerated remarkable changes in fruit diametersand plant heights of tomatillo. However, the effect of nitrogenfertilizer studies on fruit heights and fruit stemheight is insignificant (Albayrak *et al.*, 2014). Likewise, both El-Tohamy andfriends (2009) and Girapu and Kumar (2006) statedthat increasing nitrogen fertilizer studies have generated changes in fruit diameters, plant heights and plant’s nitrogen content. Wolf (1991),nevertheless; informed that the usage of inorganicfertilizing and farm manure does not have are markable effect on the fruit quality.

Trejo-Tellej *et al.* (2007) investigated the effect of nitrogen fertilization on the growth and quality parameters of tomatillo. Plant height, FA, DW and stem diameter of Mexican husk tomato plants were measured as indicators of growth. Both plant height and stem diameter were very similar between control and conventional soil fertilization. Plants treated with foliar fertilization increased height and stem diameter by 11% and 12%, respectively, in comparison to plants treated with traditional soil fertilization. Significant differences between treatments ($p<0.05$) were observed only in DW and FA. DW of plants with soil fertilization was 14% higher that control, while the combination between soil and foliar fertilization increased the DW about 74% compared to the control. Results obtained in the FA were outstanding. Foliar fertilization with FFNV3 produced about 2.2-fold higher FA than the control and 1.6-fold higher than the traditional soil fertilization alone. On the other hand, Analyses of fruit quality were determined in the juice. No significant differences were observed in EC and TA between treatments, although TA values were slightly higher in both traditional soil fertilization and its combination with foliar fertilization, whereas pH and ºBrix were positively influenced by foliar fertilization. The pH values of juice with foliar application were increased, on average 9% and 50% in comparison to soil fertilization and control, respectively. Means comparison revealed that all treatments showed statistical differences ($p<0.05$). When plants were offered fertilizers (either traditional or foliar), "Brix in juice was higher. Foliar fertilization in combination with soil fertilization increased ºBrix approximately 53% and 14% in comparison to the control and traditional soil fertilization, respectively. Differences in fruit size between treatments were not observed (data not shown).

Tomato is an important cash crop in Central Rift Valley of Ethiopia. However, the yield isconstrained by poor soil fertility management and lack of appropriate/adequate fertilizersrates recommendation. Experiments were conducted at Melkassa on station with theobjectives of evaluating effect of N and P fertilizer applications on growth and yield, anddetermining optimal requirements for tomato. The experiments were conducted under bothcool season furrow irrigated and rain-fed conditions with variable fertility status of thefields. The treatments consisted of four rates of nitrogen

(0, 50, 100 and 150 kg N ha^{-1}) andfour rates of P (0, 46, 92 and 138 kg ha^{-1}). The experiments were laid out in a CRBD in afactorial arrangement and replicated three times using Melkashola variety. Data on growthand canopy characteristics such as plant height and stem diameter, main lateral branchlength, canopy width and depth were measured from selected plants. Some of the growthand yield components such plant height, canopy diameter, canopy width, stem diameter,lateral branch length, total dry mass above the ground per plot, shoot fresh and dry weight,marketable and unmarketable fruit yield and total yield at harvest were measured wereassessed. Maximum fruit yield was estimated from regression lines of applying 105 kg Nha^{-1} and 85 kg P ha^{-1} under furrow irrigated experiment (continuously cultivated field).However, the highest fruit yield was from application of 40 kg N ha^{-1} and 10 kg ha^{-1} for therainfed experiment (relatively fertile field). Thus, results of both experiments were averagedto propose on farm verification of N and P requirement of tomato, N 73 kg ha^{-1} and P 48 $kgha^{-1}$ around Melkassa and similar soil types (Etissa *et al.,* 2013).

Unscrupulous use of synthetic fertilizers are not only increasing cost of tomato production but alsodecreasing tomato yield and quality, deteriorating soil health and environment. Organic manures canproduce quality product as well as maintain soil health. Considering this verity an experiment wascarried out at the Dr. Purnendu Gain Field Laboratory of Agrotechnology Discipline, KhulnaUniversity, Khulna to evaluate the performance of tomato crop under application of different organicand inorganic fertilizers. The experiment was designed in RCBD using two varieties (BARI Tomato-14 and BARI Tomato-15) and eight treatments i) 100% Recommended fertilizer dose (RFD) for N, Pand K; ii) 100% cowdung (CD); iii) 100% poultry manure (PM); iv) 100% vermi-compost (VC); v)100% Mustard oil cake (MOC); vi) 100% organic manures (25% of each of CD , PM , VC and MOC);vii) 80% organic manure (20% of each of CD, PM, VC and MOC) + 20% RFD; viii) 60% organicmanure (15% of each of CD, PM, VC and MOC) + 40% RFD].The tallest plant (77.5 cm) withmaximum fruit length (5.98 cm), maximum number of flower clusters $plant^{-1}$ (16.24), number offlowers $cluster^{-1}$ (13.07), number of fruit clusters $plant^{-1}$ (8.20) and number of fruits $cluster^{-1}$ (6.97)were observed from combined effect of 60% organic manures with 40% RFD in BARI Tomato-15.On the contrary, this treatment produced maximum fruit diameter (6.29cm), maximum weight ofindividual fruit (91.43g) and the highest yield (87.17 t ha^{-1}) in BARI tomato-14. From economic point of view, maximum net return (Tk. 841345) as well as benefit cost ratio (5.11) was also observed from60% organic manure + 40% RFD. Thus, BARI tomato-14 with combination of organic manures (60%)and inorganic fertilizers (40%) provided better performance concerning growth, yield and economic aspects (Saha *et al*., 2019).

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from October 2019 to February 2020 to growth and yield of tomatillo as influenced by sowing time and macro-nutrients. This chapter includes a brief description of the experimental period, location, soil and climatic condition of the experimental site and materials those were used for conducting the experiment i.e. treatment and design of the experiment, growing of crops, intercultural operations, data collection procedure and procedure data analysis procedure for conducting the experiment and presented below under the following headings:

3.1 Experimental site

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.

3.2 Characteristics of soil

The soil of the experimental area belongs to the Modhupur Tract under AEZ No. 28. The characteristics of the soil under the experiment were analysed in the Laboratory of Soil Resources Development Institute (SRDI), Dhaka (Appendix II).

3.3 Condition of the experimental site

The climate of experimental area is subtropical, characterized by three distinct seasons, the monsoon 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). Ample sunshine and moderately low temperature appear during October to March (Rabi season), which are useful for growing of tomatillo in Bangladesh. The weather report regarding temperature, rainfall, relative humidity and sunshine hours prevailed at the experimental site during the cropping season October 2019 to February 2020 have been presented in Appendix II.

3.4 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 where seeds were allowed to germinate in moist blotting paper of petri-dish for 10 days and counted the number of seeds that germinated.

3.5 Experimental treatments:

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

There were 12 treatment combinations such as T_1F_0, T_1F_1, T_1F_2, T_1F_3, T_2F_0, T_2F_1, T_2F_2, T_2F_3, T_3F_0, T_3F_1, T_3F_2, T_3F_3.

3.6 Design and layout of the experiment

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 (1.8m x 1.2 m) or 2.16m^2. The distance between two replications was 1m and two plots was 0.5 m. The experimental layout is shown in the Appendix IV.

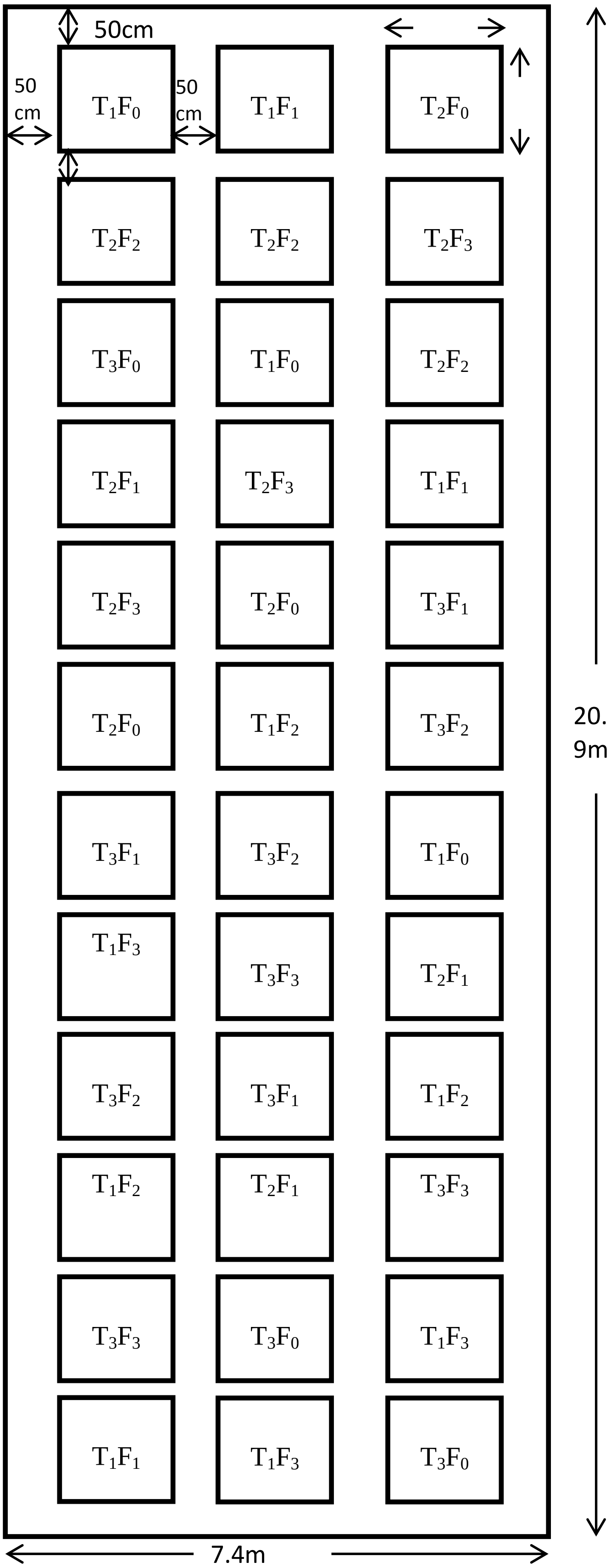
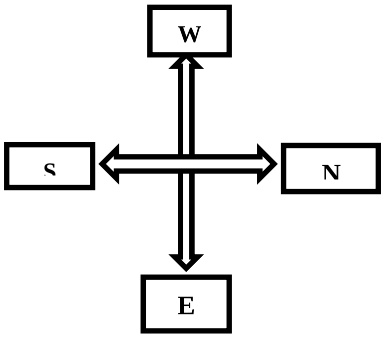


Fig 1. Layout of the experiment



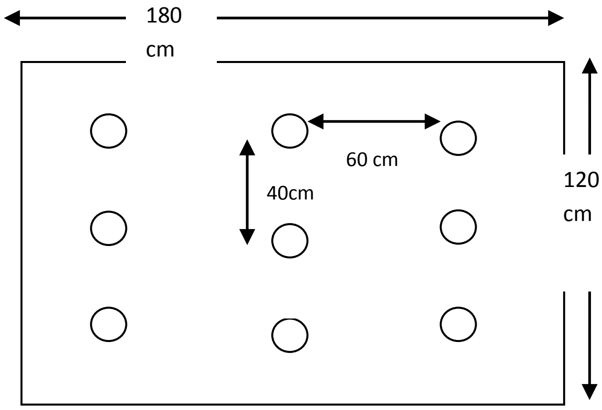


Fig. 2: A unit plot

Legend:

Plot Size: 1.8 m×1.2m (2.16 m^2)

Plant to plant distance =60cm

Row to row distance=40cm

Block to Block distance= 50cm

Plot to plot distance= 50cm

Total Seedlings= 36×12= 432

Factor A: Planting time

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

Factor B: Macronutrients
$F_0 = N_0P_0K_0$ 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

3.7 Seed bed preparation and raising of seedling

Seedlings of tomatillo were raised in three seed beds of 2 m × 1 m size. The soil of the seedbed was prepared well and converted into loose friable condition in obtaining good tilth. All weeds, stable and death roots were removed from the beds. 20 g of seeds were sown in each seed bed. Seed sowing was done in the seed bed as per the factor A such as 10 October, 20 October and 30 October in 2019. Seeds were covered with finished light soil and bamboo mates were provided to protect young seedling from scorching sunlight and heavy rainfall. Weeding, mulching and light watering were done as per need to provide a good condition for growth.

3.8 Land preparation

At first the land was ploughed through a power-tiller and kept open to sunlight. Then the land was thoroughly prepared by ploughing and again cross ploughing. The weeds and stubbles of the field were removed.The experimental field was prepared by thorough ploughing followed by laddering to have a good tilth. Finally, the land was properly levelled before transplanting. Then plots were prepared as per the design. Then the land was divided into 36 unit plots with keeping plot to plot and block to block spacing. The bed of plots was made about 5 cm high from the soil surface with the excavated soil after creating drains around each plot. Furandan @ 16 kg ha^{-1} was mixed with the soil uniformly during land preparation for controlling soil borne insects. Sevin 50 WP @ 5 $kgha^{-1}$ was also applied to soil for protecting the seed and young plants from the attack of ants and cutworms.

3.9 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 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

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**]**

3.10 Transplanting of seedling

Healthy and uniform 23days aged seedlings were uprooted separately from the seed bed and transplanted in the experimental plots in the afternoon on 02 November, 12 November and 22 November, 2019 with maintaining a spacing of 60cm×40cm between rows and plants respectively. This allowed an accommodation of 9 plants in each plot of 1.8m×1.2m size due to seeds were sowing on 10 October, 20 October and 30 October. Before uprooting of the seedlings from the seedbed, it was watered to minimize the damage of the roots. The seedlings of the tomatillo were watered after transplanting. Shading was provided by using banana leaf sheath for three days to protect seedlings from hot sunlight and removed after seedlings well established. Extra seedlings were also planted around the border area of the experimental plots for gap filling.

3.11 Intercultural operation

After transplanting of seedlings, various intercultural operations such as irrigation, weeding, staking and top dressing etc. were accomplished for better growth and development of the tomatillo seedlings. The crop field was kept free from weeds by regular weeding and irrigation was given when required.

3.11.1 Gap filling

Seedlings were transplanted to fill up the gap by using healthy plant where seedlings were damaged or died.

3.11.2 Irrigation and drainage

In the early stage of seedling establishment, light watering was given after transplanting of seedlings by a watering cane in every afternoon. After well establishment of seedlings, watering was given as per requirement. Proper and well drainage system was made surrounding the experimental plots for drainage of excess water.

3.11.3 Staking

When the plants were well established, staking was given to each plant by bamboo sticks to keep them erect**.**Within a few days of staking, as the plants grew up, the branches of plants were tied with jute rope to protect damage or broken of the branch.

3.11.4 Weeding

Weeding was done byhand weeding or khurpito keep the plots clean and easy aeration of soil which ultimately ensured better growth and development. Newly emerged weeds were uprooted carefully. Weeding for breaking the crust of the soil was done when needed.

3.11.5 Top dressing

After basal dose, the remaining doses of ureawere used as top-dressed in 3 equal instalments at 10, 25 and 40 DAT and the rest amounts of MOP were top dressed in

25 DAT and 40 DAT. The fertilizers were applied on both sides of plant rows and mixed well with the soil. Earthing up operation was done immediately after top-dressing with fertilizer.

3.11.6 Control of pest and disease

Ripcord 10 EC was applied @ 2 ml L^{-1} against the insect pests like cut worm, leaf hopper fruit borer and others.Emitaf 20SL was applied @ 1ml L^{-1} to control white fly which bring leaf curl virus of tomatillo.To control *fusarium*wilt disease, Carbendazim 50 WP@ 2gm L^{-1} was applied. The insecticide application was made fortnightly for a week after transplanting to a week before first harvesting. Furadan 10 G was also applied during final land preparation as soil insecticide. During foggy weather precautionary measured against disease infection of tomatillo was taken by sprayingDithane M-45 fortnightly @ 2 g L^{-1}, at the early vegetative stage. Ridomil gold was also applied @ 2 g L^{-1}against blight disease of tomatillo.

3.11.7 Harvesting

Harvesting of fruits was done after reaching to its maturity stage. Immature tomatillo fruits are dark green in colour and it turns into greenish to light greenishor yellowish when become mature and most often the rupture of the husk occurs as a result of increase in size of fruits with its maturity. Mature fruits were identified and harvested from plants.Harvesting was started from December 25, 2019 and completed by March 10, 2020.

3.12 Data collection

During data collection,five representative plants were selected at random from each unit of plot to avoid border effect and tagged in the field. Data were collected periodically from the sample plants at 15 days interval such as 15, 30, 45, 60 DAT. The details of data collection are given below:

1. Plant Height (cm)

The plant height was recorded at 15, 30, 45 and 60 days after Transplanting (DAT). Plant height was taken from the ground level to the tip of largest leaf of the plants in centimetre (cm). Plant height of five randomly sampled plants was recorded and mean was calculated.

2. Number of leaves per plant

Number of leaves of five randomly selected plants was counted from each unit plot at 15 days interval from 15 to 60 DAT and means were calculated.

3. Length of leaves (cm)

Leaf length of full grown leaves of five selected plant were measured by using a measuring scale in centimetre (cm) at 15 days interval from 15 to 60 days after transplanting (DAT) and mean was recorded.

4. Breadth of leaves (cm)

Leaf breadth of leaves of five selected plant were measured by using a measuring scale in centimetre (cm) at 15 days interval from15 to 60 days after transplanting (DAT) and mean was recorded.

5. Number of branches per plant

Number of branches of five randomly selected plants from each plot was recorded at15 days interval from15 to 60 DAT and mean was recorded.

6. Canopy size (cm)

Canopy size of five randomly selected plants from each plot was recorded at 15 days interval from 15 to 60 DAT and mean was recorded.

7. Chlorophyll content (SPAD Unit)

Chlorophyll content of leaves of five randomly selected plants was measured by SPAD meter at 20 DAT and 60 DAT and mean was recorded.

8. Days required to first flowering

The days required to first flowering for different treatments were counted from five randomly selected plant and their mean values were recorded.

9. Number of flower per plant

The number of flowers was counted from five randomly selected plants per unit of plot and their mean values were calculated.

10. Number of fruits per plant

Total number of fruits were counted at 15 days interval from 15 to 60 DAT and five randomly selected plants per fruits were used to calculate the average number of fruits per plant in different harvesting times.

11. Diameter of fruit (cm)

Diameter of fruit was measured at the middle portion of 20 selected marketable fruits from each plot with a slide callipers and their average was calculated in centimetre.

12. Individual Fruit weight (g)

When harvesting was done then the average weights were found out in each plant and expressed in gram (g).

13. Yield per plant (Kg)

The yellow-green mature fruits were harvested at regular interval from each unit plot and their weight was measured. When harvesting was done then the total fruit weights were found out in each plant and expressed in gram (Kg).

14. Yield (t ha^{-1})

It was measured by the following formula:

$$\text{Fruit yield (t ha}^{-1}\text{)} = \frac{\text{Fruit yield per plot(Kg)} \times 10000\text{m}^2}{\text{Area of plot in square meter} \times 1000\text{Kg}}$$

15. Brix percentage

Brix content (%) of mature tomatillo fruits were measured by using Portable Hand Refractometer (ERMA, Tokyo, Japan) at room temperature (Plate 5C). Forthe estimation, a single mature fruit from each replication of the treatments wasblended and juice was collected to measure the brix content in percentage (%).

16. Vitamin C content (mg)

Vitamin-C was measured by using Oxidation Reduction Titration Method (Tee*et al*., 1988) (Plate 5D). For the estimation, a single mature fruit from eachreplication of the treatment was blended and then the fruit extract was filtratedby Whatman no.1 filter paper. The fruit juice was then mixed with 3% ofmetaphosphoric acid solution. The titration was conducted with 2,6-dichlorophenol indophenol, a dye solution and in presence of glacial acetic acid and metaphosphoric acid to inhibit the aerobic oxidation. The mean ofobservations provided the amount of dye required to oxidize a definite amountof L-ascorbic acid solution of unknown concentration, using an L-ascorbic acidas known sample. Estimation of L-ascorbic acid content of fruit sample was doneusing the following formula:

Amount of Vit-C (mg 100 per g)

$$= \frac{\text{Titre} \times \text{dye factor} \times \text{Vol. made up} \times 100}{\text{Extract taken for titration} \times \text{Wt. of sample taken}}$$

3.13 Statistical analysis

The experimental data which was obtained for different parameters were statistically analysed by using `MSTAT C' computer program. The mean values of all the recorded characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the individual and treatment combinations means was estimated by the Duncan's Multiple Range Test (DMRT) at 5% level of probability.

CHAPTER IV
RESULTS AND DISCUSSION

The results obtained from the experiment are presented, discussed and compared in this chapter using tables. The possible interpretations have also been given under the following headlines.

4.1 Growth Parameters

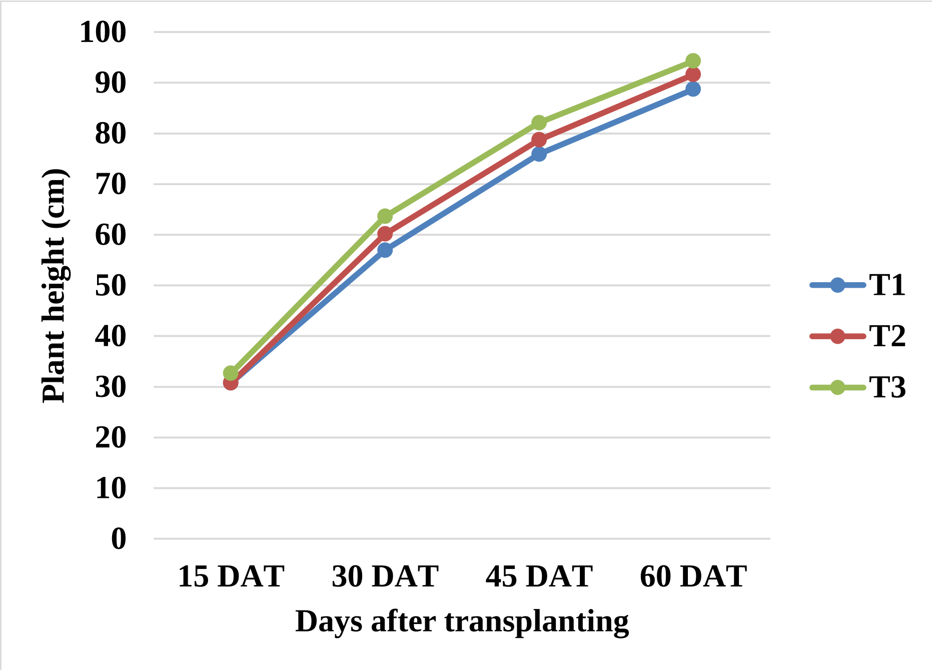
4.1.1 Plant height (cm)

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 (Moles *et al.*, 2009).

Plant height at 10, 30, 45 and 60 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 Narzis (2018) and Ahammad *et al.* (2013).

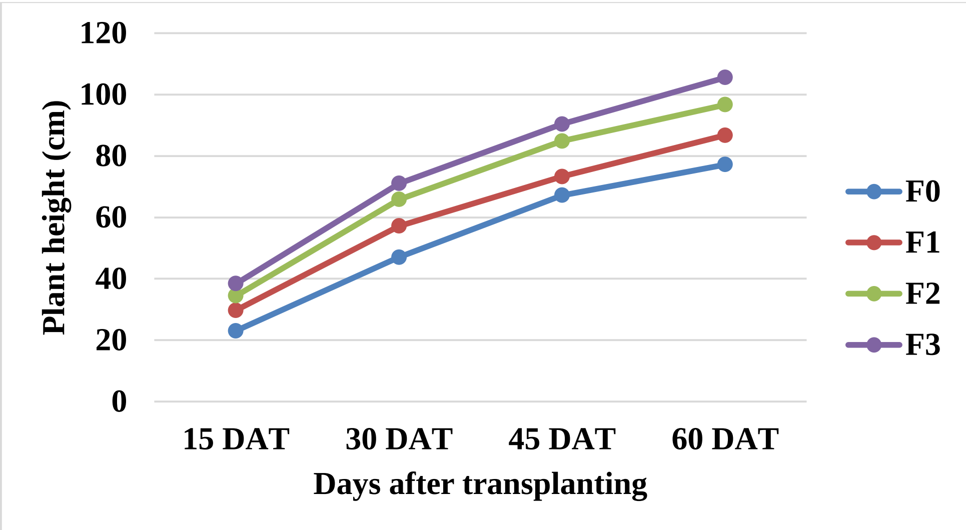
Plant height was significantly influenced by macronutrients (Fig. 2) at 10, 30, 45 and 60 DAT. At 60 DAT, the maximum plant height (105.53 cm) was noted from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment and minimum plant height (77.19 cm) was identified from F_0 ($N_0P_0K_0$ Kg/ha) treatment. The similar pattern of plant height was reported by Ahammad *et al.* (2013).

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. The results were in line with the findings of Ahammad *et al.* (2013).



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

Fig. 2. Effect of planting time on plant height at different days after transplanting of tomatillo



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

Fig. 3. Effect of macronutrients on plant height at different days after transplanting of tomatillo

Table 3. Combined effect of planting time and macronutrients on plant height at different days after transplanting of tomatillo

Treatment Combinations	Plant height (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT
T_1F_0	21.64 h	44.05 i	63.07 h	73.22 h
T_1F_1	29.72 e	54.89 f	71.95 f	84.79 f
T_1F_2	34.16 c	62.99 d	82.01 d	94.06 d
T_1F_3	36.71 b	65.92 c	86.61 c	102.77 b
T_2F_0	22.40 h	47.01 h	67.84 g	77.66 g
T_2F_1	28.28 f	56.80 f	72.84 ef	86.98 ef
T_2F_2	33.52 c	64.64 cd	83.51 d	97.11 cd
T_2F_3	38.84 a	72.15 b	90.73 b	104.67 b
T_3F_0	25.10 g	49.95 g	70.68 f	80.70 g
T_3F_1	31.12 d	59.80 e	74.98 e	88.44 e
T_3F_2	35.57 b	69.77 b	89.00 b	98.87 c
T_3F_3	39.64 a	74.98 a	93.78 a	109.13 a
$LSD_{(0.05)}$	1.24	2.39	2.37	3.51
CV%	2.34	2.35	3.78	2.27

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

4.1.2 Number of leaves per plant

The main function of a leaf is to produce food for the plant by photosynthesis. Chlorophyll is the substance that gives plants their characteristic green color, absorbs light energy. So, the higher is the number of leaves per plant, the higher is the absorption of light energy (Petruzzello, 2020).

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.

Table 4. Effect of planting time and macronutrients on number of leaves per plant at different days after transplanting of tomatillo

Treatment	Number of leaves per plant			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
Planting time				
T_1	24.27 b	107.05 c	191.99 c	229.52 c
T_2	23.75 b	118.38 b	198.28 b	235.26 b
T_3	28.53 a	124.83 a	204.60 a	242.83 a
$LSD_{(0.05)}$	0.76	2.75	2.64	2.79
CV%	2.90	2.79	3.58	4.20
Macronutrients				
F_0	14.67 c	82.13 d	121.36 d	175.80d
F_1	19.70 b	104.14 c	202.99 c	219.64 c
F_2	33.59 a	127.30 b	221.71 b	246.23 b
F_3	34.11 a	153.43 a	247.11 a	301.80 a
$LSD_{(0.05)}$	0.8834	3.18	3.05	3.23
CV%	2.90	2.79	3.58	4.20

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Combined effect of planting times and macronutrients was significantly influenced number of leaves per plant at different days after transplanting (Table 5). 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. The results were in line with the findings of Ahammad *et al.* (2013).

Table 5. Combined effect of planting time and macronutrients on number of leaves per plant at different days after transplanting of tomatillo

Treatment combinations	Number of leaves per plant			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
T_1F_0	13.61 i	76.8 g	115.8 i	170.73 j
T_1F_1	19.73 fg	97.83 e	190.90 g	214.53 h
T_1F_2	24.93 e	114.8 d	218.53 d	238.87 f
T_1F_3	37.73 b	138.76 b	242.73 b	293.93 c
T_2F_0	14.67 hi	82.73 f	121.73 h	177.93 i
T_2F_1	18.73 g	99.07 e	205.93 f	215.33 h
T_2F_2	32.80 c	132.93 c	219.67 d	247.03 e
T_2F_3	29.87 d	158.8 a	245.80 b	300.73 b
T_3F_0	15.73 h	86.87 f	126.53 h	178.73 i
T_3F_1	20.62 f	115.53 d	212.15 e	229.07 g
T_3F_2	33.16 c	134.17 bc	226.93 c	252.80 d
T_3F_3	44.60 a	162.73 a	252.8 a	310.73 a
$LSD_{(0.05)}$	1.5301	5.5185	5.2980	5.5958
CV%	2.90	2.79	3.58	4.20

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

4.1.3 Leaf Length (cm)

A new study suggests small leaves are more resistant to drought due to closer compaction of their veins, solving a long-standing mystery as to why plants in dry environments have smaller leaves while those in wet ones are bigger. Being larger in width and length, the major veins transport water more efficiently through the leaf and can be thought of as “super high ways” for water transport (Rostello, 2021).

Significant influence was exerted on leaf length by transplanting times (Table 6) at 15, 30, 45, 60 DAT under present study. At 60 DAT, the maximum leaf length (15.52) was observed from T_3 (22 November) treatment and minimum leaf length (14.64) was collected from T_1 (02 November) treatment.

Different doses of macronutrients significantly influenced leaf length (Table 6) at 15, 30, 45 and 60 DAT. At 60 DAT, the maximum leaf length (16.19 cm) was recorded from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment while minimum leaf length (13.27 cm) was obtained from F_0 ($N_0P_0K_0$ Kg/ha) treatment.

Table 6. Effect of planting time and macronutrients on leaf length at different days after transplanting of tomatillo

Treatments	**Leaf length (cm)**			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
Planting time				
T_1	9.81 b	12.57 c	13.55 c	14.64 c
T_2	10.00 b	12.92 b	13.80 b	14.93 b
T_3	10.76 a	13.26 a	14.39 a	15.52 a
$LSD_{(0.05)}$	0.34	0.22	0.24	0.29
CV%	9.81 b	2.02	2.12	2.29
Macronutrients				
F_0	8.48 c	11.73 d	12.25 d	13.27 d
F_1	9.81 b	12.74 c	13.96 c	15.03 c
F_2	11.09 a	13.26 b	14.45 b	15.62 b
F_3	11.37 a	13.93 a	15.01 a	16.19 a
$LSD_{(0.05)}$	0.39	0.25	0.28	0.33
CV%	3.55	2.02	2.12	2.29

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

There was a marked influence observed on leaf length of tomatillo due to combine effect of planting times (15, 30, 45 and 60 DAT) and macronutrients at (Table 7). From the results the experiment showed that the highest leaf length (16.85 cm) was recorded from T_3F_3 (22 November with $N_{300}P_{120}K_{140}$ Kg/ha) treatment combination at 60 DAT, whereas the lowest leaf length (12.5 cm) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

Table 7. Combined effect of planting time and macronutrients on leaf length at different days after transplanting of tomatillo

Treatment Combinations	Leaf Length (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT
T_1F_0	8.03 h	10.97 h	11.4 h	12.5 g
T_1F_1	9.57 ef	12.66 ef	13.78 ef	14.73 d
T_1F_2	11.22 b	12.98 de	14.36 bcd	15.46 bc
T_1F_3	10.40 cd	13.64bc	14.63 bc	15.84 b
T_2F_0	8.90 fg	11.75 g	11.98 g	13.17 f
T_2F_1	10.07 de	12.71 ef	13.92 de	15.03 cd
T_2F_2	10.95 bc	13.36 cd	14.45 bc	15.64 b
T_2F_3	11.92 a	13.86 ab	14.86 b	15.87 b
T_3F_0	8.50 gh	12.46 f	13.38 f	14.127 e
T_3F_1	9.78 de	12.85 ef	14.16 cde	15.32 bc
T_3F_2	10.76 bc	13.43 bc	14.52 bc	15.76 b
T_3F_3	12.13 a	14.29 a	15.52 a	16.857 a
$LSD_{(0.05)}$	0.68	0.44	0.49	0.58
CV%	3.55	2.02	2.12	2.29

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

4.1.4 Leaf breadth (cm)

Narrow leaves enable plants to shed heat through sensible heat loss during summer droughts, without the need for transpirational cooling. Additionally, small leaf dimensions confer a capacity for high transpiration when evaporative demand is low and water is abundant (i.e. winter). This may be a particularly important strategy for driving nutrient mass-flow to the roots of plants that take up most of their nutrients in the wet winter/spring months from nutrient-poor soils (Yates, *et al.*, 2009).

Marked variation was noticed on leaf breadth by transplanting times (Table 8) at 15, 30, 45 and 60 DAT under the experiment. From the result of the experiment, at 60 DAT, the maximum leaf breadth (5.67 cm) was collected from T_3 (22 November) treatment and minimum leaf breadth (5.29 cm) was revealed from T_1 (02 November) treatment.

Statistically different doses of macronutrients exerted significant influence on leaf breadth at 15, 30, 45 and 60 DAT (Table 8). It was revealed that at 60 DAT, the maximum leaf breadth (6.21 cm) was noted from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment. On the other hand, minimum leaf breadth (4.65 cm) was observed from F_0 ($N_0P_0K_0$ Kg/ha) treatment.

Table 8. Effect of planting time and macronutrients on leaf breadth (cm) at different days after transplanting of tomatillo

Treatment	**Leaf breadth (cm)**			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
Planting time				
T_1	3.61 b	4.38 c	4.81 c	5.29 c
T_2	3.70 b	4.59 b	4.97 b	5.46 b
T_3	3. 96 a	4.84 a	5.14 a	5.67 a
$LSD_{(0.05)}$	0.25	0.18	0.06	0.12
CV%	8.18	4.85	3.63	2.75
Macronutrients				
F_0	3.13 d	3.88 d	4.14 d	4.65 d
F_1	3.45 c	4.55 c	4.97 c	5.33 c
F_2	3.98 b	4.82 b	5.22 b	5.69 b
F_3	4.36 a	5.17 a	5.56 a	6.21 a
$LSD_{(0.05)}$	0.29	0.21	0.07	0.14
CV%	8.18	4.85	3.63	2.75

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Significant influence was noticed on leaf breadth of tomatillo from combined effect of planting times and macronutrients at15, 30, 45 and 60 DAT (Table 9).

From the results of the experiment showed that the highest leaf breadth (6.47 cm) was recorded from T_3F_3 (22 November with $N_{300}P_{120}K_{140}$ Kg/ha) treatment combination at 60 DAT. However, the lowest leaf breadth (4.32 cm) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

Table 9. Combined effect of planting time and macronutrients on leaf breadth at different days after transplanting of tomatillo

Treatment combinations	Leaf breadth (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT
T_1F_0	2.91 f	3.38 g	3.83 k	4.32 i
T_1F_1	3.38 ef	4.37 de	4.88 h	5.23 g
T_1F_2	4.19 b	4.76 bc	5.16 ef	5.57 ef
T_1F_3	3.68 cde	5.00 b	5.38 bc	6.02 bc
T_2F_0	3.18 ef	3.94 f	4.18 j	4.72 h
T_2F_1	3.54 de	4.54 cde	5.03 fg	5.32 fg
T_2F_2	3.97 bcd	4.82 bc	5.20 de	5.66 de
T_2F_3	4.30 ab	5.06 ab	5.45 b	6.14 b
T_3F_0	3.29 ef	4.30 ef	4.41 i	4.92 h
T_3F_1	3.44 e	4.72 bcd	5.00 h	5.44 efg
T_3F_2	4.08 bc	4.88 bc	5.3 cd	5.85 cd
T_3F_3	4.79 a	5.43 a	5.83 a	6.47 a
$LSD_{(0.05)}$	0.51	0.37	0.13	0.25
CV%	8.18	4.85	3.63	2.75

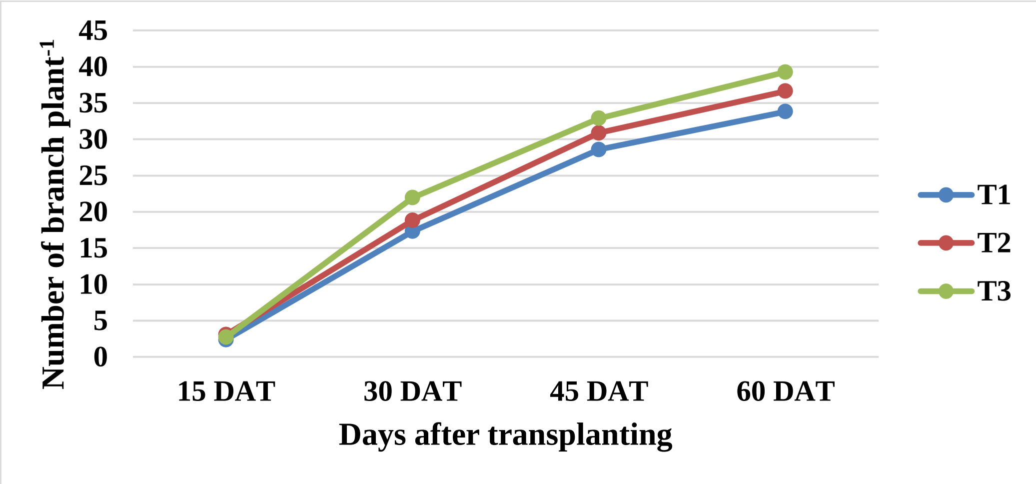
In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

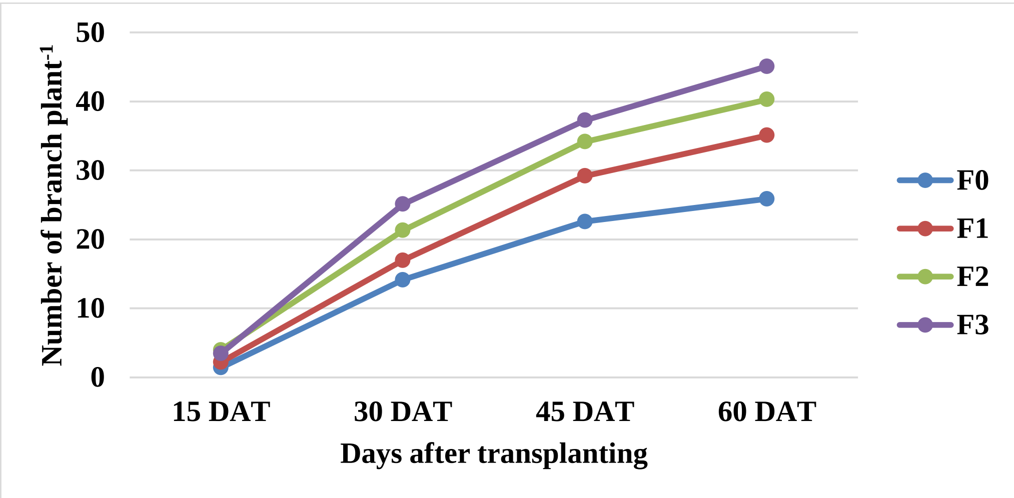
4.1.5 Number of branches plant per plant

The single-branch saplings produce the highest net photosynthetic rate. As the number of branches on a plant increases, the photosynthetic rate decreases significantly and remains relatively stable when the number of branches are three or more. In contrast, total leaf number, total leaf area, and total stem lengths of saplings increases significantly as the number of branches increases (Huihui *et al.*, 2014).



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

Figure. 4. Effect of planting time on number of branch per plant at different days after transplanting of tomatillo



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

Figure. 5. Effect of macronutrients on number of branch per plant at different days after transplanting of tomatillo

Number of branch per plant was showed significant variation by transplanting times at 15, 30, 45 and 60 DAT (Fig. 3.). The experimental result was exerted that at 60 DAT, the maximum number of branch per plant (39.26) was recorded from T_3 (22 November) treatment and minimum number of branch per plant (33.82) was noticed from T_1 (02 November) treatment.

There was marked influenced on number of branch per plant by macronutrients (Fig. 4) at 15, 30, 45 and 60 DAT. It was revealed that the maximum number of branch per plant (45.07) was recorded from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment at 60 DAT and minimum number of branch per plant (25.86) was noted from F_0 ($N_0P_0K_0$ Kg/ha) treatment.

Table 10. Combined effect of planting time and macronutrients on number of branches per plant at different days after transplanting of tomatillo

Treatment Combinations	Number of branches per plant			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
T_1F_0	1.13 i	12.36 h	20.07 h	22.86 j
T_1F_1	1.80 gh	16.13 f	27.06 f	32.66 g
T_1F_2	3.73 bc	19.13 d	32.00 de	38.73 def
T_1F_3	2.87 de	21.66 c	35.26 bc	41.03 cd
T_2F_0	1.33 hi	14.20 g	23.07 g	25.85 i
T_2F_1	2.27 fg	16.60 ef	29.86 e	35.86 f
T_2F_2	3.27 cd	19.73 d	33.73 cd	39.60 de
T_2F_3	4.13 ab	24.80 b	36.88 b	45.26 b
T_3F_0	1.67 hi	15.80 fg	24.56 fg	28.86 h
T_3F_1	2.47 ef	18.13 de	30.60 e	36.73 ef
T_3F_2	3.53 c	25.00 b	36.73 b	42.53 bc
T_3F_3	4.57 a	28.86 a	39.66 a	48.93 a
$LSD_{(0.05)}$	0.55	1.75	2.62	2.91
CV%	11.41	5.35	5.04	4.7

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Marked variation was observed on number of branch per plant of tomatillo from combined effect of planting times and macronutrients at different days after transplanting (Table 10). From the results of the experiment showed that at 60 DAT, the highest number of branches per plant (48.93) was recorded from T_3F_3 (22 November with$N_{300}P_{120}K_{140}$ Kg/ha) treatment combination. On the other hand, the lowest number of branches per plant (22.86) was noted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

4.1.6 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 is an important aspect of canopy structure and critical to plant photosynthesis, fruiting, and biomass accumulation. In addition, the canopy protects the ground from the force of rainfall and makes wind force more moderate (Jiang *et al*., 2018).

Canopy size at 15, 30, 45 and 60 DAT exerted significant difference due to transplanting times (Table 11) at . At 60 DAT, the maximum canopy size (97.68 cm) was obtained from T_3 (22 November) treatment and minimum canopy size (92.0 cm) was obtained from T_1 (02 November) treatment.

Canopy size was significantly influenced by macronutrients (Fig. 4) at different days after transplanting. Results from the experiment showed that the maximum canopy size (45.07) was revealed from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha) treatment at 60 DAT whereas the minimum canopy size (25.86) was noticed from F_0 ($N_0P_0K_0$ Kg/ha) treatment.

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Table 11. Effect of planting time and macronutrients on canopy size at different days after transplanting of tomatillo

Treatments	Canopy size (cm)			
	15 DAT	30 DAT	45 DAT	60 DAT
Planting time				
T_1	21.34 b	57.81 b	78.00 c	92.01 c
T_2	21.86 b	58.67 ab	79.67 b	95.43 b
T_3	22.91 a	59.48 a	81.85 a	97.68 a
$LSD_{(0.05)}$	0.74	1.42	1.52	1.20
CV%	3.32	3.14	2.26	2.5
Macronutrients				
F_0	15.88 c	41.37 d	66.316 d	75.52 d
F_1	20.38 b	55.48 c	77.87 c	96.08 c
F_2	25.78 a	67.07 b	83.72 b	101.74 b
F_3	26.11 a	70.70 a	91.45 a	106.84 a
$LSD_{(0.05)}$	0.86	1.64	1.76	1.39
CV%	3.32	3.14	2.26	2.5

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Combined effect of planting times and macronutrients was significantly influenced by canopy size of tomatillo plant at different days after transplanting (Table 12). 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

Table 12. Combined effect of planting time and macronutrients on canopy size at different days after transplanting of tomatillo

Treatment combinations	Canopy size (cm)			
	15 DAT	**30 DAT**	**45 DAT**	**60 DAT**
T_1F_0	15.34 i	38.81 h	63.48 f	70.80 j
T_1F_1	18.95 gh	57.73 e	76.79 d	92.79 h
T_1F_2	25.07 cd	70.36 b	82.66 c	100.33 ef
T_1F_3	24.71 de	64.35 cd	89.08 b	104.14 c
T_2F_0	17.53 h	40.48 h	66.53 ef	76.93 i
T_2F_1	22.19 f	55.72 ef	77.86 d	96.55 g
T_2F_2	23.39 ef	66.85 c	83.94 c	101.62 de
T_2F_3	26.35 bc	72.89 ab	90.33 b	106.61 b
T_3F_0	14.77 i	44.81 g	68.93 e	78.83 i
T_3F_1	20.01 g	52.98 f	78.95 d	98.9 fg
T_3F_2	27.60 ab	63.99 d	84.56 c	103.27 cd
T_3F_3	28.55 a	74.85 a	94.95 a	109.75 a
$LSD_{(0.05)}$	1.49	2.85	3.05	2.41
CV%	3.32	3.14	2.26	2.5

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

4.1.7 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 traitsare the results of long-term adaption and evolution to the external environments (Li *et al.,* 2018).

Chlorophyll content exerted significant influence due to different transplanting times (Table 13). 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 13). 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 14). 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.

4.1.8 Days to first flowering

Timing is critically important in many things in life. Sometimes it is best to be first, and sometimes it is decidedly not. A trait that illustrates this idea particularly well is the timing of flowering in plants (Primack, 1985 ; Rathcke and Lacey, 1985). A plant that flowers too early or too late can miss out on reproduction entirely and be quickly weeded from the gene pool. But while many traits influence fitness, flowering times is perhaps unique in influencing a multitude of ecological and evolutionary processes, including mating patterns, gene flow, and interactions between plant and animal pollinators (Elzinga *et al*., 2007).

Table 13. Effect of planting time and macronutrients on chlorophyll content and days to first flowering of tomatillo

Treatments	Chlorophyll content (SPAD Unit)	Days to first flowering
Planting time		
T_1	69.72 c	28.18 c
T_2	71.66 b	29.25 b
T_3	74.60 a	31.89 a
$LSD_{(0.05)}$	1.25	0.58
CV%	4.83	2.33
Macronutrients		
F_0	59.66 d	25.33 d
F_1	70.30 c	30.71 b
F_2	73.79 b	30.02 c
F_3	84.22 a	33.03 a
$LSD_{(0.05)}$	1.44	0.67
CV%	4.83	2.33

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Days to first flowering was showed significant variation due to transplanting times (Table 13). 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 was noticed on days to first flowering of tomatillo due to different levels of macronutrients (Table 13). 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.

Table 14. Combined effect of planting time and macronutrients on chlorophyll content and days to first flowering

Treatments combinations	Chlorophyll content (SPAD Unit)	Days to first flowering
T_1F_0	54.71i	24.06 h
T_1F_1	68.63 fg	27.73 f
T_1F_2	72.75 cde	29.06 e
T_1F_3	82.79 b	31.86 c
T_2F_0	57.95 h	25.4 g
T_2F_1	70.32 ef	28.60 ef
T_2F_2	73.99 cd	30.33 d
T_2F_3	84.38 ab	32.66 c
T_3F_0	66.32 g	26.53 g
T_3F_1	71.95 de	34.56 b
T_3F_2	74.64 c	30.66 d
T_3F_3	85.48 a	35.8a
$LSD_{(0.05)}$	2.50	1.17
CV%	4.83	2.33

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Combined effect of planting times and macronutrients was significantly influenced by tomatillo on days to first flowering (Table 14). From the experimental results, it was showed that the maximum days to first flowering (35.8) was recorded from T_3F_3 (22 November with $N_{300}P_{120}K_{140}$ Kg/ha) treatment combination whereas the minimum days to first flowering (24.06) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

4.2 Yield parameters

4.2.1 Number of flowers per plant

The primary purpose of the flower is reproduction. Since the flowers are the reproductive organs of the plant, they mediate the joining of the sperm, contained within pollen, to the ovules contained in the ovary. Pollination is the movement of pollen from the anthers to the stigma (Beekman *et al.,* 2016).

Table 15. Effect of planting time and macronutrients on number of flowers per plant at different days after transplanting of tomatillo

Treatment	Number of flowers per plant			
	15 DAT	30 DAT	45 DAT	60 DAT
Planting time				
T_1	2.25 b	15.68 c	25.11 c	15.98 c
T_2	2.25 b	17.99 b	28.69 b	18.92 b
T_3	3.32 a	19.80 a	31.43 a	21.70 a
$LSD_{(0.05)}$	0.68	1.53	1.75	0.90
CV%	12.19	10.17	7.28	5.66
Macronutrients				
F_0	0.86 c	10.36 d	14.66 d	9.15 d
F_1	3.64 a	27.66 a	41.71 a	29.20 a
F_2	2.62 b	18.42 b	32.68 b	20.14 b
F_3	3.31 ab	14.84 c	24.58 c	16.97 c
$LSD_{(0.05)}$	0.79	1.77	2.02	1.04
CV%	12.19	10.17	7.28	5.66

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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 16: Combined effect of planting time and macronutrients on number of flowers per plant at different days after transplanting of tomatillo

Treatment combinations	Number of flowers per plant			
	15DAT	30 DAT	45 DAT	60 DAT
T_1F_0	0.53 g	8.06 j	10.8 h	6.26 i
T_1F_1	1.73 efg	23.80 c	36.73 c	23.13 c
T_1F_2	5.43 ab	17.20 def	31.20 de	18.8 de
T_1F_3	1.33 efg	13.60 ghi	21.73 f	15.73 f
T_2F_0	0.93 fg	11.30 i	15.26 g	9.53 h
T_2F_1	2.26 def	27.66 b	41.40 b	29.06 b
T_2F_2	2.36 de	18.20 de	34.53 cd	19.90 d
T_2F_3	4.26 bc	14.80 fgh	23.56 f	17.20 ef
T_3F_0	1.13 efg	11.73 hi	17.93 g	11.66 g
T_3F_1	5.73 a	31.53 a	47.0 a	35.4 a
T_3F_2	3.13 cd	19.8 d	32.33 d	21.73 c
T_3F_3	2.46 de	16.0 efg	28.46 e	18.00 e
$LSD_{(0.05)}$	1.37	3.07	3.50	1.80
CV%	12.19	10.17	7.28	5.66

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Significant difference on number of flowers per plant at 15, 30, 45 and 60 DAT was noticed due to macronutrients (Table 15). 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 (9.15) was noted from F_0 ($N_0P_0K_0$ Kg/ha) treatment.

Number of flowers per plant was significantly influenced by transplanting times of tomatillo (Table 15) at 15, 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.

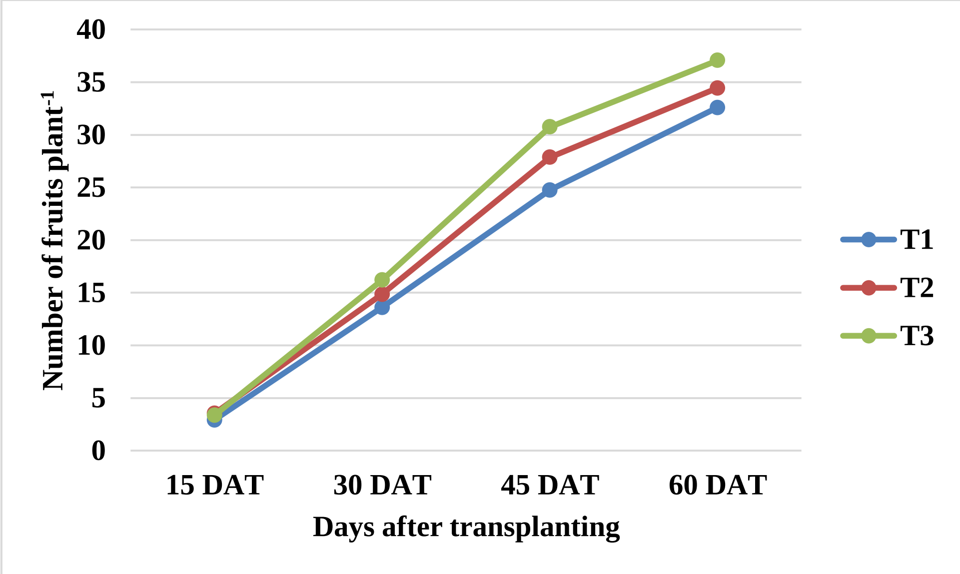
Statistically significant variation at 15, 30, 45 and 60 DAT was noticed on number of flowers per plant due to the combined effect of planting times and macronutrients (Table 16). From the experimental results, at 60 DAT he highest number of flowers per plant (35.4) was recorded from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination and the lowest number of flowers per plant (6.26) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

4.2.2 Number of Fruits per Plant

Tomatillo plants can be extremely productive. An individual plant may produce 64 to 200 fruits in a season. In test plantings at Ames, Iowa, yields averaged 212 pounds of fruit per plant, equal to approximately 9 tons per acre (Kaiser and Ernst, 2017). However, Narzis (2018) reported that the fruits plant^{-1} can be ranged from 9 to 21.

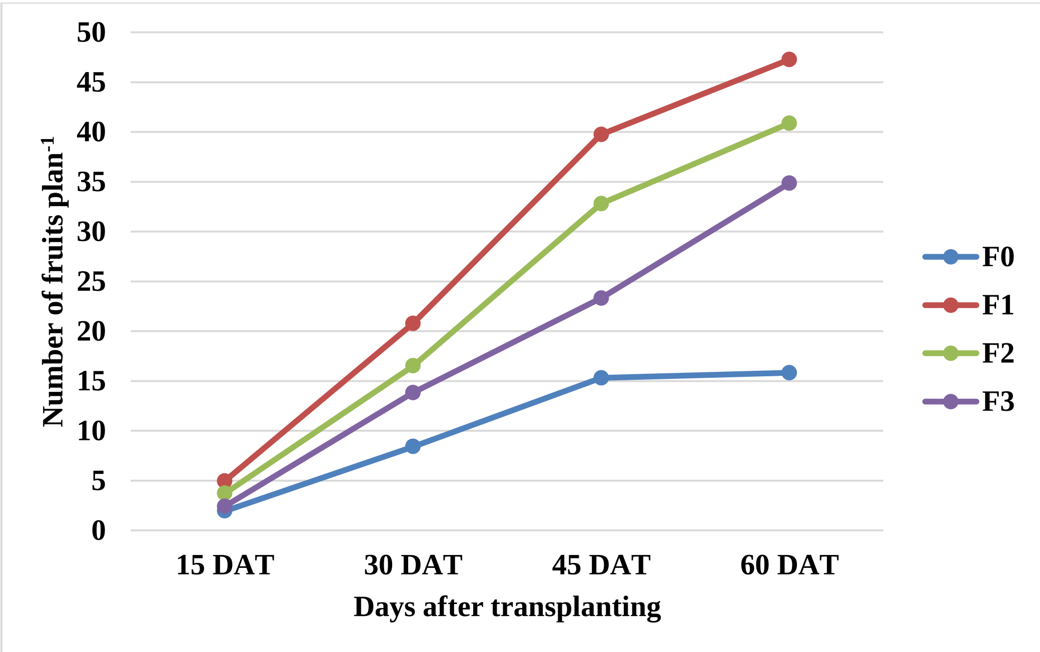
Number of fruits per plant was significantly influenced by transplanting times (Fig. 5) at different days after transplanting. It was exerted that the maximum number of fruits per plant (37.06) was noted from T_3 (22 November) treatment at 60 DAT and minimum number of fruits per plant (32.6) was obtained from T_1 (02 November) treatment.

Statistical significant variation was noticed on maximum number of fruits per plant of tomatillo due to macronutrients (Fig. 6) at 15, 30, 45 and 60 DAT. At 60 DAT, the maximum number of fruits per plant (47.26) was observed from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha) treatmentand minimum number of fruits per plant (15.82) was revealed from F_0 ($N_0P_0K_0$ Kg/ha) treatment.



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

Figure. 6. Effect of planting time on number of fruits per plant at different days after transplanting of tomatillo



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,

Fig. 7. Effect of macronutrients on number fruits per plant at different days after transplanting of tomatillo

Marked variation on number of fruits per plant of tomatillo was observed due to the combined effect of planting times and macronutrients (Table 17) at different days after transplanting. At 60 DAT, the highest number of fruits per plant (49.66) was recorded from T_3F_1 (22 November with $N_{20}P_{60}K_{100}$ Kg/ha) treatment combination and the lowest number of fruits plan per plant (14.0) was noted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

Table 17. Combined effect of planting time and macronutrients on number of fruits per plant at different days after transplanting of tomatillo

Treatment combinations	Number of per fruits plant			
	15 DAT	30 DAT	45 DAT	60 DAT
T_1F_0	1.66 g	5.93 i	13.06 i	14.00 j
T_1F_1	4.66 ab	19.94 b	36.06 c	44.66 c
T_1F_2	3.43 cd	15.53 d	31.26 d	39.13 d
T_1F_3	1.86 fg	13.00 f	18.60 g	32.60 g
T_2F_0	2.26 efg	8.00 h	15.96 h	15.86 i
T_2F_1	5.26 a	20.81 ab	39.53 b	47.46 b
T_2F_2	3.66 cd	16.73 c	32.26 d	39.80 d
T_2F_3	2.93 de	13.83 ef	23.73 f	34.6 f
T_3F_0	1.93 fg	11.33 g	16.90 gh	17.60 h
T_3F_1	4.94 a	21.56 a	43.66 a	49.66 a
T_3F_2	4.06 bc	17.26 c	34.86 c	43.66 c
T_3F_3	2.46 ef	14.66 de	27.60 e	37.33 e
$LSD_{(0.05)}$	0.74	1.15	2.22	1.19
CV%	8.14	3.94	4.72	2.03

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

4.2.3 Diameter of fruit (cm)

Fruit diameter was revealed marked variation due to planting time during the present experiment (Table 18). Result from the experiment showed that the maximum fruit diameter (4.6 cm) was noted from T_3 (22 November) treatment and minimum fruit diameter (3.61 cm) was observed from T_1 (02 November) treatment.

Significant influence was exerted on fruit diameter by macronutrients (Table 18). From the experimental result, the maximum fruit diameter (4.9 cm) was observed from F_1 ($N_{200}P_{60}K_{100}$Kg/ha) treatment and minimum fruit diameter (3.09 cm) was recorded from F_0 ($N_0P_0K_0$ Kg/ha) treatment.

Combined effect of planting times and macronutrients was significantly influenced fruit diameter of tomatillo (Table 19). It was revealed that the highest fruit diameter (6.28 cm) was recorded from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination. On the other hand the lowest fruit diameter (2.67 cm) was noted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

4.2.4 Fruit weight (g)

A healthy tomatillo plant can produce 10 to 15 pounds of tomatillo fruit and a single fruit may weigh 18 to 38.3 g (Freyre and Brent, 2000).

Fruit weight was revealed marked variation due to transplanting times (Table 18). Result from the experiment showed that the maximum fruit weight (42.7 g) was recorded from T_3 (22 November) treatment and minimum fruit weight (36.60 g) was noted from T_1 (02 November) treatment.

Table 18. Effect of planting time and macronutrients on length of fruit, diameter of fruit and fruit weight of tomatillo

Treatment	Diameter of fruit (cm)	Fruit feight (g)
Planting time		
T_1	3.612 c	36.60 c
T_2	4.21 b	38.25 b
T_3	4.60 a	42.70 a
$LSD_{(0.05)}$	0.23	0.99
CV%	6.57	2.99
Macronutrients		
F_0	3.091 c	27.65 d
F_1	4.90 a	48.47 a
F_2	4.87 a	41.77 b
F_3	3.70 b	38.84 c
$LSD_{(0.05)}$	0.26	1.14
CV%	6.57	2.99

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Significant influence was exerted on fruit weight due to macronutrients during the experimentation (Table 18). It was revealed that the maximum fruit weight (48.47 g) was recorded from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha) treatment. On the other hand minimum fruit weight (27.65 g) was noted from F_0 ($N_0P_0K_0$ Kg/ha) treatment.

Fruit weight of tomatillo revealed statistically significant variation due to the combined effect of planting time and macronutrients (Table 19) from the experimental result, it was exerted that the highest fruit weight (55.64 g) was noted from T_3F_1 (22 November with $N_{200}P_{60}K_{100}$ Kg/ha) treatment combination whereas the lowest fruit weight (24.69 g) was identified from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

Table 19. Combined effect of planting time and macronutrients on diameter of fruit and fruit weight of tomatillo

Treatment Combinations	Diameter of fruit (cm)	Fruit weight (g)
T_1F_0	2.67 i	24.69 i
T_1F_1	4.30 d	44.01 bc
T_1F_2	3.91def	40.59 ef
T_1F_3	3.57 fgh	37.13 g
T_2F_0	3.226 h	26.41 i
T_2F_1	4.13 de	45.76 b
T_2F_2	5.79 b	41.64 de
T_2F_3	3.69 efg	39.18 f
T_3F_0	3.37 gh	31.85 h
T_3F_1	6.28 a	55.64 a
T_3F_2	4.91 c	43.09 cd
T_3F_3	3.84 def	40.21 ef
$LSD_{(0.05)}$	0.46	1.98
CV%	6.57	2.99

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

4.2.5 Yield per plant (Kg)

A healthy tomatillo plant can yield 4.5 to 6.8 kg plant^{-1} and will produce well into the chilly fall weather. However, the average tomatillo yield is 1.13 kg per plant (Furman, 2013).

Yield per plant was significantly influenced by planting time (Table 20). 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 20). 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 21). From the experimental result, it was revealed that the maximum yield per plant (2.94 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.

4.2.6 Yield (t ha^{-1})

Freyre and Brent (2000) 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 20). 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 (72.14 t ha^{-1}) was noted from T_1 (02 November) treatment.

Significant influence was exerted on total yield by macronutrients (Table 20). 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 21). 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.

4.3 Quality parameters

4.3.1 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 the dissolved solid content (Instrument Choice, 2020). The highest and the lowest amount of brix percentages reported by Narzis (2018) were 3.33% and 10.21%, respectively.

Brix percentage of tomatillo revealed statistical significant variation by transplanting times (Table 20). The experimental result was showed that the maximum brix (4.8%) was noted from T_3 (22 November) treatment and minimum brix (4.31%) was observed from T_1 (02 November) treatment.

Significantly influence was exerted on brix percentage of tomatillo by macronutrients (Table 20). 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 (3.92%) 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 21). 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 (3.60%) was noted from T_1F_0 (02 November with $N_0P_0K_0$ Kg/ha) treatment combination.

4.3.2 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 (NHS, 2020). 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 (Salsaology, 2018).

Vitamin C content of tomatillo was significantly influenced by planting time during the experiment (Table 20). 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.

Table 20. Effect of planting time and macronutrients on yield plant^{-1}, total yield, brix and vitamin C content (mg) of tomatillo

Treatments	Yield plant^{-1} (Kg)	Yield (t ha^{-1})	Brix percentage	Vitamin C content (mg)
Planting time				
T_1	1.73 c	72.14 c	4.31 b	18.69 c
T_2	1.94 b	81.24 b	4.58 ab	19.88 b
T_3	2.04 a	85.06 a	4.81 a	20.78 a
$LSD_{(0.05)}$	0.05	2.14	0.29	0.83
CV%	3.19	3.19	7.73	4.99
Macronutrients				
F_0	0.58 d	24.34 d	3.92 c	14.36 d
F_1	2.75 a	114.59 a	4.40 b	24.18 a
F_2	2.38 b	99.51 b	4.58 b	21.72 b
F_3	1.90 c	79.50 c	5.36 a	18.88 c
$LSD_{(0.05)}$	0.05	2.48	0.34	0.96
CV%	3.19	3.19	7.73	4.99

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

Statistical variation on vitamin C content of tomatillo was significantly influenced by macronutrients (Table 20). 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 21). 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.

Table 21. Combined effect of planting time and macronutrients on yield per plant, total yield, brix (%), vitamin C content of tomatillo

Treatment combinations	Yield per plant (Kg)	Yield (t ha^{-1})	Brix percentage	Vitamin C content (mg)
T_1F_0	0.50 j	20.85 j	3.60 f	12.63 g
T_1F_1	2.48 cd	103.70 cd	4.49 cde	22.82 bc
T_1F_2	2.18 e	91.10 e	4.39 cde	21.18 cd
T_1F_3	1.75 h	72.93 h	4.76 bcd	18.13 e
T_2F_0	0.64 i	27.01 i	4.05 ef	15.38 f
T_2F_1	2.81 b	117.24 b	4.53 cde	23.80 b
T_2F_2	2.40 d	100.32 d	4.44 cde	21.6 c
T_2F_3	1.92 g	80.40 g	5.30 b	18.76 e
T_3F_0	0.60 i	25.16 i	4.13 ef	15.09 f
T_3F_1	2.94 a	122.81 a	4.20 def	25.92 a
T_3F_2	2.57 c	107.11 c	4.91 bc	22.38 bc
T_3F_3	2.04 f	85.18 f	6.01 a	19.73 de
$LSD_{(0.05)}$	0.10	4.29	0.59	1.67
CV%	3.19	3.19	7.73	4.99

In a column means having a similar letter(s) are statistically similar and those having a dissimilar letter(s) differ significantly at 0.05 level of probability

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

SUMMARY AND CONCLUSION

The experiment was conducted at the “Horticulture Farm” in Sher-e-Bangla Agricultural University, Dhaka during October 2019 to February 2020 to study the influence of planting time and macronutrients on the growth and yield of tomatillo. The experimental field belongs to the Agro-ecological zone (AEZ) of “The Madhupur Tract”, AEZ-28. The soil of the experimental field belongs to the General soil type, Deep Red Brown Terrace Soils under Tejgaon soil series. The experiment was set by taking two treatment factors. The treatment factors are: (1) Planting time; having three levels, *viz*. T_1 = 02 November, T_2 = 12 November, and T_3 = 22 November; and (2) Four macronutrients treatments 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. There were 12 treatment combinations. The total numbers of unit plots were 36. The size of unit plot was 2.164 m^2 (1.8m×1.2m). The experiment was conducted in factorial RCBD with three replications. Data on different parameters were recorded and analyzed statistically. Data on different growth, yield contributing characters and yield were recorded to find out the best planting time and optimum macronutrient doses for the potential fruit yield of tomatillo.

Different yield contributing characters and yield were significantly influenced due to varied planting time. Results from the experiment showed that at 60 DAT, the maximum plant height (105.53 cm), number of leaves per plant (242.83), leaf length (15.52cm), leaf breadth (5.67cm), number of branch per plant (39.26), canopy size (97.68 cm), chlorophyll content (74.60 SPAD Unit) and days to first flowering (31.89), number of flowers per plant (21.7), number of fruits per plant (37.06), diameter of fruit (4.6 cm), fruit weight (42.7 g), yield per plant (2.04 Kg), yield (85.06 t ha^{-1}), brix (4.8%), and vitamin C content (20.78 mg) were recorded from the treatment T_3 (transplanted on 22 November). On the other hand, the lowest values of plant height (88.71 cm), number of leaves per plant (229.52), leaf length (14.64 cm), leaf breadth (5.29 cm), number of branch per plant (33.82), canopy size (92.0 cm), chlorophyll content (69.72 SPAD Unit), days to first flowering (28.18), number of flowers per plant (15.98), number of fruits per plant (32.6), fruit diameter (3.61 cm), fruit weight (36.60 g), yield per plant (1.73 Kg), yield (72.14 t ha^{-1}), brix (4.31%)), and vitamin C content (18.69 mg) were recorded from the treatment T_1 (transplanted on 02 November). The experiment revealed that seedlings that were transplanted on 22 November had significant effect on the growth, yield and quality of tomatillo as compared to the seeds sown on 02 November and 12 November with a very few exceptions.

Different yield contributing characters and yield were significantly influenced due to varied macronutrient doses. Results from the experiment showed that at 60 DAT the maximum plant height (94.28 cm), number of leaves per plant (301.80), leaf length (16.19 cm), leaf breadth (6.21 cm), number of branch per plant (45.07), canopy size (106.84cm), chlorophyll content (84.22 SPAD Unit) and days to first flowering (31.89) were recorded from F_3 ($N_{300}P_{120}K_{140}$ Kg/ha). The maximum number of flowers per plant (29.2), number of fruits per plant (47.26), diameter of fruit (4.9 cm), fruit weight (48.47 g), yield per plant (2.75 Kg), yield (114.59 t ha^{-1}) were recorded from F_1 ($N_{200}P_{60}K_{100}$ Kg/ha) and the quality parameters showed that the highest brix (5.36%) and vitamin C content (24.18 mg) were recorded from the treatment F_3 ($N_{300}P_{120}K_{140}$ Kg/ha). On the other hand, the lowest values of plant height (77.19 cm), number of leaves per plant (175.80), leaf length (13.27 cm), leaf breadth (4.65 cm), number of branch per plant (25.86),canopy size (75.52cm), chlorophyll content (59.66 SPAD Unit), days to first flowering (25.33), number of flowers per plant (9.15), number of fruits per plant (15.82), fruit diameter (3.09 cm), fruit weight (27.65 g), yield per plant (0.58 Kg), yield (24.34 t ha^{-1}), brix (3.92%) and vitamin C content (14.36 mg) were recorded from the treatment F_0($N_0P_0K_0$ Kg/ha). However, the lowest results were given by the plots treated with F_0 ($N_0P_0K_0$ Kg/ha).

Finally, in case of combined effect of planting time and macronutrients, the superior results regarding plant height (109.13 cm), number of leaves per plant (310.73), leaf length (16.85 cm), leaf breadth (6.47 cm), number of branch per plant (48.93), canopy size (109.75 cm), chlorophyll content (85.48 SPAD Unit), days to first flowering (35.8), and brix percentage (6.01%) were recorded from the interaction T_3F_3 (22 November with$N_{300}P_{120}K_{140}$ Kg/ha). Nevertheless, the best findings regarding number of flowers per plant (35.4), number of fruits per plant (49.66), diameter of fruit (6.28 cm), fruit weight (55.64 g), yield per plant (2.94 kg), yield (t ha^{-1}), and vitamin C content (mg) were obtained from the plants of the plots provided with T_3F_1 (22

November with $N_{200}P_{60}K_{100}$ Kg/ha). Conversely, the lowest performances regarding all of the above parameters were recorded from the T_1F_0 treated plots. T_3F_3 and T_3F_1 were statistically significant over other combinations except few exceptions. The exceptions occurred may be due to experimental errors and genotype.

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 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.

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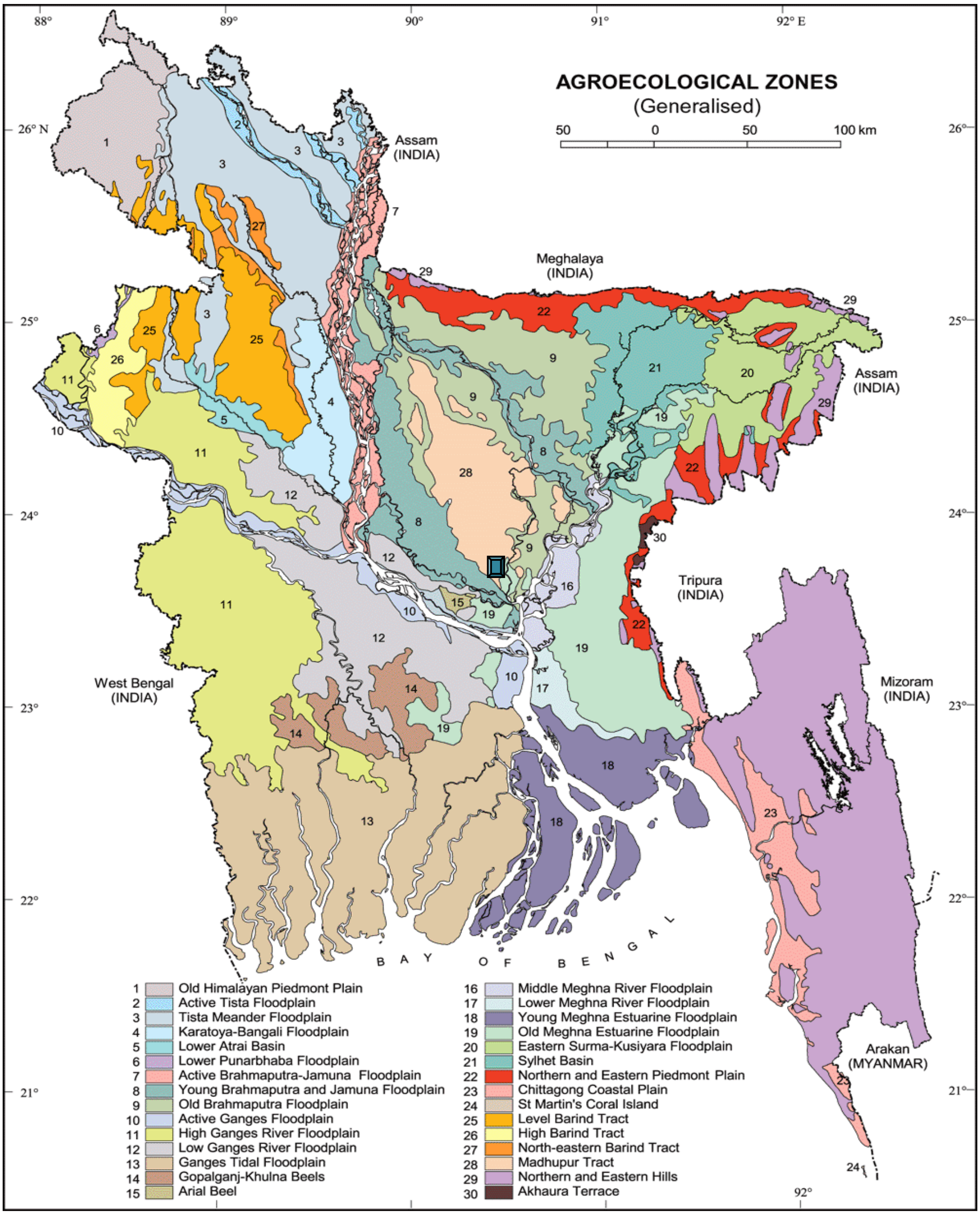
Appendix I. Map showing the experimental site under the study



The experimental site under study

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

Month	RH (%)	Air temperature (^0C)			Rainfall (mm)
		Max.	Min.	Mean	
November	65	32.0	19.0	26.0	35
December	74	29	15	22	15
January	68	26	10	18	7
February	57	15	24	25.42	25
March	57	34	16	28	65

(Source: timeanddate.com)

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

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of 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

Appendix IV: Mean square values of plant height (cm) at different days after transplanting of tomatillo under the experiment

Source of variation	Degree of freedom	Mean square of plant height at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	4.31	4.59	19.94	17.06
Transplanting time (A)	2	29.28**	133.21**	115.70**	93.18**
Macronutrients (B)	3	383.71**	994.97**	1007.02**	1352.84**
Interaction (AxB)	6	0.75**	4.39**	5.16**	3.02**
Error	22	0.54	2.00	1.97	4.3

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix V: Mean square values of number of leaves per plant at different days after transplanting of tomatillo growing under experimentation

Source of variation	Degree of freedom	Mean square of number of leaves per plant at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.30	22.63	3.9	0.4
Transplanting time (A)	2	120.72**	971.97**	477.20**	535.40**
Macronutrients (B)	3	988.32**	8442.06**	26619.20**	24977.50**
Interaction (AxB)	6	18.75**	82.14**	36.60**	28.10**
Error	22	0.53	10.62	9.8	10.9

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix VI: Mean square values of leaf length (cm) at different days after transplanting of tomatillo growing during experimentation

Source of variation	Degree of freedom	Mean square of leaf length at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.64	0.02	0.05	0.14
Transplanting time (A)	2	1.69*	1.43**	2.28**	2.42**
Macronutrients (B)	3	16.64**	7.78**	12.71**	14.44**
Interaction (AxB)	6	0.06**	0.24**	0.53**	0.30**
Error	22	0.13	0.06	0.08	0.11

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix VII: Mean square values of leaf breadth (cm) at different days after transplanting of tomatillo growing during experimentation

Source of variation	Degree of freedom	Mean square of leaf breadth at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.08	0.06	0.02	0.10
Transplanting time (A)	2	0.44*	0.63**	0.31**	0.45**
Macronutrients (B)	3	2.87**	2.69**	3.29**	3.87**
Interaction (AxB)	6	0.04**	0.09**	0.05**	0.02**
Error	22	0.09	0.04	0.006	0.02

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix VIII: Mean square values of number of branch per plant at different days after transplanting of tomatillo growing during experiment

Source of variation	Degree of freedom	Mean square number of branch per plant at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.22	0.17	1.62	4.18
Transplanting time (A)	2	1.37*	66.81**	55.31**	88.87**
Macronutrients (B)	3	13.12**	209.96**	370.60**	609.18**
Interaction (AxB)	6	0.01**	5.23**	0.97**	3.55**
Error	22	0.09	1.07	2.40	2.96

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix IX: Mean square values of canopy size (cm) at different days after transplanting of tomatillo growing during experiment

Source of variation	Degree of freedom	Mean square of canopy size (cm) at			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.35	1.66	1.43	19.24
Transplanting time (A)	2	23.65**	145.74**	44.66**	97.90**
Macronutrients (B)	3	219.29**	1203.88**	1010.55**	1698.41**
Interaction (AxB)	6	1.18**	9.72**	4.25**	4.59**
Error	22	0.54	3.43	3.26	2.03

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix X: Mean square values of chlorophyll content (SPAD Unit) and days to first flowering of tomatillo growing during experiment

Source of variation	Degree of freedom	Mean square	
		Chlorophyll content (SPAD Unit)	Days to first flowering
Replication	2	0.77	0.24
Transplanting time (A)	2	99.53**	43.73**
Macronutrients (B)	3	956.02**	93.84**
Interaction (AxB)	6	15.47**	9.19**
Error	22	1.74	0.48

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix XI: Mean square values of number of flowers per plant at different days after transplanting of tomatillo during experimentation

Source of variation	Degree of freedom	Mean square			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	0.03	13.65	25.74	12.07
Transplanting time (A)	2	6.02*	51.09**	120.4**	98.06**
Macronutrients (B)	3	32.45**	485.07**	1196.13**	618.85**
Interaction (AxB)	6	1.44**	5.18**	14.27**	15.85**
Error	22	0.10	3.28	4.28	1.14

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix XII: Mean square values of number of fruits per plant at different days after transplanting of tomatillo during the experiment

Source of variation	Degree of freedom	Mean square			
		15 DAT	30 DAT	45 DAT	60 DAT
Replication	2	1.83	2.42	2.01	2.78
Transplanting time (A)	2	1.97*	24.43**	108.36**	60.44**
Macronutrients (B)	3	15.59**	228.44**	1032.34**	1657.04**
Interaction (AxB)	6	0.05**	2.46**	6.19**	0.99**
Error	22	0.06	0.34	1.72	0.49

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix XIII: Mean square values of fruit diameter (cm) and fruit weight (g) of tomatillo during the experimentation

Source of variation	Degree of freedom	Mean square	
		Fruit Diameter (cm)	Fruit Weight (g)
Replication	2	0.146	6.37
Transplanting time (A)	2	2.99**	119.26**
Macronutrients (B)	3	7.24**	678.08**
Interaction (AxB)	6	1.48**	17.56**
Error	22	0.074	1.37

*Significant at 5% level of significance

**Significant at 1% level of significance

Appendix XIV: Mean square values of yield per plant (kg), yield (t ha^{-1}), brix percentage and vitamin C content (mg) of tomatillo

Source of variation	Degree of freedom	Mean square			
		Yield per Plant (kg)	Yield (tha^{-1})	Brix (%)	Vitamin C (mg)
Replication	2	0.0008	1.4	0.10	0.36
Transplanting times (A)	2	0.30**	528.3**	0.75*	13.21**
Macronutrients (B)	3	8.07**	14021**	3.18**	159.88**
Interaction (AxB)	6	0.01**	33.1**	0.33**	1.41**
Error	22	0.003	6.4	0.12	0.97

*Significant at 5% level of significance

**Significant at 1% level of significance

SOME PICTORIAL VIEW DURING EXPERIMENT

Seedlings in seedbed

Vegetative stage

Flower

Fruits

Plate 1. Different stages of tomatillo plant in the field

Mature fruits

Longitudinal section of mature fruits

Plate 2. Harvested mature fruits with longitudinal section of tomatillo fruits