Project ID: 376

Competitive Research Grant

Sub-Project Completion Report

on

Adaptation of a new species 'Tomatillo (*Physalis philadelphica* Lam./ *Physalis ixocarpa* Brot.)'

Project Duration

May 2017 to September 2018

Department of Genetics and Plant Breeding
Sher-e-Bangla Agricultural University
Dhaka-1207

Submitted to
Project Implementation Unit-BARC, NATP-2
Bangladesh Agricultural Research Council
Farmgate, Dhaka-1215

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Project Implementation Unit
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Bangladesh Agricultural Research Council (BARC)
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Acronyms

Abbreviations	Full word	Abbreviations	Full word
et al.	And others	LAI	Leaf area index
%	Percentage	LSD	Least Significant Difference
°C	Degree Celsius		
µg/g	Microgram per gram	mg	Milligram(s)
BARI	Bangladesh Agricultural Research Institute	mg/L	Milligram per liter
		ml	Milliliter
cm	Centimeter	mm	Millimeter
CRD	Completely randomized design	No.	Number
		pH	Negative logarithm of hydrogen ion concentration (-log[H^+])
DAS	Days after sowing		
DAT	Days after transplanting		
etc.	Etcetera		
FAO	Food and Agriculture Organization	RCBD	Randomized Complete Block Design
g	Gram	RWC	Relative water content
g/L	Gram per liter	Sl.	Serial
i.e.	That is	SRDI	Soil Resource Development Institute
Kg	Kilogram		
L	Liter	viz.	Videlicet (namely)

Table of Contents

Executive Summary

The study was undertaken at three agro-ecological zones (AEZ) of Bangladesh for evaluation of tomatillo (*Physalis ixocarpa* Brot./*Physalis philadelphica* Lam.) genotypes based on agro-morphogenic traits during the period from May 2017 to September 2018. The locations were Sher-e-Bangla Agricultural University, Dhaka (Madhupur tract, AEZ 28), Noakhali (Lower Meghna River floodplain, AEZ 17) and Rangpur (North eastern Barind tract, AEZ 27). The experiment was conducted with four genotypes of tomatillo *viz*., SAU tomatillo 1 (G_1), SAU tomatillo 2 (G_2), PI003 (G_3) and PI004 (G_4). Data on various yield attributing characters. Analysis of variance revealed significant differences among all the genotypes for all the characters under study in all three locations. The fruit yield per plant in all three AEZ are 1.86 to 3.07 Kg in Dhaka, 2 to 2.7 Kg in Noakhali and 2.2 to 3 Kg in Rangpur. G3 (PI003) showed highest yield per plant in all three locations. Phenotypic co-efficient of variation (PCV) was higher than the genotypic co-efficient of variation (GCV) for all the characters under study indicating presence of environmental influence in controlling these traits but the narrow gap between PCV and GCV for most of the characters indicates minor influence of environment and high degree of genetic variability present on the expression of these characters, also is indicative of the heritable nature of the traits. Most of the traits showed the genotypic correlation co-efficient were higher than the corresponding phenotypic correlation co-efficient suggesting a strong inherent association between the characters under study. Significant positive correlation with yield was found in average fruit weight, fruit length and fruit diameter in all three locations of Dhaka, Noakhali and Rangpur. PI003 (G_3) followed by SAU tomatillo 1 is the highest yielding and could be recommended to the farmers for cultivation. Inter genotypic crosses program could also be taken. Quality traits were observed to study genetic variability existing in different component characters of quality trait in tomatillo in the laboratory of the Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University. Analysis of variance indicated highly significant difference among all the genotypes for all characters under study. Evaluation followed by screening was done to identify drought tolerant genotypes of tomatillo. Considering the yield characters and nutritional traits such as Brix (%) and Vitamin C content, genotype G_1 followed by G_2 could be recommended to the farmers for moderate as well as severe drought stressed northern regions of Bangladesh. Similar experiment was conducted to screen salt tolerant tomatillo genotypes using three different salinity treatments. Genotype G_1 and G_3 showed minimum reduction in the parameters *viz*., fruit numbers, fruits length, fruit diameter, fruit weight and yield under slightly and moderately salinity stresses and could be recommended for quality traits in saline regions of Bangladesh.

CRG Sub-Project Completion Report (PCR)

A. Sub-project Description

1. **Title of the CRG sub-project:** Adaptation of a new species "Tomatillo (*Physalis phiadelphica* Lam./*Physalis ixocarpa* Brot.)"
2. **Implementing organization:** Sher-e-Bangla Agricultural University
3. **Name and full address with phone, cell and E-mail of PI/Co-PI (s):**

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4. **Sub-project budget (Tk):**
   4.1 Total: 1616074.00
   4.2 Revised (if any): N/A
5. **Duration of the sub-project:** One year four months and fifteen days
   5.1 Start date (based on LoA signed): 15 May 2017
   5.2 End date: 30 September 2018
6. **Justification of undertaking the sub-project:**

Tomatillo (*Physalis philadelphica* Lam./*Physalis ixocarpa* Brot.) is a very new crop in Bangladesh, so to justify of undertaking the sub-project, a short description about the Tomatillo, its introduction in Bangladesh and its nutrient composition is necessary to describe.

Tomatillo belongs to the family Solanaceae bearing round shaped and green or purple coloured fruit. The tomatillo fruit is surrounded by an inedible, paper-like husk formed from the calyx. From outside it is similar as a common weed of our country "Foshka Begun". At maturity, it fills the husk and can split it open by harvest. Inside the husk, green tomatillo fruit looks same as green tomato but inside the fruit it is compact fleshy, firm and bright green. Tomatillo is originated in Mexico. In Bangladesh, Dr. Naheed Zeba (PI of this project) started research on tomatillo since 2013 and developed two varieties of tomatillo named "SAU tomatillo 1" and "SAU tomatillo 2". She revealed that tomatillo has vigorous growth and

SAU tomatillo 1

SAU tomatillo 2

flowers early compared to a similar crop of our country, tomato (*Solanum lycopersicum* L.). Number of flowers and fruits are also higher. Because of the husks, birds rarely reach the fruit. Due to the husks in tomatillo, there is less chance of fruit borer attack, whilst most of our popular tomato varieties were at the risk of heavy yield loss due to borer damage. Tomatillo has less chance of disease infestation. Individual fruit weight is also higher as it is fleshy and compact. The fruits are used as vegetable, salad and making sauces. Tomatillo is an eco-friendly crop as there is no need of pesticide spray for insect and pest control. It was found that the yield of tomatillo is almost three times more in Bangladesh than in its origin Mexico. Tomatillo plants are highly self-incompatible and require cross- pollination, so we have to plant at least two plants for the blooms to be pollinated and fruit to be produced. One hundred gram of edible tomatillo contain 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 1.850 mg, Pyridoxine 0.056 mg, Thiamine 0.044 mg, Vitamin-A 114 IU, Vitamin-C 11.7 mg, Vitamin E 0.38 mg, Vitamin K 10.1 µg), Sodium 1 mg, Potassium 268 mg, Calcium 7 mg, Copper 0.079 mg, Iron 0.62 mg, Magnesium 20 mg, Manganese 0.153 mg, Phosphorus 39 mg, Selenium 0.5 µg, Zinc 0.22 mg, Carotene-ß 63 µg, Carotene-α 10 µg, Lutein-zeaxanthin 467 µg. Tomatillo has cancer chemo-preventive agents, antioxidant phytochemicals known as withanolides. *Ixocarpalactone-A* is one such withanolides present in tomatillo which has been found to have anti-bacterial and anti-cancer properties. It is rich in flavonoids helps to protect from lung and oral cavity cancers. Tomatillo has high pectin content which is a soluble dietary fiber and binds to cholesterol in the gastrointestinal tract and slows glucose absorption by trapping carbohydrates. Consumption of pectin has been shown to reduce blood cholesterol levels. It also has anti-constipation and anti-diarrhoeal activity. Dr. Zeba in this sub-project worked with two tomatillo varieties and another few tomatillo lines and they needed adaptive trials as well as their nutritional and antioxidant analyses are required. A comprehensive understanding of the responses of tomatillo plants to the salt and drought had also needed to be observed. Not enough publication on agronomic or breeding work of tomatillo was found previously. Therefore, through this sub-project an attempt was made to create agricultural biodiversity by introducing and adapting a new crop "Tomatillo" in Bangladesh which will satisfy some basic human needs for food security, nutrition and livelihoods.

7. **Sub-project goal:** Biodiversity and food security management by introducing and adapting a new crop "Tomatillo" in Bangladesh

8. **Sub-project objective (s):**
   - On-farm research trials of tomatillo based on agro-morphogenic traits
   - Biochemical analysis of tomatillo based on nutritional and antioxidant traits
   - Screening and physiological analysis of tomatillo against salt and drought stress

9. **Implementing location(s):**
   The sub-project implementation locations covered three agro-ecological zones of Bangladesh. The locations were, Dhaka which belongs to the agro-ecological zone of Madhupur tract (AEZ 28), Noakhali which belongs to the agro-ecological zone of Lower Meghna River floodplain (AEZ 17) and Rangpur which belongs to the Agro-ecological zone of North eastern Barind tract (AEZ 27).

10. **Methodology in brief:**
    A total of four genotypes of tomatillo were used in this experiment. The materials were collected from the Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka-1207. Two of which are SAU released varieties, SAU tomatillo 1 (G1) and SAU tomatillo 2 (G2). The other two are advanced lines PI003 (G3) and PI004 (G4). The experiments were conducted at three different Agro-ecological zones of Bangladesh, Rangpur which belongs to the Agro-ecological zone of North eastern Barind tract (AEZ 27), Noakhali which belongs to the agro-ecological zone of Lower Meghna River floodplain (AEZ 17) and Dhaka which belongs to the agro-ecological zone of Madhupur tract (AEZ 28) for adaptation in three different environments. The nutritional and physiological analyses were performed in the laboratory and in the net house of the Department of Genetics and Plant Breeding, Sher-e-Bangla Agricultural University, Dhaka-1207. The experiments in three different locations were laid out under field condition during Rabi 2017-18 in Randomized Complete Block Design (RCBD). There were three replications. Plot size were 4 x 2 m. Plant to plant and row to row spacing were 40 x 40 cm Lab experiments for physiological studies were performed in Completely Randomized Design (CRD).

The sowing of seed in the seedbed were carried out on October 06, 2017 in Rangpur, October 16 in Noakhali and October 20, 2017 in Dhaka. Seedlings of all genotypes were raised in seedbeds in Darshana of Rangpur, Somir Munshir Haat of Noakhali and Sher-e-Bangla Agricultural University of Dhaka. Seeds were sown in rows spaced at 10 cm apart, beds were watered regularly. Seedlings were raised using regular nursery practices. Twenty-five days old seedlings were transplanted in the main field. Fertilizers and farm yard manures were applied only during land preparation. Mechanical supports were provided to the growing plants by bamboo sticks to keep them erect. Necessary intercultural operations were provided as and when required. Harvesting were continued for long time because fruits of different lines were matured progressively at different dates and over long time. Seeds were collected and stored at 4^{o}C for future use. Five plants in each entry were selected randomly and were be tagged. These tagged plants were used for recording observations. Different steps of experiments in the field in Dhaka, Noakhali and Rangpur are illustrated in Appendix 1.

For agro-morphogenic study the parameters such as, days to first flowering, days to 50% flowering, days to maturity, plant height, number of branches per plant, number of clusters per plant, number of fruits per cluster, number of fruits per plant, fruit weight (g), fruit length (cm), fruit diameter (cm), external morphology etc. were recorded. For nutritional and antioxidant study, lycopene content was estimated as described by Alda *et al.*, 2009; Brix percentages was estimated using portable refractometer ERMA, Tokyo, Japan; Vitamin-C content was measured by oxidation reduction titration method as described by Tee *et al*., 1988; P^{H} of the flesh, titratable acid content of the flesh, moisture content of the flesh and dry matter content were recorded as described by Isbat *et al*., 1996. For screening and physiological study under drought and salt, two factorial experiments for each stress were conducted independently to evaluate the performance of four tomatillo genotypes. The experiments were laid out and evaluated in Completely Randomized Design (CRD). Three treatments were used for drought viz., T_1 (0 days witholding of water/Control), T_2 (30 days witholding of water) and T_3 (45 days witholding of water) and three treatments were used for salt stress viz., 0 dS/m, 8 dS/m and 12 dS/m. The experiments were conducted in five replications. Different biometric traits related to yield and its contributing characters as well as nutritional traits under control and stress conditions were recorded. Besides, yield and its component data, proline content, Na^+ and K^+ content, chlorophyll content and relative water content (RWC) were estimated as described by Zeba *et al*., 2009. Different steps of stress experiments are illustrated in Appendix 2 and in Appendix 3.

A number of statistical analyses were performed with the above data. Genotypic and phenotypic co-efficient of variation were calculated by the formula suggested by Burton (1952). Broad sense heritability was estimated (Lush, 1943) by the formula, suggested by Johnson *et al.* (1955). The expected genetic advance for different characters under selection were estimated using the formula suggested by Lush (1943) and Johnson *et al.* (1955). Genetic advance as percentage of mean was calculated from the formula as proposed by Comstock and Robinson (1952). Simple correlation co-efficient (r) were estimated with the formula by Clarke (1973) and Singh and Chaudhary (1985). For calculating the genotypic and phenotypic correlation co-efficient for all possible combinations the formula suggested by Miller *et al.* (1958), Johnson *et al.* (1955) and Hanson *et al.* (1956) were adopted. Path-Coefficient analysis was done according to the procedure employed by Dewey and Lu (1959) also quoted in Singh and Chaudhary (1985), using phenotypic correlation coefficient values.

11. **Results and discussion:**

This section comprises the presentation and discussion of the findings obtained from the experiments. The tomatillo genotypes were evaluated based on their agro-morphogenic traits, nutritional traits and stress tolerance against salt and drought. The results presented here was conducted at Sher-e-Bangla Agricultural University, Dhaka-1207.

11.1 **Evaluation based on Agro-morphogenic traits**: The data pertaining to eight agro-morphogenic (yield and yield contributing) traits in four different genotypes of tomatillo have been presented and statistically analyzed with the possible interpretations for all three locations Dhaka, Rangpur and Noakhali.

11.1.1 **Evaluation based on Agromorphogenic traits in Dhaka**: The mean values for each character of all the genotypes are shown in Table 1. The extent of variation among the genotypes in respect of fifteen characters was studied and mean sum of square, phenotypic variance (σ2p), genotypic variance (σ2g), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2b), genetic advance (GA), genetic advance in percent of mean and coefficient of variation (CV) presented is presented in Table 2. The morphological variation in tomatillo fruits are presented in Plate 1. SAU tomatillo 1 (G1) and PI003 (G3) are green coloured tomatillos and SAU tomatillo 2 (G2) and PI004 (G4) are purple tomatillos.

Table 1. Mean performance of various growth parameter and yield components of eight characters of four genotypes of tomatillo in Dhaka experiment

Genotype	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
G1	52	58	20	69	41.35	4.9	5.7	2.87
G2	53	57	25	119	17.81	2.6	2.9	2.12
G3	52	57	29	77	39.83	4.8	5.4	3.07
G4	55	60	30	378	4.90	1.5	1.7	1.86
Min	52	57	20	69	4.9	1.5	1.7	1.86
Max	55	60	30	378	41.35	4.9	5.7	3.07
Mean	53	58	26	160.75	25.97	3.45	3.93	2.48
$LSD_{(0.05)}$	2.17	2.12	1.01	9.52	0.73	1.33	1.21	0.08
CV%	5.94	5.35	5.55	8.63	4.11	5.47	4.36	4.94

DFF= Days to first flowering, D50F= Days to 50% flowering, NBPP= no. of branch per plant, NFPP= Number of fruits per plant, AFW= Average fruit weight, FL= Fruit length, FD= Fruit Diameter, FYPP= Fruit yield per plant

The mean values (Table 1) revealed that all the three genotypes G1, G2 and G3 flowered early within 52 to 53 days after transplanting (DAT) except G4 which flowered late in 55 days. Days to 50 % flowering (D50F) was also lower (57 to 58 DAT) in these three genotypes as compared to that in G4 (60 DAT). These two characters are desirable for short durated tomatillo genotypes. Number of branches per plant (NBPP) was highest in G4 (PI003) followed by G3, G2 and G1. Although the purple tomatillos (G2 and G4) are smaller in size than the green tomatillos (G1 and G3) no. of fruits per plant of G2 and G4 was much higher (119 and 378 respectively) than those of G1 and G3 (69 and 77 respectively). Among the green tomatillos, G3 showed better performance than that of G1 in respect of number of fruits per plant (77 in G3 and 69 in G1). The green tomatillos (G1 and G3) are bigger in size than the purple tomatillos (G2 and G4) in respect of average fruit weight (AFW), fruit length (FL), fruit diameter (FD) and fruit yield per plant (FYPP) which usually contribute to high yield. The AFW was 41.35 g and 39.38 g respectively in G1 and in G3 whereas 17.81g and 4.90 g respectively in G2 and in G4. Fruit length was 4.9 cm and 4.8 cm respectively in G1 and G3 whereas 2.6 cm and 1.5 cm respectively in G2 and in G4. Fruit diameter was 5.7 cm and 5.4 cm in G1 and in G3 whereas, 2.9 cm and 1.7 cm in G2 and in G4 respectively. The highest fruit yield per plant was observed in G3 (3.07 kg) followed by G1 (2.87 kg). G4 showed the lowest yield per plant (1.86 kg). The mean sum of squares (MS) revealed highly significant difference among the genotypes for all the characters under study (Table 2) suggesting presence of substantial amount of variability for all the characters in four genotypes. The phenotypic variance appeared to be higher than the genotypic variance for all the characters studied (Table 2) suggesting the influence of environment on the expression of the genes controlling these traits. A wide range of variability recorded for all characters indicated the scope for selection of better genotypes. According to Deshmukh *et al*. (1986), Phenotypic Coefficient of variation (PCV) and Genotypic Coefficient of Variation (GCV) can be categorized as low (<10%), moderate (10-20%) and high (>20%).

Table 2. Estimation of genetic parameters in eight characters of tomatillo in Dhaka experiment

Traits	MS	σ^2g	σ^2e	σ^2P	GCV	ECV	PCV	h^2b (%)	GA (5%)	GA(% mean)	CV(%)
DFF	7.25**	0.54	9.96	10.5	1.39	5.95	6.11	5.14	1.11	2.10	5.94
D50F	7.12**	0.47	9.45	9.9	1.18	5.30	5.42	4.75	0.97	1.67	5.35
NBPP	80.33**	15.63	2.17	17.8	15.21	5.67	16.23	87.81	32.20	123.84	5.55
NFPP	101226.27**	20207.10	190.77	20397.9	88.43	8.59	88.85	99.06	41626.63	25895.26	8.63
AFW (g)	1496.06**	298.99	1.13	300.1	67.05	4.12	67.17	99.63	615.92	2388.21	4.11
FL (cm)	1436.14**	286.48	3.73	290.2	490.60	55.98	493.78	98.72	590.15	17105.76	5.47
FD (cm)	1872.68**	373.92	3.06	377.0	492.04	44.51	494.06	99.18	770.28	19599.88	4.36
FYPP (kg)	1.75**	0.35	0.02	0.4	23.86	5.70	25.50	87.50	0.72	29.07	4.94

DFF- Days to 1st flowering, D50F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW-Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant

In the present study, high phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) were observed for number of fruits per plant, Average fruit weight, fruit length, fruit diameter and fruit yield per plant (Table 2), indicating the higher magnitude of variability for these traits and consequently more scope for their improvement through selection. Moderate PCV and GCV were estimated for number of branches per plant, implying equal importance of additive and non-additive gene action. Low GCV and PCV estimates were recorded for days to first flowering and days to 50% flowering which indicated presence of low variability among the genotypes. Wide difference between PCV and GCV for the characters implies their susceptibility to environmental fluctuation, whereas narrow difference suggested their relative resistance to environmental alteration. PCV in general were higher than GCV for all the traits, but narrow gap between PCV and GCV for most of the characters indicates less influence of environment on the phenotypic expression and is indicative of the heritable nature of the traits. Singh *et al*. (2002) also showed that the PCV was higher than GCV for several characters in his study. The closer GCV and PCV values were observed for number of branches per plant, number of fruits per plant, average fruit weight, fruit length, fruit diameter and fruit yield per plant, indicating minor environmental influence and high degree of genetic variability present on the expression of these characters. Thus, a greater scope for effective selection exists based upon phenotypic expression of these characters for the improvement of this crop. The wider PCV and GCV values were observed for days to first flowering and days to 50% flowering, indicating dominant role played by the environment in the expression of these traits and were not desirable for the improvement of this crop.

Heritability is the percentage of phenotypic variance that is attributed to genetic variance. According to Singh (2001), heritability of a trait is considered as very high or high when the values is 80% or more and moderate when it ranged from 40-80% and when it is less than 40%, it is low. In the present study, heritability was high (greater than 80%) for most of the character under study except for days to first flowering and days to 50% flowering (Table 2). High heritability indicates that the environmental influence is minimal on those characters. This result suggested selection could be fairly easy and improvement is possible using selection breeding for these traits improvement. Lower heritability for days to first flowering and days to 50% flowering of tomatillo may be due to masking effect of the environment for these traits and are low heritable characters. They also might be controlled by many genes. The progress in selection for this character in tomatillo is generally slow. The estimates of heritability alone fail to indicate the response to selection (Johnson *et al.,* 1955). Therefore, the heritability estimates appear to be more meaningful when accompanied by estimates of genetic advance and the genetic advance as per cent of mean. Deshmukh *et al*. (1986) classified genetic advance as percent of mean as low (<10%), moderate (10-20%) and high (>20%). Based on this classification, all of the characters had high genetic advance in percent of mean except days to first flowering and days to 50% flowering which refers to the improvement of these characters in genotypic value for the new population compared with the base population with one cycle of selection is not rewarding. In this study, high heritability coupled with high genetic advance in percentage of mean for number of bunches per plant, number of fruits per plant, average fruit weight, fruit length and fruit diameter were obtained suggesting that these traits were highly heritable and there is a wide scope for improvement through selection of these traits. Most likely the heritability of these traits is due to additive gene effects and selection may be effective in early generations for these traits. Low values for both heritability and genetic advance as percent of mean was computed for days to first flowering and days to 50% flowering suggested that the low heritability of traits due to the influence of environment and limit the scope of improvement using selection. The low heritability of traits may be due to the presence of non-additive type of gene action.

Correlation studies provide a better understanding of the association of different characters with fruit yield. Simple correlation was partitioned into phenotypic (that can be directly observed), genotypic (inherent association between characters) components as suggested by Singh and Chaudhary (1985). As we know yield is a complex product being influence by several inter-dependable quantitative characters. So selection may not be effective unless the other contributing components influence the yield directly or indirectly. When selection pressure is applied for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated characters. Hence knowledge regarding association of character with yield and among themselves provides guideline to the plant breeders for making improvement through selection with a clear understanding about the contribution in respect of establishing the association by genetic and non-genetic factors (Dewey and Lu 1959). Genotypic and Phenotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo are given in Table 3 and Table 4. Number of fruits per

Table 3. Genotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo in Dhaka experiment

	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
DFF	1.00**	0.86**	0.18	0.37	-0.35	-0.29	-0.31	-0.26
D50F		1.00**	0.07	0.38	-0.32	-0.30	-0.31	-0.24
NBPP			1.00**	0.52*	-0.45	-0.42	-0.43	-0.26
NFPP				1.00**	-0.88**	-0.84**	-0.85**	-0.81**
AFW (g)					1.00**	0.99**	0.99**	0.96**
FL (cm)						1.00**	1.00**	0.95**
FD (cm)							1.00**	0.95**
FYPP (kg)								1.00**

* = Significant at 5%, ** = Significant at 1%

DFF- Days to 1st flowering, D50%F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW- Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant.

Table 4. Phenotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo in Dhaka experiment

	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
DFF	0.96**	0.71**	0.15	0.30	-0.29	-0.24	-0.28	-0.22
D50F		0.85**	0.04	0.31	-0.26	-0.25	-0.28	-0.20
NBPP			0.97**	0.51*	-0.39	-0.37	-0.40	-0.22
NFPP				0.93**	-0.82**	-0.79**	-0.82**	-0.77**
AFW (g)					0.94**	0.94**	0.96**	0.92**
FL (cm)						0.95**	0.97**	0.91**
FD (cm)							0.97**	0.91**
FYPP (kg)								0.96**

* = Significant at 5%, ** = Significant at 1%

DFF- Days to 1st flowering, D50%F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW- Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant.

plant, average fruit weight, fruit length and fruit diameter had positive and highly significant correlation with fruit yield per plant at genotypic and phenotypic levels). Non-significant negative correlation with yield per plant was found in days to first flowering, days to 50% flowering and no. of branch per plant at genotypic and phenotypic level, respectively.

11.1.2 **Evaluation based on Agromorphogenic traits in Noakhali:** The mean values for each character of all the genotypes are shown in Table 5. The extent of variation among the genotypes in respect of fifteen characters was studied and mean sum of square, phenotypic variance (σ2p), genotypic variance (σ2g), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2b), genetic advance (GA), genetic advance in percent of mean and coefficient of variation (CV) presented is presented in Table 6. The morphological variation in tomatillo fruits are as in Dhaka experiment (Plate 1). SAU tomatillo 1 (G1) and PI003 (G3) are green coloured tomatillos and SAU tomatillo 2 (G2) and PI004 (G4) are purple tomatillos.

The mean sum of squares (MS) revealed highly significant difference among the genotypes for all the characters under study (Table 6) suggesting presence of substantial amount of variability for all the characters in four genotypes. The mean values (Table 5) revealed that all the three genotypes G1, G3 and G4 flowered early within 51 to 52 days after transplanting (DAT) except G2 which flowered late in 57 days. Days to 50 % flowering (D50F) was also lower (52 to 58 DAT) in these three genotypes as compared to that in G2 (60 DAT). These two characters are desirable for short durated tomatillo genotypes. No. of branches per plant (NBPP) was highest in G4 (PI003) and SAU tomatillo 1 (G1) followed by G2 and G1. Although the purple tomatillos (G2 and G4) are smaller in size than the green tomatillos (G1 and G3) no. of fruits per plant of G2 and G4 was much higher (119 and 184 respectively) than those of G1 and G3 (87 and 178 respectively). Among the green tomatillos, G3 showed better performance than that of G1 in respect of number of fruits per plant (178 in G3 and 87 in G1).

Table 5. Mean performance of various growth parameter and yield components of eight characters of four genotypes of tomatillo in Noakhali experiment

G	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
G1	51	52	27	87	33	4.27	4.93	2.7
G2	57	60	25	199	21	2.92	3.47	2
G3	52	58	25	178	30	3.67	4.12	3
G4	53	57	27	184	21	3.22	3.45	2.5
Min	51	52	25	87	21	2.92	3.45	2
Max	57	60	27	199	33	4.27	4.93	3
Mean	54	59	26	234	22.98	3.275	3.7	2.69
LSD (0.05)	5.36	4.93	3.39	9.97	2.58	4.97	3.63	1.07
CV%	5.25	3.82	4.17	9.76	5.54	4.76	3.27	5.71

DFF= Days to first flowering, D50F= Days to 50% flowering, NBPP= no. of branch per plant, NFPP= Number of fruits per plant, AFW= Average fruit weight, FL= Fruit length, FD= Fruit Diameter), FYPP= Fruit yield per plant

The green tomatillos (G1 and G3) are bigger in size than the purple tomatillos (G2 and G4) in respect of average fruit weight (AFW), fruit length (FL), fruit diameter (FD) and fruit yield per plant (FYPP) which usually contribute to high yield. These yield contributing characters as well as the yield per plant in G1 and in G3 showed similar results as the results in Dhaka experiment (Table 1). The AFW was 33 g and 30 g respectively in G1 and in G3 whereas 21g in both G2 and G4. Fruit length was 4.27 cm and 3.67 cm respectively in G1 and G3 whereas 2.92 cm and 3.22 cm respectively in G2 and in G4. Fruit diameter was 4.93 cm and 4.12 cm in G1 and in G3 whereas, 3.47 cm and 3.45 cm in G2 and in G4 respectively. The highest fruit yield per plant was observed in G3 (3 Kg) followed by G1 (2.7 Kg). G2 and G4 showed the lowest yield per plant (2 Kg and 2.5 Kg respectively). G3 showed highest yield in Noakhali as in Dhaka.

Table 6. Estimation of genetic parameters in eight characters of tomatillo in Noakhali experiment

Traits	MS	σ^2g	σ^2e	σ^2P	GCV	ECV	PCV	h^2b (%)	GA (5%)	GA (% mean)	CV(%)
DFF	13.85**	182.50	6.36	188.86	28.10	5.25	28.58	96.63	27.36	56.89	5.25
D50F	18.33*	184.45	3.86	188.31	26.41	4.09	26.69	97.95	27.69	53.85	3.82
NBPP	48.20**	71.11	1.42	72.53	29.50	2.48	29.80	98.05	17.20	60.18	4.17
NFPP	65329.4**	22013.78	86	22099.78	88.67	19.29	88.84	99.61	305.05	182.30	9.76
AFW (g)	941.43**	306.76	9.9	316.66	66.23	6.54	67.29	96.87	35.51	134.27	5.54
FL (cm)	859.01**	272.54	2.97	275.51	45.67	3.58	45.92	98.93	33.83	93.58	4.76
FD (cm)	1112.46**	462.40	1.67	464.07	54.49	2.69	54.59	99.64	44.22	112.05	3.27
FYPP (kg)	1.03**	8.92	0.16	9.08	71.49	0.83	72.14	98.19	6.10	145.92	5.71

DFF- Days to 1st flowering, D50F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW- Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant

The phenotypic variance appeared to be higher than the genotypic variance for all the characters studied (Table 6) suggested the influence of environment on the expression of the genes controlling these traits. A wide range of variability recorded for all characters indicates the scope for selection of better genotypes. In the present study, high phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) were observed for all the character under study, indicating the higher magnitude of variability for these traits and consequently more scope for their improvement through selection. Narrow gap between PCV and GCV for most of the characters indicates less influence of environment on the phenotypic expression and is indicative of the heritable nature of the traits. Thus a greater scope for effective selection exists based upon phenotypic expression of these characters for the improvement of this crop. Similar GCV and PCV values were also observed in Dhaka experiment (Table 2).

In the present study heritability was high (greater than 80%) for all the character under study (Table 6). High heritability indicates that the environmental influence is minimal on those characters. This result suggested selection could be fairly easy and improvement is possible using selection breeding for these traits improvement. All of the characters had high genetic advance in percent of mean as in Dhaka experiment. In this study, high heritability coupled with high genetic advance in percentage of mean for number of fruits per plant, average fruit weight, fruit length and fruit diameter were obtained suggesting that these traits were highly heritable and there is a wide scope for improvement through selection of these traits. Most likely the heritability of these traits is due to additive gene effects and selection may be effective in early generations for these traits. High heritability coupled with high genetic advance were also observed in the experiment of Dhaka (Table 2) for number of fruits per plant, average fruit weight, fruit length and fruit diameter.

Genotypic and Phenotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo observed in Noakhali are given in Table 7 and Table 8. Average fruit weight,

Table 7. Genotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo in Noakhali experiment

	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
DFF	-	0.996**	-0.897**	-0.839**	0.982**	0.983**	0.990**	0.910**
D50F		-	-0.850**	-0.796**	0.983**	0.977**	0.988**	0.865**
NBPP			-	0.833**	-0.808**	-0.829**	-0.836**	-1.000**
NFPP				-	-0.877**	-0.904**	-0.878**	-0.793**
AFW (g)					-	1.000**	1.000**	0.808**
FL (cm)						-	1.000**	0.825**
FD (cm)							-	0.841**
FYPP (kg)								-

* = Significant at 5%, ** = Significant at 1%

DFF- Days to 1st flowering, D50%F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW- Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant

Table 8. Phenotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo in Noakhali experiment

	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
DFF	-	0.991**	-0.881**	-0.826**	0.955**	0.956**	0.975**	0.892**
D50F		-	-0.830**	-0.788**	0.965**	0.959**	0.976**	0.855**
NBPP			-	0.825**	-0.781**	-0.819**	-0.827**	-0.987**
NFPP				-	-0.862**	-0.895**	-0.875**	-0.782**
AFW (g)					-	0.986**	0.984**	0.787**
FL (cm)						-	0.993**	0.819**
FD (cm)							-	0.827**
FYPP (kg)								-

* = Significant at 5%, ** = Significant at 1%

DFF- Days to 1st flowering, D50%F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW- Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant fruit length and fruit diameter had positive and highly significant correlation with fruit yield per plant at genotypic and phenotypic levels (Table 7 and Table 8). These results agree with the result of Dhaka experiments (Table 3 and Table 4).

11.1.3 **Evaluation based on Agromorphogenic traits in Rangpur:** The mean values for each character of all the genotypes in Rangpur experiment are shown in Table 9. The extent of variation among the genotypes in respect of fifteen characters was studied and mean sum of square, phenotypic variance (σ2p), genotypic variance (σ2g), phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2b), genetic advance (GA), genetic advance in percent of mean and coefficient of variation (CV) presented is presented in Table 10. The morphological variation in tomatillo fruits are as in Dhaka and Noakhali experiment (Plate 1). SAU tomatillo 1 (G1) and PI003 (G3) are green coloured tomatillos and SAU tomatillo 2 (G2) and PI004 (G4) are purple tomatillos.

Table 9. Mean performance of various growth parameter and yield components of eight characters of four genotypes of tomatillo in Rangpur

G	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
G1	51	58	23	69	41.54	5.01	5.89	3.0
G2	51	59	26	118	18.33	2.69	3.02	2.63
G3	51	56	27	78	41.85	5.06	5.37	3.32
G4	57	58	27	390	4.57	2.91	1.72	2.2
Min	51	56	23	69	4.57	2.69	1.72	2.2
Max	57	59	27	390	41.85	5.06	5.89	3.32
Mean	52	58	26	164	26.6	3.9	4.0	2.8
$LSD_{(0.05)}$	3.07	2.52	1.15	11.52	1.65	3.45	2.92	0.16
CV%	5.9	4.06	3.07	8.13	4.05	6.02	5.03	4.16

DFF= Days to first flowering, D50F= Days to 50% flowering, NBPP= no. of branch per plant, NFPP= Number of fruits per plant, AFW= Average fruit weight, FL= Fruit length, FD= Fruit Diameter, FYPP= Fruit yield per plant

The mean sum of squares (MS) revealed highly significant difference among the genotypes for all the characters under study (Table 10) suggesting presence of substantial amount of variability for all the characters in four genotypes. The mean values (Table 9) revealed that all the three genotypes G1, G2 and G3 flowered early within 51 days after transplanting (DAT) except G4 which flowered late in 57 days. This result agreed with the result in Dhaka experiment. Although the purple tomatillos (G2 and G4) are smaller in size than the green tomatillos (G1 and G3), no. of fruits per plant of G2 and G4 was much higher (118 and 390 respectively) than those of G1 and G3 (69 and 78 respectively). Among the green tomatillos, G3 showed better performance than that of G1 in respect of number of fruits per plant (78 in G3 and 69 in G1). The green tomatillos (G1 and G3) are bigger in size than the purple tomatillos (G2 and G4) in respect of average fruit weight (AFW), fruit length (FL), fruit diameter (FD) and fruit yield per plant (FYPP) which eventually contribute to high yield. These yield contributing characters as well as the yield per plant in G1 and in G3 showed similar results as in the results in Dhaka and in Noakhali experiments (Table 1 and Table 5). The AFW was 41.54 g and 41.85 g respectively in G1 and in G3 whereas 18.33 g in G2 and 4.57 in G4. Fruit length was 5.01 cm and 5.06 cm respectively in G1 and G3 whereas 2.69 cm and 2.91 cm respectively in G2 and in G4. Fruit diameter was 5.89 cm and 5.37 cm in G1 and in G3 whereas, 3.02 cm and 1.72 cm in G2 and in G4 respectively. The highest fruit yield per plant was observed in G3 (3.32 Kg) followed by G1 (3.0 Kg). G2 and G4 showed the lowest yield per plant (2.63 Kg and 2.2 Kg respectively). G3 showed highest yield in Rangpur as in Noakhali and in Dhaka.

The phenotypic variance appeared to be higher than the genotypic variance for all the characters studied (Table 10) suggested the influence of environment on the expression of the genes controlling these traits. A wide range of variability recorded for all characters indicates the scope for selection of better genotypes. In the present study, high phenotypic co-efficient of variation (PCV) and genotypic co-efficient of variation (GCV) were observed for all the character under study, indicating the higher magnitude of variability for these traits and consequently more

Table 10. Estimation of genetic parameters in eight characters of tomatillo in Rangpur

Traits	MS	σ^2g	σ^2e	σ^2P	GCV	ECV	PCV	h^2b (%)	GA (5%)	GA (% mean)	CV(%)
DFF	29.11**	92.44	7.42	99.86	20.07	15.46	20.86	92.57	19.06	39.77	5.9
D50F	12.33*	103.31	2.64	105.94	19.00	5.50	19.24	97.51	20.68	38.65	4.06
NBPP	17.14**	71.33	0.33	71.67	30.34	0.69	30.42	99.53	17.36	62.36	3.07
NFPP	69706.5**	21188.75	141.53	21330.28	88.58	294.85	88.87	99.34	298.86	181.86	8.13
AFW (g)	1001.52**	335.95	4.54	340.49	69.01	9.46	69.47	98.67	37.51	141.20	4.05
FL (cm)	502.458**	293.29	2.70	295.99	48.76	5.63	48.99	99.09	35.12	99.99	6.02
FD (cm)	1160.54**	362.69	3.09	365.78	47.93	6.44	48.14	99.16	39.07	98.32	5.03
FYPP (kg)	0.71**	7.39	0.66	8.04	65.59	1.38	68.44	91.85	5.37	129.50	4.16

DFF- Days to 1st flowering, D50F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW-Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant

scope for their improvement through selection. Narrow gap between PCV and GCV for most of the characters indicates less influence of environment on the phenotypic expression and is indicative of the heritable nature of the traits. Thus a greater scope for effective selection exists based upon phenotypic expression of these characters for the improvement of this crop. Similar trends of GCV and PCV values were also observed in Dhaka as well as in Noakhali experiments (Table 2 and Table 6).

In the present study heritability was high (greater than 80%) for all the character under study (Table 10). High heritability indicates that the environmental influence is minimal on those characters. This result suggested selection could be fairly easy and improvement is possible using selection breeding for these traits improvement. All of the characters had high genetic advance in percent of mean as in Dhaka and in Noakhali experiments. In this study, high heritability coupled with high genetic advance in percentage of mean for all the traits studied suggesting that these traits were highly heritable and there is a wide scope for improvement through selection of these traits. Most likely the heritability of these traits is due to additive gene effects and selection may be effective in early generations for these traits. High heritability coupled with high genetic advance were also observed in the experiments in Dhaka (Table 2) as well as in Noakhali (Table 6) for number of fruits per plant, average fruit weight, fruit length and fruit diameter which are directly contributing to yield.

Genotypic and Phenotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo observed in Rangpur are given in Table 11 and Table 12. Average fruit weight,

Table 11. Genotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo in Rangpur

	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
DFF	-	0.8955**	-0.8261**	-0.8041**	0.9911**	0.9913**	0.9987**	0.8266**
D50F		-	-0.8141**	-0.8032**	0.9828**	0.9849**	0.9941**	0.8229**
NBPP			-	0.8301**	-0.7481**	-0.7660**	-0.7760**	-1.000**
NFPP				-	-0.8674**	-0.8765**	-0.8515**	-0.7680**
AFW (g)					-	1.000**	1.000**	0.7352**
FL (cm)						-	0.9998**	0.7584**
FD (cm)							-	0.7743**
FYPP (kg)								-

* = Significant at 5%, ** = Significant at 1%

DFF- Days to 1st flowering, D50%F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW- Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant

Table 12. Phenotypic correlation coefficients among different pairs of yield and yield contributing characters for different genotype of tomatillo in Rangpur

	DFF	D50F	NBPP	NFPP	AFW (g)	FL (cm)	FD (cm)	FYPP (kg)
DFF	-	0.9892**	-0.7946**	-0.7748**	0.9332**	0.9415**	0.9624**	0.8050**
D50F		-	-0.8021**	-0.7929**	0.9606**	0.9644**	0.9790**	0.7915**
NBPP			-	0.8262**	-0.7468**	-0.7622**	-0.7705**	-0.9709**
NFPP				-	-0.8608**	-0.8642**	-0.8444**	-0.7430**
AFW (g)					-	0.9940**	0.9901**	0.7032**
FL (cm)						-	0.9944**	0.7095**
FD (cm)							-	0.7297**
FYPP (kg)								-

* = Significant at 5%, ** = Significant at 1%

DFF- Days to 1st flowering, D50%F- Days to 50% flowering, NBPP- No. of branches/plant, NFPP-No. of fruits/plant, AFW- Average Fruit weight, FL- fruit length, FD- fruit diameter, FYPP- Fruit yield/plant

fruit length and fruit diameter had positive and highly significant correlation with fruit yield per plant at genotypic and phenotypic levels (Table 11 and Table 12). These results agree with the results of Dhaka (Table 3 and Table 4) as well as Noakhali correlation analysis (Table 7 and Table 8).

11.2 **Evaluation based on nutritional traits**: The data pertaining to six nutritional traits in four different genotypes of tomatillo have been presented and mean performance was analyzed with the possible interpretations. The analysis of variance showed significant variation in all the characters under study (Table 13). The mean values for each character of all the genotypes are shown in Table 14. Fruit p^H differed significantly in all the genotypes ranging from 3.77 to 4.33 (Table 14). The maximum p^H was observed in genotype G3 (4.33) followed by G4 (3.90) and G1 (3.87) and the lowest p^H found in the genotype G2 (3.77). Vitamin C contents of tomatillo fruit were varied significantly among the four tomatillo genotypes (Table 13). The average value of vitamin C of fruit varied from 0.00 mg/100 g to 3.29 mg/100 g (Table 14). Maximum vitamin C (3.29 mg/100 g) was found in G4 whereas minimum (0.00 mg/100 g) in G3 (Table 14). Dry matter content varied from 0.50 g to 1.20 g in G3 and in G1 respectively (Table 14). From the result of the experiment it was observed that brix (%) of tomatillo fruit was varied significantly among the four tomatillo genotypes (Table 13). The ranges of brix percentage were 3.27% to 5.83% in G3 and in G4 respectively (Table 14). The genotype G2 recorded maximum lycopene content (0.84 mg) followed by the genotypes G1 (0.70 mg) in case of 472 nm (Table 14), while the minimum was observed by the genotype G4 (0.22 mg) in case of 472 nm. In case of 502 nm highest lycopene content of fruit was observed in genotype G3 (0.95 mg) and the lowest was observed in the genotype G4 (0.07 mg) (Table 14). Colour of fruit is an important quality parameter both for table purpose and processing varieties. Environmental factors especially temperature and light intensity exerted a great influence on lycopene level than on carotene contents in tomato fruits. Red-fruiting cultivars also have higher lycopene content than yellow, orange and black- fruiting cultivars (Cox *et al.,* 2003). Moisture ranged was observed from 77.67% to 92.33%. Maximum moisture percentage was found by the genotype G2 (92.33%) and the minimum was observed from the genotype G1 (77.67%) (Table 14).

Table 13. Analysis of variance of the data on all the characters under study

Source of variation	Degree of freedom (df)	Mean sum of square						
		p^H	Vitamin C (mg/100 g)	Dry matter content (g/100 g)	Brix (%)	Lycopene (mg/100 g)		Moisture (%)
						472 nm	502 nm	
Replication	2	0.0008	0.0022	0.0308	0.0325	0.0006	0.0008	5.250
Genotype	3	0.1888**	6.2270**	0.3133**	3.9363**	0.2358**	0.4053**	129.194**
Error	6	0.0030	0.0022	0.0141	0.0213	0.0013	0.0010	1.361
Total	11							

** Significant at 1 % level.

Table 14. Mean performance of four genotypes of tomatillo in respect of six important nutritional traits

Genotype	p^H	Vitamin C (mg/100 g)	Dry matter content (g/100 g)	Brix (%)	Lycopene (mg/100 g)		Moisture (%)
					472 nm	502 nm	
G1	3.87 bc	0.61 c	1.20 a	4.00 b	0.70 b	0.70 b	77.67 c
G2	3.77 c	1.68 b	0.53 b	3.60 c	0.84 a	0.56 c	92.33 a
G3	4.33 a	0.00 d	0.50 b	3.27 d	0.44 c	0.95 a	90.33 ab
G4	3.90 b	3.29 a	0.70 b	5.83 a	0.22 d	0.07 d	88.67 b
CV %	1.39	3.40	16.23	3.50	6.52	5.42	1.34
$LSD_{(0.05)}$	0.11	0.10	0.24	0.29	0.07	0.06	2.33

Values with same letter(s) are statistically identical at 5% level of probability.
G1 = SAU Tomatillo 1, G2 = SAU Tomatillo 2, G3 = PI 003 and G4 = PI 004

11.3 **Evaluation based on stress tolerance:**

11.3.1 **Based on drought tolerance**: The experimental work was accomplished for the evaluation of four tomatillo genotypes to different drought treatments based on agromorphogenic, physiological and nutritional traits. Analysis of variance revealed that interaction between tomatillo genotypes and drought treatments significantly affected the yield per plant, brix percentage and proline content (Table 15 and Table 16). The interaction effect of tomatillo genotypes and drought treatments on all the characters under study is presented in Table 17 and in Table 18. Maximum yield (1.1998 kg/plant) was obtained from G_1T_1 while minimum yield (0.1435 kg/plant) from G_4T_3 (Table 18). The reduction percentage of yield per plant at treatment T_2 and treatment T_3 is presented in Table 19 and in Table 20. Minimum reduction of yield/plant was found in genotype G_1 at moderate drought stress (30 days) (reduction percentage 16.8%) and maximum was found in genotype G_4 (reduction percentage 76.5%) at severe drought stress (45 days) (Table 18). G_1 could be considered as the best genotype for moderate stress while G_4 for prolonged and severe drought stress. So, G_1 and G_4 could be a good source for improving yield under drought condition and could be included into future breeding programs.

Interaction of tomatillo genotypes and drought treatments showed significant variation in brix percentage (Table 16). Maximum brix in tomatillo (8.1800%) was obtained from G_1T_3 while minimum (4.1250%) from G_2T_1 which was statistically similar with G_3T_1 (4.6975%) (Table 18). The four genotypes varied significantly under drought in brix (%) of tomatillo fruit. The increasing percentage of brix at treatment T_2 and T_3 is presented in Table 20. Increase of brix (%) was found highest in genotype G_1 both at moderate drought stress (30 days) and at severe drought stress (45 days) (reduction percentage -39.71% and -61.18% respectively).

Interaction of tomatillo genotypes and drought treatments significantly affects Vitamin-C content (Table 16). Maximum Vitamin-C (11.677 mg/100 g) content was obtained from G_2T_1 while minimum (3.215 mg/100 g) from G_1T_3 which was statistically identical with G_3T_3 (3.674 mg/100 g) (Table 18). The four genotypes varied significantly under drought in Vitamin-C content. The reduction percentage of vitamin- C content at treatment T_2 and T_3 is presented in Table 20. Vitamin-C content decreased minimum in genotype G_1 both at moderate drought stress (30 days) and at severe drought stress (45 days) (reduction percentage 12.56667% and 31.41626% respectively) (Table 20).

Table 15. Analysis of variance of the data on days to first flowering, days to maturity, plant height, no. of fruits/plant, average fruit weight/plant, leaf length, leaf width, leaf L × W and Leaf L/W

Source of variation	Degrees of freedom (df)	Days to first flowering (DAS)	Days to maturity (DAT)	Plant height (cm)	No. of fruits/ Plant	Average fruit weight (g)	Leaf length (cm)	Leaf width (cm)	Leaf L × W (cm^2)	Leaf L/W
Factor A (genotype)	3	622.167^{NS}	141.02^{NS}	238.99^{NS}	79.91^{NS}	900.437*	33.467*	6.5041*	1551.3*	0.9028*
Factor B (Drought)	2	116.292*	2780.9*	2920.73^{NS}	843.937*	800.681*	17.926 ^{NS}	2.60896 ^{NS}	638.58 ^{NS}	0.1794 ^{NS}
A×B	6	93.708 ^{NS}	89.48 ^{NS}	71.41 ^{NS}	13.66 ^{NS}	35.015^{NS}	0.8186 ^{NS}	0.27951 ^{NS}	51.87 ^{NS}	0.2934 ^{NS}
Error	33	73.333	17.67	55.64	17.364	11.304	2.3376	0.30814	99.7	0.2286

*Significant at 0.01 level of probability; ^{NS} Non-significant

Table 16. Analysis of variance of the data on average fruit length, average fruit diameter, no. of seeds/fruit, yield/plant, Brix %, Vit. C, relative water content (RWC) and proline content

Source of variation	Degrees of freedom (df)	Average fruit length (cm)	Average fruit diameter (cm)	No. of seeds/ Fruit	Yield/ plant (kg)	Brix (%)	Vit. C (mg/ 100 g)	RWC (%)	Proline (µg/g)
Factor A (genotype)	3	0.35019^{NS}	0.33792^{NS}	42674.1^{NS}	0.49781*	6.027*	74.064*	198.39*	3567845*
Factor B (Drought)	2	0.70357*	0.94839*	41838.4*	1.60575*	21.4042 *	48.4271*	1387.34*	18800000*
A×B	6	0.02426 ^{NS}	0.05298 ^{NS}	2970.6 ^{NS}	0.05659*	0.6157*	2.5078*	5.73 ^{NS}	1037661*
Error	33	0.00993	0.01088	888.6	0.01181	0.0892	0.0771	3.61	18027.7

*Significant at 0.01 level of probability; ^{NS} Non-significant

Table 17. Interaction effect of tomatillo genotypes and drought treatments on days to first flowering, days to maturity, plant height, no. of fruits/plant, average fruit weight/plant, leaf length, leaf width, leaf L × W and Leaf L/W[Y]

Interaction[X]	Days to first flowering (DAS)	Days to maturity (DAT)	Plant height (cm)	No. of fruits/ plant	Average fruit weight (g)	Leaf length (cm)	Leaf width (cm)	Leaf L × W (cm^2)	Leaf L/W
$G_1 \times T_1$	46.000	68.25	77.947	29.000	41.378	11.000	4.0500	45.020	2.7099
$G_1 \times T_2$	47.250	85.50	81.863	25.000	39.923	11.125	4.0500	44.870	2.7602
$G_1 \times T_3$	48.250	91.00	52.973	13.500	22.253	9.000	2.8500	26.965	3.2483
$G_2 \times T_1$	47.250	69.25	74.085	26.750	32.935	9.325	2.6000	24.348	3.7458
$G_2 \times T_2$	48.750	86.50	65.330	23.000	29.725	7.975	2.1750	17.513	3.6483
$G_2 \times T_3$	48.250	103.25	49.780	12.750	19.775	6.425	1.9500	12.593	3.2851
$G_3 \times T_1$	45.500	72.50	85.588	23.500	29.220	9.600	3.4750	34.222	2.8954
$G_3 \times T_2$	46.250	74.25	75.643	22.000	21.775	9.650	2.8000	30.390	3.4403
$G_3 \times T_3$	48.000	97.25	53.335	11.250	16.900	7.750	2.6250	20.875	2.9602
$G_4 \times T_1$	51.000	76.75	70.693	33.250	18.520	6.925	2.3250	16.432	3.0081
$G_4 \times T_2$	55.000	87.25	69.620	23.750	14.968	6.650	1.9750	13.265	3.3480
$G_4 \times T_3$	60.500	100.50	51.703	18.000	8.197	5.725	1.8000	10.538	3.1746
CV%	2.035	2.035	2.035	2.035	2.035	2.035	2.035	2.035	2.035
LSD $_{(0.05)}$	----	----	----	----	----	----	----	----	----

[X]Four tomatillo genotypes coded from G_1 to G_4 and three drought treatments viz. T_1, Control; T_2, 30 days; T_3, 45 days
[Y]In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly
as per 0.05 level of probability

Significant variation was observed in proline content while tomatillo genotypes and drought treatments interact (Table 16). Maximum proline content in tomatillo (4923.1 µg/g) was obtained from G_1T_3 while minimum (1620.8 µg/g) from G_4T_1 which is statistically identical with G_1T_1 (1856.8 µg/g) (Table 18) (Plate 2). The four tomatillo genotypes varied significantly under drought for proline content**.** The increasing percentage of proline content at treatment T_2 and T_3 is presented in Table 20. Increasing of proline content was found the highest in genotype G_1 both at moderate drought stress (30 days) and at severe drought stress (45 days) (reduction percentage -217.65% and -165.14% respectively). So, G_1 could be considered as a source of high proline content genotype in both moderate drought stress and severe drought stress which can be transfer to a high yielding genotype. Increasing proline content with increasing drought stress is a good qualitative trait as proline is an indicator of stress tolerance.

Table 18. Interaction effect of tomatillo genotypes and drought treatments on average fruit length, average fruit diameter, no. of seeds/fruit, yield/plant, Brix %, Vit. C, relative water content (RWC) and proline content[Y]

Interaction[X]	Average fruit length (cm)	Average fruit diameter (cm)	No. of seeds/ Fruit	Yield/ plant (kg)	Brix (%)	Vit. C (mg/ 100 g)	RWC (%)	Proline (µg/g)
$G_1 \times T_1$	1.5900	1.7623	439.00	1.1998 a	5.0750 fg	4.687 g	94.055	1856.8 hi
$G_1 \times T_2$	1.3732	1.7623	362.75	0.9982 b	7.0900 bc	4.098 gh	86.510	4041.3 c
$G_1 \times T_3$	1.0008	1.0248	259.00	0.3020 h	8.1800 a	3.215 i	77.795	4923.1 a
$G_2 \times T_1$	1.1533	1.2585	325.00	0.8750 c	4.1250 h	11.677 a	91.910	2507.9 f
$G_2 \times T_2$	0.9825	1.1878	292.25	0.6797 bc	5.4750 f	8.881 c	84.360	3126.4 e
$G_2 \times T_3$	0.8050	0.8687	237.75	0.2442 I	6.5750 c	7.327 d	71.568	4115.5 b
$G_3 \times T_1$	1.1818	1.3465	365.25	0.6885 d	4.6975 gh	10.236 b	98.313	2387.1 f

$G_3 \times T_2$	1.1350	1.3465	345.25	0.4747 e	6.0575 e	6.907 e	90.022	3696.0cd
$G_3 \times T_3$	0.7630	0.8485	287.25	0.1885 g	7.3075 b	3.674 hi	78.720	4225.3 b
$G_4 \times T_1$	1.1007	1.1180	241.75	0.6107 de	4.8500 g	10.954 b	88.970	1620.8 i
$G_4 \times T_2$	0.9465	1.0735	231.50	0.3547 f	6.1500 d	7.879 d	79.297	2115.6gh
$G_4 \times T_3$	0.8022	0.8603	184.25	0.1435 j	7.4500 b	6.177 f	70.822	3557.3 d
CV%	2.035	2.035	2.035	2.035	2.035	2.035	2.035	2.035
LSD $_{(0.05)}$	----	----	----	0.1563	0.6475	0.8483	----	379.06

[X]Four tomatillo genotypes coded from G_1 to G_4 and three drought treatments viz. T_1, Control; T_2, 30 days; T_3, 45 days
[Y]In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly
as per 0.05 level of probability

Table 19. Reduction percentage of days to first flowering, days to maturity, plant height, no. of fruits/plant, average fruit weight/plant, leaf length, leaf width, leaf L × W and Leaf L/W with increasing drought stresses

	Days to first flowering (DAS)		Days to maturity (DAT)		Plant height (cm)		No. of fruits/ Plant		Average fruit weight (g)		Leaf length (cm)		Leaf width (cm)		Leaf L × W (cm^2)		Leaf L/W	
Genotype	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3
G_1	-2.72	-4.9	-25.27	-33.33	-5.024	32.04	13.79	53.45	3.52	46.22	-1.14	18.18	0	29.63	0.33	40.11	-1.86	-19.87
G_2	-3.17	-2.12	-24.91	-49.1	11.66	32.37	14.02	52.34	9.75	39.96	14.48	31.1	16.35	25	28.07	48.28	2.6	12.3
G3	-1.65	-5.15	-2.41	-34.14	11.62	37.68	6.38	51.06	25.48	42.16	-0.52	19.27	19.42	24.46	11.2	39	-18.82	-2.24
G_4	-7.84	-18.63	-13.77	-30.94	1.52	26.86	28.57	45.86	19.9	55.76	3.97	17.33	15.05	22.58	19.27	35.87	-11.3	-5.54

T_2: 30 days witholding of water; T_3: 45 days witholding of water

Table 20. Reduction percentage of average fruit length, average fruit diameter, no. of seeds/fruit, yield/plant, Brix %, Vit. C, relative water content (RWC) and proline content with increasing drought stresses

	Average fruit length (cm)		Average fruit diameter (cm)		No. of seeds/ Fruit		Yield/ plant (g)		Brix (%)		Vit. C (mg/ 100 g)		RWC (%)		Proline (μg/g)	
Genotype	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3	T_2	T_3
G_1	13.64	37.06	0	41.85	17.37	41	16.8	74.83	-39.71	-61.18	12.56667	31.41626	8.02	17.29	-217.65	-165.14
G_2	14.81	30.2	5.62	30.97	10.08	26.85	22.32	72.09	-32.73	-59.33	23.9445	37.2527	8.21	22.13	-24.66	-64.1
G_3	3.96	34.44	0	36.98	5.48	21.36	31.05	72.62	-28.95	-55.56	32.52247	64.10707	8.43	19.93	-54.83	-77.01
G_4	14.01	27.12	3.98	23.05	4.24	23.78	41.92	76.5	-26.8	-53.61	28.0719	43.60964	10.87	20.4	-30.53	-119.48

T_2: 30 days witholding of water; T_3: 45 days witholding of water

Considering the yield character, genotype G_1 could be recommended to the farmers of the northern region of Bangladesh. Regarding antioxidant and nutritional traits such as for Brix (%) and for Vitamin C content, G_1 followed by G_2 could be recommended for moderate as well as severe drought stress regions in Bangladesh. The above genotypes could be recommended as parent material for future hybridization or genetic transformation.

11.3.2 **Based on salt tolerance**: This experimental work was accomplished for the evaluation of four tomatillo genotypes exposed to three different salinity (NaCl) treatments based on their agromorphogenic, physiological and nutritional traits. Analysis of variance revealed that interaction between tomatillo genotypes and salt treatments significantly varied all the characters under study except for, days to first flowering and fruit p^H (Table 21 and Table 22). The interaction effect of tomatillo genotypes and salt treatments on all the character under study is presented in Table 23 and in Table 24. The plant height (cm) performed significant variation among the effect of interaction between four tomatillo genotypes and three salinity treatments (Table 21). The tallest plant was found in interaction G_2T_1 (74.33 cm) which was statistically similar with G_4T_3 (69.33 cm) while the shortest plant was found in interaction G_3T_2 (63.33 cm) which was statistically identical with G_2T_3 (63.83 cm) (Table 23). The plant height of four tomatillo genotypes varied significantly under three different salinity treatments and the height was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in plant height was observed in genotype G_2 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (13.22% and 14.13% respectively) and the minimum reduction was observed in genotype G_1 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (3.03% and 1.52% respectively). Genotype G_4 showed increase in plant height at both slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (-1.23% and -2.45% respectively) (Figure 1). According to Naidoo *et al.* (1995), the stimulatory effect of moderate salinity on growth of some plants can improve their growth and it may be due to the improved shoot osmotic status as a result of increasing ions uptake.

Interaction effect between four tomatillo genotypes and three salinity treatments was found statistically significant in respect of days to maturity (Table 21). The earliest fruit harvesting period was observed in interaction G_4T_3 (76.00 days) which was statistically identical to G_1T_3 (79.33 days) and G_2T_3 (80.33 days) whereas interaction G_3T_1 (96.00 days) was the most delayed one which was statistically identical to G_1T_1 (95.33 days) (Table 23). The time required for days to maturity or first harvesting of four tomatillo genotypes varied significantly under three different salinity treatment levels and the required maturity period was decreased gradually with the increase of salinity treatment levels. The maximum reduction in days to maturity was observed in the genotype G_1 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (8.04% and 16.78% respectively) and the minimum reduction was observed in genotype G_2 (6.12%) at slightly (8 dS/m) salinity stress whereas in G_3 (10.76%) at moderately (12 dS/m) salinity stress (Figure 2). Therefore, genotype G_1 might be considered as a good source for transferring the early maturity trait in a high yielding genotype of tomatillo under salinity stress condition.

Table 21. Analysis of variance of the data on days to first flowering, plant height, days to maturity, no. of fruits/plant, average fruit length, average fruit diameter, average fruit weight/plant, yield/plant and leaf area index

Source of variation	Degrees of freedom	Days to first flowering	Plant height (cm)	Days to maturity	No. of fruits/ Plant	Average fruit length	Average fruit diameter	Average fruit weight (g)	Yield/ plant (kg)	Leaf area index (cm^2)
Factor A (genotype)	3	21.741*	33.785*	79.185**	77.657**	210.711**	294.321**	679.396**	0.242**	25.398**
Factor B (Drought)	2	128.111**	38.715*	526.750**	75.028**	332.202**	387.963**	174.807**	0.164**	95.881**
A×B	6	1.741^{NS}	27.549*	40.935*	3.880**	9.152**	16.553**	2.763**	0.012**	1.755*
Error	22	5.679	9.967	10.303	0.498	1.613	1.426	0.482	0.001	0.483

**Significance at 0.01 level of probability; *Significant at 0.05 level of probability; ^{NS} Non-significant

Table 22. Analysis of variance of the data on fruit p^H, Brix (%), Titratable acid content, Vitamin C content, Chlorophyll content, Na^+ content, K^+ content and proline content

Source of variation	Degrees of freedom (df)	Fruit p^H	Brix (%)	Titratable acid content (%)	Vitamin C content (mg/100 g)	Chlorophyll content (%)		Na^+ content (%)	K^+ content (%)	Proline content (µg/g)
						30 days after salinity stress	60 days after salinity stress			
Factor A (genotype)	3	0.125^{NS}	3.751**	0.058**	50.797**	719.190**	210.440**	0.062**	2.075**	9477.870**
Factor B (Drought)	2	0.935**	75.871**	1.526**	237.798**	6349.490**	344.080**	2.245**	7.442**	5786.620**
A×B	6	0.064^{NS}	6.531**	0.225**	13.549*	54.750**	51.680*	0.018*	0.119*	1277.210**
Error	22	0.077	0.234	0.002	3.639	14.470	16.500	0.004	0.038	382.880

**Significance at 0.01 level of probability; *Significant at 0.05 level of probability; ^{NS} Non-significant

Analysis of variance revealed statistically significant variation in the interaction effect between four tomatillo genotypes and three salinity treatments in respect of number of fruits per plant (Table 21). The highest number of fruits was obtained from interaction G_3T_1 (21.33 fruits/plant) whereas the lowest number of fruits was obtained from G_2T_3 (9.00 fruits/plant) which was statistically identical with interaction G_1T_3 (9.67 fruits/plant) (Table 23). The number of fruits obtained per plant of four tomatillo genotypes varied significantly under three different salinity treatments and the number of fruits was decreased gradually with the increase of salinity treatment levels. The maximum reduction in number of fruits per plant was found in genotype G_1 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (16.29% and 40.78% respectively) whereas the minimum reduction was found in G_2 (12.45%) at slightly (8 dS/m) salinity stress and in G_4 (12.76%) at moderately (12 dS/m) salinity stress. Genotype G_4 (-2.11%) showed increased number of fruits per plant at slightly (8 dS/m) salinity level (Figure 2). Therefore, genotype G_4 might be considered as a good source of parent material for increased number of fruits per plant as it showed the minimum reduction at 12 dS/m and even increase at 8 dS/m saline condition.

Table 23. Interaction effect of tomatillo genotypes and drought treatments on days to first flowering, plant height, days to maturity, no. of fruits/plant, average fruit length, average fruit diameter, average fruit weight/plant, yield/plant and leaf area index^Y

Interaction^X	Days to first flowering	Plant height (cm)	Days to maturity	No. of fruits/ Plant	Average fruit length (mm)	Average fruit diameter (mm)	Average fruit weight (g)	Yield/ plant (kg)	Leaf area index (cm^2)
$G_1 \times T_1$	36.33	66.00 bc	95.33 ab	16.33 c	34.01 a	38.81 a	35.29 a	0.576 b	23.23 a
$G_1 \times T_2$	33.67	64.00 bc	87.67 cde	13.67 ef	24.33 c	28.23 d	30.53 c	0.417 d	18.90 b
$G_1 \times T_3$	29.67	65.00 bc	79.33 gh	9.67 h	18.74 e	21.51 fg	25.88 e	0.250 g	15.70 c
$G_2 \times T_1$	37.67	74.33 a	92.67 bc	13.33 f	24.85 c	30.07 cd	22.25 g	0.297 f	18.83 b
$G_2 \times T_2$	35.67	64.50 bc	87.00 de	11.67 g	20.26 de	22.58 f	18.92 h	0.221 gh	15.45 c
$G_2 \times T_3$	31.67	63.83 c	80.33 fgh	9.00 h	15.50 f	20.18 gh	14.85 i	0.134 i	13.70 de
$G_3 \times T_1$	35.33	66.50 bc	96.00 a	21.33 a	29.43 b	34.99 b	33.17 b	0.708 a	18.87 b
$G_3 \times T_2$	32.67	63.33 c	90.00 bcd	18.67 b	25.88 c	31.64 c	28.41 d	0.530 c	15.87 c
$G_3 \times T_3$	30.33	67.17 bc	85.67 def	14.67 de	20.96 d	24.81 e	24.55 f	0.360 e	14.83 cd
$G_4 \times T_1$	40.00	67.67 bc	90.33 bcd	15.67 cd	19.89 de	21.89 fg	14.64 i	0.229 gh	18.43 b
$G_4 \times T_2$	36.67	68.50 bc	83.67 efg	16.00 c	15.79 f	18.39 h	12.11 j	0.194 h	15.47 c
$G_4 \times T_3$	31.67	69.33 ab	76.00 h	13.67 ef	10.89 g	13.83 i	9.54 k	0.130 i	12.70 e
CV%	6.95	4.73	3.69	4.87	5.85	4.67	3.08	6.59	4.13
LSD $_{(0.05)}$	---	5.35	5.44	1.19	2.15	2.02	1.18	0.04	1.18

^{X}Four tomatillo genotypes coded from G_1 to G_4 and three drought treatments viz. T_1, Control; T_2, 30 days; T_3, 45 days
^{Y}In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly
as per 0.05 level of probability

Table 24. Interaction effect of tomatillo genotypes and drought treatments on fruit p^H, Brix (%), Titratable acid content, Vitamin C content, Chlorophyll content, Na^+ content, K^+ content and proline content[Y]

Interaction[X]	Fruit p^H	Brix (%)	Titratable acid content (%)	Vitamin C content (mg/100 g)	Chlorophyll content: 30 days after salinity stress	Chlorophyll content: 60 days after salinity stress	Na^+ content	K^+ content	Proline content
$G_1 \times T_1$	4.27	3.70 gh	0.51 hi	13.40 hi	85.47 bc	79.13 b	0.91 g	4.12 a	652.20 j
$G_1 \times T_2$	3.89	6.60 ef	0.85 e	18.50 def	63.90 d	57.33 d	1.39 e	3.42 bc	1569.90 h
$G_1 \times T_3$	3.52	8.12 c	1.25 b	22.05 bc	36.17 g	31.17 g	1.74 c	2.68 d	3093.30 d
$G_2 \times T_1$	4.17	3.90 gh	0.56 h	14.75 ghi	102.43 a	95.67 a	1.02 fg	3.58 b	1342.30 i
$G_2 \times T_2$	4.06	6.50 ef	0.89 e	20.85 cd	79.20 c	72.13 c	1.46 de	2.32 e	2230.50 f
$G_2 \times T_3$	3.87	9.20 b	1.28 ab	24.60 ab	59.07 de	51.23 de	1.91 ab	1.75 f	3569.30 c
$G_3 \times T_1$	4.34	4.30 g	0.64 g	17.50 efg	85.93 b	80.50 b	0.97 fg	3.97 a	1361.50 i
$G_3 \times T_2$	4.21	7.10 de	0.97 d	21.80 bc	62.23 d	57.20 d	1.35 e	3.23 c	2814.00 e
$G_3 \times T_3$	3.99	10.21 a	1.34 a	25.80 a	39.83 fg	33.47 fg	1.82 bc	2.51 de	4233.80 b
$G_4 \times T_1$	4.38	3.33 h	0.46 i	11.80 i	89.37 b	83.20 b	1.08 f	3.13 c	1717.20 g
$G_4 \times T_2$	4.23	5.90 f	0.77 f	16.50 fgh	53.77 e	47.90 e	1.54 d	2.67 d	2995.70 d
$G_4 \times T_3$	3.58	7.80 cd	1.15 c	20.50 cde	44.67 f	39.23 f	1.97 a	1.56 f	4553.70 a
CV%	6.85	7.58	4.75	10.04	5.69	6.69	4.63	6.68	2.35
$LSD_{(0.05)}$	---	0.82	0.07	3.23	6.44	6.88	0.11	0.33	99.93

[X]Four tomatillo genotypes coded from G_1 to G_4 and three drought treatments viz. T_1, Control; T_2, 30 days; T_3, 45 days
[Y]In a column means having similar letter (s) are statistically identical and those having dissimilar letter(s) differ significantly
as per 0.05 level of probability

Interaction effect between four tomatillo genotypes and three salinity treatments was found statistically highly significant in respect of average fruit length (Table 21). The longest fruit was found from interaction G_1T_1 (34.01 mm) whereas the shortest fruit was found from interaction G_4T_3 (10.89 mm) (Table 23). The average fruit length (mm) of four tomatillo genotypes varied significantly under three different salinity treatment levels and the fruit length was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in average fruit length per plant was observed in genotype G_1 (28.46%) at slightly (8 dS/m) salinity stress and in G_4 (45.25%) at moderately (12 dS/m) salinity stress whereas the minimum reduction was observed in genotype G_3 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (12.06% and 28.78% respectively) (Figure 3). Therefore, genotype G_3 might be considered as a good source of parent material as it showed the minimum reduction in case of average fruit length under both slightly (8 dS/m) and moderately (12 dS/m) salinity levels.

The average fruit diameter showed highly significant variation in respect of the effect of interaction between four tomatillo genotypes and three salinity treatment levels (Table 21). The maximum diameter of fruit was obtained from interaction G_1T_1 (38.81 mm) whereas the minimum fruit diameter was from interaction G_4T_3 (13.83 mm) (Table 23). The average fruit diameter (mm) per plant of four tomatillo genotypes varied significantly under three different salinity treatments and the diameter of fruit was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in average fruit diameter (mm) per plant was observed in genotype G_1 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (27.26% and 44.58% respectively) whereas the minimum reduction was observed in genotype G_3 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (9.57% and 29.09% respectively) (Figure 3). Therefore, genotype G_3 might be considered as a good source of parent material as it showed the minimum reduction in case of average fruit diameter (mm) per plant under both at slightly (8 dS/m) and moderately (12 dS/m) salinity stress condition.

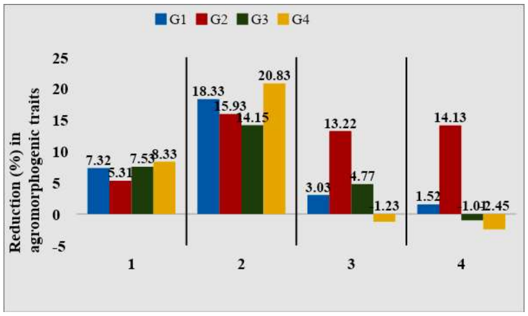


Figure 1. Reduction percentage in days to first flowering and plant height under increasing salinity stress

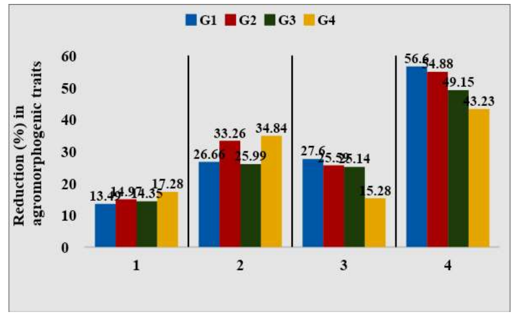


Figure 2. Reduction percentage in days to first flowering and plant height under increasing salinity stress

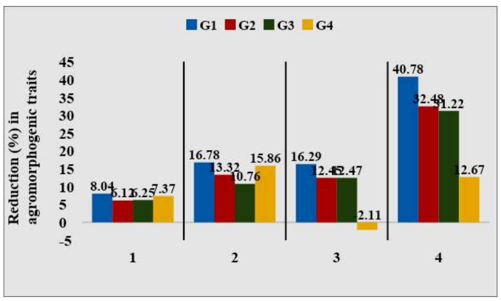


Figure 3. Reduction percentage in average fruit length and average fruit diameter under increasing salinity stress

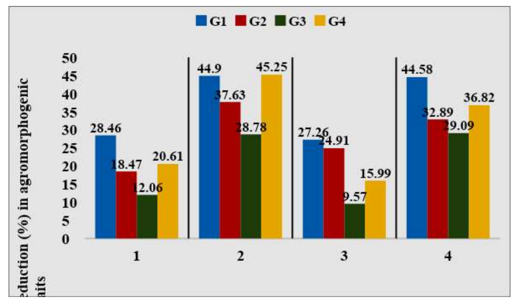


Figure 4. Reduction percentage in average fruit weight and yield per plant under increasing saline

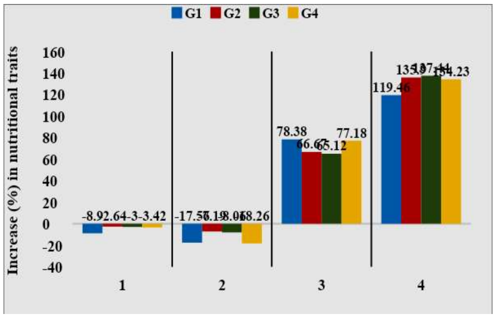
Interaction effect between tomatillo genotypes and salinity treatments was found statistically highly significant in respect of average fruit weight (Table 21). The maximum weight of fruit was found from interaction G_1T_1 (35.29 g) whereas the minimum fruit weight was found from interaction G_4T_3 (9.54 g) (Table 23). The average fruit weight of four tomatillo genotypes varied significantly under three different salinity treatments and the weight of fruit was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in average fruit weight was observed in genotype G_4 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (17.28% and 34.84% respectively) whereas the minimum reduction was observed in genotype G_1 (13.49%) at slightly (8 dS/m) salinity stress and in G_3 (25.99%) at moderately (12 dS/m) salinity stress (Figure 4). Therefore, genotype G_1 and G_3 might be considered as good source of parent materials as these showed the minimum reduction in case of average fruit weight (g) under slightly (8 dS/m) and moderately (12 dS/m) salinity stress condition respectively.

Interaction effect between tomatillo genotypes and salinity treatments was found statistically highly significant in respect of fruit yield per plant (Table 21). The highest yield of fruit was found in interaction G_3T_1 (0.708 kg/plant) whereas the lowest fruit yield was found in interaction G_4T_3 (0.130 kg/plant) which was statistically identical with G_2T_3 (0.134 kg/plant) (Table 23). The yield of fruit per plant (kg) of four tomatillo genotypes varied significantly under three different salinity treatments and the yield per plant was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in yield of fruit per plant was observed in genotype G_1 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stress (27.60% and 56.60% respectively) whereas the minimum reduction was observed in genotype G_4 at both slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (15.28% and 43.23% respectively) (Figure 4). Therefore, genotype G_4 might be considered as a good source of parent material as it showed the minimum reduction in case of yield (kg) per plant under both at slightly (8 dS/m) and moderately (12 dS/m) salinity stress condition.

The interaction effect between tomatillo genotypes and salinity treatments was found statistically highly significant in respect of the amount of brix content (%) (Table 22). The highest amount of brix content was found in interaction G_3T_3 (10.21%) whereas the lowest amount of brix content was found in the interaction G_4T_1 (3.33%) which was statistically similar with G_1T_1 (3.70%) and G_2T_1 (3.90%) (Table 24). The amount of brix content (%) of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of brix content was mainly increased gradually with the increase of salinity treatment levels. The maximum increase in the brix content amount was observed in genotype G_1 (78.38%) at slightly (8 dS/m) salinity stress and in G_3 (137.44%) at moderately (12 dS/m) salinity stress while the minimum increase was observed in genotype G_3 (65.12%) at slightly (8 dS/m) salinity stress and in G_1 (119.46%) at moderately (12 dS/m) salinity stress (Figure 5). Therefore, genotype G_1 and G_3 might be considered as good source of parent materials as these showed the maximum increase in brix percentage of tomatillo fruits under slightly (8 dS/m) and moderately (12 dS/m) salinity stress conditions respectively.

The interaction effect between tomatillo genotypes and salinity treatments was found statistically highly significant in respect of the amount of titratable acid content (%) (Table 2). The highest amount of titratable acid content was found in interaction G_3T_3 (1.34%) which was statistically identical with G_2T_3 (1.28%) whereas the lowest amount of titratable acid content was found in the interaction G_4T_1 (0.46 %) which was statistically identical with G_1T_1 (0.51%) (Table 24). The amount of titratable acid content of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of titratable acid content was mainly increased gradually with the increase of salinity treatment levels. The maximum increase in the titratable acid content amount was observed in genotype G_4 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (67.39% and 150.00% respectively) while the minimum increase was observed in genotype G_3 in both cases, at slightly (8 dS/m) and moderately (8 dS/m) salinity stresses (51.56% and 109.38% respectively) (Figure 6). Therefore, genotype G_4 might be considered as a good source of parent material as it showed the maximum increase in titratable acid content of tomatillo fruits under both slightly (8 dS/m) and moderately (12 dS/m) salinity stress conditions. The interaction effect between tomatillo genotypes and salinity treatments was found statistically significant in respect of the amount of vitamin C content in tomatillo fruits (Table 22). The highest amount of vitamin C content was found in interaction G_3T_3 (25.80 mg/100 g) which was statistically identical with G_2T_3 (24.60 mg/100 g) whereas the lowest amount of vitamin C content was found in the interaction G_4T_1 (11.80 mg/100 g) which was statistically identical with G_1T_1 (13.40 mg/100 g) and G_2T_1 (14.75 mg/100 g) (Table 24).

The amount of vitamin C content (mg/100 g) of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of vitamin C content was mainly increased gradually with the increase of salinity treatment levels. The maximum increase in the vitamin C content amount was observed in genotype G_2 (41.37%) at slightly (8 dS/m) salinity stress and in G_4 (73.73%) at moderately (12 dS/m) salinity stress whereas the minimum increase was observed in genotype G_3 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (24.57% and 47.43% respectively) (Figure 6). Therefore, genotype G_2 and G_4 might be considered as good source of parent materials as these showed the maximum increase in vitamin C (mg/100 g) content of tomatillo fruits under slightly (8 dS/m) and moderately (12 dS/m) salinity stress conditions respectively.



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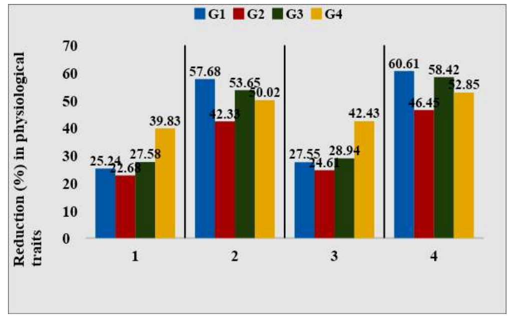

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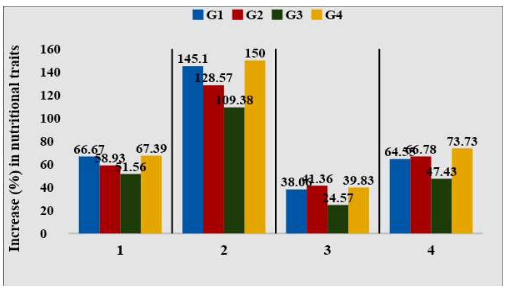

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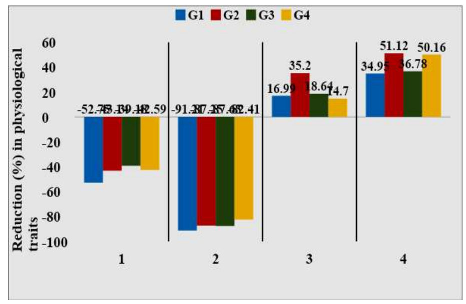


4

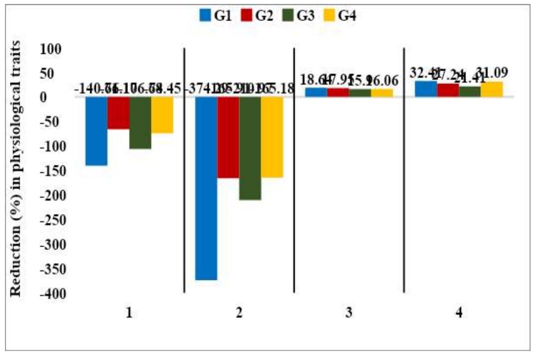
The interaction effect between tomatillo genotypes and salinity treatments was found statistically highly significant in respect of chlorophyll content (%) of plant leaves (SPAD reading) after 30 days of starting stress application (Table 22). The highest amount of chlorophyll content was found in interaction G_2T_1 (102.43%) while the lowest amount of chlorophyll content was found in the interaction G_1T_3 (36.17%) which was statistically identical with G_3T_3 (39.83%) (Table 24). The amount of chlorophyll content of plant leaves (SPAD reading) after 30 days of starting stress application of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of chlorophyll content was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in the amount of chlorophyll content was observed in genotype G_4 (39.83%) at slightly (8 dS/m) salinity stress and in G_1 (57.68%) at moderately (12 dS/m) salinity stress whereas the minimum reduction was observed in genotype G_2 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (22.68% and 42.33% respectively) (Figure 7). Therefore, genotype G_2 might be considered as a good source of parent material as it showed the minimum reduction in chlorophyll (%) content (SPAD reading) under both at slightly (8 dS/m) and moderately (12 dS/m) salinity stress conditions.

The interaction effect between tomatillo genotypes and salinity treatments was found statistically significant in respect of chlorophyll content (%) of plant leaves (SPAD reading) after 60 days of starting stress application (Table 22). The highest amount of chlorophyll content was found in interaction G_2T_1 (95.67%) while the lowest amount of chlorophyll content was found in the interaction G_1T_3 (31.17%) which was statistically identical with G_3T_3 (33.47%) (Table 24). The amount of chlorophyll content of plant leaves (SPAD reading) after 60 days of starting stress application of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of chlorophyll content (SPAD reading) was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in the amount of chlorophyll content was observed in genotype G_4 (42.43%) at slightly (8 dS/m) salinity stress and in G_1 (60.61%) at moderately (12 dS/m) salinity stress whereas the minimum reduction was observed in genotype G_2 in both cases, at slightly (8 dS/m) and moderately (8 dS/m) salinity stresses (24.61% and 46.45% respectively) (Figure 7). Therefore, genotype G_2 might be considered as a good source for minimum reduction in chlorophyll (%) content (SPAD reading) under both at slightly (8 dS/m) and moderately (12 dS/m) salinity stress conditions.

The interaction effect between tomatillo genotypes and salinity treatments was found statistically significant in respect of the amount of indigenous Na^+ content (Table 22). The highest amount of Na^+ content was found in interaction G_4T_3 (1.97%) which was statistically identical with G_2T_3 (1.91%) whereas the lowest amount of Na^+ content was found in the interaction G_1T_1 (0.91%) which was statistically identical with G_3T_1 (0.97%) and G_2T_1 (1.02%) (Table 24). The amount of Na^+ content of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of Na^+ was mainly increased gradually with the increase of salinity treatment levels. The maximum increase in the amount of indigenous Na^+ content was observed in the genotype G_1 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (-52.75% and -91.21% respectively) whereas the minimum increase was observed in genotype G_3 (-39.18%) at slightly (8 dS/m) salinity stress and in G_4 (-82.41%) at moderately (12 dS/m) salinity stress (Figure 8). Therefore, genotype G_3 and G_4 might be considered as desirable genotypes as they showed the minimum increase in indigenous Na^+ content (%) in plant shoots under slightly (8 dS/m) and moderately (12 dS/m) salinity stress conditions respectively.

The increase of Na^+ concentration in the root zone of plant gradually decreases the uptake of K^+ in plants and thus, reduce the indigenous K^+ concentration in stressed plant shoots (Edris *et al.*, 2012). Similar phenomenon was found in this experiment. The interaction effect between tomatillo genotypes and salinity treatments was found statistically significant in respect of the amount of indigenous K^+ content (%) in plant shoots (Table 14). The highest amount of indigenous K^+ content was found in interaction G_1T_1 (4.12%) which was statistically identical with G_3T_1 (3.97%) whereas the lowest amount of indigenous K^+ content was found in the interaction G_4T_3 (1.56%) which was statistically identical with G_2T_3 (1.75%) (Table 16). The amount of indigenous K^+ content in plant shoots of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of indigenous K^+ was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in the amount of indigenous K^+ content was observed in genotype G_2 in both cases, at slightly (8dS/m) and moderately (12 dS/m) salinity stresses (35.20% and 51.12% respectively) while the minimum reduction was observed in genotype G_4 (14.70%) at slightly (8 dS/m) salinity stress and in G_1 (34.95%) at moderately (12 dS/m) salinity stress (Figure 8). Therefore, genotype G_4 and G_1 might be considered as desirable genotypes as they showed the minimum reduction in indigenous K^+ content in plant shoots under slightly (8 dS/m) and moderately (12 dS/m) salinity stress conditions respectively.

The proline content was estimated from all four genotype under three different salinity treatment to evaluate proline accumulation as an indicator of drought stress and drought tolerance. Proline accumulation in whole plants showed clear genotypical differences. A positive correlation between the degree of proline accumulation and drought tolerance was found. The interaction effect between tomatillo genotypes and salinity treatments was found statistically highly significant in respect of the amount of proline content (µg/g) (Table 22). The highest amount of proline content was found in interaction G_4T_3 (4553.70 µg/g) whereas the lowest amount of proline content was found in the interaction G_1T_1 (652.20 µg/g) (Table 16). The amount of proline content (µg/g) of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of proline content was mainly increased gradually with the increase of salinity treatment levels. The maximum increase in the amount of proline content was observed in genotype G_1 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (-140.71% and -374.29% respectively) whereas the minimum increase was observed in genotype G_2 (-66.17%) at slightly (8 dS/m) salinity stress and in G_4 (-165.18%) at moderately (12 dS/m) salinity stress (Figure 9). Therefore, the genotype G_1 might be considered as a good source of parent material as it showed the maximum increase in proline content under both at slightly (8 dS/m) and moderately (12 dS/m) salinity stress conditions.



The interaction effect between tomatillo genotypes and salinity treatments was found statistically significant in respect of the amount of leaf area index (cm^2) of tomatillo plant (Table 21). The highest amount of leaf area was found in interaction G_1T_1 (23.23 cm^2) while the lowest amount of leaf area was found in the interaction G_4T_3 (12.70 cm^2) which was statistically similar with G_2T_3 (13.70 cm^2) (Table 23). The amount of leaf area index (cm^2) of four tomatillo genotypes varied significantly under three different salinity treatments and the amount of leaf area was mainly decreased gradually with the increase of salinity treatment levels. The maximum reduction in the amount of leaf area was observed in genotype G_1 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (18.64% and 32.41% respectively) whereas the minimum reduction was observed in genotype G_3 in both cases, at slightly (8 dS/m) and moderately (12 dS/m) salinity stresses (15.90% and 21.41% respectively) (Figure 9). Therefore, genotype G_3 might be considered as a good source of parent material as it showed the minimum reduction in leaf area index (cm^2) under both at slightly (8 dS/m) and moderately (12 dS/m) salinity stress.

When plants are grown under saline conditions, the excess of salts modifies the metabolic activities of the cell wall causing the deposition of various materials which limit the cell wall elasticity. The other expected causes of the reduction in yield per plant, leaf area and yield components in tomatillo could be the shrinkage of the cell contents, reduced development and differentiation of tissues, unbalanced nutrition, damage of membrane and disturbed avoidance mechanism. The reduction in leaf area, yield and yield components under saline conditions were also due to reduced growth as a result of decreased water uptake, toxicity of sodium and chloride in the shoot cell as well as reduced photosynthesis. Reduction in chlorophyll concentrations is probably due to the inhibitory effect of the accumulated ions of various salts on the biosynthesis of the different chlorophyll fractions. Salinity affects the strength of the forces bringing the complex pigment protein liquid, in the chloroplast structure. As the chloroplast in membrane bound its stability is dependent on the membrane stability which under high salinity condition seldom remains intact due to which reduction in chlorophyll was recorded. Salt tolerance is not a function of single organ or plant attribute, but it is the product of all the plant attributes. Therefore, a genotype exhibiting relative salt tolerance for all the plant attributes may be ideal one. Fortunately, the genotypes studied viz. G_1 (SAU tomatillo1) and G_3 (PI003) have shown comparatively minimum salinity induced reduction for the plant attributes. The genotypes could be used as donors for further improvements by hybridization or by any other gene transfer method to establish definite relation with yield, chlorophyll concentration and leaf area. Further study would be initiated with this basic information. By using these genotypes in breeding programme, an improved ideotype of tomatillo having higher chlorophyll concentration, more leaf area, early and better yield potential will be selected. This genotype possessing salt tolerance character will help in boosting up tomatillo production in salt-affected soils.

12. **Research highlight/findings (Bullet point – max 10 nos.):**
    - Adaptation of an eco-friendly crop (no pesticides were used),
    - The fruit yield per plant in all three AEZ are 1.86 to 3.07 Kg in Dhaka, 2 to 2.7 Kg in Noakhali and 2.2 to 3 Kg in Rangpur. G3 (PI003) showed highest yield per plant in all three locations,
    - Minor influence of environment and high degree of genetic variability present on the expression of studied characters, indicated the heritable nature of the traits. Thus a greater scope for effective selection exists based upon phenotypic expression of these characters for the improvement of this crop in all three locations. The high heritability coupled with high genetic advance at percent of mean of most of the traits might be due to additive gene effects and selection may be effective in early generations for these traits,
    - Significant positive correlation with yield was found in average fruit weight, fruit length and fruit diameter in all three locations of Dhaka, Noakhali and Rangpur. So, selection may be effective due to these contributing components influence the yield directly or indirectly,
    - Tomatillo could be a promising crop in Bangladesh as they are high yielder and selection could be applied for desired characters such as increased number of fruits per plant, fruit weight, fruit diameter and fruit length to develop high yielding varieties. PI003 (G_3) and SAU tomatillo 1 are the highest yielding and could be recommended to the farmers for cultivation,
    - All the genetic analysis showed similar results in three different independent experiments in three AEZ of Bangladesh for different agromorphogenic traits in tomatillo,
    - Short-durated (85-90 days),
    - Two previously released varieties of tomatillo (SAU tomatillo 1 and SAU tomatillo 2) were extended to the farmers at three agro-ecological zones of Bangladesh. A third line of tomatillo (PI003) is ready for variety registration.
    - SAU tomatillo 1 followed by SAU tomatillo 2 showed minimum reduction of yield and its component characters and nutritional traits such as Brix (%) and Vitamin C content at moderate to severe drought stress.
    - SAU tomatillo 1 and PI003 showed minimum reduction in the yield and most of the yield contributing characters under slightly to moderately salinity stresses.
    - PI003 showed better quality under slight to moderate salinity regarding brix percentage, titratable acid and vitamin C content and could be recommended for quality traits in saline region of Bangladesh.
    - Adaptation of "Tomatillo" which has good nutritional and medicinal values having anti-cancer, anti-cardiovascular and anti-bacterial properties (previous researches, Choi *et al*., 2006; Quiros, 1984).
    - Virus attack is absent (visual observation) and bird eating and fruit borer attack is absent due to the husk of tomatillo (visual observation).
    - Inter genotypic crosses program could also be taken,

B. Implementation Position

1. Procurement:

Description of equipment and capital items	PP Target		Achievement		Remarks
	Phy (#)	Fin (Tk)	Phy (#)	Fin (Tk)	
(a) Office equipment	Computer - 1, printer -1 scanner-1	98000	Computer, printer and scanner	98000	
(b) Lab &field equipment					
(c) Other capital items					

2. Establishment/renovation facilities:

Description of facilities	Newly established		Upgraded/refurbished		Remarks
	PP Target	Achievement	PP Target	Achievement	
Net house, laboratory and growth chamber renovation and repair			349500	349500	

3. Training/study tour/ seminar/workshop/conference organized: N/A

Description	Number of participant			Duration (Days/weeks/ months)	Remarks
	Male	Female	Total		
(a) Training					
(b) Workshop					

C. Financial and physical progress

Fig in Tk

Items of expenditure/activities	Total approved budget	Fund received	Actual expenditure	Balance/ unspent	Physical progress (%)	Reasons for deviation
A. Contractual staff salary	247674	247674	247674	0	100%	
B. Field research/lab expenses and supplies	799254	799254	799254	0	100%	
C. Operating expenses	258626	257440	255335	2105 (balance at bank)	99.54%	Tk. 1186 not yet received
D. Vehicle hire and fuel, oil & maintenance	121520	121520	121520	0	100%	
E. Training/workshop/seminar etc.	0	0	0	0	-	
F. Publications and printing	85000	0	0	85000 (not yet received)	0%	Tk. 85000 not yet received
G. Miscellaneous	6000	6000	6000	0	100%	
H. Capital expenses	98000	98000	98000	0	100%	

D. Achievement of Sub-project by objectives:

Specific objectives of the sub-project	Major technical activities performed in respect of the set objectives	Output(i.e. product obtained, visible, measurable)	Outcome(short term effect of the research)
On-farm research trials of tomatillo based on agro-morphogenic traits	• Selection of experimental site in three different districts • Review collection • soil and climate analysis • Preparation of seedbed and raising of seedlings • layout of the main field (RCBD with three replications) • manure and fertilizer application • transplanting of seedlings • intercultural operation • harvesting • data collection and analysis	• Adapted well in all three agro-ecological zones of Bangladesh. • PI003 genotype of tomatillo found high yielding among all other genotypes of tomatillo in all three agro-ecological zones of Bangladesh.	• PI003 is the best among all other genotype of tomatillo regarding yield in three different AEZ of Bangladesh.
Biochemical analysis of tomatillo based on nutritional and antioxidant traits	• fruits harvesting • preparation of solutions • extraction of different nutritional and antioxidant components • estimation • data analysis	• PI003 genotype of tomatillo contains highest brix percentage and highest vitamin C content. • The highest dry matter content was observed in SAU tomatillo 1	• PI003 is the best among all other genotypes of tomatillo regarding high brix % and high vitamin C content
ng and physiological analyses of tomatillo against salt and drought stress	• growing of tomatillo plants in pots • providing of drought and salt stress • Identification of drought and salt tolerant genotypes based on agromorphogenic, nutritional and physiological traits.	• SAU tomatillo1 followed by SAU tomatillo 2 showed tolerance against drought at moderate as well as severe drought stress considering yield characters and nutritional traits such as Brix (%) and Vitamin C content • Genotype SAU tomatillo 1 and PI003 showed tolerance against slight to moderate salinity based on agromorphogenic and nutritional data. Physiological analysis such as indegenous Na+ and K+ion content, proline content and leaf area index as tolerance indicators also supported their tolerance against high salinity.	• SAU tomatillo 1 and SAU tomatillo 2 could be recommended to the farmers for cultivation in the Northern part of Bangladesh. • SAU tomatillo 1 could be recommended to the farmers for cultivation in the Southern and coastal belt of Bangladesh. • PI003 along with SAU tomatillo 1 found best regarding tolerance to high salinity.

E. Materials Development/Publication made under the Sub-project:

Publication	Number of publication		Remarks (e.g. paper title, name of journal, conference name, etc.)
	Under preparation	Completed and published	
Technology bulletin/ booklet/leaflet/flyer etc.			
Journal publication	2		**1. Genetic diversity analysis in tomatillo (*Physalis ixocarpa* Brot./ *Physalis philadelphica* Lam.) based on agromorphogenic traits** **2. Genetic diversity analysis in tomatillo (*Physalis ixocarpa* Brot./ *Physalis philadelphica* Lam.) based on nutritional traits** **Journal of experimental Bioscience**
Information development			
Thesis		4	**Two completed in 2018 and Two completed in 2019**

F. Technology/Knowledge generation/Policy Support (as applied):

i. Generation of technology (Commodity)

ii Generation of new knowledge that help in developing more technology in future

iii. Technology transferred that help increased agricultural productivity and farmers' income

iv. Policy Support

.

G. Information regarding Desk and Field Monitoring

i) Desk Monitoring[description & output of consultation meeting, monitoring workshops/seminars etc.):

N/A

ii) **Field Monitoring (time & No. of visit, Team visit and output): (Appendix 4)**

Name of visitor(s)	Designation	Date(s) of visit	Total visit till date (No.)	Output
Dr. Md. Nazrul Islam	Director SAURES	12.12.2017	1	Gave Suggestions and guideline
Dr. Md. Abdul Jalil Bhuyan	Research management specialist PIU, BARC	13.12.2017	1	
Dr. Md. Aziz Zilani Chowdhury	Member Director (Crops), BARC	22.02.2018	1	
Md. Rafique Ahsan Chowdhury	BARC	22.02.2018	1	

H. Lesson Learned/Challenges (if any)

i) The experiments were performed at three different locations of Bangladesh and due to curtail of budget (from the proposed budget), it was a challenge to complete the research in all locations Besides physiological and nutritional analysis required huge chemicals. It was difficult but somehow managed.

ii) Lack of spectrophotometer create huge problem to measure different parameters. Learned how to manage. An application with quotation was submitted to the Director, PIU, BARC to increase the budget to buy a spectrophotometer. Some machineries and equipment are essential for this type of research.

iii) Release of fund was slow.

I. Challenges (if any)

i) Spreading of this crop all over the country at farmers' level is a great challenge.
ii) Further research for the development of this crop particularly inter-genotypic hybridization is required.
iii) Gene transfer program and marker assisted selection is required for the accuracy of the gene transfer.
iv) Transtriptional profile analysis is required to observe the expression of desirable genes in tomatillo genotypes against stress tolerance.
v) Marketing of tomatillo and extension work for awareness is also a great challenge.

Signature of the Principal Investigator

Date ………………………….

Seal

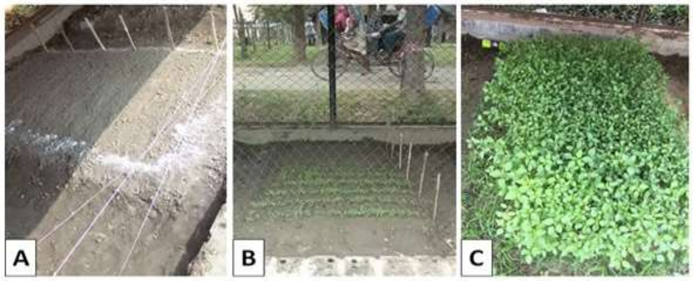
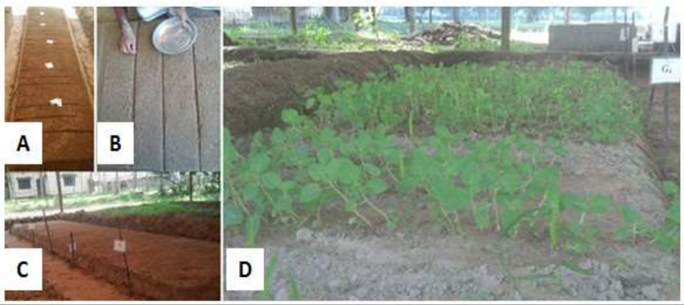
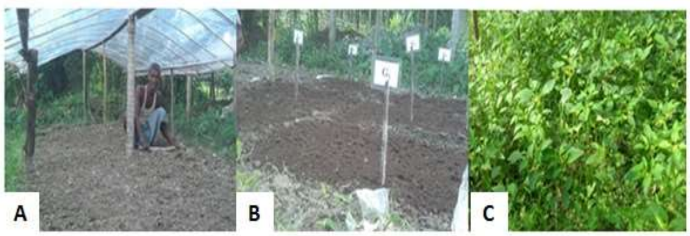
Counter signature of the Head of the organization/authorized representative

Date …………………………..

Seal

Appendix 1.

A. Seedbed preparation and raising of seedlings in three different locations

Dhaka		Seedbed preparation and raising of seedlings in Dhaka on 26-10-2017. A. seedbed preparation, B. Germination of seedlings, C. Seedlings for transplanting
Rangpur		Seedbed preparation and sowing of seed in Rangpur on 06-10-2017. A. Seedbed preparation, B. Sowing of seed, C. Tagging and labeling after sowing, D. Seedling in the seedbed in Rangpur
Noakhali		Seedbed preparation and sowing of seed in Noakhali on 16-10-2017. A. Seedbed preparation, B. Tagging and labeling of different genotypes in Noakhali, C. Seedling in the seedbed in Noakhali

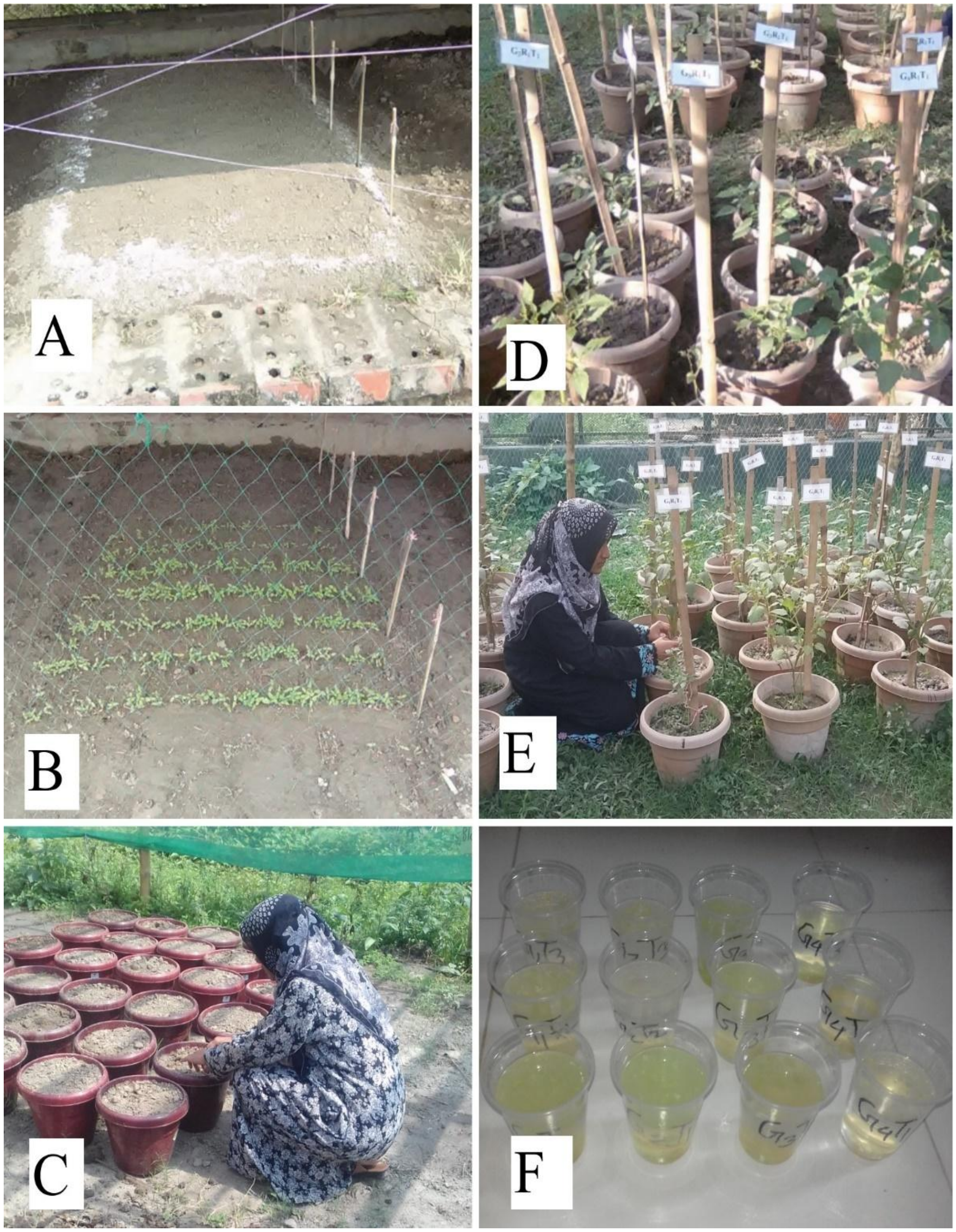
B. Land preparation to harvesting in different locations.

Dhaka		Land preparation Transplanting, Seedling in the main field, Intercultural operation, monitoring and harvesting stage at Sher-e-Bangla Agricultural University, Dhaka-1207

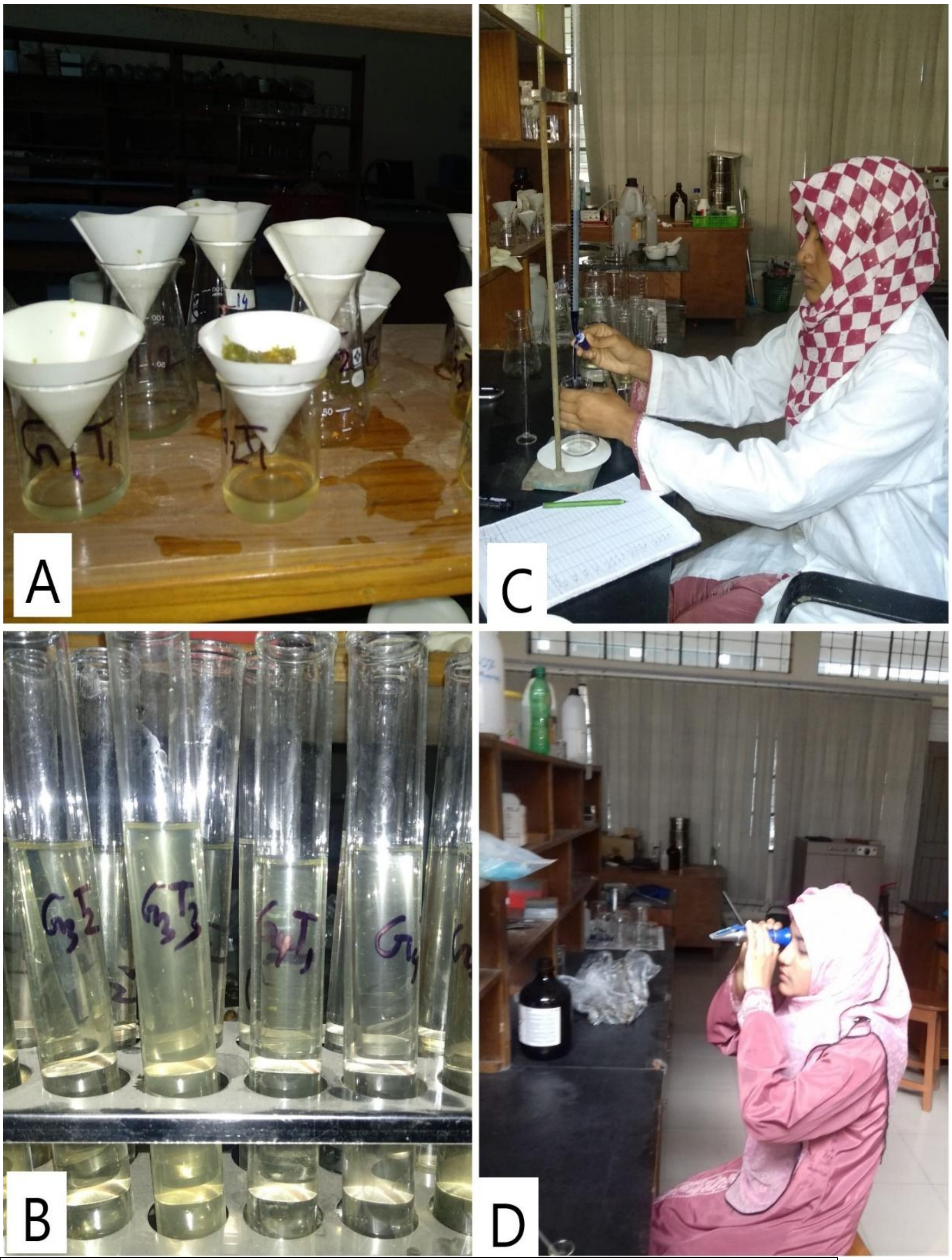
Rangpur		Land preparation, transplanting, seedling in the main field, and harvesting stage at Darshana, Rangpur
Noakhali		Land preparation, transplanting, seedling in the main field, and harvesting stage at Somir Munshir Haat, Noakhali.

Appendix 2.

Different stages of experiments conducted in net house for screening of tomatillo genotypes against drought



A) Seedbed preparation and sowing of seeds, B) Raising of seedlings, C) Plastic pot preparation, D) Transplanting and tagging of seedlings in the pot, E) Weeding in the pot and F) Seed extraction of four tomatillo genotypes



A) and B) Data recording steps in the Laboratory on proline content, C) Estimation of Vitamin C by Oxidation Reduction Titration Method in the Laboratory and D) Determination of Brix (%) by using Portable Refractometer in the Laboratory

Different stages of experiments conducted in net house for screening of tomatillo genotypes against salinity

A) Seedlings in the seedbed, B) Transplantation of seedlings, C) Tying seedlings with bamboo stick, D) Measuring EC of saline water, E) application of saline water and F) Measuring pH of soil

Appendix 4.

Field monitoring by Dr. Md. Aziz Zilani Chowdhury, Member Director (Crops), BARC and
Professor Dr. Md. Nazrul Islam, Director (SAURES), SAU