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OPTIMIZING GROWING CONDITION AND PLANTING DATE FOR GROWTH, YIELD AND QUALITY OF SQUASH IN BANGLADESH

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ABSTRACT

An experiment was conducted at the Vegetable Research field of Horticulture Research Centre Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh, during October 2018 to March 2019 to find out the effect of growing condition and planting date on yield and yield attributes of squash. The experiment comprised two sets of treatments viz., (a) Growing conditions: (i) Open cultivation (C_1); (ii) Net protected cultivation (C_2) and Cultivation with barrier crop (C_3) and (b) Planting dates: (i) 1 November (D_1); (ii) 15 November(D_2); (iii) 1 December (D_3) and (iv) 15 December (D_4) in a randomized complete block design (RCBD) with three replications. The variety BARI squash-1 was used in this experiment. The results showed that net protected cultivation showed significantly the highest fruit plant^{-1}, fruit length, yield plant^{-1} and yield ha^{-1}. Growing condition did not affect quality parameters of quash. Early planting (1 November) showed significantly higher yield, yield attributes and quality parameters than late planting. Fruit diameter did not showed any significant difference irrespective of planting date. The interaction between growing condition and planting dates was significant for yield and quality parameters. Based on the study results it is concluded that maximum yield (49.33 t ha^{-1}) and quality of BARI squash-1 could be achieved through cultivation under net protected condition with 1 November planting.

Keywords: Squash, Growing condition, Planting dates, Yield and quality.

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INTRODUCTION

Bangladesh ranked in third, in terms of the worldwide vegetables production. Considering health issue, vegetables are the cheapest source of vitamins and minerals. Squash (*Cucurbita pepo* L.) is one of the important cucurbit vegetables belongs to the family Cucurbitaceae and is grown throughout the world in both temperate and tropical climatic zones. This crop is relatively new in Bangladesh, but it is gaining popularity day by day as well as growing in economic significance, both in terms of generating cash and providing nutritional value.

Squash has various health benefits to human as well as medicinal potentials (Mohammad *et al.,* 2011). It contains a variety of vitamins, minerals, amino acids, carbohydrates, and minerals, especially potassium, as well as phenolics, flavonoids, β-carotene, vitamin A, vitamin B_2, α-tocopherol, vitamin C, and vitamin E. It has various medicinal effects comprising anti-diabetic, anti-hypertensive, anti-tumor, anti-mutagenic, immune modulating, anti-bacterial, anti-hypercholestero-lemic, intestinal anti-parasitic, antalgic, and anti-inflammation effects, and utilization possibilities of Cucurbitacious crops have been reported (Kostalova *et al*., 2009). It grows well in cool, moist weather conditions than others in the genus. This crop requires 60-70 days as fruits are harvested only few days after bloom. Squash requires 16-27°C temperature for normal growth and development (Lincoln, 1987). It is generally consumed at young immature stage before skin becomes hard. Variation in planting dates affects not only the yield but other characters as well. Squash seeds are germinate above 15°C temperature. Whitakar and Davis (1962) reported that stem elongation was increased with rise in temperature (17-26 °C day and 12-14 °C night).

Through protected cultivation quality and productivity of squash increasing many fold compared than under open field cultivation. Singh *et al.* (2005) conducted a study during 3 season of January-April (2001-2003) under protected and open conditions at New Delhi to study the effect of protected and unprotected condition (open field) on biotic stress, yield and economics of squash (*Cucurbita pepo* L.) variety of "Pusa Alankar". The incidence of biotic stress (insect-pests), plant mortality and use of chemical insecticides are minimum under protected condition. Fruit yield (kg $plant^{-1}$), gross income, net income (Rs $plant^{-1}$), cost: benefit ratio and money saving were higher under protected condition.

Squash cultivation has a great opportunity in Bangladesh as a quick growing vegetable. Keeping in view the present scenario of growing importance of this crop in the Bangladesh, the present studies have been undertaken to workout standardize planting time for optimizing production and also to find out the suitable growing condition for higher yield per unit area.

MATERIALS AND METHODS

Research Location

The research work was conducted at Vegetable Research field of Horticulture Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Gazipur, Bangladesh during the period of October 2018 to March 2019. The experimental site is located at 24.0° N latitude and 95.25°E longitude, respectively (UNDP, 1988) at an elevation of 8.4 meters from the sea level (Anon., 1995). Top soil was sandy clay loam in texture having a pH around 6.0. The selected plot was medium high land. Plenty of sunshine and moderately low temperature prevails during experimental period. The weather data during the study period are presented in Table 1.

Table 1. Monthly mean weather data during the crop growing periods at BARI, Gazipur

Year	Month	Temperature (°C)			Relative humidity (%)		Sunshine (hr./day)	Total rainfall (mm)
		Maximum	Minimum	Average	9 am	2 pm		
	October	32.10	23.17	27.64	80.16	64.06	5.89	67.4
2018	November	30.87	18.67	24.77	76.20	54.87	7.38	42
	December	27.08	14.79	20.94	78.61	55.26	6.10	9.2
	January	28.14	13.25	20.70	77.32	46.84	7.23	0
2019	February	29.41	15.39	22.40	78.25	49.36	7.08	93.4
	March	32.00	19.43	25.72	72.39	52.29	7.39	126

Source: Physiology Division, Bangladesh Rice Research Institute, Joydebpur, Gazipur, Bangladesh.

Experimental Design

The experiment consisted of two factors. Factor A: Growing conditions (3) *viz*. (i) Open cultivation (C_1); (ii) Net protected cultivation (C_2) and (iii) Cultivation with barrier crop (C_3) and (b) Planting dates (4): (i) 1 November (D_1); (ii) 15 November (D_2); (iii) 1 December (D_3) and (iv) 15 December (D_4) (Plate 1). The experiment was conducted in a randomized complete block design (RCBD) with three replications. The variety BARI squash-1 was used in this experiment. The layout of the experiment was prepared for distributing the combination of growing conditions and different planting dates. The 12 treatment combinations of the trail were assigned at arbitrary into 36 plots. The size of each unit plot 3 m × 2 m (= 6 m^2). The distance between block to block 1.0 m and plots to plot distance was 0.5 m.

Raising of seedlings and crop management

The seeds of BARI Squash-1 were collected from Olericulture Division, Horticulture Research Centre (HRC), BARI, Gazipur. The seeds of BARI Hybrid Maize-16 (as barrier crop) were collected from Plant Breeding Division, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. Squash seeds were sown on 13 October 2018, 28 October 2018, 12 November 2018 and 29 November 2018 according to treatments on in poly bags at net house of olericulture division of BARI. Seeds were sown in polybags which were filled with loose friable, dead roots free, sandy loam soil previously mixed with well rotten cowdung. Eighteen days old seedlings were transplanted in the experimental plots. One fourth of cowdung (20 t ha^{-1}) and all of gypsum (100 kg ha^{-1}) zinc (12.5 kg ha^{-1}) and borax (10 kg ha^{-1}), ½ TSP (175 kg ha^{-1}) and 1/3rd MoP (150 kg ha^{-1}) were applied, respectively during final land preparation. Cowdung @ 10 kg, TSP @ 60 g, MoP @ 50 g and Magnesium Oxide @ 8 g were applied in each pit 7-10 days before planting. Urea @ 30 g is to be top dressed each pit at 4 split applications and MoP @ 25g to be applied 10-15 days after planting according to Krishi Projukti Hatboi (BARI, 2015). Healthy and uniform sized 18 days old seedlings were taken from the net house and were transplanted in the main field on 1 November, 15 November, 1 December and 15 December, 2018 according to treatments. 1m × 1m plant spacing was maintained for transplanting. This operation was carried out during late hour of afternoon. The seedlings were watered after transplanting. The insects were controlled successfully by spraying Malathion 57 EC @ 2 ml/L water. The insecticide was sprayed fortnightly from a week after transplanting to a week before first harvesting. Squash fruits were harvested during maturity stage. Harvesting was started from 14 December, 2018 and completed by 6 March, 2019. Harvesting was done in the morning. The harvested squashes of each plot collect separately, tagged and taken to laboratory for data collection.

Plate 1. Photograph showing different growing condition (a) Open cultivation (Control) (b) Net protected cultivation (60 mesh) (c) Cultivation with barrier crop

Data collection and analysis method

The following data were collected from the experiment

Fruit length:

The length of the fruit was measured with a meter scale in centimeter from the neck of the fruit to the bottom of the fruit. It was measured from each plot and their average was calculated in centimeter.

Fruit diameter:

The diameter of individual fruit was measured in several directions from five selected fruits with slide calipers and the average of all directions was finally recorded and expressed in centimeter (cm).

Individual fruit weight:

From first harvest to last harvest total fruit number was counted and total fruit weight was measured from each plant of each plot to determine individual fruit weight and expressed in kilogram (kg).

Yield plant^{-1}:

Weight of matured fruits harvested from each picking in the tagged plants in each replication was recorded till final harvest and total yield of fruits per plant computed in kilogram.

Yield ha^{-1}:

After collection of fruit per plot, it was converted to ton per hectare by the following formula:

$$\text{Yield (ton ha}^{-1}) = \frac{\text{Fruit yield plot}^{-1}\text{ (kg)} \times 10000\ \text{m}^2}{\text{Plot size (m}^2) \times 1\,000\ \text{kg}}$$

TSS:

Total Soluble solids (TSS) content was determined by a refractometer by placing of drop of pulp on its prism. TSS obtained from direct reading of the refractometer.

Vitamin-C content:

The reagent used for the estimation of vitamin C were as follows

a) Metaphoporic acid solution (3%)

b) Standard ascorbic solution

c) Dye solution

For estimation of vitamin C were as follows

Five ml of Standard ascorbic solution was taken in conical flask and 5 ml metaphoporic acid (HPO_3) was added to it and shaken.

A micro burette was filled with dye solution then the mixed solution was titrated with dye using phenolphthalein as indicator solution to a pinked coloured end point, which persisted at least for 15 seconds. Dye factor was calculated using to the following formula-

$$\text{Dye factor} = \frac{0.5}{\text{Titre}}$$

Preparation of sample

10 g of sample was taken and transferred to 250 ml volumetric flask and the volume was made up to the mark with metaphosphoric acid.

Titration

Five ml of metaphosphoric acid extracted sample was taken in an aliquot and titrated with standard dye solution, using phenolphthalein as indicator to a pink coloured end point which persisted at least for 15 seconds.

Vitamin C content was calculated using to the following formula-

$$\text{Vitamin C content (mg/100 g sample)} = \frac{T \times D \times V_1}{V_2 \times W} \times 100$$

Where,

T = Titre

D= Dye factor

V_1= Volume made up

V_2= Volume of extract taken for estimation

W= Weight of sample taken for estimation

Virus incidence (%):

Incidence of virus disease recorded during the cropping period. Virus incidence was calculating by counting number of virus infected plants out of total number of plants assessed on two/three dates at 15 days interval, 30 days, 45 days and 60 days after transplanting. Percent data related to virus disease incidence is further subjected to angular transformation.

$$\text{Virus incidence (\%)} = \frac{\text{Number of virus infected plant}}{\text{Total number of pants assessed}} \times 100$$

Statistical analysis of data:

The recorded quantitative data were analyzed statistically by using MSTAT-C a computer based program to find out the variation among different treatments,

treatment combinations and their interactions. Treatment means were compared by Least Significant Difference (LSD) Test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Effect of growing conditions

The result presented in Table 2 show that significant effect of growing condition on fruit plant^{-1}, fruit length, yield plant^{-1} and yield ha^{-1}. Growing condition did not play any significant impact on individual fruit weight and fruit diameter. The maximum number of fruits plant^{-1} (3.39) was obtained from net protected cultivation (C_2) while open cultivation condition (C_1) gave minimum number of fruits plant^{-1} (2.24). The longest fruit (43.66 cm) was found from net protected cultivation (C_2) and shortest (33.58 cm) fruit was found from open cultivation condition (C_1). The highest yield plant^{-1} (3.43 kg) and yield ha^{-1} (34.08 t) were also found from net protected cultivation condition (C_2) whereas the lowest yield plant^{-1} (2.18 kg) and yield ha^{-1} (22.04 t) were found from open cultivation condition (C_1). For several crops, including green beans (Gogo *et al*., 2014b), tomatoes (Gogo *et al*., 2014a) and cabbage (Vidogbéna *et al*., 2015); net protected cultivation techniques increased marketable yield.

The result presented in Table 3 show that there was no significant effect of growing condition on total soluble solid (TSS) and vitamin C content.

Table 2. Yield parameters of squash as influenced by different growing conditions

Growing conditions	Yield parameters					
	Fruit plant^{-1} (no.)	Individual fruit weight (kg)	Fruit length (cm)	Fruit diameter (cm)	Yield plant^{-1} (kg)	Yield (t ha^{-1})
C_1	2.24 b	0.92	33.58 b	7.14	2.18 b	22.04 b
C_2	3.39 a	0.97	43.66 a	7.85	3.43 a	34.08 a
C_3	2.29 b	0.93	34.33 b	7.20	2.20 b	22.29 b
$LSD_{0.05}$	0.104	NS	0.7806	NS	0.128	0.969
CV (%)	4.58	12.13	2.48	1.95	5.88	4.38

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.

C_1 = Open cultivation (Control), C_2 = Net protected cultivation, C_3 = Cultivation with barrier crop.

Table 3. Quality parameters regarding TSS and vitamin C content of squash as influenced by different growing conditions

Growing conditions	Quality parameters	
	TSS (%)	Vitamin C content (mg/100g)
C_1	5.58	12.79
C_2	5.69	12.96
C_3	5.60	12.93
$LSD_{0.05}$	NS	NS
CV (%)	2.18	1.60

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

C_1 = Open cultivation (Control), C_2 = Net protected cultivation, C_3 = Cultivation with barrier crop.

Effect of planting date

The result presented in Table 4 show that there were significant effects of planting dates on fruit plant^{-1}, individual fruit weight, fruit length, yield plant^{-1} and yield ha^{-1}. Fruit diameter did not differ significantly due to planting dates. The maximum number of fruits plant^{-1} (3.54), highest individual fruit weight (1.12 kg), longest fruit (44.79 cm), highest yield plant^{-1} (3.98 kg) and yield ha^{-1} (39.56 t) were found from early planting (01 November) (D_1) whereas the minimum number of fruits plant^{-1} (1.53), lowest individual fruit weight (0.68 kg), shortest fruit (26.98 cm), lowest yield plant^{-1} (1.17 kg) and yield ha^{-1} (10.94 t) were found from late planting (15 December)(D_4). Jerry and Hmod (2011), Latifi *et al*. (2012) and Wadas and Mioduszewska, (2011) also reported that early plantation of squash contributed higher fruit number than late plantation. Khanuma *et al*. (2021) and Seong *et al*. (2004); they reported that early plantation of squash gave higher individual fruit weight whereas reduced fruit weight was recorded with delayed plantation. Khanuma *et al*. (2021) also reported that early plantation gave maximum fruit yield ha^{-1} of squash whereas delay plantation showed less yield ha^{-1} which result was also supported by the findings of Shivaprakash *et al*. (2018), Latifi *et al*. (2012) and Jerry and Hmod (2011).

The result presented in Table 5 also showed that there was significant effect of planting date on total soluble solid (TSS) and vitamin C content. The highest total soluble solid (TSS) (5.97%) and maximum vitamin C content (13.59 mg/100g) was recorded from 01 November planting (D_1) and the lowest vitamin C content (12.12 mg/100g) was recorded from 15 December planting (D_4).

Table 4. Yield parameters of squash as influenced by different planting dates

Planting dates	Yield parameters					
	Fruit plant^{-1} (no.)	Individual fruit weight (kg)	Fruit length (cm)	Fruit diameter (cm)	Yield plant^{-1} (kg)	Yield (t ha^{-1})
D_1	3.54 a	1.12 a	44.79 a	7.86	3.98 a	39.56 a
D_2	3.01 b	1.04 a	40.47 b	7.79	3.16 b	31.67 b
D_3	2.48 c	0.90 b	36.53 c	7.38	2.21 c	22.39 c
D_4	1.53 d	0.68 c	26.98 d	6.57	1.07 d	10.94 d
$LSD_{0.05}$	0.120	0.112	0.901	NS	0.148	1.119
CV (%)	4.58	12.13	2.48	1.95	5.88	4.38

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

D_1 = 1 November, D_2 = 15 November, D_3 = 1 December, D_4 = 15 December

Table 5. Quality parameters regarding TSS and vitamin C content of squash as influenced by different planting dates

Planting dates	Quality parameters	
	TSS (%)	Vitamin C content (mg/100g)
D_1	5.97 a	13.59 a
D_2	5.83 a	13.18 b
D_3	5.44 b	12.69 c
D_4	5.24 c	12.12 d
$LSD_{0.05}$	0.155	0.111
CV (%)	2.18	1.60

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

D_1 = 1 November, D_2 = 15 November, D_3 = 1 December, D_4 = 15 December

Interaction effect of growing condition and planting date

Interaction effect of growing conditions and planting dates showed significant effect on fruit plant^{-1}, individual fruit weight, fruit length, fruit diameter, yield plant^{-1} and yield ha^{-1} (Table 6). The maximum number of fruits plant^{-1} (4.30), highest individual fruit weight (1.17 kg), longest fruit (49.0 cm), highest fruit diameter (8.23 cm), highest yield plant^{-1} (4.97 kg) and yield ha^{-1} (49.33 t) were found fromnet protected growing condition with 01 November planting (C_2D_1). Nevertheless the minimum number of fruits plant^{-1} (1.20), lowest individual fruit weight (0.65 kg), shortest fruit

(21.97 cm), lowest fruit diameter (6.20 cm), lowest yield plant^{-1} (0.82 kg) and yield ha^{-1} (8.83 t) were found from open cultivation condition with 15 December planting (C_1D_4) (Table 6).

Table 7 presented interaction effect of growing condition and planting date had significant effect on total soluble solid (TSS) and vitamin C content. The highest total soluble solid (TSS) (6.03%) and maximum vitamin C content (13.70 mg/100g) was recorded from C_2D_1 but the lowest TSS (5.20%) was found C_1D_4. The lowest vitamin C content (12.10 mg/100 g) was recorded in C_1D_4 and of C_3D_4 (cultivation with barrier crop condition with 15 December planting).

Table 6. Yield parameters of squash as influenced by different growing conditions and planting dates.

Growing conditions× Planting dates	Yield parameters					
	Fruit plant^{-1} (no.)	Individual fruit weight (kg)	Fruit length (cm)	Fruit diameter (cm)	Yield plant^{-1} (kg)	Yield (t ha^{-1})
C_1D_1	3.10 c	1.10 ab	42.20 d	7.60 d	3.45 c	34.33 c
C_1D_2	2.63 d	1.03 ab	38.07 e	7.70 cd	2.65 e	26.00 e
C_1D_3	2.03 e	0.90 bc	32.10 g	7.07 e	1.82 f	19.00 f
C_1D_4	1.20 f	0.65 d	21.97 h	6.20 f	0.82 h	8.83 h
C_2D_1	4.30 a	1.17 a	49.00 a	8.23 a	4.97 a	49.33 a
C_2D_2	3.87 b	1.10 ab	45.17 b	8.07 ab	4.32 b	43.33 b
C_2D_3	3.30 c	0.90 bc	44.33 bc	7.90 bc	2.93 d	29.00 d
C_2D_4	2.10 e	0.70 cd	36.13 f	7.20 e	1.48 g	14.67 g
C_3D_1	3.23 c	1.10 ab	43.17 cd	7.73 cd	3.53 c	35.00 c
C_3D_2	2.53 d	1.00 ab	38.17 e	7.60 d	2.50 e	25.67 e
C_3D_3	2.10 e	0.91 bc	33.17 g	7.17 e	1.87 f	19.17 f
C_3D_4	1.30 f	0.70 cd	22.83 h	6.30 f	0.90 h	9.33 h
$LSD_{0.05}$	0.207	0.193	1.561	0.245	0.257	1.938
CV (%)	4.58	12.13	2.48	1.95	5.88	4.38

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

C_1 = Open cultivation (Control), C_2 = Net protected cultivation, C_3 = Cultivation with barrier crop. D_1 = 1 November, D_2 = 15 November, D_3 = 1 December, D_4 = 15 December

Table 7. Quality parameters regarding TSS and vitamin C content of squash as influenced by different growing conditions and planting dates

Growing conditions× Planting dates	Quality parameters	
	TSS (%)	Vitamin C content (mg/100g)
C_1D_1	5.90 ab	13.47 b
C_1D_2	5.80 b	13.10 c
C_1D_3	5.40 cd	12.50 e
C_1D_4	5.20 d	12.10 f
C_2D_1	6.03 a	13.70 a
C_2D_2	5.93 ab	13.23 c
C_2D_3	5.53 c	12.73 d
C_2D_4	5.27 d	12.17 f
C_3D_1	5.97 ab	13.60 ab
C_3D_2	5.77 b	13.20 c
C_3D_3	5.40 cd	12.83 d
C_3D_4	5.27 d	12.10 f
$LSD_{0.05}$	0.207	0.1931
CV (%)	2.18	1.60

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

C_1 = Open cultivation (Control), C_2 = Net protected cultivation, C_3 = Cultivation with barrier crop. D_1 = 1 November, D_2 = 15 November, D_3 = 1 December, D_4 = 15 December

CONCLUSION

From the study, it may be concluded that, growing condition and planting dates have shown statistically significant variation among the parameters studied under the experiment. Net protected cultivation showed the best performance than other growing conditions in respect of yield and quality parameters. On the other hand, early planting (01 November) gave highest performance than late planting. Squash cultivated under net protected condition with planted on 1 November produced significantly the highest number of fruits per plant (4.3) and yielded the highest (49.33 t ha^{-1}). Individual fruit weight, fruit length, fruit diameter a well as quality parameters like, TSS and vitamin C content also significantly the highest in above mentioned treatment combinations.

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