Tropical Agricultural Research & Extension 25 (3): 2022

RESEARCH ARTICLE

MORPHOLOGICAL CHARACTERIZATION AND YIELD PERFORMANCE OF EXOTIC OKRA (*Abelmoschus esculentus*) GENOTYPES AT SYLHET SADAR, BANGLADESH

Sumi FN[1], Islam AFMS[1], Hasan MM[1], Tabassum R[1] and Monshi FI[*2]

[1]Department of Crop Botany and Tea Production Technology, Faculty of Agriculture, Sylhet Agricultural University, Bangladesh

[2]Department of Genetics and Plant Breeding, Faculty of Agriculture, Sylhet Agricultural University, Bangladesh

Received: 08 June 2022, Accepted: 06 August 2022

ABSTRACT

Okra (*Abelmoschus esculentus*) is one of the most important green fruit vegetables in Bangladesh and is grown in all parts of the country. However, its production varies in the different agroecological regions. Thus, the present study was conducted in the Sadar Sylhet region, Bangladesh to assess the exotic okra genotype(s) based on morphological, reproductive and yield attributes. A total of 10 Japanese okra genotypes (JO-1 to JO-10) were comparatively evaluated with the BARI Dherosh-1 (control) in a randomized complete block design in triplicates. All the morphological features viz. stem colour, leaf, vein, petiole, pedicel, epicalyx, sepal and fruits were demonstrated almost similar in all the studied genotypes except JO-5. Considering reproductive traits, results showed the significant variations amid the studied genotypes and an individual genotype performed better in some unique traits. The highest number of flowers (17), fruit setting (84.56 %) and fruits per plant (14.1) was obtained in the genotype JO-7 while JO- 3 possessed maximum ovary length (1.5cm), fruit weight (23.86g) which in turn produced the heaviest fruit. The highest yield was recorded in the genotype JO-7 yielded the highest fruit yield (14.08 t ha-1) followed by JO-9 (11.92 t ha-1) and JO-3 (11.22 t ha-1) while the lowest yield was recorded in JO-5 (2.47 t ha-1). In conclusion, the genotypes JO-7, JO-9 and JO-3 may be promising lines for cultivating exotic okra in the Sylhet region, Bangladesh.

Keywords: attributes, evaluation, exotic genotype, morphology, okra, yield

INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench.) is an important vegetable crop in family Malvaceae. The popularity of its consumption become increased due to its intrinsic nutritional elements such as balanced essential amino acids, dietary fibers, carbohydrates, vitamins and minerals (Gemede *et al.* 2014; Petropoulos *et al.* 2018). Its polyphenols and flavonoids also acquire significant antioxidant and anti-fatigue constituents (Xia *et al.* 2015), which can be act as therapeutics to reduce blood cholesterol, diabetes, ulcers and neurodegenerative diseases (Elkhalifa *et al.* 2021; Kamalesh *et al.* 2016; Mohammed *et al.* 2022a). So, increasing its production is a crucial need to ensure global food security.

Vegetables in Bangladesh are grown mainly in two seasons- winter and summer which are not uniformly distributed throughout the year, however, most of them are cultivated in the winter season (Akter 2016). And only a few vegetables are grown in the summer season due to adverse climatic conditions (Hossain *et al.* 2019) because their production depends on soil and climate (Comas *et al.* 2010). In addition, 75% of urban and 92% of rural people in Bangladesh consumed fruits and

Corresponding author: monshifi.gpb@sau.ac.bd

vegetables which are much less than the WHO/ FAO recommended dose of a minimum of 400 g (Mustafa *et al.* 2021). Therefore, increasing the production of vegetables per unit area is important to fill the daily requirement as well as more economic growth which ultimately uplifts the farmers' socio-economic condition in the country (Rahman 2017).

In 2021-2022, the total production of okra in Bangladesh was recorded as 928 thousand metric tons from 473 thousand acres of land in which Sylhet district alone produced 267.13 metric tons using 255 acres of land (BBS 2022). Comparing its countrywide acreage and production, Sylhet district contributed a very negligible amount as this region is covered under one of the special AEZs (Agro-ecological Zone) of Bangladesh (AEZ-20: Eastern Surma Kushiyara Flood plain) which have typical soil properties, resulting in the yield loss (Paul *et al.* 2021; Rahman *et al.* 2020). The soil of this region is acidic (pH 4.5 to 6.5) with high content of iron and aluminium (Rahman *et al.* 2015; Tabassum *et al.* 2015). Many researches have already been tested in this region for different crops (Chy *et al.* 2022; Monshi *et al.* 2015; Roy *et al.* 2016, Sarker *et al.* 2022) but their performance was not up to the recommendations. Therefore, crop-specific intensive research needs to be assessed to increase the productivity by selecting appropriate genotypes for this region (Rahman *et al.* 2020).

The introduction and adaptation of a specific crop depends on the genetic as well as environmental factors (Snowdon *et al*. 2021). Cultivation of okra in this region is little challenging due to low yielding local varieties, insects, pests and diseases infestation with sub optimal plant densities (Shawon *et al.* 2020; Tanni *et al.* 2019). And yield of okra is a complex character, which is dependent on a number of morphological and yield contributing traits (Ansari *et al.* 2020; Mohammed *et al.* 2022b; Ola *et al.* 2021). Therefore, the present study was conducted to assess the morphological characteristics and reproductive variability of okra genotypes to evaluate their performance in Sylhet Sadar region, Bangladesh.

MATERIALS AND METHODS

Experimental site and materials

The experiment was conducted at the research farm of the Department of Crop Botany & Tea Production Technology, Sylhet Agricultural University, Bangladesh during April to August 2018. The soil of the experimental fields belongs to the Khadimnagar soil series under AEZ-20 (Eastern Surma Kushiyara Flood plain) is clay loam and acidic. The soil pH of the research field was measured (4.81) by Soil pH meter at the Regional Station of Soil Resource Development Institute, Sylhet, Bangladesh. Ten exotic okra genotypes (JO-1(JO; Japanese Okra), JO-2, JO-3, JO-4, JO-5, JO-6, JO-7, JO -8, JO-9 and JO-10) were collected from Japan and one local cultivar namely BARI Dherosh-1 was used as control.

Experimental design and layout

The experiment was laid out in a Randomized Complete Block Design with three replicates. The experimental field was divided into three blocks representing three replications and each block had four individual plots. The size of experimental plot was 2.8m × 0.8m. The adjacent blocks and neighboring plots were separated by 0.70m and 0.50m, respectively. The total number of plots were 33. Recommended fertilization according to Bangladesh Agricultural Research Institute, Gazipur, Bangladesh guidelines (Urea, Triple super phosphate, Muriate of potash, Gypsum, Zinc sulphate and Borax @150, 100, 150, 40, 10 and 8Kg/ha, respectively), irrigation, weeding, pest control, mulching and other management operations were carried out as per the crop requirement.

Data collection

Some morphological visible parameters including stem color, leaf color, vein color, petiole pubescence, pedicel color, epicalyx color, ovary pubescence fruit color, fruit length and fruit width were measure and enlisted in the table 1. The number of days taken to first flowering was recorded when the first flower appeared in each treatment. Similarly, the number of days for 50% of flowering was recorded and from first days of flowering to last flowering date i.e. flowering

duration was also recorded. Fruit picking duration varies genotype to genotype. To evaluate the fruit growth in terms of size and weight, fruits within common harvesting dates are needed to be analyzed. Under this consequence, ten randomly selected fruits were harvested from five days after flowering (DAF) to eight DAF. In case of fruit length (cm), a meter scale was used to measure length. Similarly, in fruit diameter (mm) data were measured by a slide calipers at three points (tip, middle and base) of fruit. Fresh weight of the fruits (g) was recorded by using digital weighing balance and after taking the fresh weight fruits and kept in a fresh paper bag and placed into the oven at 70ºC until constant dry weight was found. After drying, the samples were taken out from the oven and cooled in a desiccator and the dry weight of fruit (g) was recorded. The individual fruit weight (g) and the number of fruits at each harvest was counted and weighed. Then the individual fruit weight was calculated through dividing the total weight by total number of fruits. Yield at the research farm was calculated in ton per ha.

Statistical analysis

The quantitative parameters were statistically analyzed. In case of reproductive features, the mean of six flowers was calculated and in fruit growth parameters, ten randomly selected fruits were taken and mean was calculated. The data were analyzed using R-Studio statistical software (Developed by JJ Allaire which was published by Chapman and Hall/CRC; 2nd edition) and the differences among the treatment means were compared by Duncan's New Multiple Range Test (Gomez and Gomez, 1984) at the 5% probability level.

RESULTS AND DISCUSSION

Morphological features

All the exotic genotypes produced erect plant with no branching habit, palmatisect shape of leaf, lanciolate shape of epicallyx segments, large size flowers with yellow colour petal, white colour style and staminal coloum and green colour ovary with dark maroon colour segment of stigma. Other visible morphological traits and colour varied significantly among the exotic okra genotypes (Table 1). Variations in growth and branching habit, stem pubescence and epicalyx segment, leaf shape and stem color, petiole color, petal and fruit colour were reported by many researchers in their previous studies in okra genotypes (Eshiet and Brisibe, 2015; Ogwu *et al.* 2018; Rajesh *et al.* 2018).

A significant difference (0.01% level) was found in pedicel length and diameter, number and size of flower epicalyxes, and size of calyx and petal. The longest pedicel was found in genotype JO-5 (3.07 cm) followed by the genotype JO-1 (2.60 cm) (Figure 1A) and diameter of pedicel (mm) of flower ranged from 0.32 to 0.54 cm (Figure 1B). The highest number of epicalyxes was found in JO-9 (10.33) (Figure 1C) and in case of the size on epicalyx (cm^2) ranged from 0.17 cm^2 to 0.53 cm^2 (Figure 1D). The largest and smallest calyx size was recorded from JO-9 (12.68 cm^2) and JO-3 (6.70 cm^2), respectively (Figure 1E). Moreover, the largest and smallest average petal size was recorded from JO-4 (22.30 cm^2) and JO-8 (11.82 cm^2), respectively (Figure 1F). The obtained variations among the studied okra genotypes were happed due to the genetic diversity as well as some environmental factors like excessive rainfall and acidic nature of soil. Variation of morphological characteristics in okra genotypes was also reported by Oppong-Sekyere *et al.* (2020) in pedicel length and diameter, Binalfew and Alemu (2016) in size and number of epicalyxes, Ashraf *et al.* (2020) in petal size.

Reproductive features

For varietal development reproductive features is important for maximum yield in okra. In the present study, significant variations were found in reproductive features among the okra genotypes. In case of stamen number, variation was found among the eleven okra genotypes ranged from 76.33 to 122.33. The highest number of stamens was found in JO-1 (122.33) (Figure 2A). The longest and smallest staminal column length was recorded from JO-1 (2.53 cm) and JO-9 (1.62 cm), respectively (Figure 2B) and in staminal column diameter (mm) of flower was

Table 1: Visible morphological features of different okra genotypes

Genotype	Stem color	Leaf color	Vein color	Petiole pubescence	Pedicel color	Epicalyx color	Ovary pubescence	Fruit color	Fruit length	Fruit width
JO-1	Medium Green	Dark Green	Light green	Medium	Medium Green	Medium green	High	Medium Green	Medium	Medium
JO-2	Dark green	Dark Green	Light green	Low	Medium Green	Medium Green	Medium	Medium Green	Medium	Medium
JO-3	Light green	Green	Light green	Medium	Light green	Medium Green	Medium	Light Green	Large	Medium
JO-4	Dark green	Green	Light green	Medium to high	Medium Green	Medium Green	High	Dark Green	Large	Medium
JO-5	Dark maroon	Maroon patches	Dark maroon	Low to medium	Dark maroon	Dark maroon	Medium	Dark maroon	Medium	Medium
JO-6	Medium Green	Light Green	Light green	Low	Medium Green	Medium Green	Medium	Dark Green	Medium	Medium
JO-7	Dark green	Light Green	Light green	Medium to high	Medium Green	Medium Green	Medium	Medium Green	Large	Medium
JO-8	Medium Green	Dark Green	Light green	Low	Medium Green	Medium Green	Medium	Medium Green	Medium	Small
JO-9	Dark green	Dark Green	Light green	Medium	Dark green	Medium Green	Medium	Medium Green	Large	Long
JO-10	Dark green	Green	Light green	Low to medium	Medium Green	Medium Green	Medium	Medium Green	Medium	Medium
BO-1	Medium Green	Green	Light green	High	Medium Green	Dark green	Medium	Medium Green	Medium	Medium

JO = Japanese Okra and BO = BARI Dherosh-1

ranged from 0.30 to 0.52 mm (Figure 2C). In case of ovary length (cm) of flower, it was ranged from 0.61 cm to 1.50 cm. The longest and smallest ovary length was recorded from JO-3 (1.50 cm) and BARI Dherosh-1 (0.61 cm), respectively (Figure 2D) and their ranged

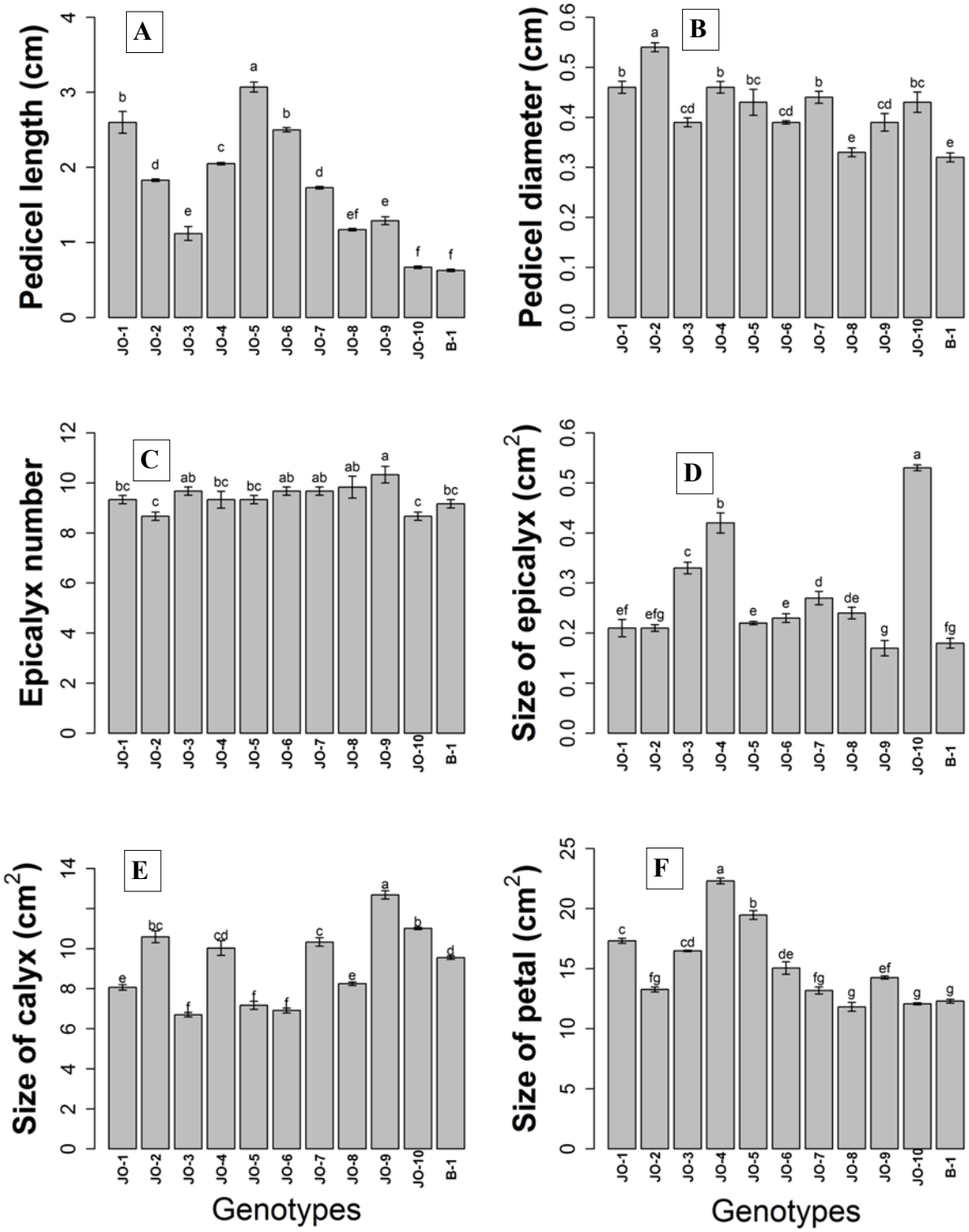

Figure 1: Variation in reproductive features of okra genotypes.
(A) Pedicel length (cm); (B) Pedicel diameter (cm); (C) Epicalyx number; (D) Size of epicalyx (cm^2); (E) Size of calyx (cm^2); (F) Size of petal (cm^2). Vertical bars indicate 1 sem. B-1 = BARI dherosh-1

from 0.52 mm to 0.72 mm (Figure 2E). The longest and smallest style length was recorded from JO-4 (2.08 cm) and BARI Dherosh-1 (0.62 cm), respectively (Figure 2F). In the studied genotypes it was found that in staminal column length and number of stamens has a positive relation. When staminal length is maximum, the number of stamens is highest in that genotype and this difference exists due to their unique genetic

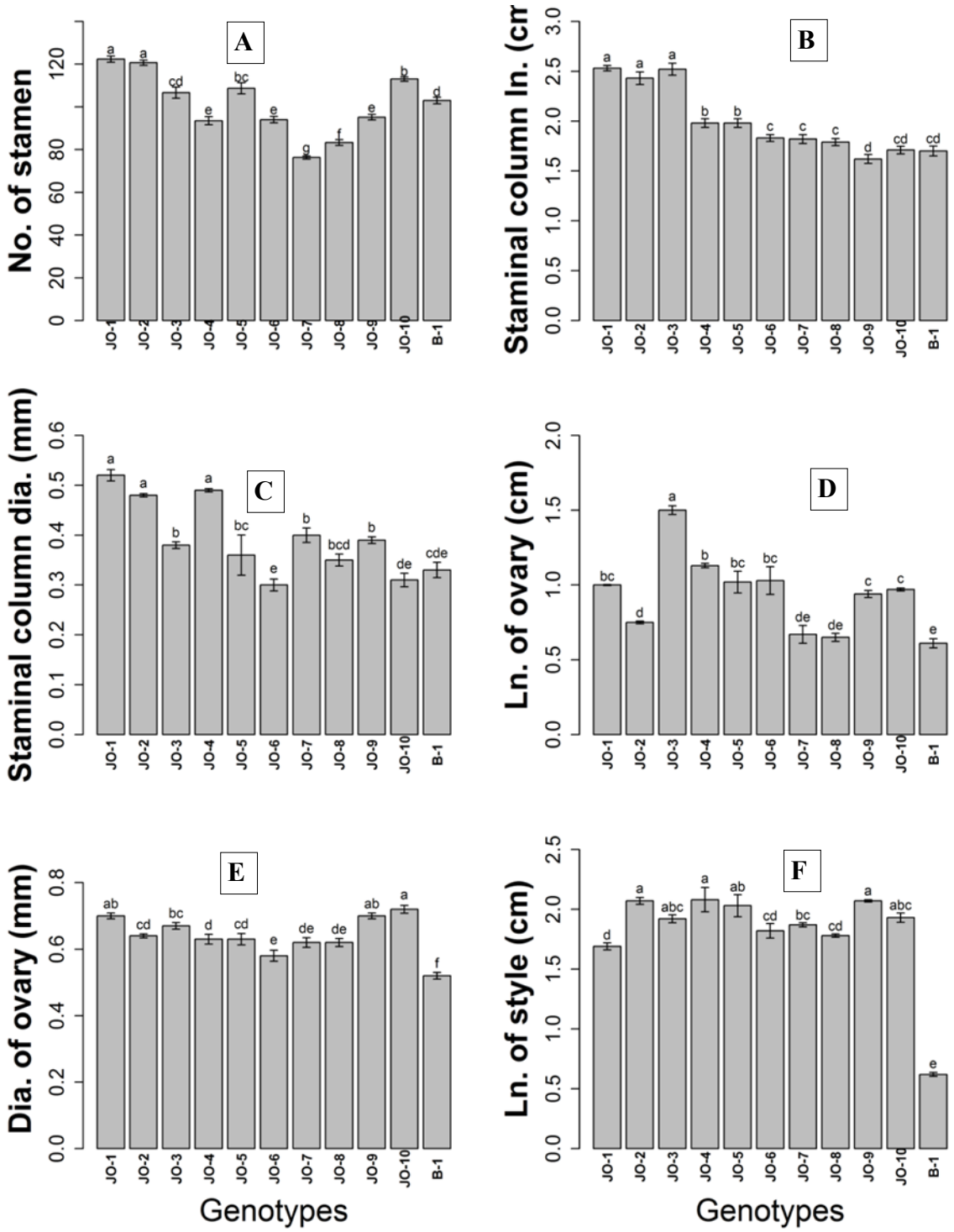

Figure 2: Variation in reproductive features of okra genotypes.
(A) Number of stamen; (B) Length of staminal column (cm); (C) Diameter of staminal column (mm); (D) Length of ovary (cm); (E) Diameter of ovary (mm); (F) Length of style (cm).

characteristics and environmental factors. The present findings are corroborated with the findings of Anusheel (2015) and Kumar *et al.* (2015) stated that shape, size and number of reproductive features can influence the okra yield.

Flowering behaviors

Earliness in flowering, days to 50% flowering, total flower number per plant and flowering duration have been considered as vital for the varietal development. The result of the analysis pertaining to days to first flowering revealed a significant difference in days to first flowering. Among the genotypes the genotype JO-1 showed early flowering (47.67 days) and the genotype BARI dherosh-1 required longest time to produce first flower (63.83 days) (Figure 3A). Among all genotypes it was observed that the genotype JO-5 produce 50% flower within short time (8.33 days) and the genotype JO-7 required long time to 50% flower (41.67 days) (Figure 3B). The flowering duration varied significantly among the all okra genotypes and genotype JO-10 (66.33) had to the highest flowering duration and genotype JO-5 (26.33) showed the lowest flowering duration (Figure 3C). Genotype JO-4 (14.33) was recorded the highest number of flowers and the genotype

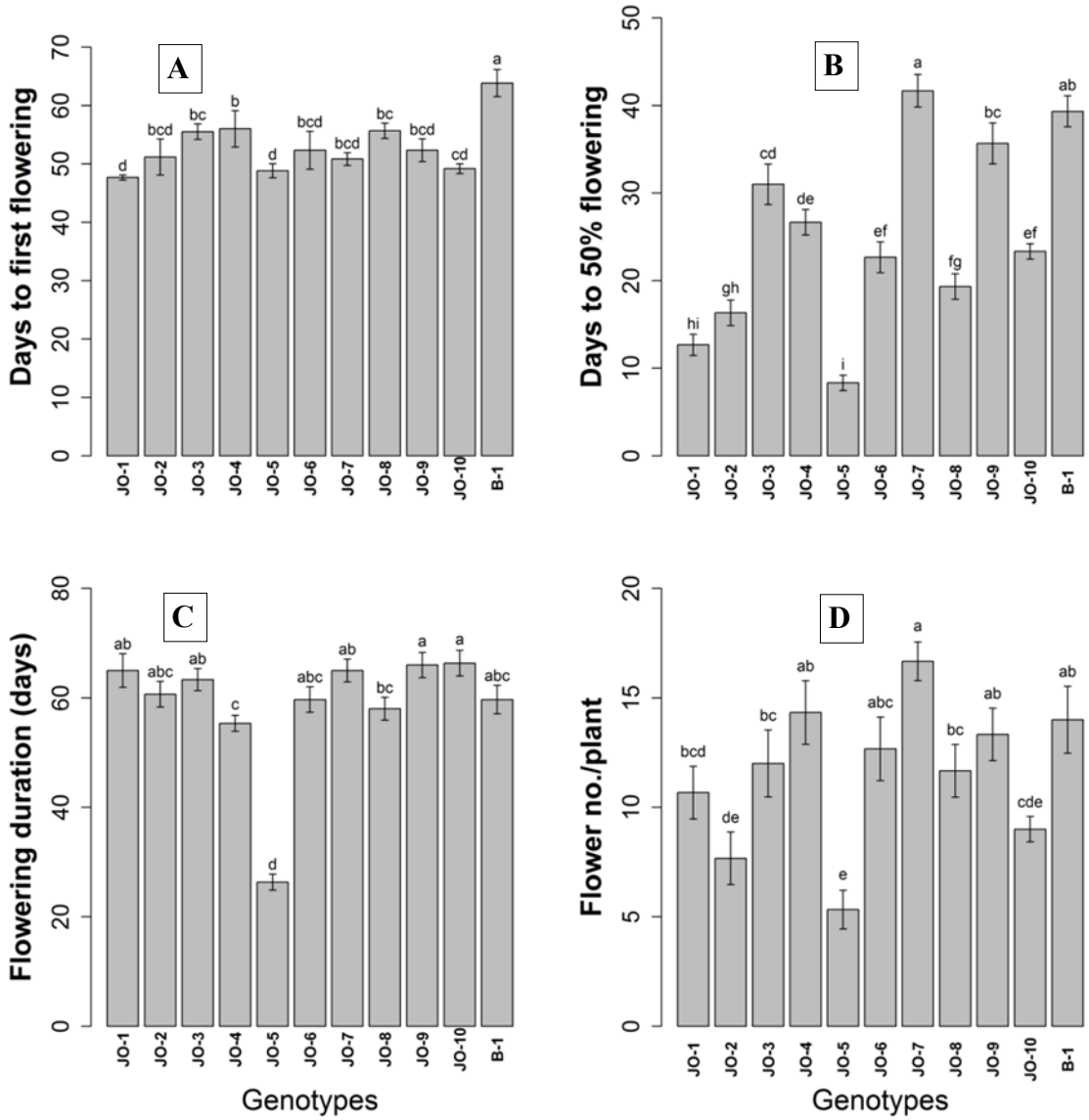

Figure 3: Variation in flowering behavior of okra genotypes. (A) Days to first flowering; (B) Days to 50% flowering; (C) Flowering duration (days); (D) Flower no./plant.

JO-5 (5.33) showed the lowest number of flower plant^{-1} (Figure 3D).

There were significant (0.01% and 1%) variations in flowering traits among the genotypes which might be happened due to genetical factors as well as environmental interaction. Minimum days required to produce first flower and comparatively fewer days to 50% flowering were noticed in JO-1 which in turn showed inferiority in yield (Figure 3A, 3B; 4D). Variation in flowering behavior in okra was also reported by Joshi *et al.* (2020), Shawon *et al.* (2020) and Rahman *et al.* (2020) in days to first flowering; and Oagu *et al.* (2018) in days to 50% flowering. The genotype produced maximum flower number plant^{-1} (JO-7) showed the highest

Table 2: Fruit length and diameter of okra genotypes at different ages

Genotypes	Fruit length (cm) at different days after flowering (DAF)				Fruit diameter (cm) at different days after flowering (DAF)			
	5DAF	6 DAF	7 DAF	8 DAF	5DAF	6 DAF	7 DAF	8 DAF
JO-1	5.53^{g}	7.67^{h}	11.50^{g}	12.03^{e}	0.88^{cd}	0.98^{f}	1.23^{f}	1.55^{e}
JO-2	8.03^{cd}	9.07^{e}	10.40^{i}	11.47^{c}	1.01^{a}	1.26^{b}	1.31^{e}	1.88^{c}
JO-3	8.70^{b}	11.17^{c}	16.18^{a}	16.28^{abc}	0.87^{cd}	1.14^{c}	1.45^{d}	1.85^{c}
JO-4	8.20^{c}	8.57^{f}	15.20^{c}	17.67^{ab}	0.78^{e}	1.08^{de}	1.47^{d}	1.90^{c}
JO-5	7.05^{e}	8.00^{g}	11.85^{f}	13.23^{de}	0.90^{c}	1.22^{b}	1.44^{d}	1.90^{c}
JO-6	5.18^{h}	8.72^{f}	11.13^{h}	11.95^{c}	0.96^{b}	1.40^{a}	1.85^{a}	2.15^{b}
JO-7	6.03^{f}	11.48^{b}	13.20^{e}	16.42^{abc}	0.86^{d}	1.12^{cd}	1.80^{b}	2.18^{ab}
JO-8	7.85^{d}	11.22^{c}	11.92^{f}	15.95^{bc}	0.71^{f}	1.21^{b}	1.88^{a}	2.30^{a}
JO-9	4.70^{i}	8.07^{g}	13.28^{e}	15.65^{c}	0.38^{h}	0.85^{g}	1.08^{h}	1.50^{e}
JO-10	6.80e	10.32^{d}	13.93^{d}	14.93^{cd}	0.56^{g}	0.88^{g}	1.16^{g}	1.70^{d}
B-1	11.40^{a}	12.67^{a}	15.80^{b}	18.23^{a}	0.76^{e}	1.04^{e}	1.63^{c}	2.10^{b}
Sign. level	***	***	***	***	***	***	***	***

Mean (s) within a column bearing similar letter (s) are statistically similar. *** indicates significant at 1% level of probability.

Table 3: Fresh and dry weight of okra in different genotypes

Genotypes	Fruit fresh weight (g) at different days after flowering (DAF)				Fruit dry weight (g) at different days after flowering (DAF)			
	5 DAF	6 DAF	7 DAF	8 DAF	5 DAF	6 DAF	7 DAF	8 DAF
JO-1	7.88^{c}	10.50^{f}	13.13^{j}	18.65^{g}	0.85^{b}	1.12^{d}	1.42^{f}	1.55^{f}
JO-2	8.57^{b}	12.20^{d}	14.67^{h}	16.08^{j}	0.66^{c}	0.87^{g}	1.87^{b}	2.10^{bc}
JO-3	9.93^{a}	14.20^{b}	32.35^{a}	38.40^{a}	1.14^{a}	1.58^{a}	1.95^{a}	2.33^{a}
JO-4	7.32^{d}	8.10^{h}	15.23^{f}	22.70^{d}	0.63^{c}	1.18^{c}	1.97^{a}	2.17^{b}
JO-5	7.48^{d}	9.97^{g}	15.62^{e}	18.30^{h}	0.48^{d}	0.97^{e}	1.23^{h}	1.81^{e}
JO-6	3.58^{h}	13.00^{c}	17.10^{d}	18.95^{f}	0.46^{d}	0.94^{f}	1.63^{e}	1.91^{d}
JO-7	5.18^{f}	17.05^{a}	19.50^{b}	26.83^{c}	0.64^{c}	1.27^{b}	1.69^{d}	2.12^{bc}
JO-8	2.80^{i}	4.50^{i}	12.60^{k}	15.83^{k}	0.38^{e}	0.54^{j}	0.84^{j}	1.88^{de}
JO-9	4.50^{g}	8.25^{h}	13.37^{i}	17.98^{i}	0.38^{e}	0.75^{i}	1.77^{c}	2.31^{a}
JO-10	6.92^{e}	12.05^{d}	19.02^{c}	29.50^{b}	0.38^{e}	0.84^{h}	0.93^{i}	1.41^{g}
B-1	8.17^{c}	11.15^{e}	14.87^{g}	22.13^{e}	0.63^{c}	0.85^{gh}	1.33^{g}	2.07^{c}
Sign. level	***	***	***	***	***	***	***	***

Mean (s) within a column bearing similar letter (s) are statistically similar. *** indicates significant at 1% level of probability.

yield positively influenced to gain maximum yield (Figure 3C, 3D; 4D). Similar trend was also noticed by Oppong-Sekyere *et al.* (2020) and Shawon *et al.* (2020). The least number of flower per plant was produced in present research might be due to the heaviest rainfall (650 mm in average), high temperature (32^{0}C in average) during April to August and continuous interruption in dark period by artificial light during night in Sylhet region assessed by the local meteorological station. The superior genotype (JO-7) possessed relatively the longest flowering duration and showed the highest yield (14.08 tha^{-1}). This result is confirmed with the finding of Rahman *et al.* (2020) and Temam *et al.* (2020).

There was a significant variation between genotypes for fresh and dry weight of fruits. At eight days after flowering, the highest fruit fresh weight was found in the genotype JO-3 (28.5 g) and the lowest fruit fresh weight was recorded in the genotype JO-8 (15.83 g) and

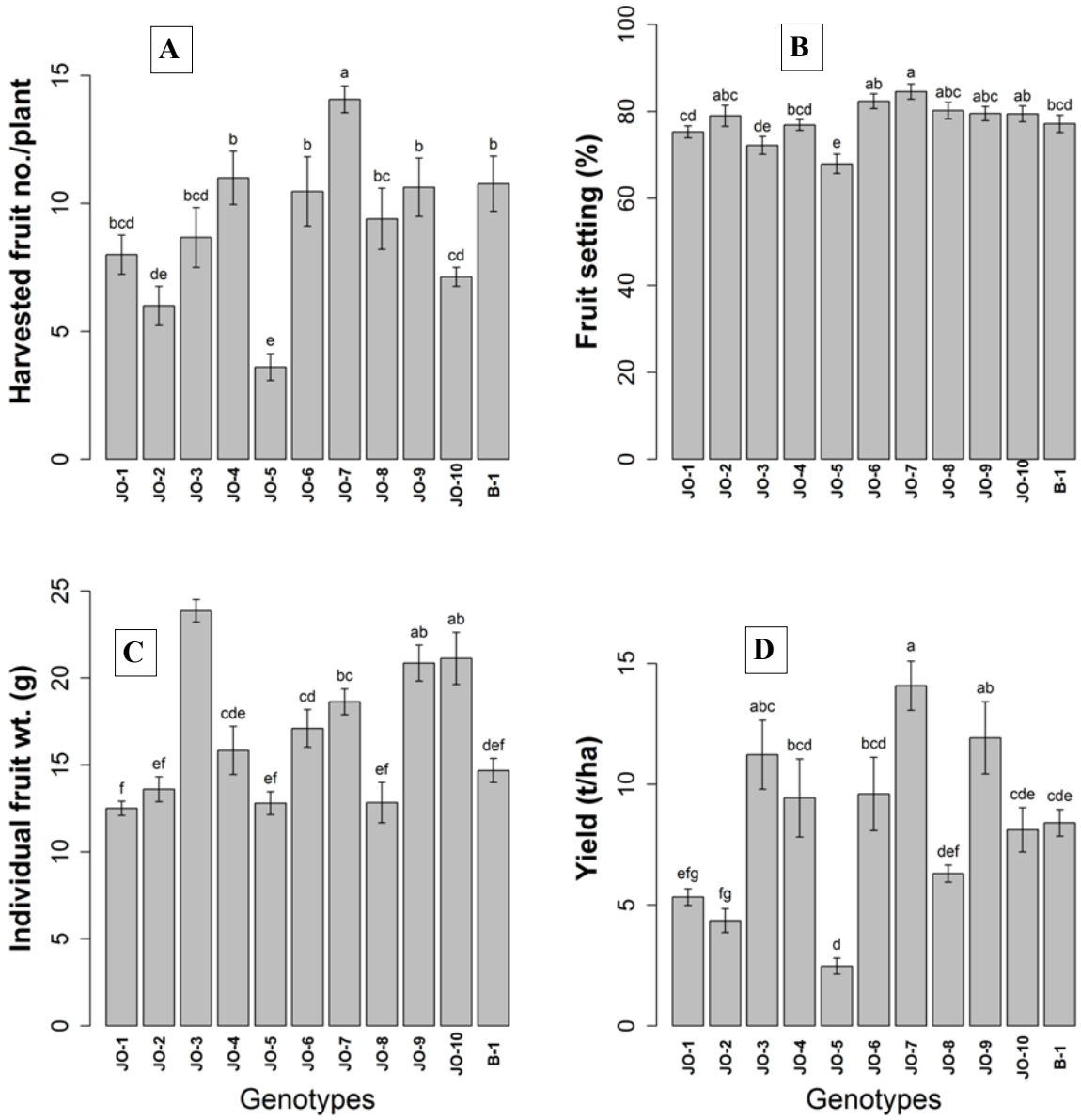

Figure 4: Variation in yield and yield attributes of different okra genotypes.
(A) Harvested fruit number/plant; (B) Fruit setting (%); (C) Individual fruit weight (g); (D) Yield (t/ ha).

the highest fruit dry weight was found in the genotype JO-3 (2.33 g) while the lowest fruit dry weight was recorded in the genotype JO-10 (1.41 g) (Table 3). As fruit size (fruit length and diameter) and weight (fruit fresh weight and dry weight), significant variation was found within common harvesting duration. Similar information was cited in fruit size and fruit weight by Aboyeji *et al.* (2021); Jangde *et al.* (2019); Singla *et al.* (2018) and Temam *et al.* (2020).

The highest number of harvested fruits recorded in the genotype JO-7 (14.1) and the lowest number of harvested fruit per plant showed in the genotype JO-5 (3.60) (Figure 4A). The highest fruit setting was found in the genotype JO-7 (84.56 %) and the lowest fruit setting recorded in the genotype JO-5 (67.93 %) (Figure 4B). The fresh weight of the fruit was significantly different between genotypes and the highest fruit weight was observed in the JO-3 (23.86g) and the lowest fruit weight was recorded in JO-1 (12.50 g) (Figure 4C). The highest yield was found in JO-7 (14.08 t ha-1) followed by JO-9 (11.92 t ha-1) and JO-3 (11.22 t ha-1) and the lowest yield was recorded in JO-5 (2.47 t ha-1) followed by JO -2 (4.35 t ha-1) (Figure 4D). Number of fruits depends on flower production and fruit setting capability of the genotypes and the individual fruit weight in okra which was also reported by Alam *et al.* (2021); Asare *et al.* (2016) Muluken *et al.* (2016). And positive relation between fruit number and the yield was noticed by Rahman *et al.* (2020) and Saleem *et al.* (2018). The obtained superior performance of JO-7 might be due to the highest fruit setting (%), number of flower per plant, longest flowering duration and number of harvested fruits (Figure 4B, 3D, 3C and 4A, respectively). Variation in yield among okra genotypes was reported by Anusheel (2015), Kumar *et al.* (2015), Mohammed *et al.* (2022b); Ola *et al.* (2021) and Shawon *et al.* (2020).

CONCLUSIONS

Wide morphological variation and flowering behavior were observed among the tested exotic okra genotypes. All the studied genotypes reveled almost similar types of visible appearance like stem colour, leaf, vein, petiole, pedicel, epicalyx and sepal except the genotype JO-5. Due to the wide diversity of reproductive features among the studied genotypes, yield and its related traits was varied being some unique traits in each of the genotypes. Assessing all the characteristics, the exotic genotypes JO-7, JO-9 and JO-3 performed better rather than the others which can be used as promising lines for cultivating in the Sylhet region, Bangladesh.

AUTHOR CONTRIBUTION

FNS performed the experiments, analyzed and interpreted data. AFMSI and MMH conceptualized and designed the study. RT and FIM performed the statistical analysis and drafted the manuscript.

REFERENCES

Aboyeji CM, Dahuns SO, Olaniyan DO, Aruna LD, Adekiya O, Olayanju A 2021 Performance and quality attributes of okra *Abelmoschus esculentus* (L.) Moench) fruits grown under soil applied Zn-fertilizer, green biomass and poultry manure. Scientific Reports 11: 82-91.

Akter A, Hoque F, Zafar A, Mukul A, Kamal R, Rasha RK 2016 Financial analysis of winter vegetables production in a selected area of Brahmanbaria district in Bangladesh. International Research Journal of Agricultural and Food Sciences 1(6): 120-127.

Alam MA, Hafizuddin AA, Gobilik J, Mijin S, Khandaker MM 2021 Evaluation of best quality okra parental lines based on morpho-physiological and nutritional attributes. Bulgarian Journal of Agricultural Science 27(6): 1127-1135.

Ansari AM, Ahmad E, Nazrussalam, Singh DN 2020 Evaluation of okra (*Abelmoschus esculentus* L. Moench) genotypes for important quantitative characters. International Journal of Agricultural and Applied Sciences 1 (1): 1-5.

Anusheel M 2015 Study on different

genotypes of Okra [*Abelmoschus esculentus* (L.) Moench.] on growth, yield and quality parameters, MS Thesis, Department of Horticulture, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior.

Asare AT, Asare-Bediako E, Agyarko F, Taah K, Osei EO 2016. Phenotypic traits detect genetic variability in Okra (*Abelmoschus esculentus*. L. Moench). African Journal of Agricultural Research 11(33): 3169-3177.

Ashraf ATMH, Rahman MM, Hossain MM Sarker U 2020 Performance evaluation of some selected okra genotypes. International Journal of Plant & Soil Science 32(3): 13-20.

BBS (Bangladesh Bureau of Statistics) 2022 Year book of Agricultural statistics of Bangladesh. Government of the People's Republic of Bangladesh, p.47.

Binalfew T, Alemu Y 2016 Characterization of okra (*Abelmoschus esculentus* (L.) Moench) germplasms collected from Western Ethiopia. International Journal of Research in Agriculture and Forestry 3(2): 11-17.

Chy HMR, Islam AFMS, Saha JK, Tabassum R, Aziz MA, Monshi FI 2022 Evaluation of morphological traits and biochemical parameters of tea (*Camellia sinensis*) genotypes for the quality and yields. Tropical Agricultural Research & Extension 25 (2): 28-39.

Comas LH, Bauerle TL, Eissenstat DM 2010 Biological and environmental factors controlling root dynamics and function: effects of root ageing and soil moisture. Australian Journal of Grape and Wine Research 16: 131-137.

Elkhalifa AEO, Alshammari E, Adnan M, Alcantara JC, Amir M *et al.* 2021 Okra (*Abelmoschus Esculentus*) as a potential dietary medicine with nutraceutical importance for sustainable health applications. Molecules 26(3): 696.

Eshiet AJ, Brisibe EA 2015 Morphological characterization and yield traits analysis in some selected varieties of okra (*Abelmoschus Esculentus* L. Moench). Advances in Crop Science and Technology 3: 197.

Gemede HF, Ratta N, Haki GD, Woldegiorgis AZ 2014 Nutritional quality and health benefits of Okra (*Abelmoschus esculentus*): A review. Food Science and Quality Management 33: 87-97.

Gomez KA, Gomez AA 1984 Statistical procedures for agricultural research. 2" end, John Wiley and sons, New York.

Hossain MS, Qian L, Arshad M, Shahid S, Fahad S, Akhter J 2019 Climate change and crop farming in Bangladesh: an analysis of economic impacts. International Journal of Climate Change Strategies and Management 11(3): 424-440.

Jangde SK, Jaiswal RK, Dixit R, Kurre R 2019 Evaluation of different varieties/ hybrids of okra (*Abelmoschus esculentus* (L.) Moench.): A review. International Journal of Chemical Studies 7(4): 2240-2246.

Joshi JL, Anbuselvam YA, Ranganayaki SS, Muraleedharan A, Rajan REB, Kumar CPS 2020 Comparative studies on fifteen genotypes of okra (*Abelmoschus esculentus* (L.) moench) for vegetative characters. Plant Archives 20(2): 3773-3775.

Kamalesh P, Subrata D, Asraf AK, Pranabesh C 2016 Phytochemical investigation and hypoglycemic effect of *Abelmoschus esculentus*. Research Journal of Pharmacy and Technology 9: 162-164.

Kumar A, Verma RB, Solankey SS, Adarsh A 2015 Evaluation of okra (*Abelmoschus esculentus*) genotypes for yield and yellow vein mosaic disease. Indian Phytopathology 68(2): 201-206.

Mohammed J, Mohammed W, Shiferaw E 2022a Performance and genetic variability of okra (*Abelmoschus esculentus* (L.) Moench) genotypes in Ethiopia for geomorphology and biochemical traits. Hindawi Advances in Agriculture Article ID 5521151, 8 pages.

Mohammed J, Mohammed W, Shiferaw E

2022b Phenotypic diversity assessment of okra (*Abelmoschus Esculentus* (L.) Moench) genotypes in Ethiopia using multivariate analysis. Hindawi Scientifica Article ID 3306793, 9 pages.

Monshi FI, Bhuiyan MSU, Tabassum R 2015 Adaptability of litchi germplasm in hilly areas of Sylhet Agricultural University and screening their genetic variation by using RAPD markers. International Journal of Plant Breeding and Genetics 9 (4): 218-227.

Muluken D, Wassu M, Endale G 2016 Variability, heritability and genetic advance in Ethiopian okra [*Abelmoschus esculentus* (L.) Monech] collections for tender fruit yield and other agro-morphological traits. Journal of Applied Life Sciences International 4(1): 1-12.

Mustafa S, Haque CE, Baksi S 2021 Low daily intake of fruits and vegetables in rural and urban Bangladesh: influence of socioeconomic and demographic factors, social food beliefs and behavioural practices. Nutrients 13(8): 2808.

Ogwu MC, Ohwo UO, Osawaru ME 2018 Morphological characterization of okra (*Abelmoschus* [Medik.]) accessions. Makara Journal of Science 22(2): 67-76.

Ola AL, Pandey AK, Sharma G, Pandey M, Lavlesh, Tiwari D 2021 Evaluation of okra [*Abelmoschus esculentus* (L.) Moench] hybrids for growth, yield attributes and yield. Annals of Plant and Soil Research 23(4): 437-440.

Oppong-Sekyere D, Akromah R, Nyamah EY, Brenya E, Yeboah S 2020 Morphological characterization of okra (*Abelmoschus sp.* L.) germplasm in Ghana. Research and Development in Agricultural Sciences 2: 129-146.

Paul SR, Islam AFMS, Maleque MA, Tabassum R, Monshi FI 2021 Growth parameters and yield evaluation of tropical and temperate sweetpotato genotypes under acid soil conditions. Journal of Food and Agriculture 14 (2): 32-49.

Petropoulos S, Fernandes A, Barros L, Ferreira ICFR 2018 Chemical composition, nutritional value and antioxidant properties of Mediterranean okra genotypes in relation to harvest stage. Food Chemistry 242: 466-474.

Rahman H, Islam AFMS, Maleque MA, Tabassum R 2015 Morpho-physiological evaluation of sweet potato (*Ipomoea batatas* L.) genotypes in acidic soil. Asian Journal of Crop Science 7(4): 267-276.

Rahman M, Islam AFMS, Hasan M, Uddin M 2020 Growth and yield performance of okra genotypes in acidic soil at Sylhet region, Bangladesh. Archives of Agriculture and Environmental Science 5(3): 283-291.

Rahman MT 2017 Role of agriculture in Bangladesh economy: Uncovering the problems and challenges. International Journal of Business and Management Invention 6(7): 36-46.

Rajesh J, Prasad VM, Banothu LN 2018 Evaluation of okra [*Abelmoschus esculentus* (L.) Moench] hybrids for growth parameters under Allahabad agro climatic condition. Journal of Pharmacognosy and Phytochemistry 7 (6): 1813-1816.

Roy A, Islam AFMS, Tabassum R 2016 Morphological features and yield evaluation of onion (*Allium cepa* L.) genotypes in acid soil. International Journal of Plant Breeding and Genetics 10: 116-124.

Saleem AM, Amjad M, Ziaf K, Sahi ST 2018 Characterization of okra (*Abelmoschus esculentus*) genotypes for fruit firmness, other horticultural traits and heritability studies. International Journal of Agriculture and Biology 20: 345-352.

Sarker S, Islam AFMS, Maleque MA, Tabassum R, Monshi FI 2022 Screening of onion (*Allium cepa* L.) genotypes for acid tolerance based on morpho-physiological and yield

associated traits. Journal of Tropical Crop Science 9(2): 87-95.

Shawon MRA, Islam AFMS, Moonmoon S 2020 Yield and yield attributes of exotic and local Okra (*Abelmoschus esculentus*) cultivars in acid soil. International Journal of Current Research in Biosciences and Plant Biology 7(5): 7-12.

Singla R, Kumari P, Thaneshwari 2018 Evaluation of growth and yield parameters of okra (*Abelmoschus esculentus* L. Moench) genotypes. International Journal of Pure and Applied Bioscience 6(5): 84-89.

Snowdon RJ, Wittkop B, Chen TW *et al.* 2021 Crop adaptation to climate change as a consequence of long-term breeding. Theoretical and Applied Genetics 134: 1613-1623.

Tabassum R, Islam AFMS, Rahman MM, Monshi FI 2015 Morpho-physiological features and yield attributes of soybean genotypes in acid soil. Research Journal of Agricultural & Biological Science 11 (1): 11-20.

Tanni AS, Maleque MA, Choudhury MAR, Khan AU, Khan UHS 2019 Screening of exotic okra genotypes to explore breeding materials for developing pest resistant and high yielding okra variety. Bangladesh Journal of Entomology 29(1): 17-26.

Temam N, Mohamed W, Aklilu S 2020 Agro-morphological characterization and evaluation of okra [*Abelmoschus esculentus* (L.) Moench] genotypes for yield and other variability components at Melkassa, Central Ethiopia. MOJ Ecology & Environmental Sciences 5 (2): 80-87.

Xia F, Zhong Y, Li M, Chang Q, Liao Y, Liu X, Pan R 2015 Antioxidant and Anti-fatigue constituents of okra. Nutrients 7(10): 8846-8858.