Research Article

Evaluation of Local and Exotic Hybrid Genotypes of Yardlong Bean (*Vigna unguiculata*) in Saline Prone Area of Bangladesh

Shakil Ahmed[1], Mahin Das[2], Md. Rayhan Sojib[3*], Shishir Kanti Talukder[4], Sadia Sultana[5], Prantika Datta[1], Shofiqul Islam[1] and Gazi Md. Mohsin[2]

[1]Department of Soil Science, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh; [2]Department of Agriculture, Noakhali Science and Technology University, Noakhali-3814, Bangladesh; [3]Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh; [4]Department of Agronomy, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh; [5]Department of Horticulture, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh.

Abstract | In the face of climate change and a greater likelihood of extreme weather events, selecting appropriate varieties of Yardlong bean (*Vigna unguiculata*) can help ensure proper yield even under stressful conditions, particularly in saline conditions. However, choosing the right variety is a challenge. In 2019, a field trial was conducted at Nobogram Farm in Noakhali, Bangladesh to evaluate the performance of local and exotic varieties of Yardlong bean under saline conditions. The experiment involved seven traits, including germination percentage, days to first flowering, fruit weight, fruits per plant, fruit length, seeds per plant, and yield. The study compared local hybrids (Saba, Lalbeni, Tokii, and 1070) and exotic hybrid (White Beauty, imported from Thailand) using a Randomized Complete Block Design (RCBD). The results revealed that exotic hybrid varieties had a positive significant difference ($p<0.001$) in the number of seeds per fruit compared to other local hybrids. Local hybrids showed positive significant differences ($p<0.05$) in the number of fruits per plant than exotic hybrid variety. However, germination percentage and first flowering were disproportionate, with exotic V_3 (White Beauty) showing moderate germination and fast first flowering, while local hybrids showed high germination percentage and late first flowering. In terms of weight per fruit and yield, varieties showed high weight per fruit and the highest yield, except for V_4 (Tokii), which showed the lowest weight per fruit but moderate yield. Overall, the study suggests that locally developed hybrids are more promising for the study site.

Received | October 21, 2023; **Accepted** | January 08, 2024; **Published** | April 12, 2024
***Correspondence** | Md. Rayhan Sojib, Department of Agricultural Extension Education, Bangladesh Agricultural University, Mymensingh-2202, Bangladesh; **Email:** rayhansojibnahid786@gmail.com
Citation | Ahmed, S., M. Das, M.R. Sojib, S.K. Talukder, S. Sultana, P. Datta, S. Islam and G.M. Mohsin. 2024. Evaluation of local and exotic hybrid genotypes of Yardlong bean (*Vigna unguiculata*) in Saline Prone Area of Bangladesh. *Sarhad Journal of Agriculture,* 40(2): 347-353.
DOI | https://dx.doi.org/10.17582/journal.sja/2024/40.2.347.353
Keywords | Exotic, Evaluation, Genotypes, Local, Yardlong bean, Yield

Introduction

Yardlong beans (*Vigna unguiculata* Walp. Subsp. sesquipedalis (L.) Verdc.; $2n = 2\times11 = 22$) are a member of the Fabaceae family (Pornsuriya and Chittawanij, 2019) and are believed to have originated in Africa, although they are widely grown in South Asia (Pidigam *et al*., 2021). The species is highly variable, with up to 10 subspecies distinguished, most of which are perennial wild types (Tantaswat *et al*., 2010). Due to its economic importance, agriculturalists aim to increase production to meet the high demand from consumers, particularly in Southeast Asian, Chinese, and Filipino cultures (Nooprom and Santipracha, 2015).

Yardlong beans are an important source of nutrition, providing 17% and 31% of the recommended daily allowance of vitamins A and B-12, respectively, as well as vitamin C (Quamruzzaman *et al*., 2022). In addition, it is a significant source of protein in many tropical and subtropical countries (da Cunha *et al*., 2020). As a legume crop, it has the additional benefit of being grown for forage and can enhance soil productivity by converting atmospheric nitrogen into a form usable by plants, through a symbiotic relationship with Rhizobium bacteria (Mitran *et al*., 2018).

Yardlong bean is a vegetable crop of significant economic importance in Bangladesh (Roy *et al*., 2022). The area occupied by this crop was 16284 acres and the production was 25651 metric tons during the year 2017-2018 (BBS, 2019), It is a vegetable with significant export potential in Bangladesh. Significant quantities of Yardlong beans are exported annually from Bangladesh to high-value markets in the United Kingdom, Belgium, the Netherlands, France, the UAE, Singapore, and Hong Kong (Khan *et al*., 2015).

However, Bangladesh achieves a production of 3640 kg/ha out of the global annual production of 13450 kg/ha of Yardlong beans (Hossain *et al*., 2013). Lack of good quality seeds and appropriate varieties according to spatial hinders high yield of Yardlong bean in Bangladesh (Huque *et al*., 2012). Bangladeshi farmers, particularly those in coastal regions or areas prone to salinity, use a variety of local cultivars and released Yardlong bean varieties. However, their yield is not satisfactory. Varietal performance may be key to addressing this issue.

With this in mind, our research aimed to evaluate the performance of five commercial varieties of Yardlong bean (Lalbeni, Saba, Tokii, White Beauty, and Yardlong bean 1070) in the saline-prone area of Bangladesh (Noakhali). Our hypothesis was that locally developed hybrid varieties would outperform imported ones under the prevailing physical conditions.

Materials and Methods

Description of experimental site

A study was conducted in 2019 to evaluate the performance of a Yardlong bean variety during kharif-1 and kharif-2 seasons at Nobogram Farm in Noakhali, Bangladesh. The research was carried out in the Young Meghna Estuarine Floodplain (AEZ-18), an agro-ecological zone characterized by young alluvial land with highly silty, finely stratified, and slightly calcareous sediments. The region is also prone to salinity, having a soil pH of 7.5 and a soil salinity of 4.32 dSm^{-1} (Misu *et al*., 2023) and an average annual temperature of 25.6 °C and an average annual rainfall of 3,302 mm (Osman *et al*., 2020).

Experimental varieties

Five varieties of beans were experimented with in this research. Four were local hybrids (Saba, Lalbeni, Tokii, and 1070) and one was an imported hybrid (White Beauty). Saba, Lalbeni, Tokii, and 1070 were developed through local popular breeding and seed producing commercial organizations 'Lal Teer Seed Limited' (Hossain *et al*., 2013), while White Beauty was imported from Thailand and considered an exotic variety for the study.

Experimental layout

To conduct the experiment, a Randomized Complete Block Design (RCBD) with three replications was utilized. The overall plot size was 15.24m×1.82m, resulting in a total area of 27.57m^2. The plot was divided into five subplots for each variety, with a distance of 50cm between each subplot. Each subplot contained two rows of nine plants, with a row-to-row distance of 150cm and a plant-to-plant distance of 25cm. A distance of 1m and 0.50m was maintained between the blocks and within a block, in the form of drainage.

Land preparation

The land was prepared for planting by thoroughly ploughing the soil and then loosening it with a spade to create a good tilth. All weeds, debris, and seedlings from previous crops were removed with hoeing, hand picking, and the addition of well-decomposed cow dung. Five raised sub-plots, each measuring 3.04m×1.53m, were created to accommodate 18 plants in two rows. The individual plots were prepared with a spade. Pre-sowing final weeding was done to facilitate seed germination and minimize crop-weed competition.

Seed treatment and seed sowing

Seed was treated with Vitavex-200, followed by a rate of @2 g/kg of seed, and also treated by sun drying with a view to avoiding seed-borne disease. After 7 days of plot preparation, seeds were sown in two rows, maintaining a spacing of R×R=150cm and P×P=25cm, accommodating 9 pits in each row and using 2 seeds per pit, followed by flood irrigation to ensure soil moisture for germination.

Post sowing operations

"A" shape stalking was provided with bamboo sticks and GI wire tightening with jute rope to make it storm resistant. First weeding was done when the stand establishment was completed. Another two weeding were done at 30 and 50 days after sowing. As the experiment was carried out in hot summer and the crop was very much sensitive to soil moisture, hence, throughout the flowering period irrigation was given frequently. There was an incidence of rust disease in the leaves of Yardlong beans. For this reason, Acimix 55EC, coloropsis 50%+Cypermethrin 5% was applied in the crop.

Manure and fertilizer application

The following doses of manure and fertilizers were applied according to the recommendation of (BARC, 2012). The full amount of cow dung was applied as basal during final land preparation. Full amount of TSP, Gypsum and half MP were applied basally in plots and mixed with the soil one week before seed sowing. The remaining amount of urea and MP were applied as top dressing at 20 days after sowing (Table 1).

Table 1: *Amount of manures and fertilizer used in experiment for Yardlong bean as follows.*

S. No.	Manure/ Fertilizer	Doses of total plot (0.7 decimal) (15.24m * 1.82m = 27.57m^2)	Dose/ hectare
01.	Urea	140g	20kg
02.	TSP	540g	150kg
03.	MOP	130g	50kg
04.	Gypsum	140g	10kg
05.	Cowdung	20kg	5Mt

Source: *(BARC, 2012).*

Collection of data

Data were collected from eighteen randomly selected plants five times with five days intervals on the following parameters in each sub plot.

Germination percentage (%)

The number of seeds germinated was recorded starting from 7 days after sowing (DAS) and end in 16 days. The germination result was obtained in each day and finally it was converted into germination percentage by using following formula:

$$\textit{Germination percentage } (\%) = \frac{\text{Number of seeds germinated}}{\text{Number of seeds planted}} \times 100$$

Days to first flowering

It was estimated the number of days required from sowing to first flowering of one plant.

Number of fruits per plant

The average value of total number of fruits per plant harvested at different dates from selected nine plants was counted and taken as fruit per plant.

Length of fruit (cm)

By measuring tape, fruit length was measured from the neck of the fruit to the bottom after harvesting of each fruit and mean value was recorded accurately.

Seeds per fruit

Seeds of each fruit were extracted and counted.

Weight per fruit (gm)

The weight of fruit was recorded in gm by balance for each variety. The average yield data were recorded in kg after harvesting by using a digital balance.

Fruit yield (ton/ha)

After harvest, a digital balance was used to calculate the total yield (Kg) for the 28.35 m^2 of land. In order to facilitate future comprehension, the total yield (Kg/m^2) was then converted to a standard unit (ton/ha).

Statistical analysis

All the analyses were conducted on three replicate subplots of the field experiment (n=3), using the one-way analysis of variance (ANOVA) followed by the Tukey's Honest Significant Difference (HSD) Post-Hoc Test in Programming Software R version (4.0.3) to detect significant differences. A biplot was created using Principal Component Analysis (PCA) with a concentration ellipse level of 95% to analyze the diversity of parameters related to the varieties, using the PAST program (v. 2.17c). Pearson correlation was used for normally distributed datasets based on the Jarque-Bera-Test, and Spearman rank correlation was used for non-normally distributed datasets.

Results and Discussion

Number of fruits per plant

The analysis of variance demonstrated that the varieties were significant in relation to the number of fruits per plant within the selected saline areas (Table 2). A significant difference was observed in Figure 1, with Boxplot illustrating that the data were well distributed and V_2 (Lalbeni), V_3 (White Beauty), and V_5 (1070) being significantly different from each other ($p<0.05$). These varieties showed a positive response towards the number of fruits per plant in the studied area. The biplot clearly shows that varieties do not overlap, indicating a high variability in the results obtained (Figure 2).

Table 2: *ANOVA test for number of fruits per plant.*

Experimental factors	df[1]	Sum sq[2]	Mean sq[3]	F values[4]	Pr (>F)[5]
Variety	4	212.5	53.12	3.631	0.0447*
Residuals	10	146.3	14.63	N/A	N/A

*1/df: Degrees of freedom; 2/Sum Sq: Sum of squares; 3/Mean Sq: Mean square; 4/F value: The value of the F statistic; 5/Pr (>F): Probability of rejecting the null hypothesis. Levels of significance are as follows: *, p <0.05; **, p < 0.01 and ***, p < 0.001*

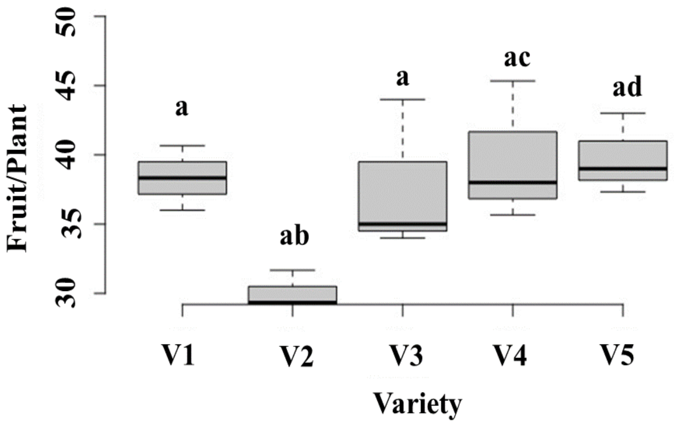

Figure 1: *Number of fruits per plant in different varieties V_1 (Saba), V_2 (Lalbeni), V_3 (White Beauty), V_4 (Toki) and V_5 (1070). Boxes: the interquartile range. Lines across the boxes: the average of the values. The line above and below the vertical dashed lines: the maximum and minimum values. The letters a, ab, b, . . . indicate significant differences between boxes.*

Fruit length

When comparing traits among different varieties, the average fruit length in V_3 (45.99 cm) was higher than in V_1 (35.77 cm), which showed the lowest average value (S_1). Results from analysis of variance showed that fruit length is a highly significant ($p<0.001$) trait among the varieties (Table 3). More importantly, analysis revealed that there were highly significant differences ($p<0.001$) between the varieties in terms of fruit length (Figure 3). The biplot clearly shows that the varieties do not overlap, which denotes a very high variability of the results obtained (Figure 2).

Table 3: *ANOVA test for fruit length.*

Experimental factors	df[1]	Sum sq[2]	Mean sq[3]	F values[4]	Pr(>F)[5]
Variety	4	197.33	49.33	110.3	3.14e-08***
Residuals	10	4.47	0.45	N/A	N/A

*1/df: Degrees of freedom; 2/Sum Sq: Sum of squares; 3/Mean Sq: Mean square; 4/F value: The value of the F statistic; 5/Pr (>F): Probability of rejecting the null hypothesis. Levels of significance are as follows: *, p <0.05; **, p < 0.01 and ***, p < 0.001*

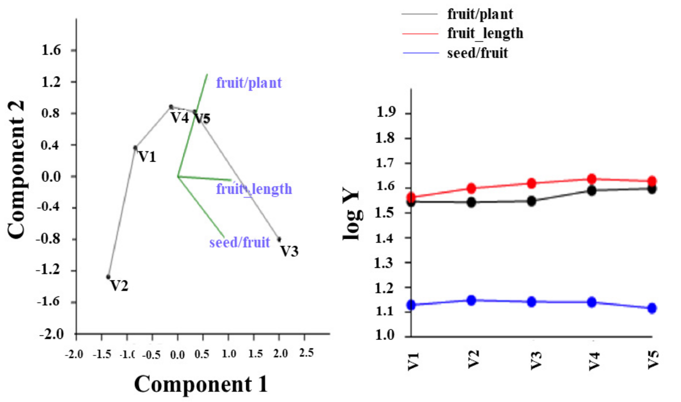

Figure 2: *Principal component analysis (PCA) biplot showing interaction between varieties of Long yard beans and selected traits. fruit/plant = Number of fruits per plants, seed/fruit = Number of seeds per fruit.*

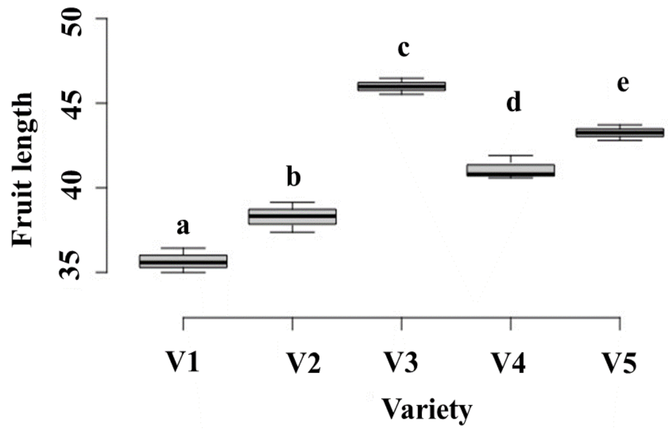

Figure 3: *Fruit length in different varieties V_1 (Saba), V_2 (Lalbeni), V_3 (White Beauty), V_4 (Toki) and V_5 (1070). Boxes: the interquartile range. Lines across the boxes: the average of the values. The line above and below the vertical dashed lines: the maximum and minimum values. The letters a, b, c, . . . indicate significant differences between boxes.*

Number of seeds per fruit

The data related to the comparison of seed quantity per fruit (number of seeds per fruit) showed that V_3 (White Beauty) had an average of 15.52 seeds per fruit, which was the highest, while V_4 (Tokii) had the lowest number of 12.98 seeds per fruit on average (S_1). This trait exhibited a highly significant difference ($p<0.001$) among the varieties. The one-way analysis of variance results (Table 4) indicated that the number of seeds per fruit was significantly different ($p<0.001$) among the varieties. The boxplot displayed that the data was well distributed (Figure 4). Post hoc test results symbolized with boxplot showed that V_3 (White Beauty) was significantly different from the other varieties (Figure 4). The biplot clearly showed that the varieties did not overlap, indicating a very high variability in the results obtained (Figure 2).

Table 4: *ANOVA test for number seeds per fruit.*

Experimental factors	df[1]	Sum sq[2]	Mean sq[3]	F values[4]	Pr (>F)[5]
Variety	4	13.193	3.298	40.51	3.79e-06***
Residuals	10	0.814	0.081	N/A	N/A

*1/df: Degrees of freedom; 2/Sum Sq: Sum of squares; 3/Mean Sq: Mean square; 4/F value: The value of the F statistic; 5/Pr (>F): Probability of rejecting the null hypothesis. Levels of significance are as follows: *, p <0.05; **, p < 0.01 and ***, p < 0.001.*

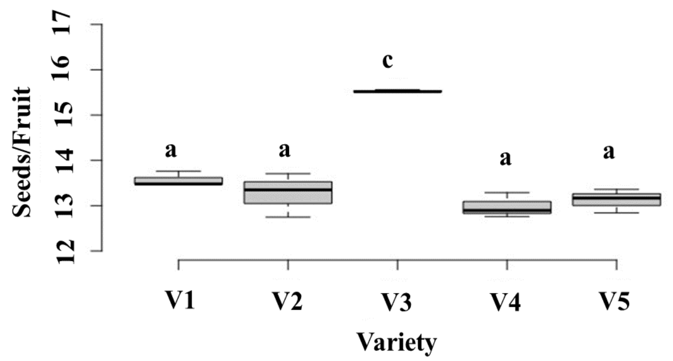

Figure 4: *Seeds per fruit in different varieties V_1 (Saba), V_2 (Lalbeni), V_3 (White Beauty), V_4 (Toki) and V_5 (1070). Boxes: the interquartile range. Lines across the boxes: the average of the values. The line above and below the vertical dashed lines: the maximum and minimum values. The letters a, b, c, . . . indicate significant differences between boxes.*

Germination percentage (%) and first flowering

Data showed that the germination percentage was higher in V_5 (89.47%) compared to the other samples, but V_5 had a later first flowering date (38 DAT) than the others (S_1). V_3 had moderate germination (55.26%) and faster first flowering (34 DAT) than the others (S_1). There was a negative correlation between germination and first flowering days (Figure 5).

Weight per fruit and Yield

Yield can be influenced by a number of plant characteristics that interact with a range of external influences throughout the plant's life (Gurmu *et al.*, 2022). The order of preference of varieties based on yield may be regarded as an accurate representation of genotypic performance (Niazian and Niedbała, 2020). Weight per fruit had the highest value in V_5 (7.93 gm), and yield also had the highest value (5 ton/ha) in V_5 according to the average value of them (S_1). In V_2, the moderate weight per fruit (6.56 gm) was found, along with the lowest yield (3.08 ton/ha). On the other hand, V_4 had the lowest weight per fruit (6.44 gm) but gave a moderate yield (4.05 ton/ha). There was a mixed relationship between weight per fruit and yield (Figure 5).

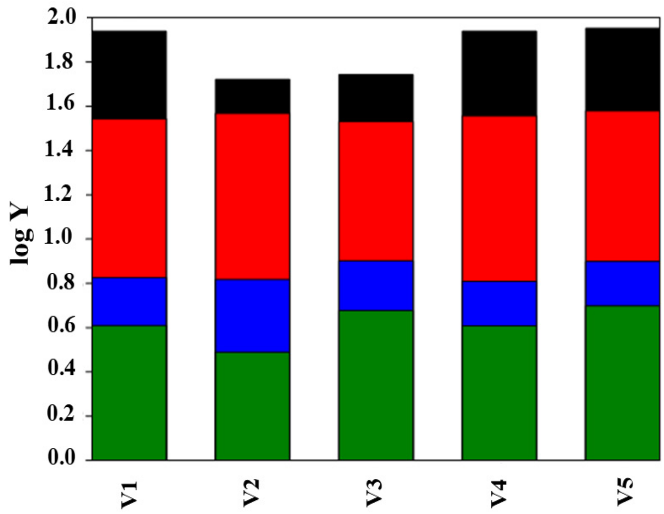

Figure 5: *Different traits in different varieties in Yardlong Bean. Germination, Days to first flowering, Weight per fruit and Yield were displayed in the graph.*

Note: *Black color denotes germination, Red color denotes first flowering, Blue color denotes weight per fruit and Green color denotes yield.*

The selection of varieties is important based on the characteristics of the area. In saline areas, suitable varieties are required. The study conducted in a saline-prone area of Bangladesh involved five hybrid varieties of Yardlong bean, with one variety imported from Thailand and the others developed locally. The data collected revealed that the imported hybrid variety had a significant difference ($p<0.001$) in the number of seeds per fruit compared to the other local hybrids. Additionally, local hybrids V_2, V_4, and V_5 showed a significant difference ($p<0.005$) in the number of fruits per plant. In terms of fruit length, all varieties showed a positive difference ($p<0.001$) from each other. However, the germination percentage and first flowering were disproportionate, with the imported V_3 variety having moderate germination and fast first flowering, while local hybrids had high germination percentage and late first flowering. Despite this, the weight per fruit and yield were found to be proportionate. The study also found that local hybrids had high weight per fruit and the highest yield, except for V_4, which had the lowest weight per fruit but still gave a moderate yield. Karim *et al*. (2020) found that germination percentage of Yardlong beans increased with seed priming consistent with the finding, our study revealed that germination percentage increased in locally developed hybrids with seed treatments. The local hybrids in our study showed positive significance ($p<0.005$) towards the study area and agreed to the study of Huque *et al*. (2012) have found the local hybrids performed better than exotic ones. PCA analysis of Huque *et al*. (2012) showed that Lal beni variety performed better than Saba which is fully compatible with our study. Ullah *et al*. (2012) used GGE biplot techniques to select high-yielding and stable mungbean genotypes, which is almost similar to our study. We have found that the number of fruits per plant and yield are highest in variety 1070 (V_5) which is consistent with the study of Pornsuriya and Chittawanij (2019) that also found a positive significant relation between the number of fruits per plant and yield. Additionally, we have found that fruits per plant in hybrid is also significant ($p<0.005$) in our study area. In the study of Pornsuriya and Chittawanij (2019), it was found that pod per plant was significant in Yardlong bean line varieties. We have found that locally developed hybrids are more promising in our study site.

Conclusions and Recommendations

To address the pressing need for research on crop selection and adaptation in contemporary agriculture, our study focused on evaluating different hybrid varieties of local and imported origin in a saline-prone area. The genotype White Beauty (V_3) was found to have the minimum number of days to first flowering, highest fruit weight, and the highest seed per fruit, while the genotype Yardlong Bean 1070 (V_5) was the best in terms of germination percentage, maximum fruit per plant, and yield. Yardlong Bean 1070 (V_5) was therefore recommended for extensive cultivation, as it also demonstrated the highest yield and market value potential compared to other varieties. The results also indicated that local and exotic varieties did not show superiority in all parameters, and Yardlong Bean 1070 (V_5) was found to be the most cost-effective option for farmers. More participatory and explanatory research is needed to recommend the selection of varieties in saline areas of Bangladesh.

Acknowledgements

The authors would like to thank the Department of Agriculture, Noakhali Science and Technology University, Noakhali-3814, Bangladesh for their support and for allowing this research study.

Novelty Statement

A study conducted in 2019 at Nobogram Farm in Bangladesh revealed a significant discovery: locally bred Yardlong bean hybrids were found to be more resilient than other varieties, highlighting their importance in ensuring sustainable agriculture in the face of climate change and salinity.

Author's Contribution

Shakil Ahmed: Designed the methodology, conducted research works, collected data.
Mahin Das and Shishir Kanti Talukder: Did statistical analysis.
Shakil Ahmed and Md. Rayhan Sojib: Wrote the manuscript.
Shofiqul Islam and Shishir Kanti Talukder: Reviewed the whole manuscript.
Gazi Md. Mohsin, Sadia Sultana and Prantika Datta: Edited the manuscript.
Gazi Md. Mohsin: Supervised the whole research work.
All authors read and approved the final manuscript.

Conflict of interest
The authors have declared no conflict of interest.

References

BARC, 2012. Bangladesh Agricultural Research Council. Fertilizer recommendation guide. pp. 27.

BBS, 2019. Bangladesh Bureau of Statistics. Statistical Year Book Bangladesh 2018. 38th ed., Dhaka, Bangladesh, ISBN-978-984-475-020-3, pp. 569.

da Cunha, A.L.B., F.C.M. Chaves, C. Kano, Í.G.

Braga and M.R. de Oliveira. 2020. Nutrient uptake rate for yard long bean. Hortic. Brasil., 38: 175-184. https://doi.org/10.1590/s0102-053620200210

Gurmu, G.N., T.B. Mulisa, A.L. Gemechu, K.G. Amena and G.N. Terfa. 2022. Evaluation of field pea (*Pisum sativum* L.) varieties for yield and yield-related traits. Sarhad J. Agric., 38(4): 1219-1227. https://doi.org/10.17582/journal.sja/2022/38.4.1219.1227

Hossain, M.K., N. Alam, A. Jaime, T. da Silva, B.K. Biswas and G.M. Mohsin. 2013. Genetic relationship and diversity based on agromorphogenic characters in yard long bean (*Vigna sesquipedalis* L. Fruw) germplasm. Int. J. Plant Breed, 7(2): 129-135.

Huque, A.M., M.K. Hossain, N. Alam, M. Hasanuzzaman and B.K. Biswas. 2012. Genetic divergence in yardlong bean (*Vigna unguiculata* (L.) Walp. ssp. sesquipedalis Verdc.). Bangladesh J. Bot., 41(1): 61-69. https://doi.org/10.3329/bjb.v41i1.11084

Karim, M.N., M.N.H. Sani, J. Uddain, M.O.K. Azad, M.S. Kabir, M.S. Rahman and M.T. Naznin. 2020. Stimulatory effect of seed priming as pretreatment factors on germination and yield performance of yard long bean (*Vigna unguiculata*). Horticulturae, 6(4): 104. https://doi.org/10.3390/horticulturae6040104

Khan, M.J., T.M.T. Iqbal, M.A. Kabir, N. Muhammad and M.R. Islam. 2015. Quality assessment of yard long bean (*Vigna unguiculata*) seeds through the controlled deterioration technique. Int. J. Agron. Agric. Res., 7(4): 117-127.

Misu, I.J., M.S. Ali, A.I. Rony, M.N. Siddike, N.A. Payel, M.F. Islam, S. Tanvir, M. Shikder and G.M. Mohsin. 2023. Effect of plant growth regulators on growth, yield and yield contributing characters of brinjal (*Solanum melongena* L.) in coastal zone of Bangladesh. Res. Agric. Livest. Fish., 10(2): 91-97. https://doi.org/10.3329/ralf.v10i2.68752

Mitran, T., R.S. Meena, R. Lal, J. Layek, S. Kumar and R. Datta. 2018. Role of soil phosphorus on legume production. In Legumes for Soil Health and Sustainable Management. pp. 487-510. https://doi.org/10.1007/978-981-13-0253-4_15

Niazian, M. and G. Niedbała. 2020. Machine learning for plant breeding and biotechnology. Agriculture, 10(10): 436. https://doi.org/10.3390/agriculture10100436

Nooprom, K. and Q. Santipracha. 2015. Effect of varieties on growth and yield of yard long bean under Songkhla Conditions, Southern Thailand. Modern Appl. Sci., 9(13): 247-251. https://doi.org/10.5539/mas.v9n13p247

Osman, M.A., K. Hossen, R.H. Chowdhury, C.N. Tabassum, M.K. Islam, R. Ahmed and T. Ferdous. 2020. Assessment of different weed control methods on growth and yield performance of *T. aus* rice. Agric. Res. Technol. Open Access J., 24(3): 87-92. https://doi.org/10.19080/ARTOAJ.2020.24.556267

Pidigam, S., V. Thuraga, S.R. Pandravada, S. Natarajan, S. Adimulam, G. Amarapalli and K. Venkateswaran. 2021. Genetic Improvement of Yardlong Bean (*Vigna unguiculata* (L.) Walp. ssp. *Sesquipedalis* (L.) Verdc.). Adv. Plant Breed. Strat. Vegetable Crops, 10: 379-420. https://doi.org/10.1007/978-3-030-66969-0_10

Pornsuriya, P. and A. Chittawanij. 2019. Augmented analysis for yield and pod characteristics of yardlong bean (*Vigna unguiculata* (L.) Walp. ssp. sesquipedalis Verdc.) lines. Int. J. Agric. Technol., 15(6): 987-996.

Quamruzzaman, A.K.M., F. Islam, L. Akter, A. Khatun, S.R. Mallick, A. Gaber and A. Hossain. 2022. Evaluation of the quality of yard-long bean (*Vigna unguiculata* sub sp. *Sesquipedalis* L.) cultivars to meet the nutritional security of increasing population. Agronomy, 12(9): 2195. https://doi.org/10.3390/agronomy12092195

Roy, N., P. Dash, M. Islam, S. Das and M. Mannan. 2022. Genotype and spacing on growth, yield and profitability of Yardlong bean. Bangladesh J. Agric. Res., 47(2): 169-189.

Tantasawat, P., J. Trongchuen, T. Prajongjai, W. Seehalak and Y. Jittayasothorn. 2010. Variety identification and comparative analysis of genetic diversity in yardlong bean (*Vigna unguiculata* spp. sesquipedalis) using morphological characters, SSR and ISSR analysis. Sci. Hortic., 124(2): 204-216. https://doi.org/10.1016/j.scienta.2009.12.033

Ullah, H., I.H. Khalil, Durrishahwar, Iltafullah, I.A. Khalil, M. Fayaz and F. Ali. 2012. Selecting high yielding and stable mungbean (*Vigna radiata* (L.) Wilczek) genotypes using GGE biplot techniques. Can. J. Plant Sci., 92(5): 951-960. https://doi.org/10.4141/cjps2011-162