



Prospect of Cocoa (*Theobroma cacao* L.) Cultivation in the Environmental Conditions of Gazipur, Bangladesh

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Abstract: Cocoa is a newly introduced plant in Bangladesh but globally recognized as a cash crop because it is used as a raw material for chocolate. This article aimed to introduce the cocoa plant with cultivation practices to the local environmental conditions in the Gazipur district in Bangladesh. The study of cocoa plants concerning morphology, extracting cocoa beans from ripened pods, and producing cocoa powder from fermented beans were investigated. The investigation revealed that cocoa plants were grown successfully under the climatic conditions in Gazipur. The planted cocoa tree stood at about four meters in height, and it started producing fruits five years after being planted on the plantation. Data was collected from seven ripened pods of a cocoa plant. The mature yellow pod was found to average 13.27cm in length and 8.63cm in diameter. The average pod weight was found 294.14g. Each pod contains 42 beans, which become cocoa beans after completing the fermentation and drying process. Each pod produced an average of 24.73g dry seeds and 19.30g cocoa powder. The seedling production was successfully done in the local environmental conditions. The study concluded that prospective cocoa plants might be grown well in Bangladesh.

Keywords: Cacao; Morphology; Chocolate beans; Adaptation; Environmental conditions.

INTRODUCTION

Theobroma cacao L., a tropical plant grown for its seeds and beans, is known as the cocoa or cacao plant (Family: Malvaceae). Although it is a relatively new plant in Bangladesh, it is well-known as a cash crop across the globe. Most of the cocoa products, including premium chocolate, butter, ice cream, bread, pudding, cosmetics, and drinks, are made with cocoa bean powder (Payne et al., 2010; Beg et al., 2017). African nations' economies rely heavily on cocoa beans (Akinnifesi et al., 2006; Folayan, 2010; Ntiamoah and Afrane, 2008). Furthermore, cocoa is utilized in the pharmaceutical and cosmetics industries (Beg et al., 2017). The aroma and nutritional value of the bean are highly valued. The yield of cocoa beans is cocoa butter, which is a primary commercial product of cocoa. Cocoa beans yield cocoa butter as their primary commercial product. Two key parameters fat and polyphenols, determine the quality of cocoa beans. The presence of phenolic compounds in cocoa beans influences the quality of raw cocoa, which forms the foundation for all chocolate products (Karthikkumar, 2014). The plant known as cocoa originates from the Amazon valley in South America. It is primarily grown in Central America

and Africa. The leading cocoa-producing nations are currently Ivory Coast, Ghana, Indonesia, Nigeria, Cameroon, Brazil, Ecuador, Peru, the Dominican Republic, and Colombia (Aremu-Dele, 2022). Cocoa is also grown in a few Asian countries such as Malaysia, Indonesia, and India. Peru currently holds the top rank in the world for yield per hectare (FAOSTAT, 2020).

The cocoa tree thrives in tropical regions and is most suited to elevations ranging from 10 to 400 meters above sea level, with the optimal range being from 4 to 800 meters above sea level (Montaldo, 1982). The ideal temperature range for cocoa cultivation is between 18°C and 32°C. Annual precipitation should not fall below 1,000 mm or exceed 3,000 mm. To enhance cocoa production, it is essential to provide shade to protect the plants from direct sunlight and strong winds (UNCTAD/WTO, 2001). Cocoa is cultivated across a broad geographical area, with loamy and clay-loamy soils being the most suitable for cocoa growth, ideally with a pH of 6.0-7.5 (Wood, 1982). Extreme cold or hot temperatures are not tolerable for cocoa tree growth. In various parts of Bangladesh, a limited number of thriving cocoa plants have been sighted, suggesting that cocoa plants have successfully adapted to the local

environment in Bangladesh. The study aims to assess the morphological traits and seed yield of cocoa plants within the environmental context of the Gazipur district in Bangladesh.

MATERIALS AND METHODS

Climatic condition and soil status of the study area

This research was carried out from January to June 2024 on the flowering, fruiting, pod harvesting, seed extraction, and powder preparation of beans; but even so, the initial observations on a cocoa plant (from seedling to the onset of flowering) were initiated in 2018. In 2018, the cocoa plants were cultivated at the Bangladesh Open University's (BOU) field laboratory in Gazipur Sadar Upzila, Bangladesh (Fig. 1). The experimental site is situated under the Agro-Ecological Zone 28 (AEZ-28) (UNDP and FAO, 1988). The Gazipur district is located between 23°53'-24°2' north latitude and between 90°09'-92°39' east longitude (Rony et al., 2021).

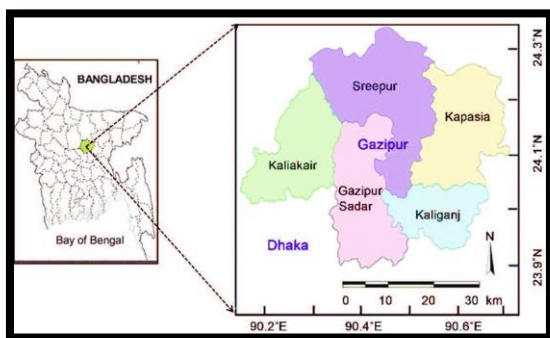


Figure 1. Location map of Gazipur District, Bangladesh (Rony et al., 2021)

The overall environmental conditions of the study area are characterized by relatively scanty rainfall, low humidity, low temperature, short days, and long clear sunshine from October to March. The monthly average temperature gradually decreased from October to December and then stable up to February. Minimum monthly rainfall and maximum sunshine hours with sunny days were observed from December to February. The monthly average relative humidity gradually decreased from October to March. The field soil is sandy loam with a pH of 6.95 and organic matter of 1.21%. Other major soil elements are 0.054% N, 26.541% P, 0.132% K, 10.718% S, 0.891% Zn, and 0.244% B (BRAC-Lab, 2022).

Plantation of cocoa seedlings

The cocoa seedlings were collected from Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur, Bangladesh in 2018. The seedlings were grown in polybags and transplanted in the field. The variety of collected cocoa seedlings was not identified. The individual seedling height was measured at approximately 50 cm at the time of transplanting and the age was five months (Fig. 2). A planting hole was made measuring

40×40×40 cm at the staked-out positions and taking care to separate the surface soil from the deeper soil. Each hole was fertilized only with approximately five kg of dry cow dung. After preparing the soil, the seedling was planted in the hole. Carefully cut and remove the plastic bag from the base of the seedling before planting. The planted seedling was irrigated uniformly with one-day intervals to ensure plant establishment. Stalking is done with a bamboo stick to prevent plant fall on the ground due to transplanting socks.



Figure 2. Seedling of cocoa

Intercultural operations

Three manual weeding operations were conducted within a year to promote the optimal growth, flowering, and fruiting of cocoa plants. To enhance pod production, the trunk of each cocoa tree was pruned at a height of 1.2 m above the ground, and pruning shears were utilized to remove parts of the plants affected by insects and diseases. Fertilizers, specifically urea, TSP, and MP, were applied at the rate of 300, 250, and 200g, respectively, in a circular band one month following the pruning. The bands were established at distances of 25, 50, and 100 cm from the base of the plant for the second, third, and fourth years, respectively, and were subsequently covered with soil after the fertilizer application. Irrigation was carried out as needed. Although symptoms of leaf insects and pod diseases were noted in the cocoa plants, the level of infestation was not significant, thus no control measures were deemed necessary for managing insects and pests in this crop.

Data collection

The data on ripened pods and beans were collected from 1 to 15 April 2024. Seven ripened cocoa pods were used for measuring different parameters of pods (Table 1). Plant height was measured by using a metering tape and was expressed in meters. The length and diameter of the fruits were measured as the vertical and horizontal distance from one side to another in cm by a small centimeter scale. The individual fruit weight, fresh pulp weight, fresh seeds weight, fresh husk weight, dry seed weight, roasted seed weight, and cocoa powder weight were measured by an electronic balance and expressed in grams (g).

Data analysis

The design of this experiment was done as CRD (complete randomized design) with seven replications. Data on ripen pod weight (g), pod length (cm), pod diameter (cm),

number of seeds/pod, fresh seed with pulp weight before fermentation (g/pod), fresh husk weight (g/pod), total seed weight after fermentation and before sundry (g/pod), total seed weight after fermentation and sundry (g/pod), total roasted dry seed weight (g/pod) and total dry cocoa powder weight (g/pod) were analyzed with a one-way analysis of variance (ANOVA). The statistical analyses were performed using the procedure of SAS and means were separated using the Least Significant Difference (LSD) test at a 5% level of significance (SAS Institute, 2001).

RESULTS

Morphological characteristics



Figure 3. Showing pod-bearing matured plant and matured pods of cocoa plant

Fruit harvesting and seed extraction

The cocoa tree can produce fruit twice a year. The pods grow both along the main stem of the tree and throughout the canopy. Pods were harvested on 10 April 2024 at the optimum maturity stage when the color turned green to

The height of the planted cocoa tree was found around four meters, and it bore fruit after five years from the plantation. Planted cocoa is an evergreen tree and bushy in appearance (Fig. 3). The flowers were pinkish-yellow in cluster form on the stems and branches. Six branches were observed at 1.4 m in height. The appearance of the plant was found vigorous. Five years old plant produced 16 green pods in January 2024. Young green pods were turned into yellow color at the mature stage (Fig. 3). The color of mature cocoa pods was yellow those took 5-6 months for formation from pollinated flowers. The mature pods contained pale to deep purple color beans (Fig. 5).

yellow (Fig. 3). At a time seven matured pods out of 16 pods were harvested to measure selected parameters under the study and seeds were collected for preparing the fermentation process. Pods were broken after harvest and opened to extract seeds by using a sharp knife without any damage.

Table 1: Physical properties of ripened fruit/pod and beans of cocoa plant

Parameter	Mean ± SE (Standard Error)
Ripen pod weight (g)	294.14± 12.22 a
Pod length (cm)	13.27± 0.23 e
Pod diameter (cm)	8.63± 0.18 e
Number of seeds/pod	41.71± 1.67 d
Fresh seed with pulp weight before fermentation (g/pod)	68.43± 3.05 c
Fresh husk weight (g/pod)	205.43± 12.58 b
Total seed weight after fermentation and before sundry (g/pod)	56.71± 2.35 cd
Total seed weight after fermentation and sundry (g/pod)	24.73± 0.97 e
Total roasted dry seed weight (g/pod)	22.91± 0.91 e
Total dry cocoa powder weight (g/pod)	19.30± 0.91 e

Means with the same letter within a column are not significantly different (LSD-test, following one-way ANOVA: P < 0.05)

The mature pods contained pale to deep purple color beans. Only the healthy pods were separated from the damaged ones to collect seeds. Defective beans and debris were removed by hand after breaking the pods. Significant differences ($df = 9, 69; F= 281.34; P < 0.0001$) were observed among the ten physical properties of the ripened pod. The average mean values of investigated ten physical parameters of ripened pod of cocoa have been presented in Table 1. The average pod length was observed 13.27cm long and the diameter was 8.63cm. Each fruit contains 42 seeds, which become cocoa beans when fermented and dried. The individual pod weight was found 294.14g.

Fermentation and dry bean preparation

Seed fermentation is essential to develop the aroma of the chocolate. The freshly extracted beans were collected from seven ripened pods and placed on banana leaves inside a plastic basket (Fig. 4). The beans were covered by banana leaves and left for 6 days for fermentation. The beans were changed in color from white to brown (Fig. 4 & 5). After fermentation, the rest of the pulps were removed by washing the beans with sand. The beans were dried in an open place under clear sunshine. Thereafter, the beans were spread out on mats placed in the sunlight and stirred beans frequently for 5 days. Sorting was done by removing defective or flat beans. Beans were placed in a dry and well-aerated space to protect beans from a damp environment.



Figure 4. Showing cocoa seeds with pulp

Cocoa powder

Approximate 173 g of dried fermented cocoa beans were roasted in a frying pan in the home environment following the household practice of making roasted beans and then powder (Fig. 5). Each pod produced an average of 24.73g of dry seeds and 19.30g cocoa powder. A special aroma was developed in roasted beans and later in cocoa powder due to fermentation. The developed smell was similar to commercial cocoa powder that is available at local markets in Bangladesh. The similarity of aroma in home-produced cocoa powder was justified by following sensory evaluation by the faculty members and other officials of BOU.



Figure 5. Showing cocoa dry beans and powder

Seedling production

The extracted healthy beans are cleaned thoroughly in water to produce seedlings and then scrubbed with fine sand to remove the whitish pulp. Rinse the seed again in water after the seed was sown in prepared polybags.



Figure 6. Showing of cocoa seedlings in polybags after one month of sowing

Cocoa seedlings can be established first in polybags in a nursery for better growth. Filled polybags with sandy loam soil with 50% dry cow dung. The bag size was 15x25x10 cm (Fig. 6). One bean at the center of each bag, with the fatter end of the seed pointing down or flat for the better upright growth of the root. Push the seed to a depth of one cm, cover it with soil, press it lightly with the fingers, and then water abundantly. The polybags were placed under a shade. Watering the cocoa seedlings was done every day early morning for the first 15 days after sowing, then every other day to ensure that the bags of soil remained moist. The results also revealed that the seedlings' multiplication was successfully done in our local environmental conditions (Fig. 6).

DISCUSSION

Bangladesh's climate is referred to as the tropical monsoon. It boasts tropical cyclones and an average annual precipitation of about 2,200 mm in a warm, humid climate. Throughout the year, the average temperature ranges from 15°C to 34°C (CCKP, 2021). Climate and soil conditions have a significant impact on cocoa growth and yield (Ramírez-Jaramillo et al., 2021). After planting, cocoa trees start to bear fruit four to five years later. According to Edoh

and Samnick (2014), a plant can continue to be productive for several decades (UNCTAD/WTO, 2001). Typically, a plant produces 10-80 pods, with each pod containing 20-50 beans. The primary factors used in selecting a cocoa variety are yield and seed quality (Eskes and Lauaud, 2001). The primary element influencing cocoa production is the number of pods produced by each plant in a given year. According to Thondaiman et al. (2013), yield-contributing traits like the number of pods per plant and the dry bean yield per plant impact the production of cocoa. Within five days of harvesting, the plant's pods broke down. Traditional fermentation is the outcome of a series of events that are inoculated naturally into cocoa pulp by lactic acid, acetic, and yeast bacteria, among other microorganisms. Ultimately, the final byproducts of fermentation give beans their unique scent (Schwan and Wheals, 2004). To maintain the product's quality, the storage area needs to be dry, hygienic, well-ventilated, and secure (Edoh and Samnick, 2014). Cultivar groups Forastero, Trinitario, and Criollo are used to categorize cocoa plants. All domesticated varieties are native to America, and Forastero beans account for the majority of chocolate produced worldwide today. Strong-tasting fermented beans are produced by the robust Forastero tree. Its pods are yellow, short, and smooth on the outside with just little, non-warty furrows. Pale to deep purple beans are found in it (Asare, 2006). Most probably, the cultivated variety of cocoa plants under study is Forastero. Because the physical properties of the studied cocoa plant with pods and beans match with Forastero as mentioned by Asare (2006).

CONCLUSION

The agroclimatic requirements of cocoa plants are more or less similar to the climatic conditions of Bangladesh. The cocoa plant is grown well and produces desirable beans under the climatic conditions of the Gazipur district of Bangladesh. Practiced cultivation technology of cocoa plants can be recommended for interested growers in Bangladesh. There is a possibility to become a cocoa plant as a prospective crop in Bangladesh. Therefore, research on cocoa cultivation is needed to study and evaluate the performance of this newly introduced cocoa plant under different agroecological zones in Bangladesh.

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Conflict of interest

The authors declare no conflicts of interest.

REFERENCES

- Aremu-Dele, O., Sobowale, I.O., Nduka, B.A., Adesanya, K.A., Solomon, O. 2022. Cocoa production improvement in some major producing countries of the world.

- Conference paper. [Available at: <https://www.researchgate.net/publication/362154696>].
- Akinnifesi, T. A., Asubiojo, O. I. and Amusan, A. A. 2006. Effects of fungicide residues on the physicochemical characteristics of soils of a major cocoa-producing area of Nigeria. *Science of the Total Environment*. 366:876–879.
- Asare, R. 2006. A Review on Cocoa Agro-Forestry as a Means for Biodiversity Conservation. World Cocoa Foundation Partnership Conference, Brussels, 1-17.
- Beg, M. S., Ahmad, S., Jan, K. and Bashir, K. 2017. Status, supply chain, and processing of cocoa-A review. *Trends in food science and technology*. 66: 108- 116.
- BRAC-Lab. 2022. Soil-testing laboratory. BRAC-Seed and Agro Enterprise (SAE), CERDI Road, 1701 Gazipur, Bangladesh.
- CCKP. 2021. WBG Climate Change Knowledge Portal. Climate Data: Historical. Bangladesh. URL: <https://climateknowledgeportal.worldbank.org/country/bangladesh/climate-data/historical>
- Edoh, A.K. and Samnick, E.L.N. 2014. The Pro-Agro Collection is a joint publication by Engineers without Borders, Cameroon (ISF Cameroun), and The Technical Centre for Agricultural and Rural Cooperation (CTA).
- Eskes, A.B. and Lauaud, C. 2001. Cocoa. *Tropical Plant Breeding*, (Eds Charrier, A., M. Jacquot, S. Hamon, and D. Nicolas), (Translation ed Razdan, M.K), Plymouth UK, Science Publishers Inc., France, CIRAD, 78-105.
- FAOSTAT. 2020. Food and Agriculture Organization of the United Nations (FAO). FAOSTAT Database. <https://www.fao.org/faostat/en/#data/QC> L. Accessed 02/03/2022.
- Folayan, J. A. 2010. Nigerian cocoa and cocoa by-products: Quality parameters, specification and roles of stakeholders in quality maintenance. *Pakistan Journal of Nutrition*, 9:915–919.
- Karthikkumar, R.B. 2014. Performance evaluation and adaptability behavior of plus trees of cocoa (*Theobroma cacao* L.). Ph.D. (Hort.) Thesis, submitted to Tamil Nadu Agricultural University, Coimbatore, 2014.
- Montaldo, P. 1982. Agroecología del tropica Americano. Instituto Interamericano de Cooperacion para la Agricultura. Serie de Libros y Materials Educativos Num.51. San Jose, Costa Rica. 15-21.
- Ntiamoah, A. and Afrane, G. 2008. Environmental impacts of cocoa production and processing in Ghana: Life cycle assessment approach. *Journal of Cleaner Production*, 16:1735–1740.
- Payne, M.J., Hurst, W.J., Miller, K.B., Rank, C. and Stuart, D.A. 2010. Impact of fermentation, drying, roasting, and Dutch processing on epicatechin and catechin content of cacao beans and cocoa ingredients. *Journal of Agricultural and Food Chemistry* 58(19): 10518-10527.
- Ramírez-Jaramillo, G., Romo-Olán, M.J., Lozano-Contreras, M.G. and Ramírez-Silva, J.H. 2021. Agro-Ecological Aptitude to Produce Cocoa under Rain-fed Conditions in Tabasco Mexico. *Open Access Library Journal*, 8: 1-12.
- Rony, S.A., Islam, M.A., Anisuzzaman and Alam, M.Z. 2021. Small-scale farmers' perception and practice on coccidiosis management in broiler farm at Gazipur, Bangladesh. *Annals of Parasitology*, 67(1): 85-94. [https://www.researchgate.net/figure/Location-map-of-Gazipur-district-in-the-northern-outskirts-of-Dhaka-highlighted-with_fig1_350520221].
- Schwan, R.F. and Wheals, A.E. 2004. The microbiology of cocoa fermentation and its role in chocolate quality. *Critical Reviews in Food Science and Nutrition*, 44(4), 205-221.
- SAS Institute. 2001. SAS/Stat User's Guide, Version 8.1. SAS Institute, Cary, North Carolina, USA.
- Thondaiman, V., Rajamani, K., Senthil, N., Shoba, N. and Joel, A.J. 2013. Variability studies and identification of high-yielding plus trees of cocoa (*Theobroma cacao* L.) in Tamil Nadu. *African Journal of Agricultural Research*. 8(26):3444-3453.
- UNCTAD/WTO. 2001. Cocoa: A guide to trade practices. International Trade Centre. Product and market development. International Trade Centre UNCTAD/WTO 2001.
- UNDP-FAO. 1988. Land Resources Appraisal of Bangladesh for Agricultural Development: Agroecological Regions of Bangladesh. Technical Report No. 2, FAO, Rome.
- Wood, G. 1982. Cacao, Trad. por Marino, Primera edicion en español, Compania Editorial Continental S.A., Mexico, D.F. 53-69, 255-274.

