Technical Report on Bangladesh GAP Validation Trial 2023-24

GAP Unit

Bangladesh Agricultural Research Council

Farmgate, Dhaka-1215, Bangladesh

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Technical Report
Bangladesh GAP Validation Trial (2023-24)

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Preface

Food safety has become a critical issue globally, closely tied to both public health and economic stability. Ensuring the safety and quality of food from farm to table is essential to protect consumers and enhance market competitiveness, both domestically and internationally. In this context, Good Agricultural Practices (GAP) have emerged as a proven framework to guide farmers in producing safe, high-quality and environmentally sustainable agricultural products.

In Bangladesh, the concept of GAP is still relatively new, and efforts are underway to build awareness and capacity among farmers, consumers, and other stakeholders. Recognizing the importance of a structured approach, the Bangladesh Agricultural Research Council (BARC) in collaboration with Bangladesh Agricultural Research Institute (BARI) and the Department of Agricultural Extension (DAE), has initiated a nationwide programme to validate crop-specific GAP protocols. These protocols are based on a comprehensive standard comprising five core modules, with 18-19 components and 246 control points tailored to individual crops.

This technical report presents the outcomes of the first phase of Bangladesh GAP field validation trials, conducted across 8 locations in 8 districts. Among the selected crops three were fruits (Mango, Jackfruit and Guava) and five were vegetables (Brinjal, Yard-long bean, Bottle gourd, Pointed gourd and Green papaya). The crops were chosen based on criteria such as productivity, safety, export potential, and market demand. The most potential areas for respective crops with good road communication facilities were selected for validation trial. Each trial was implemented on 80 to 100 decimals (0.32 to 0.40 ha) of land, under the direct supervision of BARI scientists with the help on DAE Personnel and local farmers.

The results of these trials demonstrate that implementing GAP can significantly enhance crop yields, reduce contamination risks, improve product quality, and boost profitability. Benefit-Cost Ratios across trials ranged from 1.31 to 2.38, reflecting strong economic viability. Notably, Maximum Residue Limit (MRL) tests confirmed the absence of harmful chemical residues, underscoring the food safety advantages of GAP adoption.

This report is intended to provide practical insights, evidence and policy guidance to support the broader adoption of GAP in Bangladesh. We hope it will serve as a valuable reference for researchers, policymakers, extension workers, and producers committed to advancing sustainable agriculture and safe food systems in the country.

Editors

Abbreviation and Acronyms

AEO	:	Agriculture Extension Officer
AEZ	:	Agro-Ecological Zone
BARC	:	Bangladesh Agricultural Research Council
BARI	:	Bangladesh Agricultural Research Institute
BBS	:	Bangladesh Bureau of Statistics
BCR	:	Benefit-Cost Ratio
BLQ	:	Below the Limit of Quantification
BW	:	Bacterial Wilt
DAE	:	Department of Agricultural Extension
DAM	:	Department of Agricultural Marketing
ESFB	:	Eggplant Shoot and Fruit Borer
FAO	:	Food and Agriculture Organization
FRG	:	Fertilizer Recommendation Guide
GAP	:	Good Agricultural Practices
HRC	:	Horticulture Research Centre
HSC	:	Higher Secondary Certificate
HYV	:	High Yielding Variety
LOQ	:	Limit of Quantification
MoP	:	Muriate of Potash
MRL	:	Maximum Residue Limit
PPE	:	Personal Protective Equipment
RH	:	Relative Humidity
SAAO	:	Sub-Assistant Agriculture Officer
TDS	:	Total Dissolved Solids
TSP	:	Triple Super Phosphate
TSS	:	Total Soluble Solids

Contents

Executive Summary

Food safety has become increasingly important due to its impact on both public health and the economy. Producing safe food helps protect consumers from foodborne illnesses and strengthens both domestic markets and export opportunities. Food safety risks can arise at any stage of the food chain, starting from the farm, and may include excessive agro-chemical residues, microbial contamination, or heavy metals. Therefore, ensuring food safety must begin at the production level. Applying Good Agricultural Practices (GAP) during farming and post-harvest handling is crucial to delivering safe, high-quality agricultural products and maintaining a secure food supply.

Good Agricultural Practices (GAP) are a set of guidelines that help farmers produce safe, high-quality, and environmental friendly crops. These practices cover key farming areas like soil management, efficient water use, pest and disease control, and proper post-harvest handling. By following GAP, farmers can boost yields, protect the environment, and meet both local and international market standards.

Many export markets and organized domestic buyers now require GAP certification to ensure food safety and quality. Beyond market access, GAP supports sustainable farming by promoting responsible use of pesticides, fertilizers and water. It also protects farm workers from harmful exposure to chemicals and places food safety as its top priority.

In Bangladesh, the GAP standard is organized into five modules. Crop-specific GAP protocols have been developed, each with 18 to19 components and 246 control points. Scientists, including plant pathologists and entomologists from the Bangladesh Agricultural Research Institute (BARI), were involved in creating these protocols. Field trials are conducted under BARI's supervision in partnership with the Department of Agricultural Extension (DAE).

GAP is still a relatively new concept in Bangladesh, and awareness among farmers and consumers remains limited. The GAP value chain is in its early stages, with protocols recently developed but not yet widely disseminated to stakeholders. Training programmes for various levels are currently ongoing. By 2024-25, GAP protocols for 15 selected crops are expected to be fully developed, and a significant number of stakeholders will be trained. The ultimate goal is to establish GAP implementation at the field level for these targeted crops.

Currently, GAP field validation trials are underway in 8 locations across 8 upazilas or districts. In the first year, GAP protocols were developed for 8 crops across 8 sites. Locations were selected based on criteria like productivity, safety, export potential, market access, progressive farmers, year-round production and demand in domestic and export markets.

The selected crops include, Fruits: Mango, Jackfruit, and Guava, while Vegetables: Brinjal, Yard-long bean, Bottle gourd, Pointed gourd, and Green papaya. Each trial was conducted on 80-100 decimals of land (approximately 0.32-0.40 hectares) per crop.

The summary of the field validation trials are as follows

Mango

A GAP validation trial on Mango was conducted from December 2023 to August 2024 at Kendobona, Nachole, Chapainawabganj. The trial included two export-potential mango varieties developed by BARI: BARI Aam-3 and BARI Aam-4. A 100-decimal (0.405 ha) orchard owned by Md. Rafiqul Islam was used for the trial, yielding 6.1 metric tons of mangoes at full maturity. By following GAP guidelines, high-quality mangoes were produced and sold to local supermarkets and international markets. The farmer earned Tk. 672,000/- from sells. The yield under GAP was 15.0 mt/ha, which is higher than the national average yield of 11.96 mt/ha. Level of the residues of chemicals found in harvested mangoes were below recommended limit.

Jackfruit

A validation trial on GAP for jackfruit was carried out in Chanpur village under Bhaluka upazila of Mymensingh district from January to June 2024. The trial involved 40 jackfruit trees, each around 30 years old. Fruits were harvested between June and July 2024. Before harvesting, Maximum Residue Limit (MRL) tests confirmed that pesticide residues were well below safe limits. The results showed clear improvements in fruit size, shape, and quality, with no harmful residues detected. The GAP trial led to the production of high-quality jackfruits, which were bought by local traders at premium prices and sold in both local markets and supermarkets. Farmers earned Tk. 199,742/- from 100 decimals of land (equivalent to Tk. 978,592 per hectare). The yield reached 27,250 kg per 100 decimals (67.35 metric tons/ha), which is four times of the national average yield (6.81 mt/ha). The gross margin was Tk. 484,765 per hectare, with a benefit-cost ratio (BCR) of 1.98.

Guava

A field trial on Bangladesh GAP for guava was conducted at Kodomsohor village, Godagari, Rajshahi from December 2023 to August 2024. The Thai Peyara-3 guava variety, known for its great taste and popularity, was used in the study. Two progressive farmers, Mr. Golab Hossain and Mr. Alamin, each contributed 50 decimals (total 100 decimals or 0.405 ha) of land. During the reporting period, only Mr. Golab Hossain's orchard produced guavas. He harvested 4.5 metric tons of high-quality fruit from 50 decimals, earning Tk. 202,500/-. After spending Tk. 85,000 on production, he made a net profit of Tk. 117,500. Using GAP methods, Mr. Hossain achieved a yield of 22.5 mt/ha, significantly higher than the national average of 13.94 mt/ha. The benefit-cost ratio (BCR) was 2.38, proving the GAP approach to be profitable. Pesticide residues found in guava fruits harvested from GAP validation trial field were far below the safe limit.

Brinjal

To validate Bangladesh GAP standards for brinjal a trial (variety: Caity, Ispahani Seed Company) was conducted in a farmer's field at Shibpur, Narsingdi during the 2024 summer season. The goal was to produce safe, high-quality brinjal following GAP guidelines. The trial, fully aligned with GAP protocols, covered 37 decimals of land owned by Md. Belayet Hossain. Brinjal was transplanted on 13 March 2024, with 22 harvests carried out between 8 May and 26 July. The final harvest took place 168 days after transplanting. Yield per plot ranged from 69.69 kg to 206.19 kg per harvest, the translated yields stood at 465.23 to1,376.46 kg/ha/harvest. The total yield obtained from the trial was 3.05 mt/plot, equivalent to 20.33 mt/ha, which is almost double of the national average yield (10.94 mt/ha) of the crop. The pesticide residues observed in harvested brinjal were too low to be accurately quantified. These results demonstrate that GAP-compliant brinjal farming can achieve high-quality yields suitable for both domestic and export markets. The economic analysis showed a positive return, with a Benefit-Cost Ratio (BCR) of 1.31.

Yard long bean

A Bangladesh GAP validation trial on yard long bean was conducted from January to June 2024 at Borkoit village, Chandina upazila, Cumilla. The aim was to promote GAP among farmers and produce safe, high-quality yard long beans. Three farmers viz. Md. Rafiqul Islam, Md. Mobarok Hossain and Mahin Ahmed participated in the programme cultivating 70 decimals (0.28 hectares) of land. Before planting, farmers received training on Bangladesh GAP protocols. Soil and water tests were conducted to assess nutrient levels and water quality. The locally popular 'Kagornatoky' variety was used, and technical support was provided throughout the process, strictly following GAP guidelines. The average yield reached 14.64 MT/ha wich is more than double of the national average of 5.50 MT/ha. The Benefit-Cost Ratio (BCR) was 1.41. Farmers were highly satisfied,

benefiting from higher yields and premium prices due to the quality and safety of their produce. The MRL analysis report indicated that there were no health hazardous materials detected in the products.

Bottle gourd

Bangladesh GAP aims to improve the safety, quality, and sustainability of agricultural products through better soil, water, pest, and post-harvest management. A validation trial for bottle gourd (variety: BARI Lau-4) was carried out in Basna village, Dhamrai, Dhaka, during the summer season of 2024 to assess GAP's impact on yield and quality. The trial followed strict GAP protocols in land preparation, seedling care, fertilization, irrigation, and disease control. Despite challenges like drought, gummy stem blight, and high labour costs, the trial achieved an impressive yield of 35.00 MT/ha-well above the national average of 13.7 MT/ha. The Benefit-Cost Ratio (BCR) stood at 1.93. Farmers received training on GAP, which led to improved practices, higher productivity, and increased profits.

Pointed Gourd

A Good Agricultural Practices (GAP) validation trial on pointed gourd was carried out in Borohoibotpur village, Jashore to promote safe and high quality production among farmers. Three trained farmers participated in the programme cultivating 85 decimals (0.34 hectares) of land. Soil and water samples were tested in a certified lab before planting. All activities followed the Bangladesh GAP protocol for pointed gourd with proper record-keeping supported by the Sub-Assistant Agriculture Officer (SAAO), DAE. The trial produced 3.9 metric tons of pointed gourd, with an average fruit weight of 60g. This yield (11.47 MT/ha) was much higher than the national average of 1.21 mt/ha. The total production cost was Tk. 150,000/- and the market price of the vegetable was Tk. 60/- per kg, total revenue reached Tk. 234,000/-. The Benefit-Cost Ratio (BCR) was 1.56. Farmers were pleased with the outcome. The MRL analysis report indicated that there were no health hazardous materials detected in the products.

Green Papaya

A validation trial of the Bangladesh GAP protocol for green papaya was conducted at Atgharia village, Pabna (24°6'51" N, 89°14'48" E) from January to November 2024. The trial followed the Bangladesh GAP standards throughout. On 25 March, 2024, Green Lady variety seedlings were transplanted into the main field. Flowering began in early May. All farming practices including intercultural operations were carried out according to GAP guidelines with proper data recording in the field note book. Regular field monitoring and farmer's training were also conducted. Harvesting took place from September to November, yielding 15.50 metric tons of green papaya from one acre (equivalent to 37 metric tons per hectare), which is a bit higher than the national average yield (35.77 mt/ha). The total revenue was Tk. 450,000/- with a Benefit-Cost Ratio (BCR) of 1.71. MRL testing by SGS Bangladesh Ltd. confirmed that no harmful chemical residues were present in the harvested produce.

Technical Report of Bangladesh GAP Validation Trial: Mango

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Abstract

A study was carried out at Kendobona, Nachole, Chapainawabganj on Bangladesh Good Agricultural Practices (GAP) validation trial during December 2023 to August 2024. Two popular mango varieties of Bangladesh Agricultural Research Institute (BARI) viz. BARI Aam-3 and BARI Aam-4 were included in this trial. These two varieties also have export potentiality. A total of 100 decimals (0.405 ha) mango orchard owned by Md. Rafiqul Islam was selected for this trial and 6.1 metric ton mangoes were harvested during this period. Through this GAP validation trial, good quality mangoes were produced, which were sold to the local super shop and foreign market. This year, the producer earned Tk. 672,000 from 100 decimals (0.405 ha) of land. From Bangladesh GAP followed mango production practices, more yield (15.0 mt/ha) was produced Compared to the Chapainawabganj district average (9.26 mt/ha) compared to The BCR of BARI Aam-3 and BARI Aam-4 were 2.01 and 1.88, respectively.

Introduction

Mango (*Mangifera indica* L.) is considered as a major cash crop and one of the most important commercial fruit crops in Bangladesh. Currently, the area under mango production is 123998 ha and annual production is 14.83 lakh matric tones (BBS, 2024). The area under mango cultivation in Chapainawabganj District is 37,604 ha and the production is 3,48,278 MT. The national average yield is 11.96 t/ha. At present, many medium and large mango orchards are established by the entrepreneurs. GAP for mango production involve a series of steps and techniques aimed at ensuring high-quality fruit and better yield, environmental sustainability and worker safety. Implementing GAP ensures that mango trees receive optimal care, leading to higher yields and better-quality fruits. This includes proper planting techniques, irrigation and pest management. GAP are essential for mango cultivation in Bangladesh. GAP promotes sustainable farming practices that protect the environment. This includes minimizing the use of chemical fertilizers and pesticides, which can be harmful for soil and water sources. Higher quality and yield can lead to better market prices and increased income for farmers. Additionally, GAP can help farmers access international markets by meeting export standards (https: //www.fao.org/ bangladesh/ news/detail-events/en/c/1645232/). It is important to follow GAP standards at every stage from crop production to postharvest management, processing, supply and marketing to ensure safe food. Mango GAP protocol is based on in light of Bangladesh GAP Standards of 18 components and each component explains the requirement of GAP (Bokhtiar *et al.,* 2024 a). In recent years, there has been a growing emphasis on safe fruit production in Bangladesh. Initiatives such as the adoption of GAP and the use of safer production technologies have been instrumental in reducing pesticide residues and ensuring the safety of fruits for consumers. All management practices were done as per Bangladesh GAP protocol (Bokhtiar *et al.,* 2024 b) These practices not only enhance the quality of the produce but also open up new avenues for export.

Despite its abundant production, the export of mango from Bangladesh remains relatively low. However, there is significant potential for growth in this sector. Efforts are being made to reduce postharvest losses and develop value-added products such as mango bars, pickles, drinks, juice, dried mango slice etc. Considering this in mind, Bangladesh GAP validation trial of mango has been undertaken to ensure safe and exportable mango production in Bangladesh.

Methodology

Site selection and justification

Md. Rafiqul Islam's mango orchard is located at Kendobobona village, Nachole, Chapainawabganj. This orchard is situated at 24º77´N latitude and 88º38´E longitude. RS Dag no. 1113, Mouza-Kochra, Union-Kashba and district-Chapainawabganj and owned by Md. Rafiqul Islam. The land is terrace type and the soil is clay loam. Compact soil and upon received water become muddy. The soil pH range is 5.5-6.5. There were no industry or brick field nearer to the research field. Total area under mango orchards was 100 decimals (50 decimal under BARI Aam-3 and 50decimal under BARI Aam-4).

Spacing and plant age

Planting distance for BARI Aam-3 variety was 4.0 × 4.5 m and tree age was 7 years and that for BARI Aam-4 was 3.0 × 2.5 m and plant age 3.5 years. This experiment was conducted at an established orchard.

Land preparation and planting of saplings

The orchard was kept clean throughout the fruiting season. The fencing was done with 60 mesh filter net with a height of 5 feet prior to commencement of research work. The land was prepared by ploughing with power tiller and leveled by using ladder. The grafted saplings of desired varieties were planted in the year 2020 (BARI Aam-4) and 2017 (BARI Aam-3). One and half years' old mango grafts were transplanted into the previously prepared pits. He prepared 1.0 x 1.0 x 1.0 m pits for planting saplings. He applied well decompost 10 kg cowdung, 500 g TSP, 200g MoP, 313g Gypsum, 28 g Zinc Sulphate and 59 g Boric acid per pit.

Fertilizer application

The mango orchard was fertilized following soil analysis result and Fertilizer Recommendation Guide (Ahmmed *et.al.,* 2018 and Azad *et.al.,*2020) The manures and fertilizers eg. 25 kg cow dung, Urea-1085g, TSP-500g, MºP-300g, Gypsum-438 g, Zinc sulphate-22g and Boric acid 47g per plant were applied for 7 years BARI Aam-3 mango tree. For 3.5 years BARI Aam-4 mango tree Cowdung-15kg, Urea-470g, TSP-250g, MoP-180g, Gypsum-188 g, Zinc sulphate-14g and Boric acid 29g per plant were applied.

Irrigation

The experimental site is located at barind area. There were no rainfall in the month of March, April and May. So, five times irrigation was applied to the mango orchard at an interval of 15 days starting from 15 March 2024.

Previous crop history

Rice was cultivated earlier on that area. Last 6 years, the land was taken as lease and planted mango tree. At present only mango is cultivated in this land.

Soil and water analysis result

The soil was analyzed from SGS Bangladesh Limited to check the nutrient status and confirmation of the presence of any kind of heavy metals in the soil. From the soil analysis report, different parameters like Moisture (5.18%), Arsenic (less than 1.0 mg/kg), Cadmium (less than 1.0 mg/kg),

Chromium (17.59 mg/kg), Lead (11.22 mg/kg), Mercury (less than 1.0 mg/kg), Nickel (14.40 mg/kg), Zinc (26.98 mg/kg), Boron (less than 1.0 mg/kg), Potassium (1363.99 mg/kg), Magnesium (1677.87 mg/kg), Conductivity (0.06 dS/m) were found and suitable for GAP validation trial. No hazardous chemical and heavy metals were found in the soil above critical limit, and suitable for GAP validation experiment (Appendix-1).

Water analysis result

The water was analyzed from SGS Bangladesh Limited to check the nutrient status and confirmation of the presence of any kind of heavy metals. From the water analysis report, different parameters like Arsenic (less than 0.01 mg/L), Calcium (57.15 mg/L), Iron (0.08 mg/L), Magnesium (26.14mg/L), Potassium (1.46 mg/L), Sodium (31.81 mg/L), Conductivity 700.0 µS/cm, Total dissolved solids (TDS) (490 mg/L), Chloride (14.0 mg/L), pH-6.7%, Nitrate (0.70 mg/L) and total Phosphorus (less than 1.0 mg/L) were found. Presence of hazardous chemical and heavy metals were below critical limit in water and is suitable for irrigation in GAP validation trial.

Intercultural operation

Weeding: Weeds are competitive for main crops. They are the harbour of insect and disease. So, GAP field should be clean at regular basis. Weeds are not major problem in the winter season but in summer it is very difficult to control. Weeds were controlled manually four times during crop period using spade.

Removal of dead, dried and infected branches: This is a regular orchard management activity. All dead, dried and infected branches were removed just after harvest of the previous year's fruit. Die back infected branches were cut with few inches' of healthy parts.

Use of bamboo sticks

At fruit development stage weight was increased in each branch and touched to the ground. To keep the fruits away from ground, bamboo sticks were used as stake. This bamboo sticks remained in the field up to harvest.

Pruning

Pruning is a good practice to maintain tree canopy. So, pruning practice was done as and when necessary. For this trial pruning was done just after harvest.

Preparation of irrigation canal

To maintain proper moisture in mango orchard, irrigation canal was prepared in between two rows of tree. The canal was kept clean and maintained regularly and was used both for irrigation and drainage of excessive water.

Fencing/netting around the GAP validation trial

The experimental mango orchard was protected by fencing with net with 60 mesh and blue in colour. Normally the roll available in the market is 100 feet long and 5 feet wide. This fencing served as a physical barrier to safeguard the crop from animals and unauthorized access, ensuring the integrity of the trial.

Maintaining of register book and documentation

Data recording is essential for GAP trial. Each activity was noted down in a register book. The activities like land preparation, soil analysis, water analysis, weeding, pit preparation, transplanting, source of grafts, name of pesticides, doses, purpose, who recommended, irrigation time and frequency, maturity, MRL test, dates of all harvests, etc. were noted clearly in the register book. Farm details like owner of the orchard, with contact information, location and size etc. were

also recorded. This unique signboard was designed by GAP unit, BARC, Farmgate, Dhaka.

Pest management

Different insecticides and fungicides were used in mango orchard with various reasons. First the problems were identified then appropriate pesticides were used. The name of insecticides and fungicides, purpose of use and spraying dates are presented in table 1.

Table 1. List of pesticides applied to control insects and diseases.

Spray date	Name of pesticides with doses	Purpose
10.2.2024	Mancozeb @ 2g/ L & Cypermethrin @ 1.0 ml/L of water	To make mango tree pathogen and insect free. This is a preventive measure.
27.2.2024	Mancozeb @ 2 g/ L & Imidacloprid @ 0.5 ml/ L of water	To protect the panicles from Mango hopper and anthracnose
23.3.2024	Carbendazim @ 1g /L & Imidacloprid @ 0.5 ml/L of water	To protect newly developed mango fruit from fruit borer
06.4.2024	Carbendazim @ 1.0 g/L & Abamectin @ 2ml/L of water	To control mite, fruit borer and anthracnose
04.5.2024	Carbendazim @ 1.0 g/L & Imidacloprid @ 0.5 ml/L of water	Before bagging one spray is essential. This is a protective measures for disease and insect free mango production.

Fruit bagging

Fruit bagging is an important technology to produce good quality, safe and exportable mangoes. Fruit bagging was started at first week of May and continued up to mid-May. Bagging was done following all kind of recommendations of fruit bagging technology and with trained skilled labour. Fruit bagging was done 55-60 days after fruit set. The fruit bag size was 20 cm X 30 cm, brown coloured and double layered.

Worker health safety issues as well as environmental issues

Worker health, safety, and environmental stewardship were prioritized throughout the GAP validation trial for mango. To ensure the safety and well-being of all workers, they were provided with protective gear including aprons, masks, hand gloves, caps, and shoes. Additionally, a comprehensive farm instrument manual was issued to guide the proper use of tools and machinery. A training about the use of different tools and machineries as well as health safety issues was provided to the workers. All kinds of activities hazardous to nature and environment were avoided.

Harvesting

Before harvesting fruit, maturity was ensured following both destructive and non-destructive method to confirm maturity. These are days to maturity, external colour, firmness, TSS (%), specific gravity and internal colour. Harvesting was done by sharp knife or secateurs with portion of pedicel to avoid out coming of latex. The harvested fruits were then brought to farm house, pedicels were removed from fruits and these were kept upside down to facilitate drain out of latex. The first harvest was done on 27.6. 2024 (BARI Aam-3) and the last harvest was done 31.7.2024

(BARI Aam-4). Care was taken to keep the harvested fruit away from soil contact. Most of the mangoes were sold in super shop, popular fruit shop, important persons and foreign buyers for export.

MRL analysis results

Maximum Residue Limit (MRL) is important for consumers' safety. Fruit samples of mango were collected by the assigned authorities on 9.6.2024 and results were sent on 15.6.2024. The test was done in the Laboratory of SGS Bangladesh Ltd. Abamectin LOQ: 0.005 mg/kg, Azoxystrobin 0.068 mg/kg, Carbendazim 0.098 mg/kg, Imidacloprid 0.025 mg/kg, Cypermethrin 0.035mg/kg, Mancozeb LOQ: 0.010 mg/kg and Sulphur 307.90 mg/kg were found. This analysis was done not in appropriate time. It was done a month before harvest. Normally, MRL test for mango is suggested one week before mango harvest. There was no harmful level of the chemicals were found for human body (Appendix-3).

Postharvest management

Mango harvesting was done in a clear sunny day. Labourers used gloves, gumboots and appropriate cloths. The harvested mangoes were kept on tarpaulin and sorting, grading were also performed there. Then the fruits were removed from bags and kept in clean plastic crates with linear. Newspaper was used as lining material. Mangoes were not washed by water or any other chemicals.

Training

There were no alternatives of training to the different stakeholders like Agriculture officers, farmers, SAAO, Workers etc. engaged in GAP mango production. Farmers and workers training was done on 8.2.2024. Twenty five (25) participants were trained in the light of GAP mango production, GAP standards and Principles.

Yield

A total of 0.405 ha of land was selected under GAP trial of mango and production was 6.10 metric ton that is (15.04 mt/ha) mango was harvested. BARI Aam-3 was sold @ 120 taka per kg and BARI Aam-4 @100 taka per kg. Total cost of production was 345000 taka and total return was 672000 taka. The district average yield of mango was 9.26 mt/ha (DAE, 2024) mt/ha. So, Bangladesh GAP followed mango production is more (15.04 mt/ha) compared to national average yield (table 2). In this trial we harvested more mangoes (3100 kg) from BARI Aam-3 variety and 3000 kg from BARI Aam-4 variety.

Table 2. Area, Production Income from GAP followed mango orchard.

Variety	Area (ha)	No. of trees	Total cost of Production (Tk.)	Yield (kg)	Yield (mt/ha)	Income (Tk.)	BCR (Tk.)
BARI Aam-3	0.2024	112	185000	3100	15.31	372000	2.01
BARI Aam-4	0.2024	270	160000	3000	14.82	300000	1.88
Total/mean	0.4048	382	345000	6100	15.04	672000	1.95

Benefit cost analysis

GAP protocol ensures production of good quality exportable mangoes. The BCR of BARI Aam-3 was 2.01 where 1.88 recorded from BARI Aam-4. Therefore, BARI Aam-3 is more profitable for farmer.

Farmer's profile and reaction

Md. Rofiqul Islam, father's name: late Koyes Uddin, a leading mango entrepreneur living in Rajarampur village under Gomostapur upazila, Chapainawabganj. He has completed his Honours and Masters degrees and served as a college teacher. Side by side he cultivates mango in his own land. Later he resigned from his teaching profession and fully deployed him as a mango entrepreneur. To be a successful entrepreneur he selected mango cultivation as his current profession. At present, he is cultivating more than 100 hectares of land under eight small projects. He sold all his GAP produced mangoes in a fair price. He is happy to be a part of Bangladesh GAP mango production partner. He mentioned that other farmers are being motivated to his profession and work with him in future.

Export opportunity

GAP produced mangoes are exportable as they meet international standards for quality and safety. Therefore, it may be a good candidate for global markets. Mr. Rofiq exported his mangoes to Sweden. A total of 1500 kg of mangoes were exported this year from GAP orchard. In addition, 50 Kilograms to different Ambassadors, Ministers and other VIP guests. A Diplomats team visited this GAP mango orchard and organized jointly Ministry of Agriculture and Ministry of Foreign Affairs. This is one kind of export promotional activities.

Marketing

Department of Agricultural Marketing (DAM), Hortex Foundation, Department of Agricultural Extension (DAE) and other stakeholders are working for GAP mango marketing. Farmer himself sold his produce. It is necessary to link with other buyers. Finally, the GAP produced mango was sold at a fair price.

Challenges and Way forward

It is very difficult to address all GAP principles, practices and standards in the field level. The farmers do not want to do other activities which are not directly related to mango production. Farmers thought scientists are outsider and they knew it very well rather than scientists. But in the later stages, they completely follow us and then it became easy for us to continue the trial. It would very difficult to execute GAP trial to small and medium farmers' field. So, only big innovative farmers or entrepreneurs are suitable for GAP mango production. Price of GAP produced mango was 10-15 taka higher than that of the conventional ones. So, we must ensure fair price of GAP produce.

This is first field experience for all concern (scientist, DAE worker, farmer and consumer). To do such type of trial or research at least a structure or small warehouse should be established in the field. An educated and trained person must be present on site to handle the operation as well as record data. If we want to conduct GAP experiment or trial, we must fulfill some criteria. The farmers are not always aware about sanitation, health safety issues and clean cultivation. GAP training ensures for all stakeholders before execution in their area or in field. Marketing linkage should be established for GAP produce to ensure fair price.

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DAE 2024 (Personal Communication) Deputy Director, Department of Agricultural Extention, Chapainawbabganj.

Appendix-1. Soil analysis results

Laboratory of SGS Bangladesh Ltd.	**TEST REPORT** DHF240000306	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	22.02.2024
		Date of analysis:	22.02.2024 - 10.03.2024
		BOSS Order:	1030832

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Nachole, Chapai)
Type of sample	Soil
Sample Condition	Soil in One Plastic Bag
Sample Quantity	2 Kg

Parameter	Method of Analysis	Unit	Test Result	Test Requirements
Total Nitrogen as N	IS 14684: 1999	%	0.09	0.0-0.36
Phosphorus as P	ASTM D6349-13 (by ICP-OES)	mg/kg	172.30	0.0-30
Sulfur as S	ASTM D6349-13 (by ICP-OES)	mg/kg	122.70	0.0-43.20
Total Organic carbon C:N=13.5:1.0	Walkely and Black, 1934	%	0.87	

Remark: This test has been subcontracted from SGS India Private Ltd.,Test report number: KE24-000399.001 , Dated at 09-03-2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000108

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Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000313	Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	18.02.2024
		Date of analysis:	18.02.2024 - 25.02.2024
		BOSS Order:	1030818

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Jashore Sadar)
Type of sample	Soil
Sample Condition	Soil in Two Plastic Packet
Sample Quantity	2 Kg

Physical & Compositional tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Moisture	APHA 2540 G, 23rd edn.: 2017	%	0.5	14.09	

Chemical tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Arsenic (As)	US EPA 3052	mg/kg	1	<1.00	20
Cadmium (Cd)	US EPA 3052	mg/kg	1	<1.00	3
Chromium (Cr)	US EPA 3052	mg/kg	1	17.53	100
Lead (Pb)	US EPA 3052	mg/kg	1	7.18	85
Mercury (Hg)	US EPA 3052	mg/kg	1	<1.00	0.02-0.06
Nickel (Ni)	US EPA 3052	mg/kg	1	15.80	100
Zinc (Zn)	US EPA 3052	mg/kg	1	101.07	0.0-1.60
Boron (B)	US EPA 3052	mg/kg	1	<1.00	0.0-0.61
Potassium (K)	US EPA 3052	meq/100g	2.5	**5.91**	0.0-0.36
Magnesium (Mg)	US EPA 3052	meq/100g	2.5	**34.23**	0.0-1.62
Conductivity (EC)	APHA 2510 B, 23rd edn.:2017	dS/m		0.29	<8.0

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Folder Number : DHF24-0000097

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Appendix-2. Water analysis report for Mango

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TEST REPORT

DHF240000307

Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	22.02.2024
		Date of analysis:	22.02.2024 - 03.03.2024
		BOSS Order:	1030833

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Water (Nachole, Chapai)
Type of sample	Water
Sample Condition	Water in Three Plastic Bottle
Sample Quantity	3.5 litre

Chemical tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Arsenic (As)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.01	<0.01	0.1
Calcium (Ca)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	57.15	401
Iron (Fe)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	0.08	1.0-5.0
Magnesium (Mg)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	26.14	61
Potassium (K)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	1.46	2
Sodium (Na)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	31.81	920
Taste	APHA 2160 A, 23rd edn.:2017	-	-	Agreeable	-
Colour	Visual Examination (APHA 2120 B, 23rd edn.:2017)	Pt-Co	5	<5	-
Turbidity	APHA 2130 B, 23rd edn.:2017	NTU	5	<5.00	-
Odor	Sensory Evaluation(APHA 2150 B, 23rd edn.:2017)	-	-	Unobjectionable	-
Conductivity	APHA 2510 B, 23rd edn.:2017	µS/cm	-	700.00	3000
Total Dissolved Solid (TDS)	APHA 2540 C, 23rd edn.:2017	mg/L	1	490.00	2000
Temperature	APHA 2550 B, 23rd edn.:2017	°C	1	27.0	-
Chloride	APHA 4500-Cl- B & D, 23rd edn.:2017	mg/L	0.5	14.00	600
pH	APHA 4500-H+ B, 23rd edn.:2017	-	-	6.70	6-5-8.8
Nitrate	APHA 4500-NO3 B, 23rd edn.:2017	mg/L	0.05	0.70	1-10.0
Total Phosphorus	APHA 4500-P-J, B & E, 23rd edn.:2017	mg/L	0.1	< 0.10	2

Folder Number : DHF24-0000107

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Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Sulfate	APHA 4500-SO4 2- E, 23rd edn.:2017	mg/L	5	< 5.00	1000

Microbiology tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Total Coliform	APHA 9221B_23rd Edition 2017	MPN/100 mL	1.8	<1.80	-
Fecal Coliform	APHA 9221E_23rd Edition 2017	MPN/100 mL	1.8	<1.80	-

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Remark:
1) If no evidence of Total Coliform observed in the tested sample, as per 5 tube MPN table result expressed as <1.8 MPN/100ml.
2) If no evidence of Fecal Coliform observed in the tested sample, as per 5 tube MPN table result expressed as <1.8 MPN/100ml.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

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Appendix-3. MRL test report for Mango

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TEST REPORT

DHF240000858

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	09.06.2024
		Date of analysis:	09.06.2024 - 21.06.2024
		BOSS Order:	1031133

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Mango (Nachole, Chapi N Gonj, Village: Kendobona)
Type of sample	Fruit
Sample Condition	Fruit in One Plastic Packet
Number of Container/Packet	01
Sample Quantity	500 gm

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Abamectin	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Azoxystrobin	SO-IN-MUL-TE-085 by LC-MS/MS	0.068	mg/kg
Carbendazim	SO-IN-MUL-TE-085 by LC-MS/MS	0.098	mg/kg
Chlorpyrifos	SO-IN-MUL-TE-085 by LC-MS/MS	0.044	mg/kg
Cyproconazole	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Imidacloprid	SO-IN-MUL-TE-085 by LC-MS/MS	0.025	mg/kg
Cypermethrin	SO-IN-MUL-TE-085 by GC-MS/MS	0.035	mg/kg

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Mancozeb as CS2	SO-IN-MUL-TE-112 by GC-MS/GC-MS/MS	BLQ (LOQ :0.010)	mg/kg
Sulphur (as S)	SO-IN-MUL-TE-063 by ICPOES	307.90	mg/kg

Note: This test has been subcontracted from SGS India Pvt. Ltd. Test Report No. CG24-014919.001(A&B); Date:15/06/2024.

Folder Number : DHF24-0000297

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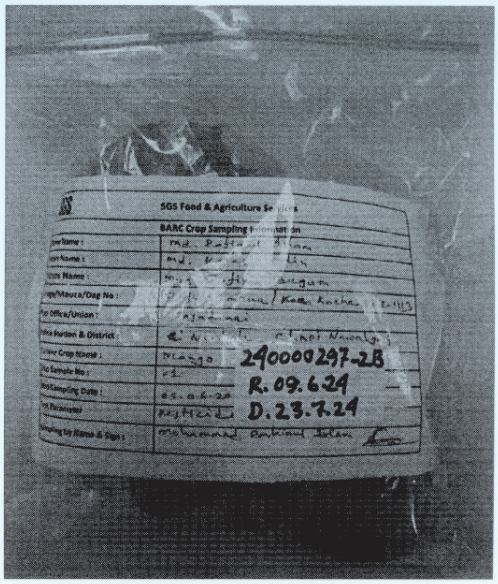
Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager



SAMPLE AS RECEIVED

This electronically generated test report has been checked and approved. It is also valid without handwritten signatures.

--------- End of Report ---------

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Technical Report of Bangladesh GAP Validation Trial: Jackfruit

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Abstract

A validation trial on Good Agricultural Practices (GAP) of jackfruit was implemented in the Chanpur village of Bhaluka upazila under Mymensingh district during January to June 2024. Forty jackfruit plants around 30 years old were taken for the validation trial. Pruning and cleaning the base of the trees were done prior to flowering and fruiting (1st week of March, 2024). Insecticides and fungicides were used to protect the fruits. Fertilizers and irrigation were applied as per recommendation. Fencing the plants and bagging of fruits were also done. Matured fruits were harvested during the month of June to July 2024. Before harvesting, maximum residue limit (MRL) test of fruit was done. In all cases which were below the acceptable levels. The results indicated a significant improvement of fruit in size, shape and quality with no detectable pesticide residues. Through this GAP validation trial, good quality jackfruits were produced, which were purchased by local traders at relatively high prices and sold to the local market and super shop. This year, the producer earned Tk.199742/- from 100 decimal of land (Tk. 978592/ha). Following the Bangladesh GAP 27,250 kg/100 decimal (67.35 MT/ha) jackfruits were produced under the trial, which was 4 times higher than the national average yield (19.00 MT/ha) and the gross margin was Tk. 484765/ha with 1.98 BCR. This successful implementation of GAP demonstrated its potential to enhance jackfruit production sustainably and ensuring food safety.

Introduction

Jackfruit (*Artocarpus heterophyllus* L.) is a member of the Moraceae family and a subtropical fruit and mainly available in summer. Jackfruit is regarded a multipurpose fruit tree as every part of its fruit and plant is utilized and one of the most important and frequently encountered trees in Bangladeshi household gardens. Due to its availability, low price, versatile use and nutritive value it is commonly referred to as "the poor man's food" (Rahman *et al.,* 1995). Bangladesh is considered as secondary centre of origin for jackfruit (Arora, 1998) and due to its importance and diversity, it has been considered as priority crop in Bangladesh (Azad, 1999). The role of jackfruit in the nutritional fruit and food security is very important. In addition to being eaten directly, jackfruit pulp is an excellent ingredient for processing. In recent years, jackfruit has been used industrially to make chips. jams, beverages, treats, candies, preserves, meat and dehydrated forms (Nair *et al.,* 2013). Green jackfruit can be used as a vegetable and vegetable meat. Its seeds are of excellent quality vegetables. Jackfruit ranks second position in production behind India. According to BBS (2024), during 2022-23 about 10.62 lakh metric tons of jackfruit were produced from gardens and homesteads. Out of which 2.09 lakh metric tons of fruits were produced from 30.69 thousand hectares of garden land, with an average yield of 19.00 MT/ha. The fertile land and favourable climate of regions like Madhupur and Bhawal contribute to the high yield of this nutritious fruit. Despite its abundant production, the export of jackfruit from Bangladesh remains relatively low. However, there is significant potential for growth in this sector. Efforts are being made to produce safe fruit, reduce post-harvest losses and develop value-added products aim to tap into international markets and increase the economic benefits for local farmers and entrepreneurs.

The presence of harmful chemicals, microbial contamination, harmful heavy metals and other harmful substances at any stage of the food chain can be a cause of concern and danger to human

health (Bokhtiar *et. al.,* 2024). Due to lack of proper knowledge and awareness, jackfruit can be unsafe and harmful to health for the mentioned reasons, which poses a threat to public health. Good Agricultural Practices (GAP) ensures protection from these hazards. However, safe and healthy jackfruit production is possible by following GAP protocols. GAP ensures safe production high yield, quality jackfruit, as well as environmental sustainability and worker safety. GAP ensures optimal care and safe management of jackfruit trees, viz. proper production techniques, irrigation, pest management, etc. resulting in high yields, improved quality and safe of fruit produced. As a result, it can be said without a doubt that GAP is essential for healthy and safe jackfruit cultivation, and jackfruit production using this method is profitable and exportable.

In recent years, there has been a growing emphasis on safe fruit production in Bangladesh. GAP is ensuring environmentally sustainable farming practices that include judicial use of fertilizers, pesticides and inputs, thereby protecting the soil, water, environment and workers' health. Ensuring higher quality and yield that can lead to better market prices and increased income for farmers. In addition, GAP can help farmers access to international markets by meeting export standards (https://www.fao.org/bangladesh/news/detail-events/en/c/1645232/). GAP has played a helpful role in this journey by reducing pesticide residues and ensuring food safety for consumers. With this in mind, Bangladesh GAP validation trial was conducted to ensure safe and exportable jackfruit production in Bangladesh. By adopting GAP, jackfruit farmers in Bangladesh will be able to increase their productivity, protect the environment and improve their livelihoods. Considering this in mind, Bangladesh GAP validation trial of jackfruit has been undertaken to ensure safe and exportable production in Bangladesh.

Materials and Methods

Site selection

The validation trial was conducted in the Chanpur village of Bhaluka upazila under Mymensingh district from January 2024 to June 2024. This region is known for its fertile soil and favourable climatic conditions for jackfruit cultivation. Forty jackfruit trees of uniform age (around 30 years) and size covering 100 decimal (0.405 ha) of land were selected for the study. Those trees were healthy and free from any visible diseases or pests during the beginning of the study. The trees were not planted in a planned garden pattern, and internal spacing between trees was 15 to 20 meters. The name of farmer, geographical position and soil and climatic condition of the selected location are given below in Table 1.

Table 1. Name of farmer, geographical position and soil & climatic of the trails' location.

Sl. No.	Farmer's Name	Address	Area (decimal)	Geographical position	Soil and Climatic
1.	Name: Md. Billal Hossain Father's Name: Late Kalu Sheikh Mother's Name: Late Zayeda Khatun	Village: Chanpur Upazila: Bhaluka District: Mymensingh Block: Katlamari NID No. 2820349765 Mobile-01727824363	35	Latitude=24.37548ºN Longitude=90.30615^{0}E	The soils are acidic in nature which contains low organic matter. The texture of soil is medium silty loam to heavy clay. The climatic condition of Bhaluka is a Tropical wet and dry.

Sl. No.	Farmer's Name	Address	Area (decimal)	Geographical position	Soil and Climatic
2.	Name: Md. Abdul Awal Father's Name: Ahammod Ali Mother's Name: Sahera Khatun	Village: Chanpur Upazila: Bhaluka District: Mymensingh Block: Katlamari NID No. 100916597 Mobile-01715813653	40	Latitude=24.38093^{0}N Longitude=90.3047^{0}E	
3.	Name: Md. Abul Khair Father's Name: Arfan Ali Mother's Name: JubedaKhatun	Village: Chanpur Upazila: Bhaluka District: Mymensingh Block: Katlamari NID No. 5535209042 Mobile-01771907180	25	Latitude=24.38127^{0}N Longitude=90.30714^{0}E	

Land preparation: The land was prepared by tilled around the base of the plants and removing all types of weeds, bushes, vines and debris. The soil was tilled to a depth of 30 cm to ensure proper aeration and root penetration and help removing soil borne diseases and insects.

Intercultural operation

Intercultural operations for jackfruit during the implementation of GAP trial involved several key activities to ensure healthy growth and high-quality fruit production. Some important practices were pruning, weeding, application of fertilizer and irrigation, pests and disease management, mulching and fruit bagging.

Weeding

Weeds are competitive for main crops. They are the harbour of insect and disease. So, GAP field should be clean at regular basis. Weeds are not major problem in the winter season but in summer it is very difficult to control. Weeds were controlled manually four times during crop period using spade.

Pic1. Image before validation trial.

Pic 2. Clean up and weeding underway before validation trial set up.

Pic 3. The land was prepared by tilled around the base of the plant.

Fertilizer application

The jackfruit orchard was fertilized following soil analysis result and Fertilizer Recommendation Guide (FRG, 2018) and and Krishi Projukti Hatboi (2020). Accordingly the jackfruit plants were fertilized with compost 50 kg, urea 1300 g, Triple Super Phosphate (TSP) 1600 g, Muriate of Potash (MoP) 1250 g, Gypsum 300 g, Zinc Fertilizer 50 g and Boric acid 0.2% 50 g. In the first installment, all the manure, TSP, gypsum and zinc fertilizers along with 50 % urea and MoP were

applied. After fruit set, 25 % urea and MoP were applied in the second installment and rest 25 % urea and MoP were applied in the third installment. To get good size and quality fruits, boric acid was sprayed at the rate of 0.2 % when male and female inflorescences were appeared. The first doses were applied on 10th January, 2024, second doses were applied on 4th April, 2024 and third doses were applied on 5th May.

Irrigation and drainage

The experimental site is located at Mymenshingh. There were no rainfall in the month of March to May. In this regard four times of irrigation was applied to the orchard. Since the selected trees are located at a fairly high elevation, hence, no drainage was required.

Pruning

Dead and diseased branches and all previously fruited stalks, shoots and branches were removed. Pruning was also done to improve light penetration and air circulation and to provide desirable shape of the trees. In this operation sterilized tools were used to prevent the spread of disease.

Fencing

The experimental jackfruit plants were protected by fencing with the blue coloured 60 mesh nylon net. The length of each fencing was 80 to 100 feet and 5 feet height. This fencing served as a physical barrier to safeguard the crop from animals and unauthorized access, ensuring the integrity of the trial. Date wise list of all operation and intercultural operations are mentioned in Table-2.


Pic 4. The trees are protected with fencing of nylon net.

Table 2. List of intercultural operations

Sl. No.	Date	Name of operation	Remarks
1.	30.01.2024	Clearing the base of the plants and removing weeds and debris	
2.	10.04.2023	Application-1, Organic and in organic fertilizer	
3.	02.10.2024	Application-2, Organic and in organic fertilizer	
4.	15 .01.2024	1st date of irrigation application	
5.	18.02.2024	2nd date of irrigation application	
6.	13.03.2024	3rd date of irrigation application	
7.	10.04.2024	4th date of irrigation application	

Previous crop history

Sugarcane, vegetable and rice were cultivated previously under the jackfruit trees and their surroundings. At present only jackfruits are cultivated in this land.

Soil and water analysis result

Soil and water analyses were done by SGS Bangladesh Limited. The soil was analyzed to check

the nutrient status and confirmation of the presence of any kind of heavy metals in the soil. From the soil analysis report, different parameters like Moisture (10.67%), Arsenic (less than 1.0 mg/kg), Cadmium (less than 1.0 mg/kg), Chromium (19.46 mg/kg), Lead (10.28 mg/kg), Mercury (less than 1.0 mg/kg), Nickel (9.71 mg/kg), Zinc (29.56 mg/kg), Boron (less than 1.0 mg/kg), Potassium (780.21 mg/kg), Magnesium (703.30 mg/kg), Conductivity (0.04 dS/m) were found and suitable for GAP Criteria.

The water was analyzed to check the nutrient status and confirmation of the presence of any kind of heavy metals. From the water analysis report, different parameters like Arsenic (less than 0.01 mg/L), Calcium (9.67 mg/L), Iron (0.12 mg/L), Magnesium (4.64 mg/L), Potassium (1.02 mg/L), Sodium (9.31 mg/L), pH (6.20), Nitrate (1.85), Total Phosphorus (less than 0.10 mg/L), Sulfate (less than 5.00 mg/L), Taste (Agreeable), Colour (less than 5.00 Pt-Co) Conductivity (184.30 µS/cm), Total Dissolved Solids (TDS) (132.00 mg/L), Temperature (27.0ºC) were found. No hazardous chemical and heavy metals were found in water and suitable for irrigation in GAP Validation trial. Detail report of physical and chemical characters of soil and water analysis is attached as Appendix-I.

Harvesting of fruit

Fruits were harvested during June to July 2024 when they reached optimal maturity. Forty plants of jackfruit were studied during 2024 for GAP validation trial, some of which are firm, some are juicy, or medium in nature. Is this study, mature but firm jackfruit were harvested at 95-110 days after anthesis. At this time, the skin of the jackfruit becomes quite flat and the latex becomes thin. When hit the jackfruit, it makes a dull and lack sound. At that time, jackfruits were harvested. Harvesting was done manually, care was taken to avoid any damage to the fruits and ensures worker safety. Postharvest, the fruits were assessed for quality parameters such as size, weight, colour, and taste. Laboratory tests were conducted to check for pesticide residues, ensuring the fruits were safe for consumption and attached as appendix-II.

Pic 5. Jackfruit trees under GAP trial were producing abundant fruits.

Pic 6. Jackfruit produced under the GAP trial are being supplied for sell.

Maintaining of register book and documentation

Data record is essential for GAP validation trial. Every activity must be noted down in a register book. Activities like land preparation, crop management records, soil and water analysis records, irrigation schedules and method of irrigation, fertilizer and manuring, types and amounts of organic and inorganic fertilizer used in this trial, including date of application, pest and disease monitoring with pest and disease management activities and results, with name, dosage and date of application including biological control with the name of recommender. MRL test, date of first harvest, second harvest etc. are clearly mentioned in the register book. The weed management with types and schedules are recorded. Date and method of pruning, mulching type and application of mulch are recorded. Harvest records included date of harvest, yield, number and weight of fruit, postharvest handling and operation methods are also recorded. Audit reports, training records: record of training received by farm workers on GAP. Date of fruit maturation, name and address of the owner of the orchard was also included in the register. In addition, the number of workers used for each operation is also recorded to ensure accurate records of resource utilization. This register served as an essential tool to monitor the progress of the trial and ensure the integrity of the data collected. All the observation teams that visited the GAP orchards signed the said register book.

Pest management

Pesticides were applied judiciously following GAP protocol. Pesticides were used only when necessary and in accordance with recommended safety guidelines. To protect the developing fruits from pests and environmental damage, bagging was done using brown paper bags. This practice also helped reducing pesticide use and residues on the fruits. The name of insecticides and fungicides, purpose of use and spraying dates are presented in Table 3.

Table 3. Name of pesticides, active ingredient, dose, date of spray and purpose

Date of spray	Name of pesticides	Active ingredient	Doses	Purpose
02-03-2024	Autostin 50 WDG	Carbendazim 50 WDG	2 g/L water	For controlling fruit rot and anthracnose disease of jackfruit
02-03-2024	Ripcord 10 EC	Cypermethrin10 EC	1.0 ml/L water	For controlling fruit borer of jackfruit
25-04-2024	Autostin 50 WDG	Carbendazim 50 WDG	2 g/L water	For controlling fruit rot and anthracnose disease of jackfruit
25-04-2024	Ripcord 10 EC	Cypermethrin10 EC	1.0 ml/L water	For controlling fruit borer of jackfruit
12-05-2024	Autostin 50 WDG	Carbendazim 50 WDG	2 g/L water	For controlling fruit rot and anthracnose disease of jackfruit
14-05-2024	Success 45 SC	Spinosad 45 SC	1.2 ml/L water	For controlling fruit borer of jackfruit

Fruit bagging

Fruit bagging is an important technology to produce good quality, safe and exportable fruits. Fruit bagging was done from 15 to 25 April 2024. Bagging was done following all kind of recommendations of fruit bagging technology and with trained skilled labour. Fruit bagging was done 50-55 days after fruit set. The fruit bag size was 35 cm x 25 cm, wheat coloured plastic bag.

Pic 7. Fruits were protected by plastic bags.

Worker health safety issues as well as environmental issues

Worker health, safety, and environmental stewardship were prioritized throughout the GAP validation trial for jackfruit. Farmers and workers received training on safe handling and application of agrochemicals to minimize exposure and health risks. To ensure the safety and well-being of all workers, they were provided with use of personal protective equipment (PPE) such as gloves, masks protective clothing etc. Was followed to protect workers from harmful substances. Regular health check-ups and monitoring were conducted to ensure early detection and treatment of any health issues arising from agricultural activities. GAP promotes the use of sustainable farming practices, including crop rotation, organic farming, and integrated pest management to reduce environmental impact. Proper storage, handling, and disposal of agrochemicals were enforced to prevent soil and water contamination. Efforts were made to conserve local biodiversity by maintaining natural habitats and using environment friendly farming techniques. Additionally, a comprehensive farm instrument manual was issued to guide the proper use of tools and machinery. Pure drinking water was made available to all workers and their working hours were restricted to a maximum of eight hours per day to prevent fatigue. All kinds of activities hazardous to nature and environment were avoided.

Harvesting based on maturity

Maturity determination

The maturity stage of jackfruit varies according to use and type. For ripe eaten, mature but hard jackfruit should be collected within 95-110 days after anthesis. At that time colour of fruits changed from green to yellowish green, spines became flattened, a dull sound was produced when tapped on skin, seeds were fully developed with brown colour, density of latex were thin and low.

Techniques of jackfruit harvesting

Jackfruit should be harvested from the tree by cutting the peduncle with a sharp sickle with 3-4 cm of stalk attached to the fruits. The collected jackfruit should be held by hand for avoiding rupture or bruise and kept on the tarpaulin. Several techniques have been adopted to collect jackfruit from the high branches of the tree to avoid damage to the fruit during collection. For this, a person climbs the tree to collect the jackfruit. He carries a sack with one end tied tightly with a long rope. Another person standing under the tree holds the other end of the rope. Now, the person in the tree puts the jackfruit in the sack and the person below holds the rope tightly. In this situation, the person in the tree cut off the peduncle of the jackfruit and it was placed in the sack. The person below slowly releases the rope and lowered to the ground from the tree without any damage. After harvesting, the fruits were kept under the tree for an hour to release the latex from the fruit. The collected jackfruit should be kept on a burlap sack, tarpaulin or straw spread in the shade under tree. Generally, all the jackfruits of a tree do not ripen or mature at a time. Therefore, the jackfruits should be collected step by step accordingly. The first harvest was done on 21.06. 2024 and the last harvest was done 25.07.2024. Most of the jackfruits were sold at super shop, popular fruit shop, important persons and foreign buyers for export.

Postharvest management

Harvesting period

The harvesting period of jackfruit is limited and there is some variation in the timing of its harvest in different parts of the country. Jackfruit usually ripens earlier in the hilly regions of the north-eastern part of the country and in most cases, jackfruit starts ripening gradually from the last week of May.

Sorting and grading

Diseased and insect-infested, deformed, cracked, mechanically damaged or defective jackfruits were detected and separated. Then, the selected good quality jackfruits were graded or divided into different classes according to the stage of maturity, size and weight. This made the packaging and marketing easier. Generally, sorting and grading is done in the pack house or under the shade.

Ripening

Jackfruit is climacteric in nature, due to this if mature hard jackfruit is collected it will ripen under the influence of endogenous ethylene. Depending on the stage of maturity, jackfruit usually ripens naturally within 2-6 days. A study by the HRC, BARI has shown that mature fruits of the 'Gala' variety of jackfruit, collected at 100 days of age, ripen within 36 hours maintaining the acceptable taste, sweetness and aroma of the fruit.

Transportation and marketing

After collection from the tree, it is necessary to wait until the fruit falls off before transferring it to the pack house or market. To prevent the fruit from falling off, as an extra precaution, wrap the cut bottom of the fruit with thick paper or polythene and tie it well with rubber band or thread. Jackfruit should be packed in large bamboo baskets or suitable plastic crates with newsprint or in large burlap bags and taken to the local market or pack house. Whether the van, truck, boat or any other vehicle is used to transport the fruit to the market, it should be transported in layers rather than randomly stacked. While arranging, care should be taken not to over-pressurize. This can cause mechanical damage to the jackfruit due to pressure. Ripe and unripe jackfruit should be transported separately while transporting to the market. If that is not possible, at least the ripe jackfruit should be arranged separately in the vehicle so that it does not get damaged due to pressure. After reaching the market, the jackfruit should be unloaded from the vehicle with care and kept in a warehouse or shop for sale.

Jackfruit storage

The permissible storage temperature for mature but hard jackfruit is 13.1ºC and relative humidity 90.5%. Jackfruit remains good for about a week if stored in this environment. However, chilling injury will occur if the store temperature drops below 12ºC.

Results of MRL analysis

A maximum residue level (MRL) is the highest level of a pesticide residue that is legally tolerated in or on food or feed when pesticides are applied correctly. In this study Cypermethrin 10 EC (Ripcord 10 EC), Carbendazim 50 WDG (Autostin 50 WDG) and Spinosad 45 SC (Success 45 SC) were used. Fruit samples of jackfruits were collected by the assigned authorities on 09.06.2024 and results were sent on 15.06.2024. The MRL of all the pesticides used in this trial have been tested at laboratory of SGS Bangladesh ltd. The MRL of each pesticide was less than 0.005 mg/kg which were below the acceptable levels and safe for consumption. The analysis report of the MRL tests has been attached as Appendix-II.

Farmers' training

To produce any crop following GAP protocol there are several procedures and issues hence jackfruit production under GAP, training is essential for stakeholders like Agriculture Officers, farmers, SAAO, workers etc. In this point of view, a farmer's training was conducted on 12 June, 2024 at the office of the Upazila Agriculture Officer (UAO), Department of Agricultural Extension (DAE), Bhaluka, Mymensingh. A total of 25 (Twenty five) jackfruit farmers, including the trial farmers participated in the training.

Yield (MT/ha) compared to national average

A total of 100 decimals (0.405 ha) of land was selected for jackfruit production under GAP trial. The number of plants under the trial was 40. The total number of fruits produced by the 40 trees were 9122. The average weight of each fruit was 2.99 kg. Accordingly, the amount of fruit produced from the said area of land was 27250 kg. That, the yield of the trial was 67.35 MT/ha. On the other hand, the national average yield of jackfruit in Bangladesh is 19.00 MT/ha. Hence, the yield of the trial is about ten times higher over national average. Plant number, yield and yield contributing characteristics of validation trial and national average is provide in Table 4.

Table 4. Plant number, fruit number, weight and yield of validation trial and national average

Validation trial					National average
Number of plants	Number of fruits	Average weight	Yield (kg/trial)	Yield (MT/ha)	
40	9122	2.99 kg	27250	67.35	19.00 MT/ha

Farmer's profile and reaction

In the case of validation trial of Jackfruit under Bangladesh GAP Mr. Md. Billal Hossain, father- deceased Kalu Sheikh, Mr. Md. Abdul Awal, father- Ahmed Ali and Mr. Md. Abul Khair, father- Arfan Ali are valued farmers of this activity. They are residents of village: Chanpur, Upazila: Bhaluka, District: Mymensingh. Their ages are 54, 65 and 55 years respectively. Among them, Billal Hossain have signature knowledge, Abdul Awal has passed class IX and Abul Khair's educational qualification is SSC. Billal Hossain does small-scale business along with agricultural work. On the other hand, Abdul Awal is involved in tailoring work and in addition to agricultural work. Abul Khair is involved in buying and selling various fruits and vegetables. They are happy to be a part of GAP production partner. They mentioned other farmers are being motivated to their profession and work with them in future. Farmer's profile and opinions provided in Table 4.

Table-5. Profile of the selected farmer and their opinions

Sl. No.	Name & Father's name of farmer	Address	Age and educational qualification and other profession	Opinion
1.	Name: Md. Billal Hossain Father's Name: Late Kalu Sheikh	Village: Chanpur Upazila: Bhaluka District: Mymensingh Mobile 01727824363	Age: 54 Qualification: Have signature knowledge Other profession: Small business	The size and colour of the jackfruit are good, and the yield is higher than before. As a result, we were benefited greatly.
2.	Name: Md. Abdul Awal Father's Name: Ahammod Ali	Village: Chanpur Upazila: Bhaluka District: Mymensingh Mobile 01715813653	Age: 65 Qualification: Class IX Other profession: Tailoring	We have made much more profit than before. Since the jackfruit looks beautiful, buyers have bought the fruit from the tree this time and we have not had to worry about selling the fruit.
3.	Name: Md. Abul Khair Father's Name: Arfan Ali	Village: Chanpur Upazila: Bhaluka District: Mymensingh Mobile 01771907180	Age: 55 Qualification: SSC Other profession: Seasonal dealer	We have benefited a lot. We have received good prices for our jackfruit. And we will continue this method in the future as well.

Benefit cost analysis

Jackfruit production following GAP protocol has improved the yield and quality of jackfruit. Apart from this, the demand and market price of the produced fruit was also high as it was healthy and safe. As a result farmers have more benefited. The gross margin of jackfruit produced by this method was Tk. 484765.43 and BCR was 1.98. On the other hand, GAP protocol capable to produce good quality exportable jackfruit, hence GAP is profitable for the farmers.

Table-6. Cost and return as well as BCR of jackfruit under GAP production system

Fruit Yield (MT/ha)	Unit price	Gross return (1x2)	Total variable cost	Gross margin (3-4)	BCR (4/3)
1	2	3	4	5	6
67.35	7.33 Tk/kg	978592.60 Tk/ha	493827.16 Tk/ha	484765.43 Tk/ha	1.98

Export opportunity

Jackfruit produced under GAP has a significant opportunity to be exported to the international market, as it meets international standards for quality and safety. Therefore, it can be a good candidate for the global market. Bangladesh has significant potential to expand its jackfruit exports, leveraging its abundant production and growing global demand. Here are some key opportunities:

1. **High production volume:** Bangladesh produces about 1.5 million metric tons of jackfruit annually. This high production volume provides a strong base for export activities.
2. **Value-added products:** There is increasing interest in value-added jackfruit products such as jackfruit chips, pickles, jam, and dried jackfruit. These products have a longer shelf life and can cater to international markets more effectively.
3. **Global demand for plant-based foods:** Jackfruit is gaining popularity as a meat substitute in many countries due to its texture and nutritional benefits. This trend opens up new markets for Bangladeshi jackfruit, especially in regions with a high demand for vegan and vegetarian products.
4. **Government and international support:** Initiatives by the Food and Agriculture Organization (FAO) and the Bangladesh government aim to promote jackfruit production and marketing. These efforts include training programs, infrastructure development, and market linkages to support small-scale farmers and entrepreneurs.
5. **Diaspora Market:** A significant portion of jackfruit exports currently caters to expatriate Bangladeshis. Expanding beyond this niche market to mainstream consumers can further boost export volumes.
6. **Research and Development:** On-going research and development efforts are focused on reducing postharvest losses and improving the quality of jackfruit products. Innovations in processing and packaging can enhance the competitiveness of Bangladeshi jackfruit in international markets.
7. **Strategic Partnerships:** Forming strategic partnerships with international buyers and distributors can help establish a stable market for Bangladeshi jackfruit. Collaborations with food processing companies can also lead to the development of new products tailored to global tastes.
8. By capitalizing on these opportunities, Bangladesh can significantly increase its jackfruit exports, contributing to economic growth and providing sustainable livelihoods for farmers.

Marketing

Marketing of jackfruit products obtained through GAP can be highly effective if we can focus on several key strategies:

1. **Highlighting Quality and Sustainability:** Emphasize that jackfruit is grown using GAP, which ensures high quality, safety, and sustainability. This can appeal to health-conscious and environmentally aware consumers.
2. **Value-Added Products:** Consider creating and marketing value-added products such as jackfruit chips, pickles, ice cream, jelly, sweets, and beverages like squash, nectar, wine etc.
3. **Branding and Packaging:** Develop a strong brand identity that reflects the benefits of GAP. Use eco-friendly packaging to reinforce your commitment to sustainability.
4. **Targeting Niche Markets:** Identify and target niche markets such as: Health food stores, organic markets and specialty food shops.
5. **Online Presence:** Create a robust online presence through: A dedicated website, social media platforms and E-commerce sites.
6. **Educational Campaigns:** Educate consumers about the benefits of jackfruit and GAP through workshops and cooking demonstrations, informative blog posts and videos.
7. **Collaborations and Partnerships:** Partner with local chefs, restaurants, and food bloggers to create awareness and demand for the products.
8. **Export Opportunities:** Explore international markets where there is growing interest in exotic and sustainable foods.
9. **Utilizing Jackfruit Waste:** Innovatively use jackfruit waste to create bio-refinery products like biofuels, enzymes, and bio-plastics. This can open up additional revenue streams and appeal to eco-conscious consumers.

Challenges and way forward

It is very difficult to address all GAP principles, practices and standards in the field level. The farmers do not want to do other activities which are not directly related to jackfruit production. It was observed that sometimes they do not follow the instructions and try to practice in the conventional method. They thought they knew it very well rather than us. But in the later stages, they completely follow the instructions and then it was easy to continue the trial. It would very difficult to execute GAP trial to small and medium farmers' field. So, only big innovative farmers or entrepreneurs will suitable for GAP production. Price of jackfruit under GAP protocol was higher than the conventional ones. So, GAP must ensure fair price. Otherwise, it will create negative impact on Bangladesh GAP.

This is first field experience for all concern (scientist, DAE worker, farmer and consumer). It does not include all the threats, challenges and costs in first session. It is necessary to insure for other activities related to GAP protocol. At least one structure or small warehouse needs to be ensured in the field for this type of trial or research. A trained person should be present on trial location for conducting the operation as well as recording the data. If GAP protocol or test will be conducted, certain criteria must be ensuring. Farmers are often not aware of sanitation, health protection and clean farming, as well as judicial use of chemicals and inputs it is a great challenge for GAP. GAP training must be ensured for all stakeholders before implementing in any area or land. To ensure fair price, marketing linkages need to be established and fair price should be ensured for the products produced under GAP system.

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Appendices

Appendix-I. Soil Analysis report for Jackfruit

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000242	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	14.02.2024
		Date of analysis:	14.02.2024 - 27.02.2024
		BOSS Order:	1030839

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Bhaluka, Mymensingh)
Type of sample	Soil
Sample Condition	Soil in One Plastic Bag
Sample Quantity	2 Kg

Parameter	Method of Analysis	Unit	Test Result	Test Requirements
Total Nitrogen as N	IS 14684: 1999	%	0.12	0.0-0.36
Phosphorus as P	ASTM D6349-13 (by ICP-OES)	mg/kg	941.06	0.0-30
Sulfur as S	ASTM D6349-13 (by ICP-OES)	mg/kg	149.93	0.0-43.20
Total Organic carbon C:N=13.5:1.0	Walkely and Black, 1934	%	1.21	

Note: This test has been subcontracted from SGS India Pvt. Ltd. Test Report No. KE24-000346.001; Date: 27/02/2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000089

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TEST REPORT

DHF240000304

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	14.02.2024
		Date of analysis:	14.02.2024 - 22.02.2024
		BOSS Order:	1030808

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Bhaluka, Mymensingh)
Type of sample	Soil
Sample Condition	Soil in Two Plastic Packet
Sample Quantity	2 Kg

Physical & Compositional tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Moisture	APHA 2540 G, 23rd edn.: 2017	%	0.5	10.67	

Chemical tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Arsenic (As)	US EPA 3052	mg/kg	1	<1.00	20
Cadmium (Cd)	US EPA 3052	mg/kg	1	<1.00	3
Chromium (Cr)	US EPA 3052	mg/kg	1	19.46	100
Lead (Pb)	US EPA 3052	mg/kg	1	10.28	85
Mercury (Hg)	US EPA 3052	mg/kg	1	<1.00	0.02-0.06
Nickel (Ni)	US EPA 3052	mg/kg	1	9.71	100
Zinc (Zn)	US EPA 3052	mg/kg	1	29.56	0.0-1.60
Boron (B)	US EPA 3052	mg/kg	1	<1.00	0.0-0.61
Potassium (K)	US EPA 3052	meq/100g	2.5	**2.00**	0.0-0.36
Magnesium (Mg)	US EPA 3052	meq/100g	2.5	**5.78**	0.0-1.62
Conductivity (EC)	APHA 2510 B, 23rd edn.:2017	dS/m		0.04	<8.0

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Folder Number : DHF24-0000088

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Appendix-II. Water Analysis report for Jackfruit

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000243	Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	14.02.2024
		Date of analysis:	14.02.2024 - 22.02.2024
		BOSS Order:	1030808

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Water (Bhaluka, Mymensingh)
Type of sample	Water
Sample Condition	Water in Three Plastic Bottle
Sample Quantity	3.5 litre

Chemical tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Arsenic (As)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.01	<0.01	0.1
Calcium (Ca)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	9.76	401
Iron (Fe)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	0.12	1.0 - 5.0
Magnesium (Mg)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	4.64	61
Potassium (K)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	1.02	2
Sodium (Na)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	9.31	920
Taste	APHA 2160 A, 23rd edn.:2017	-	-	Agreeable	-
Colour	Visual Examination (APHA 2120 B, 23rd edn.:2017)	Pt-Co	5	<5	-
Turbidity	APHA 2130 B, 23rd edn.:2017	NTU	5	<5.00	-
Odor	Sensory Evaluation(APHA 2150 B, 23rd edn.:2017)	-	-	Unobjectionable	-
Conductivity	APHA 2510 B, 23rd edn.:2017	µS/cm	-	184.30	3000
Total Dissolved Solid (TDS)	APHA 2540 C, 23rd edn.:2017	mg/L	1	132.00	2000
Temperature	APHA 2550 B, 23rd edn.:2017	°C	1	27.0	-
Chloride	APHA 4500-Cl- B & D, 23rd edn.:2017	mg/L	0.5	4.00	600
pH	APHA 4500-H+ B, 23rd edn.:2017	-	-	6.20	6.6 - 8.8
Nitrate	APHA 4500-NO3 B, 23rd edn.:2017	mg/L	0.05	1.85	1.0 - 10.0
Total Phosphorus	APHA 4500-P-J, B & E, 23rd edn.:2017	mg/L	0.1	< 0.10	2
Sulfate	APHA 4500-SO4 2- E, 23rd edn.:2017	mg/L	5	< 5.00	1000

Folder Number : DHF24-0000088

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Appendix-III. MRL test report for Jackfruit

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TEST REPORT

DHF240000757

Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	28.05.2024
		Date of analysis:	28.05.2024 - 13.06.2024
		BOSS Order:	1031077

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Jackfruit (Valuka,Mymensingh,Chanpur)
Type of sample	Fruit
Sample Condition	Fruit in One Plastic Packet
Number of Container/Packet	01
Sample Quantity	500 gm

NABL Accredited Tests

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Cypermethrin	SO-IN-MUL-TE-065 by GC-MS/MS	BLQ (LOQ:0.005)	mg/kg
Carbendazim	SO-IN-MUL-TE-065 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Spinosad	SO IN MUL TE 065 by LC MS/MS	BLQ(LOQ : 0.005)	mg/kg

Note: This test has been subcontracted from SGS India Pvt. Ltd. Test Report No. CG24-013950.001; Date:03/06/2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000272

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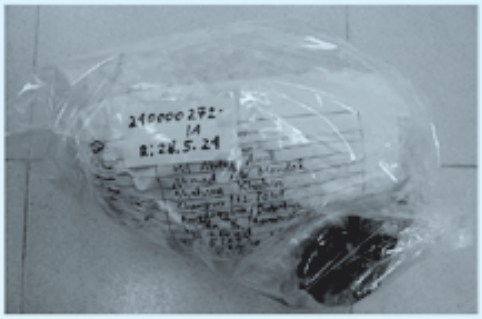

SAMPLE AS RECEIVED

This electronically generated test report has been checked and approved. It is also valid without handwritten signatures.

-------- End of Report --------

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Technical Report of Bangladesh GAP Validation Trial: Guava

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Abstract

A study was carried out at the Kodomsohor village, Godagari, Rajshahi on Bangladesh Good Agricultural Practices (GAP) validation trial during December 2023 to August 2024. Thai Peyara-3 variety was selected for the trial. This variety is tasty and very popular throughout the country. A total of 100 decimals (0.405ha) guava orchard of two innovative farmers (Mr. Golab Hossain and Mr. Alamin 50 decimals land each) were selected for the trial. In the reporting period, only Golab Hossain's guava orchard produced fruits. Through this validation trial good quality guava was produced which was sold in the local market. From 50 decimals of land Mr. Golab Hossain produced 4.5 metric tons of fruit and earned 202500 Taka. The production cost was 85000 Taka for 50 decimal guava orchard. His net income was Tk. 117500/-. The farmer achieved more yield and benefit compared to other guava cultivation, and national average following Bangladesh GAP. The yield of GAP orchard was 22.50 mt/ha since the Rajshahi district average yield was 16.48 mt/ha. The BCR was calculated 2.38 and found profitable for the farmers.

Introduction

Guava is one of the important commercial fruit crops in Bangladesh. It is widely cultivated in Godagari, Rajshahi. Total area under guava cultivation in Bangladesh is 18375 ha and annual production is 256106 metric tons. The area under guava cultivation in Rajshahi is 612.50 ha and Production is 10094 MT (BBS, 2024). It is a very popular fruit among the people of all social strata for its nourishing value, good taste and lower price. It is a rich source of Vitamin C (260 mg/100g) next to aonla (600 mg/100g), containing 2 to 5 times more than orange. One hundred grams of guava per capita is sufficient for meeting the requirement of vitamin C and iron. Calcium, phosphorus, potassium, sulphur, sodium, chlorine, iron, manganese, and magnesium are more or less available in guava. Many small, medium and large orchards have already been established in Godagari area. At first, an expert team visited this area and decided to conduct validation trial of guava on Bangladesh GAP in Rajshahi district which is famous for good quality guava production. Many countries are producing superior quality guavas following Good Agricultural Practices (GAP). In Bangladesh Good Agricultural Practices have just been initiated. It is necessary to follow Good Agricultural Practices for the production and marketing of guava in the country to ensure the exportable position in the world market by ensuring the fruit quality. GAP for guava production involve a series of steps and techniques aimed at ensuring high-quality fruit and better yield, environmental sustainability, and worker safety. Implementing GAP ensures that guava trees receive optimal care, leading to higher yields and better-quality fruits. This includes proper planting techniques, irrigation, and pest management. GAP promotes sustainable farming practices that protect the environment. This includes minimizing the use of chemical fertilizers and pesticides, which can be harmful for soil and water sources. Higher quality and yield can lead to better market prices and increased income for farmers. Additionally, GAP can help farmers access to international markets by meeting export standards (https://www.fao.org/bangladesh/news/detail-events/en/c/1645232/). It is important to follow GAP standards at every stage from crop production to postharvest management, processing, supply and marketing to ensure safe food. Guava GAP protocol is based on in light of Bangladesh

GAP Standards of 18 components and each component explains the requirement of GAP (Bokhtiar *et al.,* 2024 a).The GAP orchard is restricted to enter any kind animals and other bodies which may create non-compliances. In the traditional guava production system, farmers were using many pesticides together and many times and did not make guava cultivation as profitable. In addition, we cannot export these produces. All management practices were done as per Bangladesh GAP protocol (Bokhtiar *et al.,* 2024 b)). Considering this in mind, Bangladesh GAP validation trial of guava has been undertaken.

Materials and Method

Site selection: The farmer Md. Golab Hossain's guava orchard is located at Kodomsohor, Godagari, Rajshahi. The orchard situated under 24º44"N latitude and 88º50"E longitude. The land is terrace type and the soil is Clay loam and belongs to AEZ-26. Compact soil and upon received water become muddy. The soil pH range from 5.5 to 6.5. There were no industry or brick field nearer to the research field. A unique signboard designed by GAP unit, BARC was used in the experimental field.

Land preparation

The orchard was made clean of weeds and debris, and fencing was provided with 60 mesh filter net with a height of 5 feet. The land was prepared by ploughing with power tiller and leveled using ladder. The farmers collected grafts from private nursery and planted in the year 2022.

Spacing and Pit preparation

One year old saplings of Thai Peyara-3 variety was selected and planting distance was maintained 3.0 × 3.0 m. Pits were prepared 60 x 60 x 45 cm for planting saplings and fertilizers were applied at the following rate per pit: 10-15 kg of well decomposed cow dung or compost, Muriate of Potash (MoP) 250 g and Triple Super Phosphate (TSP) 250 g (Azad *et al.,* 2020). The above mentioned fertilizers were mixed well with the soil of the pit and the hole was filled up and kept it for 10-15 days. Then the soil of the pits were spades properly for releasing gases and filled again with the same soils. One guava sapling was planted at the middle of each pit. After planting the saplings were tied to a strong pole to keep them upright. The validation trial was conducted at this established orchard. During experimentation tree age was 2.0 years

Fertilizer application and Irrigation

The guava orchard was fertilized following soil analysis result and Fertilizer Recommendation Guide, BARC-2018 (Ahmed *et al.,* 2018). The manures and fertilizers eg. 15 kg cow dung, Urea-200g, TSP-200g, MoP-200g, Gypsum-100 g, Zinc sulphate-15g and Boric acid 20g per plant were applied for two years guava tree. The manures and fertilizers were applied in the month of September and February. Five times irrigation was applied to the guava orchard during experimental period with an interval of 15 days.

Weeding

The guava garden was kept weed free at all times. Weeds were controlled by light ploughing in the garden at the beginning and end of monsoon.

Pruning and Training

Pruning means removal of dead, diseased and unnecessary branches. When the planted saplings were one year old, all the branches at the base were pruned leaving 4 to 5 branches spreading in

different directions at 2 to 3 feet above the ground level to give it a beautiful structure. Limbs were pruned in August-September after harvesting the fruits of mature trees. Pruning the limbs causes the tree to grow new branches and bear more fruit.

Use of Bamboo sticks

After fruit set and fruit developmental stage weight increased in each branch and touched to the ground resulting in fruit rot. To prevent lodging of branches bamboo sticks were used as stake. This sticks remained in the field up to harvest.

Irrigation canal

To maintain proper moisture in the guava orchard irrigation canal was prepared in between two rows. The canals were maintained regularly for irrigation and drainage of excessive water.

Fencing/netting: The experimental guava orchard was protected by fencing with 60 mesh nylon net which was blue in colour. Each roll was 100 feet's long and 5 feet's heights. Bamboo pole was used in every 10 feet's distances and tightly by GI wire.

Previous crop history

Rice, wheat and mustard were cultivated in this land before establishment of guava orchard. The land was leased for Guava cultivation.

Soil analysis result (SGS Bangladesh Ltd)

The soil of the experimental field was analyzed to check the nutrient status and presence of any kind of heavy metals. From the soil analysis report the following parameters were observed: Soil Moisture 12.76%, Arsenic less than 1.0 mg/kg, Cadmium less than 1.0 mg/kg, Chromium 20.30 mg/kg, Lead 10.13 mg/kg, Mercury less than 1.0 mg/kg, Nickel 14.79 mg/kg, Zinc 35.33 mg/kg, Boron less than 1.0 mg/kg, Potassium 1759.06 mg/kg, Magnesium 2048.77 mg/kg, Conductivity 0.30 dS/m (Appendix-1). Reported chemicals and heavy metals found in the soil are not harmful, and suitable for GAP validation trial.

Water analysis result (SGS Bangladesh Ltd)

The water was analyzed to check the nutrient status and presence of any kind of heavy metals in irrigation water. The different parameters like Arsenic less than 0.01 mg/L, Calcium 86.34 mg/L, Iron 0.13 mg/L, Magnesium 21.38 mg/L, Potassium 1.48 mg/L, Sodium 77.36 mg/L, Conductivity 1210.0 µS/cm, Total dissolved solids (TDS) 786.0 mg/L, Chloride 145.95 mg/L, pH-6.60%, Nitrate 1.18 mg/L and Total Phosphorus less than 0.10 were found (Appendix-2). Reported chemicals and heavy metals found in the water are not harmful and suitable for GAP validation trial.

Maintaining of register book and documentation

Data recording is essential for GAP trial. Each activity was noted down in a register book. The activities like land preparation, soil analysis, water analysis, weeding, pit preparation, transplanting, source of planting materials, name and source of pesticides, doses, purpose, who recommended, irrigation time and frequency, maturity, MRL test, dates of all harvests, labour wages for all operations, etc. were noted clearly in the register book. Farm details like owner of the orchard, with contact information, location and size etc. were also recorded in a register book.

Discase and Pest management

Different insecticides and fungicides were used in guava orchard with various reasons. Firstly the problems were identified then suggested to use appropriate pesticides. The name of fungicides, purpose of use and spraying dates are presented in table 1.

Table 1. Spray dates, name of pesticides with doses and purposes of spray

Spray date	Name of pesticides	Purpose
27.2.2024	Carbendazim @1 g/L water Fifronil 5% @ 1.0ml/ L water	To control anthracnose disease To control nematode
15.3.2024	Imidacloprid @ 0.5 ml/L water Azoxystrobin + Difenoconazole @ 1 ml/L water	To control fruit borer and anthracnose
18.4.2024	Imidacloprid @ 0.5 ml/L water and Fifronil 5% @ 1 ml/L water	To control fruit borer and nematode
11.5.2024	Imidacloprid @ 0.5 ml/L water and Mancozeb @ 2 g/L water	To control fruit fly and anthracnose
25.5.2024	Carbosalphan @ 2 g/ L water Tebuconazole +Trifloxystrobin @ 0.5 ml/L water	To control fruit fly and anthracnose

* Instalation of sex pheromone traps for fruit fly control.

Fruit bagging

Fruit bagging is an important technology to produce good quality, safe and exportable guava. Fruit bagging was done with transparent poly bag as well as with white coloured butter paper bag. Bagging was done following all kind of recommendations and with skilled labourer. Normally, bagging is done 50-55 days after fruit set. The fruit bag size was 20 cm x 15 cm. For poly bag proper ventilation and drain out of water deposited inside it was ensured.

Worker health safety issues as well as environmental issues

Worker health, safety, and environmental stewardship were prioritized throughout the GAP validation trial for guava. To ensure the safety and well-being of all workers, they were provided with protective gear including aprons, masks, hand gloves, caps, and shoes. Additionally, a comprehensive farm instrument manual was issued to guide the proper use of tools and machinery. A training about the use of different tools and machineries as well as health safety issues was provided to the workers. All kinds of activities hazardous to nature and environment were avoided.

Harvesting

Guava maturty was ensured before harvest. Both destructive and non-destructive methods were followed to confirm maturity. Days to maturity, external colour, firmness, TSS (%) and internal colour were considered during harvesting. Harvesting was done in the cooler period of the day (Within 09.00 am) and first harvesting was started from 15 June 2024. A total of 3-4 times harvesting was done after every 15-20 days' interval from starting period.

MRL analysis result

Guava fruits harvested from GAP validation trial field were free of any kind of pesticide residues, whereas in other trial it was impossible. MRL test was done by the Laboratory of SGS Bangladesh Ltd on 09 June 2024. Azoxystrobin BLQ (LOQ: 0.005) mg/kg, Carbendazim BLQ (LOQ: 0.005) mg/kg, Carbosulphan BLQ (LOQ: 0.005) mg/kg, Difenoconazole BLQ (LOQ: 0.005) mg/kg, Fifronil BLQ (LOQ: 0.005) mg/kg, Imidacloprid 0.032 mg/kg, Tebuconazole BLQ (LOQ: 0.005) mg/kg and Mancozeb BLQ (LOQ: 0.010) mg/kg were found in GAP trial samples. Reported chemicals are below the MRL.

Postharvest management

Guava harvesting was done in a clear sunny day. Labourers used gloves, Gumboots and appropriate clothes/apron. Then harvested guava were kept on tarpaulin and sorting, grading were performed there. Then remove from bags and packaged in clean plastic crates with linear. White plain paper was used as lining material.

Farmer's Training

There are no alternatives of training to the different stakeholders like Agriculture Officers, farmers, SAAO, Workers etc. engaged in GAP guava production. Farmers and workers training was done on 08 February 2024. The training covered GAP guava production technology, GAP standards and principles. Twenty five (25) participants attended in the training programme.

Yield

Fruit dropping and rotting of fruit were comparatively less observed in the GAP validation trial field at the mature stage of fruit, because of less infestation of the fruit fly. Finally, validation trial produced more yield and money compared to other guava cultivation. Total yield was recorded 4.50 metric tons from 50 decimal of the validation trial land i.e. 22.50 mt/ha against district average yield of guava 16.48 mt/ha (BBS, 2024). The cost for this production was Tk. 85000/-, return was Tk. 202500/- and BCR was 2.38. We capable to control insect pest infestation and diseases infections, reduced post-harvest losses and ensure good prices. Therefore, farmers income increased compared to conventional cultivation.

Table 2. Area Production of income for GAP followed guava orchard

Variety	Area (hg)	No. of trees	Total cost of Production (Tk.)	Yield (hg)	Income (Tk.)	BCR (Tk.)
Thai Peyara-3	50	225	85000	4500	202500	2.38

Farmer's profile and reaction

Md. Golab Hossain, Son of Md. Nurshed Ali is an innovative guava farmer living in Doriapur village under Godagari upazila, Rajshahi. He has completed primery level education and then stopped it because of the need of his family. Then he joined in a company in Narsingdi district and 12 years worked over there. He made an accident in Narsingdi and again came back to his village and tsart work on agriculture. He is a owner of two hectares of land and he leased another 2 hectares of land and established Guava orchard. He cultivated his land by his own knowlwdge and sometimes took necessary help from local agricultural office. We have selected him for

Bangladesh GAP practice. At the begining of these activities, he has a tendency of not follow GAP guidlines proparly and always thought GAP is not work on that area and he will be looser. But after sometimes he getting understand and cooperate us completely. Finally, we capable to produce good quality guavas from his field and he is happy.

Export opportunity

This year all guava were sold to local marketand no linkage was developed for export. In addition that season was not suitable for guava export. Winter season guavas are in good quality and will have export potentiality.

Marketing

No effective marketing channel has yet been developed for GAP produce. Most of the Guavas were sold in the chain shop market. Some guavas were sold to local market. Department of Agricultural Marketing (DAM), DAE, can make a linkage with exporter as well as local super shop like Shawpno, Agora, Meenabazar, etc.

Challenges and way forward

Farmers generally use huge amount of pesticides in their guava orchard throughout the growing period. Which is very much alarming for our health condition. So, availability and use of pesticides (Insecticides & Fungicides) should be made more restricted.

An appropriate market channel/export channel in/from Bangladesh should be developed immediately for getting higher price after selling of fruits/vegetables produced following GAP protocol.

All farmers are not capable to follow GAP standards. Only the educated and highly trained and advanced farmers should be selected to produce fruits/vegetables, following appropriate GAP protocol.

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Appendix-1. Soil Analysis report for Guava

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000309	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	22.02.2024
		Date of analysis:	22.02.2024 - 10.03.2024
		BOSS Order:	1030835

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Godagari, Rajshahi)
Type of sample	Soil
Sample Condition	Soil in One Plastic Bag
Sample Quantity	2 Kg

Parameter	Method of Analysis	Unit	Test Result	Test Requirements
Total Nitrogen as N	IS 14684: 1999	%	0.1	0.0-0.36
Phosphorus as P	ASTM D6349-13 (by ICP-OES)	mg/kg	554.64	0.0-30
Sulfur as S	ASTM D6349-13 (by ICP-OES)	mg/kg	216.49	0.0-43.20
Total Organic carbon C:N=13.5:1.0	Walkely and Black, 1934	%	1.02	

Remark: This test has been subcontracted from SGS India Private Ltd.,Test report number: KE24-000400.001 , Dated at 09-03-2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000110

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Appendix-2. Water analysis report for Guava

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000341	Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	22.02.2024
		Date of analysis:	22.02.2024 - 03.03.2024
		BOSS Order:	1030834

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Water (Godagari, Rajshahi)
Type of sample	Water
Sample Condition	Water in Three Plastic Bottle
Sample Quantity	3.5 litre

Chemical tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Arsenic (As)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.01	<0.01	0.1
Calcium (Ca)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	86.34	401
Iron (Fe)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	0.13	1.0-5.0
Magnesium (Mg)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	21.38	61
Potassium (K)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	1.48	2
Sodium (Na)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	77.36	920
Taste	APHA 2160 A, 23rd edn.:2017	-	-	Agreeable	-
Colour	Visual Examination (APHA 2120 B, 23rd edn.:2017)	Pt-Co	5	5	-
Turbidity	APHA 2130 B, 23rd edn.:2017	NTU	5	<5.00	-
Odor	Sensory Evaluation(APHA 2150 B, 23rd edn.:2017)	-	-	Unobjectionable	-
Conductivity	APHA 2510 B, 23rd edn.:2017	µS/cm	-	1210.00	3000
Total Dissolved Solid (TDS)	APHA 2540 C, 23rd edn.:2017	mg/L	1	786.00	2000
Temperature	APHA 2550 B, 23rd edn.:2017	°C	1	29.0	-
Chloride	APHA 4500-Cl- B & D, 23rd edn.:2017	mg/L	0.5	145.95	600
pH	APHA 4500-H+ B, 23rd edn.:2017	-	-	6.60	6.5-8-8
Nitrate	APHA 4500-NO3 B, 23rd edn.:2017	mg/L	0.05	1.18	1-10.0
Total Phosphorus	APHA 4500-P-J, B & E, 23rd edn.:2017	mg/L	0.1	< 0.10	2

Appendix-3. MRL test report for Guava

SGS Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000843	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	09.06.2024
		Date of analysis:	09.06.2024 - 15.06.2024
		BOSS Order:	1031133

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Guava (Godagari, Rajshahi, Village: Kodom Shohor)
Type of sample	Fruit
Sample Condition	Fruit in One Plastic Packet
Number of Container/Packet	01
Sample Quantity	500 gm

NABL Accredited Tests

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Azoxystrobin	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Carbendazim	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Carbosulfan	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Difenconazole	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Fipronil	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Imidacloprid	SO-IN-MUL-TE-085 by LC-MS/MS	0.032	mg/kg
Pyraclostrobin	SO-IN-MUL-TE-085 by LC-MS/MS	0.008	mg/kg
Thiamethoxam	SO-IN-MUL-TE-085 by LC-MS/MS	0.006	mg/kg
Tebuconazole	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Trifloxystrobin	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg

Non-Accredited tests

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Mancozeb as CS2	SO-IN-MUL-TE-112 by GC-MS/GC-MS/MS	BLQ (LOQ :0.010)	mg/kg

Technical Report of Bangladesh GAP Validation Trial: Brinjal

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Abstract

To validate the Good Agricultural Practices (GAP) standards, a trial of brinjal (variety: Caity from Ispahani Seed Company) was conducted at a farmer's field in Shibpur, Narsingdi, Bangladesh during the summer season of 2024. The objective was to produce high-quality and safe brinjal following GAP guidelines. The Government of Bangladesh officially authorized the Bangladesh GAP protocol in 2023, providing a framework for producers to cultivate high-quality crops for consumers. All activities in this trial adhered to the Bangladesh GAP protocol to ensure superior brinjal production. A total of 37 decimals of land, owned by Md. Belayet Hossain was planted with brinjal on 13 March 2024. The crop was managed strictly according to GAP standards. Harvesting took place over a period from 08 May 2024 to 26 July 2024, with a total of 22 harvests. The first harvest was done on 08 May 2024, while the final (22nd) harvest occurred 168 days after transplanting, on 26 July 2024. The yield ranged from 69.69 kg to 206.19 kg per plot. A similar trend was observed in the fruit yield per hectare, which ranged from 465.23 kg/ha to 1,376.46 kg/ha. These values represent single-harvest yields. The total fruit yield from the 37 decimal plot was 3.045 MT, while the estimated yield per hectare was 20.331 MT. These findings indicate that brinjal production under GAP standards can ensure high-quality yields, contributing to both local and export markets. The economic analysis of brinjal production revealed a positive return on investment, as indicated by the Benefit-Cost Ratio (BCR) was 1.31.

Introduction

Eggplant, brinjal or aubergine belongs to the family Solanaceae and under the botanical name Solanum melongena L. (Thompson, 1951). It is a major vegetable crop throughout the tropics and subtropics (Bose and Som, 1986). Brinjal is the most important vegetable crop concerning total acreage (53,665 ha) and production (587,212 tons) in Bangladesh (BBS, 2023). The average yield is only 10.94 tons per hectare, which is very low compared to other brinjal producing countries. China, India, Egypt, Turkey, and Iran are the top five eggplant producers, with production of 28.4, 13.4, 1.2, 0.82, and 0.75 million tons, respectively (Taher *et al.,* 2017). This low yield is mainly due to a lack of high yielding varieties, as well as pest and disease infestation or due to improper management. Though high yielding variety is an important factor for higher yield. Besides this variety, quality and proper management play important roles in quality and higher yield for farmers. Proper management, like judicious use of manure, fertilizer, water, pesticide, and fungicide, is the main concern to boost the brinjal yield. Nowadays, farmers are interested in growing quality eggplant, which is safe for consumers. So, to make available quality eggplant, it is needed to ensure all plant husbandry is done on time with the prescribed amount.

Bangladesh exports eggplants primarily to the Middle East, Europe, and some Southeast Asian countries. The demand in these regions is driven by the popularity of brinjal in diverse cuisines. Exporting eggplants involves several steps, including harvesting, sorting, packaging, and transportation. Quality control is crucial to ensure the produce meets international standards. The export process also involves compliance with the regulations of the importing country. The brinjal export sector faces several challenges, among which the main issues related to pests and diseases can impact the quality and quantity of eggplant. There is potential for growth in the brinjal export

market due to the increasing global demand for diverse vegetables, and the expansion of brinjal export can be achieved following the Bangladesh GAP in brinjal production.

Good Agricultural Practices (GAP) represent a comprehensive set of guidelines designed to promote the production of safe, high-quality, and environmentally sustainable agricultural products (FAO, 2003). These practices cover various aspects of farming, including soil management, water use efficiency, pest and disease control, and post-harvest handling (FAO, 2016). By implementing GAP, farmers can enhance productivity, reduce environmental impacts, and meet both local and international market standards (FAO, 2003). The adoption of GAP is critical for improving crop yields, ensuring food safety, and supporting sustainable agricultural development (World Bank, 2007). Very recently Bangladesh government authorized Bangladesh GAP in 2023 and Bangladesh GAP Protocol: Brinjal in 2024 (Bokhtiar *et. al.,* 2024), which will help the producers to grow quality brinjal for the consumers. As a part of this activity, a validation trial was chalked out with a farmer with 37 decimals (0.15 ha) of land area to grow quality and safe brinjal for the consumers at Shibpur, Narshingdi, Bangladesh.

Materials and Methods

Site Selection and Justification

The validation trial of brinjal was conducted at the farmer's (Md. Belayet Hossain) field of Vill: South Joymongol, Shibpur, Narshingdi during the summer season of 2024. The validation trial was situated at 23.9917º N Latitude and 90.4124º E Longitudes, having an elevation of 8.2 m from sea level under the AEZ 28. The land selection was done for the brinjal cultivation trial by the DAE personnel (Md. Bin Sadek, AEO, DAE, Shibpur, Narshingdi and Ms. Josna, SAAO, DAE, Shibpur, Narshingdi). The trial spanned an area of 37 decimals of land, The area is in AEZ28 (Madhupur tract) and prevailed congenial climatic condition for growing brinjal.

Land Preparation

The land was prepared with 4-5 ploughings by a power tiller. The bed was prepared to maintain a 0.7m width and 14.0 m length, having a 50 cm drain in between the two beds. Fertilizer and manuring (vermicompost was used from the DAE authorized site). The trial spanned an area of 37 decimals, with land preparation beginning on 10 March 2024.

Seedling Preparation and Transplanting: The Brinjal variety Caity of Ispahani Seed Company was used in the trial. Thirty-day old seedlings were transplanted in the main field on 09 March 2024. The unit plot size was 14.0 x 0.70m, and 20 plants were accommodated in a plot with a plant spacing of 70 cm apart in a single row, the row-to-row distance of 1m with a 50 cm drain.

Fig. 1. Seedling transplanting in the plot

Application of manure and fertilizer

Fertilizer and manure (vermicompost) were procured from the DAE authorized site. The land was fertilized with organic fertilizer (vermicompost)-N-P-K-S-Zn-B @ 10,000-170-50-125-18-4.3-1.70 kg/ha, respectively (Ahmed *et al.,* 2018). One-third of the organic fertilizer and half of P and full of S, Zn and B were applied during final land preparation. The rest of the organic fertilizer and P and 1/3 of K were applied as basal in pit 7 (seven) days before transplanting of seedlings. One-fifth of N and K were top-dressed after 20 days of transplanting. The rest of N and K were applied in equal four instalments at 20 days intervals, starting from 20 days after the first top-dressing.

Irrigation

Irrigation was provided 6 times during the growing season, carefully scheduled based on the crop's water requirements and prevailing weather conditions to ensure adequate soil moisture levels. This combination of irrigation techniques helped maintain optimal soil moisture, supporting healthy plant growth and maximizing yield potential (Allen *et al.,* 1998; Steduto *et al.,* 2012).

Previous crop history

The previous crop in the field was country bean, and bitter gourd, which were harvested before the initiation of brinjal cultivation. Consequently, the field required thorough preparation, including soil testing and nutrient replenishment, to address any nutrient deficiencies and prepare it adequately for the eggplant. Additionally, managing any residual pests and diseases from the country bean and bitter gourd was essential to prevent potential impacts on the subsequent brinjal cultivation. The transition from country bean and bitter gourd to brinjal involved a comprehensive approach to restore soil fertility and ensure optimal growing conditions for the new crop.

Soil and water analysis results

The soil and water were tested on 08 February 2024 by a certified laboratory (SGS) (Appendix i and appendix ii). After conducting soil and water analysis, it was confirmed that no hazardous materials were present in the trial site. Based on these analyses, adjustments were made following the Fertilizer Recommendation Guide (FRG) 2018, with guidance from a soil scientist. The adjusted fertilizer doses, including nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), and boron (B), were applied to the field. Fertilizers were incorporated into the soil prior to planting to ensure nutrient availability and additional applications were made throughout the growing season as needed. Regular monitoring of soil and plant tissue was conducted to ensure optimal nutrient levels and make any necessary adjustments to maximize plant growth and yield.

Intercultural operations

Intercultural operations of brinjal are crucial for maintaining the health and productivity of the crop throughout the growing season. The successful cultivation of brinjal involved a series of intercultural operations aimed at optimizing plant growth and yield. Irrigation was applied ten times between 01 April 2024 and 30 July 2024, ensuring consistent soil moisture levels essential for healthy crop development. Black polythene mulch was used to protect weeds and ensure sufficient soil moisture. The bamboo stick was used to support the brinjal crops, to keep the plant upright and to facilitate better air circulation and exposure to sunlight. Intercultural operations like top dressing of fertilizer, irrigation, side pruning of plants, and infested plant parts pruning (sanitation) were done as and when necessary. Efficient drainage systems were also implemented to remove excess water following heavy rains, preventing waterlogging and root rot disease.

Fencing around the trial

A physical barrier with nylon net and bamboo stick fencing was erected around the trial area to protect the crop from livestock, pests and unauthorized access, ensuring the integrity of the trial. Fencing was completed on 25 March 2024, using nylon net and bamboo sticks. The fencing was regularly inspected and maintained to ensure its effectiveness throughout the growing season.

Fig. 2. Fencing around the trial

Maintaining the register book and documentation

A comprehensive register book was meticulously maintained for the GAP validation trial, documenting all relevant information and activities conducted throughout the project. The register included the name of the farmer, crucial details such as the crop name, variety name, soil and water test results, and the precise location of the trial site. The register also tracked the dates of key operations, including irrigation, weeding, pesticide and fungicide applications, and other intercultural activities such as loosening the soil and removing side suckers. A signboard was used to mention important information regarding the GAP validation trial. Additionally, the number of labourers used for each task was documented to ensure accurate records of resource utilization. This detailed register served as an essential tool for monitoring the trial's progress and ensuring the integrity of the data collected.

Fig. 3. A signboard is used to display important information regarding the GAP trial

Discase and Pest management

During the GAP validation trial for eggplant, a variety of integrated pest and disease management practices were employed to ensure crop health and optimize yield. Pesticide and fungicide spraying were done as per GAP schedule after 12-14 day intervals. The pesticides used viz., biorational pesticides (Antario, Tracer, Success, Fizimite, K-mite), and synthetic pesticides (Imitaf, Actara, Vertimec). Fungicides were used viz., Autostin, Provax. Yellow sticky traps and sex pheromone traps were used as per instructions.

Table 1: List of fungicides and pesticides applied to control disease and insect

Sl.	Generic name	Trade name	Application dose	Purpose
1.	Carbendazim	Autostin WDG	1.0 g/L of water	Stem blight, phomopsis
2.	Carboxin and Thiram	Provax	2.5 g/kg seed	Seed treatment
3.	Biorational insecticide	Antario	1.0 g/lit of water	Brinjal fruit and shoot borer
4.	Imidacloprid	Imitaf 20 SL	1.0 ml/L of water	Adult whitefly, aphids, jassid
5.	Thiamethoxam	Actara 25 WG	0.25 g/L of water	Aphids, jassid
6.	Spinosad	Tracer	0.5 ml/L of water	Brinjal fruit and shoot borer
7.	Spinosad	Success	1.2 ml/L of water	Adult whitefly, aphids, jassid
8.	Biopesticide	Fizimite	1.0 ml/L of water	Adult whitefly, aphids
9.	Microbial biopesticide	K-mite	1.0 ml/L of water	Mite
10.	Abamectin	Vertimec 18 EC	1.2 ml/L of water	Mite

* Instalation of sex pheromone treps for brinjal shoot & fruit borer

Fig. 4. The concerned farmer sprays the pesticides using standard protective measures such as aprons, gum boots, hand gloves, masks, goggles, etc., in the trial

Worker health safety and environmental issues

To ensure the safety and well-being of all workers, they were provided with protective gear including aprons, masks, hand gloves, caps, and shoes. Additionally, a comprehensive farm instrument manual was issued to guide the proper use of tools and machinery. Worker health, safety, and environmental stewardship were prioritized throughout the GAP validation trial for eggplant. The pesticides were sprayed by the concerned farmers using standard protective measures viz., aprons, gum boots, hand gloves, mask, goggles, etc. The spraying direction was in favour of the wind, and especially the spraying nozzle was kept towards the pest locations or habitats concerned. These measures not only ensured a safe and healthy working environment but

also reinforced the importance of environmental responsibility and the ethical treatment of workers within the framework of Good Agricultural Practices (GAP).

Harvesting based on maturity index with dates

The edible matured brinjal fruits were harvested at cooler times of the day (early morning and evening) using secateurs and sharp knives. The harvesting container was plastic crate instead of bamboo basket, and harvested fruit was kept in a shady place. Postharvest activities were done carefully. After harvesting, the fruits were kept on the tarpaulin to sort out the non-marketable ones, grading the fruits for marketing and kept on crates. Before marketing, the fruits sorting and grading are essential, as packaging material is used for transportation, and finally ensure clean management with personal sanitization.

Maximum residue level (MRL) analysis

The pesticides used in brinjal cultivation viz., Spinosad, Thiamethoxam, Imidacloprid, and Carbendazim were analyzed using the SO-IN-MUL-TE-085 method by LC-MS/MS, with a Limit of Quantification (LOQ) set at 0.005. The results indicated that all four compounds were below the Limit of Quantification (BLQ), meaning their concentrations were too low to be accurately quantified (Table 2). Specifically, Spinosad, Thiamethoxam, Imidacloprid, and Carbendazim were recorded as BLQ, confirming that none of these substances were detected at levels above the LOQ threshold.

Table 2. MRL analysis results of pesticides used in brinjal cultivation

Parameter/Chemical	Method	Result	Unit
Spinosad	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ (LOQ: 0.005)	mg/kg
Thiamethoxam	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ: 0.005)	mg/kg
Imidacloprid	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ: 0.005)	mg/kg
Carbendazim	SO-IN-MUL-TE-085 by LC-MS/MS	BLO(LOQ: 0.005)	mg/kg

Farmers' Training

The training on brinjal production technology with GAP protocol was conducted in Shibpur, Narsingdi, on 30-01-2024, with 30 participants in attendance. These sessions focused on equipping farmers with the knowledge and skills needed to implement GAP effectively, thereby enhancing the quality and yield of their eggplant. To inform the GAP protocols regarding brinjal cultivation, thirty farmers including the four farmers concerned were trained in a day-long training. The farmers were trained in the GAP activities.

Data collection

Maintaining a register book for all information specially the data on days to 1st harvest, number of marketable fruit, average fruit weight, fruit length (cm), fruit diameter (cm), plant height at last harvest (cm), fruit yield per plant (kg), ESFB infestation (%), bacterial wilt (BW) infection (%), fruit yield (kg/plot), fruit colour and fruit shape were recorded from selected plants.

Data for the average monthly minimum and maximum temperatures (^{o}C), RH (%), and rainfall (mm) were measured during the experimental period (March 2024 to July 2024) and were 26.84^{o}C, 30.44^{o}C, 51.2%, 171.2mm, respectively.

Results and Discussion

There were twenty-two effective harvests made during the whole harvesting period. During the first phase of harvesting, the number of fruits harvested was less compared to the mid period, while in the later stage, the number of fruits gradually decreased. From the 6th to the 20th harvest, the number of fruits was comparatively higher than the rest of the harvests. The results correlate with the findings of Katarzyna (2013). In this study, within 37 decimal areas, the number of marketable fruits per harvest ranged from 505 to 1305, and the single fruit weight was 138g to 158 g. There was a variation observed among the fruit length and fruit diameter with different harvests of eggplant. The range of fruit length and diameter was 27.5 cm to 32.4 cm and 3.5 cm to 3.7 cm, respectively.

There was a significant amount of ESFB infestation and wilt infection observed in the brinjal trial. ESFB infestation was severely observed, and the main cause was the summer, hot and humid conditions during the growing period. Though the infestation range was 10.5-22.5, in the earlier and later stages, the infestation was higher compared to the mid stage (Fig 1). It might be due to the lack of control measures. Very little wilt infection (0-5%) caused by bacteria and fusarium was observed during the growing period. In earlier stages, the infection was 0%, while it was 5% at the later stage.

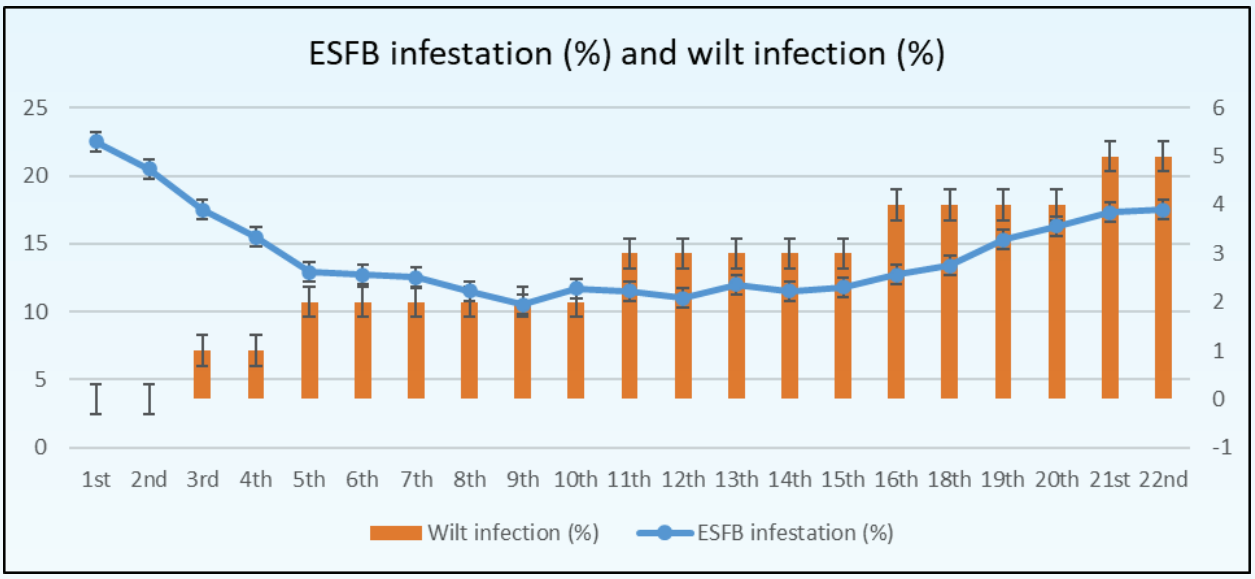

Fig 5. ESFB infestation (%) and wilt infection (%) with different harvest stages

The yield performance of brinjal under Good Agricultural Practices (GAP) in Narsingdi shows a significant improvement compared to the district average (table 3). In a unit plot of 37 decimal, the total fruit yield under GAP reached 3.045 MT, equivalent to 20.331 MT per hectare, whereas the district average was only 1.88 MT per 37 decimal and 12.56 MT per hectare. This clearly highlights the advantage of GAP over traditional practices. Per harvest, the minimum and maximum yields recorded under GAP were 69.69 kg and 206.19 kg per 37 decimal, respectively, which translate into 465.23 kg and 1376.46 kg per hectare. These findings indicate that GAP not only enhances total yield but also ensures greater stability and higher productivity across harvests.

Table 3. Yield parameters of brinjal in unit plot (37 decimal) and one hectare area for GAP practice and district average (Narshingdi)

Parameter	Fruit yield (37 decimal)	Fruit yield (One hectare)
GAP Practice	3.045 MT	20.331 MT
Minimum yield per harvest	69.69 kg	465.23 kg
Maximum yield per harvest	206.19 kg	1376.46 kg
District average (Narshingdi)	1.88 MT	12.56 MT

Fig. 6. Brinjal is harvested using secateur and appropriate safety measures in the trial

Fruit harvest, sorting, grading, and packaging

Brinjal harvesting, sorting, grading, and packaging are crucial steps in maintaining quality and ensuring compliance with Bangladesh GAP standards. So, harvesting was done at the proper maturity stage, when the fruits are firm, glossy, and have attained the desired size. Farmers used clean and sharp tools (secateur) to minimize damage and contamination. After harvesting, sorting was performed to remove damaged, diseased, or deformed fruits, ensuring only high-quality produce moves forward. Grading is then carried out based on size, shape, color, and overall appearance to maintain uniformity and meet market standards. Proper packaging is essential to protect brinjal during transportation and storage. Fruits were packed in clean, ventilated crates, avoiding excessive stacking to prevent bruising. Adopting these GAP-compliant practices enhanced the shelf life, market value, and safety of brinjal, benefiting both producers and consumers.

Fig. 7. Sorting, grading, and packaging of brinjal

Benefit-Cost analysis

The economic analysis of brinjal production reveals a positive return on investment, as indicated by the Benefit-Cost Ratio (BCR) of 1.31 (Table 4). This suggests that for every 1 Tk spent on production, there is a return of 1.31 Tk, demonstrating the profitability of the venture. The total brinjal yield from the cultivation was 3,045 kg, with a unit price of 30 Tk per kg, leading to a total income of 91,350 Tk. However, after deducting the total expenses of 69,500 Tk, the actual net income stands at 21,850 Tk. Despite the profitability, the relatively moderate BCR suggests that while the production system is economically viable, further optimization may enhance profitability. This indicates a profitable return, though further optimizations in cost management and yield improvement could enhance profitability.

Table 4. The economic analysis (BCR) of brinjal production

Brinjal yield (kg)	Unit price (Tk)	Income (Tk)	Expenses (Tk)	Actual income (Tk)	BCR
3045	30	91350	69500	21850	1.31

Potential areas for improvement include

Yield Enhancement: Implementing better agronomic practices, adopting high-yielding brinjal varieties, and ensuring adherence to Good Agricultural Practices (GAP) could improve yield and overall returns.

Market Optimization: Exploring better market linkages, value addition, or direct marketing strategies could help secure higher prices for the producer, further increasing income.

Farmer's profile and reaction

Belayet Hossain, a resident of South Joymongol, Shibpur, Narsingdi, successfully cultivated brinjal following Good Agricultural Practices (GAP) standards. He is an HSC-passed educated farmer. He expressed satisfaction with the results, noting that the optimum use of compost, fertilizers, insecticides, fungicides, and irrigation water significantly improved their yield. Compared to his previous farming methods for eggplant, adopting GAP led to better crop performance and higher profitability, confirming the advantages of these sustainable farming practices.

Marketing and export opportunities

GAP-produced brinjal can be marketed as a premium, safe, and sustainable product. Strategies include targeting health-conscious consumers and supermarkets, emphasizing their compliance with international safety standards, and positioning it for export to high-demand markets. Leveraging certifications and promoting the benefits of GAP can also attract buyers looking for quality and traceable produce. The involvement of the Department of Agricultural Marketing (DAM) can establish better marketing channels.

GAP-produced brinjal meets international standards for quality and safety, making it highly competitive in global markets. The adherence to GAP enhances the crop's appeal to foreign buyers, offering farmers the chance to access lucrative export opportunities. This not only boosts income but also strengthens Bangladesh's presence in the international agricultural market.

Challenges and way forward

During the plant fruiting stage, heavy rainfall conditions led to the death of some plants, compounded by an outbreak of fusarium wilt. Additionally, the farmer was not fully acquainted

and habituated to GAP practices, while plant protection measures were complex to them. They are interested in purchasing and applying pesticides and fungicides following the advice of pesticide dealers rather than the Agriculture Officer or the GAP Protocol.

To overcome these challenges, a coordinated approach is needed under a unified framework involving researchers, DAE, DAM, exporters' associations, and BARC to enhance brinjal exports while ensuring the availability of quality products in the local market. Agricultural entrepreneurs interested in exporting can collaborate with farmers to implement GAP practices. All activities in this trial followed the Bangladesh GAP protocol to ensure high-quality brinjal production.

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Appendix- i. Soil analysis report for Brinjal

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000236	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	12.02.2024
		Date of analysis:	12.02.2024 - 28.02.2024
		BOSS Order:	1030842

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Shibpur, Narsingdi)
Type of sample	Soil
Sample Condition	Soil in One Plastic Bag
Sample Quantity	2 Kg

Parameter	Method of Analysis	Unit	Test Result	Test Requirements
Total Nitrogen as N	IS 14684: 1999	%	0.1	0.0-0.36
Phosphorus as P	ASTM D6349-13 (by ICP-OES)	mg/kg	1031.83	0.0-30
Sulfur as S	ASTM D6349-13 (by ICP-OES)	mg/kg	158.06	0.0-43.20
Total Organic carbon C:N=13.5:1.0	Walkely and Black, 1934	%	1.35	

Note: This test has been subcontracted from SGS India Pvt. Ltd. Test Report No. KE24-000356.001; Date: 28/02/2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000081

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TEST REPORT

DHF240000284

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	12.02.2024
		Date of analysis:	12.02.2024 - 19.02.2024
		BOSS Order:	1030802

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Soil (Shibpur, Narsingdi)
Type of sample	Soil
Sample Condition	Soil in Two Plastic Packet
Sample Quantity	2 Kg

Physical & Compositional tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Moisture	APHA 2540 G, 23rd edn.: 2017	%	0.5	20.03	

Chemical tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Arsenic (As)	US EPA 3052	mg/kg	1	<1.00	20
Cadmium (Cd)	US EPA 3052	mg/kg	1	<1.00	3
Chromium (Cr)	US EPA 3052	mg/kg	1	27.53	100
Lead (Pb)	US EPA 3052	mg/kg	1	9.44	85
Mercury (Hg)	US EPA 3052	mg/kg	1	<1.00	0.02-0.06
Nickel (Ni)	US EPA 3052	mg/kg	1	19.53	100
Zinc (Zn)	US EPA 3052	mg/kg	1	62.96	0.0-1.60
Boron (B)	US EPA 3052	mg/kg	1	7.73	0.0-0.61
Potassium (K)	US EPA 3052	meq/100g	2.5	**3.64**	0.0-0.36
Magnesium (Mg)	US EPA 3052	meq/100g	2.5	**33.28**	0.0-1.62
Conductivity (EC)	APHA 2510 B, 23rd edn.:2017	dS/m		0.05	<8.0

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Folder Number : DHF24-0000080

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Appendix- ii. Water analysis report for Brinjal

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TEST REPORT

DHF240000288

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	12.02.2024
		Date of analysis:	12.02.2024 - 19.02.2024
		BOSS Order:	1030802

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Water (Shibpur, Narsingdi)
Type of sample	Water
Sample Condition	Water in Three Plastic Bottle
Sample Quantity	3.5 litre

Chemical tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Arsenic (As)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.01	<0.01	0.10
Calcium (Ca)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	14.69	401
Iron (Fe)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	11.52	1.0 - 5.0
Magnesium (Mg)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	5.93	61
Potassium (K)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	3.76	2.0
Sodium (Na)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	11.12	920
Taste	APHA 2160 A, 23rd edn.:2017	-	-	Agreeable	-
Colour	Visual Examination (APHA 2120 B, 23rd edn.:2017)	Pt-Co	5	5	-
Turbidity	APHA 2130 B, 23rd edn.:2017	NTU	5	206.00	-
Odor	Sensory Evaluation(APHA 2150 B, 23rd edn.:2017)	-	-	Unobjectionable	-
Conductivity	APHA 2510 B, 23rd edn.:2017	µS/cm	-	253.00	3000
Total Dissolved Solid (TDS)	APHA 2540 C, 23rd edn.:2017	mg/L	1	178.00	2000
Temperature	APHA 2550 B, 23rd edn.:2017	°C	1	26.0	-
Chloride	APHA 4500-Cl- B & D, 23rd edn.:2017	mg/L	0.5	6.00	600
pH	APHA 4500-H+ B, 23rd edn.:2017	-	-	6.50	6.5 - 8.8
Nitrate	APHA 4500-NO3 B, 23rd edn.:2017	mg/L	0.05	< 0.05	1.0 - 10.0
Total Phosphorus	APHA 4500-P-J, B & E, 23rd edn.:2017	mg/L	0.1	< 0.10	2.0
Sulfate	APHA 4500-SO4 2- E, 23rd edn.:2017	mg/L	5	< 5.00	1000

Folder Number : DHF24-0000080

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Appendix- iii. MRL test report for Brinjal

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TEST REPORT

DHF240000876

Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	28.06.2024
		Date of analysis:	28.06.2024 - 08.07.2024
		BOSS Order:	1031172

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Brinjal (Shibpur, Norsingdi, Village: Nawhala)
Type of sample	Fruit
Sample Condition	Fruit in One Plastic Packet
Number of Container/Packet	01
Sample Quantity	500 gm

NABL Accredited Tests

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Spinosad	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Thiamethoxam	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Imidacloprid	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Carbendazim	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg

Remark : BLQ- Below Limit of Quantification, LOQ- Limit of Quantification

Remark: This test has been subcontracted from SGS India Private Ltd. Test report number: CG24-016892.001 , Dated at 05-07-2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000326

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Technical Report of Bangladesh GAP Validation Trial: Bottle Grourd

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Abstract

Good Agricultural Practices (GAP) is designed to enhance the safety, quality and sustainability of agricultural products by covering soil management, water use, pest control and post-harvest handling. A GAP validation trial for bottle gourd (*Lagenaria siceraria*), was conducted at the Basna village of Dhamrai, Dhaka during summer 2024 with the variety BARI Lau-4. The study aimed to assess the effectiveness of GAP in improving yield and quality. The trial involved meticulous site selection, land preparation, seedling management, and fertilization. Recommended practices including balanced fertilization, efficient irrigation, and disease management were implemented. Despite challenges such as drought, gummy stem blight, and high labour price, the trial achieved a yield of 35 MT per hectare, surpassing the national average of 13.7 MT per hectare and benefit cost ratio was 1.93. Training sessions were conducted to equip farmers with GAP knowledge, resulting in enhanced productivity and higher profitability. The GAP-produced bottle gourd meets international quality standards, presenting strong export opportunities. Recommendations include adopting drought-resistant practices, improving farmer engagement, and involving the Hortex Foundation and Department of Agricultural Marketing (DAM) for better market access. Future efforts should focus on addressing challenges and leveraging export potential to strengthen both local and international market presence.

Introduction

Good Agricultural Practices (GAP) represent a comprehensive set of guidelines designed to promote the production of safe, high-quality, and environmentally sustainable agricultural products (FAO, 2003). These practices cover various aspects of farming, including soil management, water use efficiency, pest and disease control, and post-harvest handling (FAO, 2016). By implementing GAP, farmers can enhance productivity, reduce environmental impacts, and meet both local and international market standards (FAO, 2003). The adoption of GAP is critical for improving crop yields, ensuring food safety, and supporting sustainable agricultural development (World Bank, 2007). Bottle gourd (*Lagenaria siceraria* (Molina) Standl.), also known as white-flowered gourd or calabash, is a diploid species (2n=2x=22) belonging to Cucurbitaceae family (Beevy and Kuriachan, 1996; Morimoto *et al.,* 2005). The bottle gourd variety under study, BARI Lau-4, is specifically adapted for summer cultivation in Bangladesh. With its ability to thrive in the climatic conditions of Dhamrai, Dhaka, where it has been extensively validated, this variety represents a significant advancement in local vegetable production. In Bangladesh, bottle gourd is a crucial vegetable crop cultivated across various regions. According to the Bangladesh Bureau of Statistics (BBS, 2023), the production of bottle gourd is 14000 MT from the area of 838.5 hectare in Bangladesh and Dhaka district yield is 16.7 MT per hectare, with extensive cultivation in different districts. Dhamrai, a prominent area in Dhaka Division, is known for its vegetable production, including bottle gourd. This crop contributes significantly to the local economy and food security. The cultivation of bottle gourd in Dhamrai supports many farmers and plays a vital role in the local vegetable market. Beyond local consumption, bottle gourd has export potential due to its popularity in international markets. With increasing global demand for diverse and nutritious vegetables, bottle gourd offers opportunities

for export growth and can contribute to solving problems related to micronutrient malnutrition (Nesamvuni *et al.,* 2001; Flyman and Afolayan, 2006; Modi *et al.,* 2006; Odhav *et al.,* 2007; Schonfeldt and Pretorius, 2011). Properly managed production practices can enhance the quality of the produce, meeting international standards and expanding market access. Exploring export opportunities can provide additional income for farmers and contribute to the agricultural economy. Bottle gourd, while a significant crop, represents a smaller fraction of the total vegetable production compared to other major crops. However, its role in crop diversity and its importance to local diets and economies cannot be underestimated. By comparing bottle gourd production with total vegetable production, it becomes evident that while it may not dominate in volume, its value and impact on local agriculture and markets are substantial. Improving production practices through GAP can enhance its competitiveness and contribute to a more balanced and resilient agricultural sector. The GAP validation trial for bottle gourd conducted in Dhamrai, Dhaka, Bangladesh, aims to assess and validate the effectiveness of Bangladesh GAP protocols specific to this region. This trial seeks to enhance the productivity, quality and sustainability of bottle gourd production. By evaluating the impact of GAP on local farming practices, the trial aims to provide practical recommendations for farmers, improve crop management strategies and contribute to sustainable agricultural practices in the region.

Materials and Mathods

Site selection and justification

The GAP validation trial of bottle gourd was conducted in the village Basna of Dhamrai upazila, Dhaka, Bangladesh and the names of the two local participating farmers, Babul Hossain and Azmin Akter. This region was selected due to its favourable climatic conditions, which align well with the requirements of the BARI Lau-4 variety. Dhamrai is renowned for its optimal growing conditions for bottle gourd, including temperature, soil type, and water availability as in AEZ 8 (Young Brahmaputra Jamuna Floodplain).

Fig. 1. Site selection at Dhamrai, Dhaka

The precise location of the trial site at 23.9459171ºN Latitude and 90.1300177ºE Longitude. The region's climate is characterized by summer temperatures ranging from 20.83-36.61°C. Additionally, Dhamrai's soil quality and local farming expertise provide a supportive environment for validating and demonstrating the effectiveness of GAP in enhancing yield and quality.

Land preparation

The land was cleared of previous crop residues, weeds, and debris. The soil was then ploughed and harrowed four times on 10 March 2024 in Azmin Akter's land and 12 April 2024 in Babul Hossain's land until a fine tilth was achieved, ensuring good seed-to-soil contact and optimal root development.

Azmin Akter and Babul Hossain cultivated bottle gourd in 40 decimal (0.162 ha) and 50 decimal (0.202 ha) plots, respectively. Soil samples were collected and tested for pH, nutrient levels, and organic matter content. Based on the results, appropriate soil amendments were applied to correct nutrient deficiencies in accordance with FRG, 2018 guidelines.

Fig. 2. Field layout for bottle gourd

Seedling preparation

High-quality seeds of the BARI Lau-4 variety were selected based on their germination potential and health. Seeds were sown on 12 March, 2024 for Azmin Akter's land and on 16 April 2024 for Babul Hossain's land in seed trays filled with a well-draining, nutrient-rich growing medium such as compost and well decomposed cow dung.

The seeds were treated with Carbendazim (Autostin) fungicide on 12 March and 16 April 2024 and the same day they were sown. The trays were covered by nylon net to protect the young seedlings from extreme temperatures and direct sunlight and attack of red pumpkin beetle. Regular watering was provided to maintain soil moisture. Seedlings were monitored for any signs of disease or pest incidence and necessary treatments such as applying D-limonene 5% (Bioclean) and Carbendazim (Autostin) fungicide to control red pumpkin beetle and fungal infections, respectively.

Fig. 3. Seedling raising of bottle gourd

Fertilizer application

Well-rotten compost or manure @ 5 ton/ha (3kg/pit) and N-P-K-S-Mg-Zn-B at 75-36-60-22-12-2.1-1.4 kg per hectare (45-22-36-13.2-7.2-0.60-0.84 g/pit) were applied for promoting growth and yield (FRG, 2018). In addition, Cadusafos 10% (Ragbi 10G) was used to prevent soil-borne diseases. This nutrient management strategy ensures the soil is adequately enriched, supporting the healthy growth and development of crops right from the onset of the planting season (Fageria, 2009 and Havlin *et. al.,* 2014). Full doses of all the manure and P-S-Mg-Zn-B and one-third of K were applied during final land preparation; entire nitrogenous and two-third of the potassium fertilizers were applied in four splits throughout the growing season.

This strategy was implemented to ensure that plants receive a continuous supply of essential nutrients, particularly during critical growth stages such as vegetative growth, flowering, and fruit development. By splitting the application, the risk of nutrient leaching was reduced and nutrient use efficiency was enhanced, leading to improved crop performance and yield (Fageria *et al.,* 2011; Singh *et al.,* 2017).

Fig. 4. Mixing compost with fertilizers

Transplanting

Seventeen days old seedlings at 3-4 true leaf stage were transplanted in the field on 29 March 2024 in Azmin Akter's plot and on 03 May 2024 in Babul Hossain's plot. This transplanting in the well-prepared pits encourage the plants to establish a strong root system and become robust enough to handle field conditions. Seedlings were carefully removed from the seedling trays and transplanted into pre-prepared pits (50 x 50 x 45 cm) in the field, maintaining 2.5 meters spacing in both the ways as per GAP guidelines.

Irrigation

Irrigation was provided 8 times in each plot from 05 April 2024 to 20 July, 2024 during the growing season, carefully scheduled based on the crop's water requirements and prevailing weather conditions. Watering can irrigation methods were preferred to ensure efficient water use, targeting the root zone directly and minimizing water wastage. Additionally, flood irrigation was

applied 4 times in each plot at the same time during periods of dry soil conditions to ensure adequate soil moisture levels. This combination of irrigation techniques helped maintaining optimal soil moisture, supporting healthy plant growth and maximizing yield potential (Allen *et al.,* 1998; Steduto *et al.,* 2012).

Fencing or netting around the GAP validation trial

To protect the GAP validation trial, a sturdy fence was constructed around the 90 decimal land area using nylon netting and bamboo sticks. This fencing served as a physical barrier to safeguard the crop from animals and unauthorized access, ensuring the integrity of the trial.

In addition to the fencing, two signboards were strategically placed at the entrance of the trial area. These signboards provided essential information about the validation trial, including details such as the crop variety, the objectives of the trial, and the implementation of Good Agricultural Practices (GAP). The signboards also served as a communication tool to inform visitors and passersby about the research being conducted, reinforcing the importance of sustainable farming practices in enhancing crop yield and quality.

Fig. 5. Signboard and fencing placed around the trial

Previous crop history

The previous crop in the field was maize (*Zea mays*), which was harvested before starting bottle gourd cultivation process. Maize, being a heavy feeder, significantly depletes soil nutrients, particularly nitrogen, and can influence the soil's physical and biological properties. Consequently, the field required thorough preparation, including soil testing and nutrient replenishment to address any nutrient deficiencies and prepare it adequately for the bottle gourd crop. Additionally, managing any residual pests and diseases from the maize crop was essential to prevent potential impacts on the subsequent bottle gourd cultivation. The transition from maize to bottle gourd involved a comprehensive approach to restore soil fertility and ensure optimal growing conditions for the new crop.

Soil and water analysis result

After conducting soil and water analysis, it was confirmed that no hazardous materials were present in the trial site. Based on these analyses, adjustments were made following the Fertilizer Recommendation Guide (FRG) 2018, with guidance from a soil scientist. The adjusted fertilizer doses including nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), and boron (B) were applied to the field. Fertilizers were incorporated into the soil prior to planting to ensure nutrient availability and additional applications were made throughout the growing season as needed. Regular monitoring of soil and water quality was conducted to ensure optimal nutrient levels and make any necessary adjustments to maximize plant growth and yield.

Fig. 6. Collection of soil sample on 12 February, 2024

Fig. 7. Collection of water sample on 12 February, 2024

Intercultural operations

The successful cultivation of bottle gourd involved a series of intercultural operations aimed at optimizing plant growth and yield. Weeding was performed 12 times from 10 April 2024 to 25 July 2024 to keep the field free of competitive weeds, which could otherwise impact plant growth and nutrient uptake. A trellis system was constructed using bamboo and nylon rope to support the climbing nature of the bottle gourd vines, facilitating better air circulation and exposure to sunlight. After each irrigation, the soil was loosened around the plants to enhance aeration and root development. Water suckers were regularly removed from the stem to direct more energy into fruit production. Efficient drainage systems were also implemented to remove excess water following heavy rains, preventing waterlogging and root rot. These intercultural practices were crucial for maintaining the health and productivity of the crop throughout the growing season.

Maintaining register book and documentation

A comprehensive register book was meticulously maintained for the GAP validation trial, documenting all relevant information and activities conducted throughout the project. The register included the names of the two participating farmers and recorded crucial details such as the crop name, variety name, soil and water test results and the precise location of the trial site. The register also tracked the dates of key operations, including irrigation, weeding, pesticide and fungicide applications, and other intercultural activities such as loosening the soil, removing water suckers and hand pollination. Additionally, the number of labourers used for each task was documented to ensure accurate records of resource utilization. This detailed register served as an essential tool for monitoring the trial's progress and ensuring the integrity of the data collected.

Discase and Pest management

During the GAP validation trial for bottle gourd, a variety of integrated pest and disease management practices were employed to ensure crop health and optimize yield. Fungicide of carbendazim group (Autostin WDG) was used for seed treatment before sowing. To control the red pumpkin beetle, the insecticide D-limonene 5% (Bioclean) was used at vegetative stage. For fruit fly management, sex pheromone (Cuelure sex pheromone) traps were strategically placed every twelve meters interval to attract and capture the pests, reducing their population and better impact on the crop. Additionally, yellow sticky traps were deployed every ten meters distance across the field to target a range of other insect pests, providing an eco-friendly method of pest control. In terms of disease management, Copper oxychloride 50% (Cupravit), a copper-based fungicide, was applied entire the cropping period as a preventive measure against gummy stem blight, a common fungal disease of bottle gourd. To treat any instances of gummy stem blight that occurred, Bordeaux paste bandage was used to effectively cure the affected plants. These targeted interventions were crucial in maintaining the health of the bottle gourd plants, preventing significant yield losses, and ensuring the success of the GAP validation trial.

Table 1: List of pesticides applied to control insect and disease

Sl.	Generic name	Trade name	Application dose	Purpose
1.	Carbendazim	Autostin WDG	2.5 g/kg seed	Seed treatment
2.	Copper oxychloride	Cupravit 35WG	2.0 g/L of water	To control gummy stem blight
3.	Copper sulphate and quicklime	Bordeaux mixture	2.5 g/plant	To control gummy stem blight
4.	D-limonene	Bioclean	1.0 mt/L of water	To control red pumpkin beetle
5.	Success	Spinosad	1.2 ml/L	Sab beetle control

Worker health safety and environmental issues

Worker health, safety, and environmental stewardship were prioritized throughout the GAP validation trial for bottle gourd. To ensure the safety and well-being of all workers, they were provided with protective gear including aprons, masks, hand gloves, caps, and shoes. Additionally, a comprehensive farm instrument manual was issued to guide the proper use of tools and machinery. Regular health checks were conducted to monitor worker health, and essential health safety items such as soap were supplied, with washrooms being cleaned regularly using appropriate detergents like lizol.

Fig. 8. Spraying with health safety measures

Pure drinking water was made available to all workers and their working hours were restricted to a maximum of eight hours per day to prevent fatigue. Training sessions were conducted to educate workers on health safety protocols, the correct use of pesticides and the provision of first aid treatment. These measures not only ensured a safe and healthy working environment but also reinforced the importance of environmental responsibility and the ethical treatment of workers within the framework of Good Agricultural Practices (GAP).

Harvesting based on maturity index

Obscure spine present on the fruit, easily cut with pinch by nail, usually harvest 12-15 days after anthesis, the more harvest the more bearing fruits, harvest must be done with sharp knife during cooler time of the day (early morning or evening).

Harvested fruits were kept in plastic crate instead of bamboo basket and placed in shady place. Before marketing of the fruits, sorting and grading is essential, packaging material used for transportation, finally ensure clean management.

Fig. 9. Suitable harvesting stage of bottle gourd

MRL analysis results

The SGS Bangladesh Limited conducted a Maximum Residue Limit (MRL) test for copper oxychloride using a bottle gourd sample collected from Dhamrai, Dhaka, on 09 June, 2024. Following laboratory analysis, the company reported residue levels below 5 mg/kg, which falls within safe thresholds for human consumption, indicating no significant health risks.

Fig. 10. Bottle gourd sample taken for MRL test

Farmers' Training

The first batch of training on bottle gourd production technology with GAP protocol was conducted in Dhamrai on 20-01-2024 with 30 participants in attendance. Following the success of this session, a second batch of training was held in Basna village on 21-03-2024 involving 5 participants. These sessions focused on equipping farmers with the knowledge and skills needed to implement GAP effectively, thereby enhancing the quality and yield of their bottle gourd crops.

Fig. 11. Farmers training on 20 January 2024

Yield

A total of 27 effective harvests were conducted during the cropping period. In the initial phase, fewer fruits were harvested compared to the mid-period. Then the number of fruits gradually declined in the later phase. Higher number and yield of fruits were observed between 7th and 19th harvests than that of rest of the harvests. This pattern of fruit yield distribution is consistent with findings from earlier research on bottle gourd harvest patterns (Kader *et al.,* 2019). In addition, individual fruit weight ranged from 2.1 to 2.8 kg and harvest duration was 53 days in the cropping period.

From a 90-decimal plot of land, the number of fruits harvested was 5098, resulting in a total yield of 12.75 MT. The average individual fruit weight was 2.5 kg. This translated to a fruit yield of 35.0 MT per hectare, which is significantly higher than the Dhaka district of 16.7 MT per hectare. These results highlight the effectiveness of the cultivation practices implemented, particularly the use of GAP standards, in substantially improving productivity.

Fig. 12. Farmers harvested bottle gourds

Table 2. Yield of GAP produced bottle gourd compared to dristict average

Practice	Fruits number	Individual fruit weight (kg)	Yield (t/ 90 decimal land)	Yield (MT/ha)
GAP	5098	2.5	12.75	35.0
Dhaka dristict	-	-	6.1	16.7

Benefit-cost analysis

The production of bottle gourd on 90 decimals of land adhering to Good Agricultural Practices (GAP) resulted in a total yield of 12.75 MT, with 5,098 gourds produced. The total production cost was Tk. 2,11,500/-, while the market price per gourd was Tk. 80, generating a total revenue of 4,07,840 Taka. The Benefit-Cost Ratio (BCR) was 1.93. This demonstrates the economic viability of GAP-based cultivation, highlighting its potential for profitability and sustainability. The yield exceeded the national average, showcasing the effectiveness of improved practices in enhancing productivity and market competitiveness.

Farmer's Profile and Reaction

Babul Hossain, aged 40 with an eighth-grade education, and Azmin Akter, aged 32 and a Secondary School Certificate (SSC) holder, both are residents of Basna village in Dhamrai, Dhaka, achieved successful bottle gourd cultivation by adhering to Good Agricultural Practices (GAP) guidelines.

They expressed satisfaction with the results, noting that the optimum use of compost, fertilizers, insecticides, fungicides and irrigation water significantly improved their yield. Compared to their previous farming methods, adopting GAP led to better crop performance and higher profitability, confirming the advantages of these sustainable farming practices.

Export opportunity

GAP-produced bottle gourd meets international standards for quality and safety, making it highly competitive in global markets. The adherence to GAP enhances the crop's appeal to foreign buyers,

offering farmers the chance to access lucrative export opportunities. This not only boosts income but also strengthens Bangladesh's presence in the international agricultural market.

Marketing

GAP-produced bottle gourd was sold at the local market in Dhamrai, Dhaka. However, there was no noticeable difference in pricing or consumer preference between GAP-produced bottle gourd and those from normal production methods in the local market. There is vast scope for GAP-produced bottle gourd can be marketed as a premium, safe and sustainable product. Strategies include targeting health-conscious consumers, super markets, emphasizing its compliance with international safety standards and positioning it for export to high demand markets. Leveraging certifications and promoting the benefits of GAP can also attract buyers looking for quality and traceable produce. The involvement of the Hortex Foundation and Department of Agricultural Marketing (DAM) can establish better marketing channels.

Challenges and way forward

During the seedling stage, drought conditions caused the death of some plants, which was further compounded by an outbreak of gummy stem blight. Additionally, scarcity of labourer and high labour costs during April and May posed challenges. Moreover, the Sub-assistant Agriculture Officer (SAAO) requires training on record keeping for the GAP validation trial.

To overcome the challenges faced during the GAP validation trial, several steps can be taken for moving forward. Efficient irrigation methods, such as drip irrigation or mulching, should be introduced to mitigate the effects of drought during the seedling stage. Implementing disease-resistant varieties and enhancing monitoring systems will help manage outbreaks like gummy stem blight more effectively. The issue of labour scarcity and high costs during peak periods, particularly in April and May, can be addressed through mechanization or community labour-sharing initiatives. Additionally, training should be provided to the Sub-assistant Agriculture Officer (SAAO) on record-keeping and data management for GAP trials, ensuring more accurate tracking and reporting. These measures will enhance productivity and sustainability, leading to better outcomes in future GAP practices.

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Appendix-1: Soil test report for Bottle Gourd

Laboratory of SGS Bangladesh Ltd.	**TEST REPORT** DHF240000237	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	13.02.2024
		Date of analysis:	13.02.2024 - 28.02.2024
		BOSS Order:	1030843

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Dhamrai, Dhaka)
Type of sample	Soil
Sample Condition	Soil in One Plastic Bag
Sample Quantity	2 Kg

Parameter	Method of Analysis	Unit	Test Result	Test Requirements
Total Nitrogen as N	IS 14684: 1999	%	0.09	0.0-0.36
Phosphorus as P	ASTM D6349-13 (by ICP-OES)	mg/kg	701.3	0.0-30
Sulfur as S	ASTM D6349-13 (by ICP-OES)	mg/kg	156.99	0.0-43.20
Total Organic carbon C:N=13.5:1.0	Walkely and Black, 1934	%	0.92	

Note: This test has been subcontracted from SGS India Pvt. Ltd. Test Report No. KE24-000378.001; Date: 28/02/2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000084

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Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000296	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	13.02.2024
		Date of analysis:	13.02.2024 - 20.02.2024
		BOSS Order:	1030804

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Dhamrai, Dhaka)
Type of sample	Soil
Sample Condition	Soil in One Plastic Packet
Sample Quantity	01 Kg

Physical & Compositional tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Moisture	APHA 2540 G, 23rd edn.: 2017	%	0.5	19.05	

Chemical tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Arsenic (As)	US EPA 3052	mg/kg	1	<1.00	20
Cadmium (Cd)	US EPA 3052	mg/kg	1	<1.00	3
Chromium (Cr)	US EPA 3052	mg/kg	1	30.77	100
Lead (Pb)	US EPA 3052	mg/kg	1	11.21	85
Mercury (Hg)	US EPA 3052	mg/kg	1	<1.00	0.02-0.06
Nickel (Ni)	US EPA 3052	mg/kg	1	30.68	100
Zinc (Zn)	US EPA 3052	mg/kg	1	57.36	0.0-1.60
Boron (B)	US EPA 3052	mg/kg	1	<1.00	0.0-0.61
Potassium (K)	US EPA 3052	meq/100g	2.5	**4.74**	0.0-0.36
Magnesium (Mg)	US EPA 3052	meq/100g	2.5	**55.81**	0.0-1.62
Conductivity (EC)	APHA 2510 B, 23rd edn.:2017	dS/m		0.05	<8.0

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Folder Number : DHF24-0000083

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Appendix-2: Water test report for Bottle Gourd

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TEST REPORT

DHF240000238

Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	13.02.2024
		Date of analysis:	13.02.2024 - 20.02.2024
		BOSS Order:	1030804

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Water (Dhamrai, Dhaka)
Type of sample	Water
Sample Condition	Water in Four Plastic Bottle
Sample Quantity	3.5 litre

Chemical tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Arsenic (As)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.01	<0.01	0.1
Calcium (Ca)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	47.41	401
Iron (Fe)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	6.24	1.0 - 5.0
Magnesium (Mg)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	19.49	61
Potassium (K)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	1.45	2
Sodium (Na)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	13.51	920
Taste	APHA 2160 A, 23rd edn.:2017	-	-	Agreeable	-
Colour	Visual Examination (APHA 2120 B, 23rd edn.:2017)	Pt-Co	5	5	-
Turbidity	APHA 2130 B, 23rd edn.:2017	NTU	5	138.00	-
Odor	Sensory Evaluation(APHA 2150 B, 23rd edn.:2017)	-	-	Unobjectionable	-
Conductivity	APHA 2510 B, 23rd edn.:2017	µS/cm	-	392.00	3000
Total Dissolved Solid (TDS)	APHA 2540 C, 23rd edn.:2017	mg/L	1	284.00	2000
Temperature	APHA 2550 B, 23rd edn.:2017	°C	1	26.0	-
Chloride	APHA 4500-Cl- B & D, 23rd edn.:2017	mg/L	0.5	14.00	600
pH	APHA 4500-H+ B, 23rd edn.:2017	-	-	6.60	6.6 - 8.8
Nitrate	APHA 4500-NO3 B, 23rd edn.:2017	mg/L	0.05	0.16	1 - 10.0
Total Phosphorus	APHA 4500-P-J, B & E, 23rd edn.:2017	mg/L	0.1	< 0.10	2
Sulfate	APHA 4500-SO4 2- E, 23rd edn.:2017	mg/L	5	21.03	1000

Folder Number : DHF24-0000083

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Appendix-3: MRL test report for Bottle Gourd

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TEST REPORT

DHF240000859

Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	09.06.2024
		Date of analysis:	09.06.2024 - 21.06.2024
		BOSS Order:	1031133

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Bottle Gourd (Dhamrai, Dhaka, Village: Basna)
Type of sample	Vegetable
Sample Condition	Vegetable in One Plastic Packet
Number of Container/Packet	01
Sample Quantity	500 gm

Test/Parameter	Method	Result	Unit
Copper oxychloride (Copper determined as elemental copper)	SO-IN-MUL-TE-063 by ICPMS	<5.00	mg/kg

Note: This test has been subcontracted from SGS India Pvt. Ltd. Test Report No. CG24-014920.001; Date:18/06/2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000297

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Technical Report of Bangladesh GAP Validation Trial: Yardlong Bean

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Abstract

A Good Agriculture Practices (GAP) validation trial on yardlong bean was conducted in the farmer's field at Borkoit village of Chandina upizilla, Cumilla district during January to June 2024 aiming to validate and popularize GAP among the farmers and for producing quality and safe yard long bean. There were three farmers (Md. Rafiquil Islam, Md. Mobarok Hossain and Mahin Ahmed) involved in these activities with 70 decimal (0.28 hectare) of land. Full production cost was provided to purchase relevant inputs covering labour cost too. Prior to starting production activities, farmers were trained focusing Bangladesh GAP protocols. The soil and water were tested to assess soil nutrient status and detection of stress elements in irrigation water. Proper technical support was provided in every step of the production system following GAP protocols. Locally popular "Kagornatoky" variety of yard long bean was used in this trial. The yield performance of yard long bean under trial revealed that the obtained average yield (14.64 MT/ha) at farmers level was two times higher than that of national average yield (5.50 MT/ha) of the crop. The Benefit-Cost Ratio (BCR) was calculated to be 1.41. Farmers were satisfied enough performing GAP as they obtained higher yield with premium price due to the quality and safeness of the produces.

Introduction

The main feature of Good Agricultural Practices (GAP) represents a comprehensive set of guidelines designed to promote the production of safe, high-quality and environmentally sustainable agricultural products (FAO, 2003). These practices cover various aspects of farming system, including soil management, water use efficiency, pest and disease control, and post-harvest handling (FAO, 2016). By implementing GAP, farmers can enhance productivity, reduce environmental hazards, and meet both local and international market standards (FAO, 2003). The adoption of GAP is critical for improving crop yields, ensuring food safety, and supporting sustainable agricultural development (World Bank, 2007).

Yardlong bean (*Vigna unguiculata*) is one of the nutritious and popular vegetables of Bangladesh and worldwide too. Though, this is a summer vegetable but recently it is being grown round the year due to its increasing demand among consumers. Green pod, immature and mature seed of yard long bean contains abundant quantity of health benefited compounds that covers, protein (3.5g), carbohydrate (8.0g), fat (0.2g), and vitamin C (16.0mg) with minerals among others in 100g of edible pod. In Bangladesh 39529 MT yard long bean pods produced from 7181 ha of land (BBS, 2023) having national average yield 5.50 MT/ha. This yield scenario is lower compared to other yard long bean producing countries of the world. The yield may be increased applying modern production technologies and adopting high yielding varieties (HYV). At present, farmers are intended to grow HYV having pest and disease resistance and high quality short duration year round cultivable varieties. But the yard long bean production is constrained by availability of HYV, severe incidence of pest and diseases and threat of climate change. Apart from this, imbalanced fertilizer use, lower application of modern technology and insufficient farmer's training specially

personal hygiene, security, knowledge of labour's right are also considered to be the cause of lower yield of yard long bean resulting producers are depriving from desired quality yield and price.

Quality yard long bean is being produced following Good Agriculture Practices (GAP) protocol in different countries of the world. Recently, Bangladesh has started GAP. Now, it is necessary to produce quality yard long bean in the country with a view to promote export of this product in the world market ascertaining safe and intact food values. Based on Bangladesh GAP standard, the yard long bean production system supports of Bangladesh GAP protocol: yard long bean containing 18 GAP components. Therefore, a validation trial on yard long bean was conducted during 2024 for further dissemination of this technology among the growers of the vegetable in Bangladesh.

Materials and Methods

Site Selection and Justification

A validation trial following Bangladesh GAP protocols was conducted during January to June 2024 at Borkoit village of Chandina upazila, Cumilla district located at 23.4833ºN latitude and 91.0083ºE longitude. This area is situated aside Cumilla-Dhaka highway and prevailed congenial climatic condition for growing yard long bean. However, aiming to execute GAP validation trial, there were 70 decimal (0.28 hectare) of land selected covering three farmers viz. Md. Rafiquil Islam, Md. Mobarok Hossain and Mahin Ahmed.

Previous crop history

Information on previous crop history was collected from the farmers. They opined that the land was occupied with red amaranth, radish, potato and cabbage (mixed/inter cropping) for previous two seasons. Specifically, before growing yard long bean, cabbage was grown in Rafik's plot, while radish and potato were grown in Mobarok and Mahin's field, respectively.

Land Preparation

The land was cleared of any previous crop residues, weeds and debris. The soil was then ploughed and harrowed 4 times to a fine tilth to ensure good seed-to-soil contact and optimal root development. Soil samples were collected and tested for pH, nutrient levels, and organic matter content. Based on the results, appropriate soil amendments were applied to correct deficiencies according to FRG (2018).The land was prepared and pulverized with conventional ploughing and one-meter-wide bed was prepared on 11March, 2024. Half portion of Md. Rafiqual Islam's plot was covered with polythene mulch.

Fig. 1. Land preparation

Fencing trial field

To protect the GAP validation trial, a sturdy fence was constructed around the 0.28 hectare land area using nylon netting and bamboo sticks. This fencing served as a physical barrier to safeguard the crop from animals and unauthorized access, ensuring the integrity of the trial. In addition to the fencing, three signboards were strategically placed at the entrance of the trial area. These signboards provided essential information about the validation trial, including details such as the crop variety, objectives of the trial, and the implementation of GAP. The signboards also served as a communication tool to inform visitors and passersby about the research being conducted, reinforcing the importance of sustainable farming practices in enhancing crop yield and quality.

Fig. 2. Fencing around the trial field

Seed sowing

Seeds (variety-Kegornatoky) were collected from the local registered seed dealer and treated with Provax @ 2g/kg and treated seeds were sown on 19 March, 2024 maintaining 60cm row to row and 30 cm plant to plant spacing. The whole plot was covered with bird protecting net.

Fertilizer application

Prior to sowing, a base application of well-decomposed compost or manure was incorporated into the soil to improve fertility. This organic manure helps in enhancing soil structure, moisture retention, and nutrient availability. As per fertilizer recommendation guide (FRG, 2018) compost (3kg), urea-200g, TSP-600g, MoP-600g, Gypsum-400g, zinc sulphate-50g and borax-40g was applied per decimal of land. During land preparation entire dosages of compost, TSP, Gypsum, zinc sulphate and borax and half of urea and MoP were applied as basal. The remaining halves of urea and MoP were applied in equal two splits before seed sowing and 30 days after sowing (DAS) as top dressing (Bokhtiar *et al.,* 2024b).

Irrigation

Irrigation with safe water (deep tube well water) was done four times between 25 March to 20 April, 2024 ensuring soil moisture levels essential for healthy crop growth and maximizing yield potential as stated by Allen *et al.,* 1998 and Steduto *et al.,* 2012. After each irrigation, the soil was loosened around the plants to enhance aeration and root development. Efficient drainage systems were also implemented to remove excess water following heavy rains, preventing water logging and root rot.

Other intercultural operations

Other cultural management like weeding, soil earthing up, stick setting (trellis), top dressing of fertilizers, crop protection measures and irrigation were done as and when necessary, maintaining GAP protocols.

Trellising and pruning

At early seedling stage, 'A' shaped trellis was provided with bamboo stick to support the climbing of yard long bean vines and facilitating better aeration and exposure to sunlight. Excess branches, suckers and pods were pruned and thinned out timely for increasing pod retention capability and quality of pod, respectively (Bokhtiar *et al.,* 2024b).

Fig. 3. Supporting the plants

Soil and water analysis result

Soil and water samples were collected by the assigned farms for analysis. As per analysis report, it was confirmed that no hazardous materials were found in the water and soil of the trial site. Based on these analysis reports, adjustments were made following the Fertilizer Recommendation Guide (FRG) 2018 with guidance of a soil scientist. The adjusted fertilizer doses including nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), and boron (B), were applied to the field. The reports are shown in appendix-I.

Maintaining of register book and documentation

A comprehensive register book was meticulously maintained for the GAP validation trial, documenting all relevant information and activities conducted throughout the project. The register included the names of the three participating farmers. The register also tracked the dates of key operations, including irrigation, weeding, pesticide and fungicide applications, and other intercultural activities such as loosening the soil, pruning and pod thinning. Additionally, the number of labourers used for each task was documented to ensure accurate records of resource utilization. This detailed register served as an essential tool for monitoring the trial's progress and ensuring the integrity of the data collected. However, as with GAP protocols, field and producer's register were supplied to SAAO for recording details field information of yard long bean validation trials and both were duly filled as has been formulated by DAE (Bokhtiar *et al.,* 2024a).

Disease and Pest management

During the GAP validation trial of yard long bean, integrated pest and disease management practices were employed to ensure protection of crop. Both the preventive and control measure tools were employed. The following pesticides and fungicides were used: carboxin and thiram (Provax 200WP), carbendazim (Autostin 50WDG), abamectin (Vertimac 18EC), Spinosad (Success/Trasser 45Sc), matrine (Biotrin 0.5%), cypermethrin (Ripcord), cumulus (80% Sulphur)-Kumulus DF and propiconazole (Tilt 250 EC). Sex pheromone traps were used for the control of fruit fly as per instruction.

Table 1. List of insecticides and fungicides for controlling insect pest and diseases

Trade name	Active ingredient	Dose	Date of application
1. Provax 200 WP (fungicide)	Carboxin and Thiram	2.5g/kg seed	19/3/24
2. Autostin WDG (fungicide)	Carbendazim	1.0g/L of water	26/3/24
3. Vertimac 18EC (insecticde)	Abamectin	0.5ml/L of water	12/4/24
4. Success (insecticde)	Spinosad	1.2ml/L of water	22/4/24
5. Biotrin 0.5%(insecticde)	Matrine	1.5ml/L of water	14/5/24
6. Trasser 45 SC (insecticde)	Spinosad	0.4ml/L of water	8/5/24
7. Ripcord (insecticde)	Cypermethrin	1.0ml/L of water	30/4/24
8. Kumulus DF(fungicide)	Kumulus (80% Sulphur)	2.0g/L of water	24/5/24
9. Tilt 250 EC	Propiconazole	0.5ml/L of water	20/5/24

Worker health safety

Worker health safety, and environmental stewardship were prioritized throughout the GAP validation trial. To ensure the safety and well-being of all workers, they were provided with protective gear including aprons, masks, hand gloves, caps, and shoes (gumboot). Additionally, a comprehensive farm instrument manual was issued to guide the proper use of tools and machinery. Regular health checks were conducted to monitor workers' health, and essential health and safety items such as soap and detergent were supplied, with washrooms being cleaned regularly using appropriate detergents like Lizol. Pure drinking water was made available to all workers and their working hours were restricted to a maximum of eight hours per day to prevent fatigue. Hands on field training sessions were conducted to educate workers on health safety protocols, the correct use of pesticides and the provision of first aid treatment. These measures not only ensured a safe and healthy working environment but also reinforced the importance of environmental responsibility and the ethical treatment of workers within the framework of GAP (Bokhtiar *et al.,* 2024a).

Fig. 4. The pesticides were sprayed by the concerned farmer using standard protective measures

Harvesting based on maturity

Yard long bean usually attains maturity (pod purpose) within 40-45 days after seed emergence. The most important indicator of maturity index-if a double folded pod breaks gently into two parts when pressed by finger. This stage is considered to be suitable for harvesting. It was suggested to harvest the pods with sharp knife. During harvesting, all equipment related to harvest were treated with 100 ppm chlorinated water. Harvesting was done at cooler parts of the day- at early morning or evening are the suitable time. Pod harvesting was started from 12.5.2024 and continued up to 06.06.2024.

Postharvest management

Harvested pods were kept in shady places on a flat mat to avoid soil contact. Then pods were sorted and graded properly followed by cleaning with 100 ppm Clorox. The graded pods were made 0.5 kg and 1.0 kg bundle using packaging materials. The place of production, date of harvesting and other relevant information were mentioned on the packet.

MRL Analysis results

Yard long bean pod sample was collected by the assigned authorities on 31 May 2024. The analysis report indicated that there were no health hazardous materials detected in the products. The presence of harmful chemicals was lower than MRL. The detailed findings of the analysis are shown in appendix-III.

Farmers' Training

The training on yard long bean production technology with GAP protocols was conducted at Chandina, Cumilla on 17 January 2024 with 25 participants focusing benefits of GAP production.

Yield compare with national average

Due to prolong drought spell, high temperature (above 42ºC for successive several days) and natural calamities (northern storm and heavy shower), yield was hampered to some extent. But the yield potential of yard long bean revealed that the obtained average yield at farmers' level was above two times higher than that of Regional yield (cumilla) average yield, which was at per with projected yield target (Table 2). Virtually, it may be the impact of following GAP protocols.

Table 2: Yield of GAP produced yard long bean compared to national average

Practice	Area (ha)	Yield (kg)	Yield (MT/ha)	Income (Tk.)	Total Cost of Production (Tk.)	BCR
GAP	0.28	4099	14.64	225445/-	160000/-	1.41
Regional yield (Cumilla) District	1.0	4800	4.80	-	-	-

Benefit-Cost analysis

The production of yard long bean in 0.28 hectare of land adhering to GAP resulted in a total yield of 14.64MT. The total production cost was Tk. 160000/-, while the market price per kg yard long bean was 55 Taka, generating total revenue of 225445 Taka. The Benefit-Cost Ratio (BCR) was calculated to be 1.41.

Farmer's profile and reaction

Mahin Ahmed, Md. Mobarok Hossain and Md. Rafiqul Islam residents of Borkoit village in Chandina upazila of Cumilla district were involved in GAP validation trial on yard long bean and successfully cultivated the crop following GAP protocols. Their educational qualification was below primary level except Md. Mahin. He was SSC passed farmer. They opined that GAP is better than their previous conventional practices. They also stated that GAP taught them how to use optimum dosage of compost and fertilizers, judicious use of insecticides, fungicides and irrigation water. All these facts significantly improved their yield resulting certainty of safe produces and economic benefits.

Export opportunity

As the GAP produced yard long bean meets international standards for quality and safety. Therefore, it may be a good candidate for global markets. The adherence to GAP enhances the crop's appeal to foreign buyers, offering farmers the chance to access lucrative export opportunities. This is not only boosting income but also strengthens Bangladesh's presence in the international agricultural market too.

Marketing

Yard long bean producers were able to establish the level of reliability of safeness of products. As a result, consumers acceptance has been increased to purchase GAP produced product. Therefore, it may be marketed as a premium, safe and sustainable product. Strategies include targeting health-conscious consumers, supermarkets, emphasizing its compliance with international safety standards, and positioning it for export to high-demand markets. Leveraging certifications and promoting the benefits of GAP can also attract buyers looking for quality and traceable produce. The involvement of the Department of Agricultural Marketing (DAM) can establish better marketing channels.

Challenges

Scarcity of suitable land with desired area. Scarcity of prescribed insecticides and fungicides at local market; and scarcity and high labour wages due to rice cultivation during yard long bean production period.

Way forward

To overcome the challenges faced during the GAP validation trial, several steps can be taken for moving forward. Efficient irrigation methods, such as drip irrigation or polythene mulching, should be introduced to mitigate the effects of drought during the seedling stage. Implementing disease-resistant varieties and enhancing monitoring systems will help manage outbreaks like gummy stem blight more effectively. The issue of labourer scarcity and high costs during peak periods, particularly in April and May, can be addressed through mechanization or community labour-sharing initiatives. Additionally, training should be provided to the Sub-Assistant Agriculture Officer (SAAO) on record-keeping and data management for GAP trials, ensuring more accurate tracking and reporting. These measures will enhance productivity and sustainability, leading to better outcomes in future GAP standards.

Appendix-1. Soil analysis report for Yardlong bean

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000277	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	15.02.2024
		Date of analysis:	15.02.2024 - 27.02.2024
		BOSS Order:	1030840

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Chandina, Comilla)
Type of sample	Soil
Sample Condition	Soil in One Plastic Bag
Sample Quantity	2 Kg

Parameter	Method of Analysis	Unit	Test Result	Test Requirements
Total Nitrogen as N	IS 14684: 1999	%	0.10	0.0-0.36
Phosphorus as P	ASTM D6349-13 (by ICP-OES)	mg/kg	1474.67	0.0-30
Sulfur as S	ASTM D6349-13 (by ICP-OES)	mg/kg	121.40	0.0-43.20
Total Organic carbon C:N=13.5:1.0	Walkely and Black, 1934	%	0.93	

Note: This test has been subcontracted from SGS India Pvt. Ltd. Test Report No. KE24-000379.001; Date: 27/02/2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000092

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TEST REPORT

DHF240000303

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	15.02.2024
		Date of analysis:	15.02.2024 - 22.02.2024
		BOSS Order:	1030817

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Chandina, Comilla)
Type of sample	Soil
Sample Condition	Soil in Two Plastic Packet
Sample Quantity	2 Kg

Physical & Compositional tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Moisture	APHA 2540 G, 23rd edn.: 2017	%	0.5	18.66	

Chemical tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Arsenic (As)	US EPA 3052	mg/kg	1	<1.00	20
Cadmium (Cd)	US EPA 3052	mg/kg	1	<1.00	3
Chromium (Cr)	US EPA 3052	mg/kg	1	14.34	100
Lead (Pb)	US EPA 3052	mg/kg	1	5.80	85
Mercury (Hg)	US EPA 3052	mg/kg	1	<1.00	0.02-0.06
Nickel (Ni)	US EPA 3052	mg/kg	1	14.60	100
Zinc (Zn)	US EPA 3052	mg/kg	1	37.01	0.0-1.60
Boron (B)	US EPA 3052	mg/kg	1	<1.00	0.0-0.61
Potassium (K)	US EPA 3052	meq/100g	2.5	**1.03**	0.0-0.36
Magnesium (Mg)	US EPA 3052	meq/100g	2.5	**22.59**	0.0-1.62
Conductivity (EC)	APHA 2510 B, 23rd edn.:2017	dS/m		0.12	<8.0

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Folder Number : DHF24-0000091

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Appendix-2. Water analysis report for Yardlong bean

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TEST REPORT

DHF240000278

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	15.02.2024
		Date of analysis:	15.02.2024 - 22.02.2024
		BOSS Order:	1030817

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Water (Chandina, Comilla)
Type of sample	Water
Sample Condition	Water in Three Plastic Bottle
Sample Quantity	3.5 litre

Chemical tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Arsenic (As)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.01	<0.01	0.1
Calcium (Ca)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	31.63	401
Iron (Fe)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	2.34	1.0 - 5.0
Magnesium (Mg)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	39.27	61
Potassium (K)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	7.89	2
Sodium (Na)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	27.72	920
Taste	APHA 2160 A, 23rd edn.:2017	-	-	Agreeable	-
Colour	Visual Examination (APHA 2120 B, 23rd edn.:2017)	Pt-Co	5	5	-
Turbidity	APHA 2130 B, 23rd edn.:2017	NTU	5	29.49	-
Odor	Sensory Evaluation(APHA 2150 B, 23rd edn.:2017)	-	-	Unobjectionable	-
Conductivity	APHA 2510 B, 23rd edn.:2017	µS/cm	-	719.00	3000
Total Dissolved Solid (TDS)	APHA 2540 C, 23rd edn.:2017	mg/L	1	470.00	2000
Temperature	APHA 2550 B, 23rd edn.:2017	°C	1	26.0	-
Chloride	APHA 4500-Cl- B & D, 23rd edn.:2017	mg/L	0.5	37.99	600
pH	APHA 4500-H+ B, 23rd edn.:2017	-	-	7.00	6.5 - 8.8
Nitrate	APHA 4500-NO3 B, 23rd edn.:2017	mg/L	0.05	0.20	1.0 - 10.0
Total Phosphorus	APHA 4500-P-J, B & E, 23rd edn.:2017	mg/L	0.1	< 0.10	2
Sulfate	APHA 4500-SO4 2- E, 23rd edn.:2017	mg/L	5	< 5.00	1000

Folder Number : DHF24-0000091

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Microbiology tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Total Coliform	APHA 9221B_23rd Edition 2017	MPN/100 mL	1.8	<1.80	-
Fecal Coliform	APHA 9221E_23rd Edition 2017	MPN/100 mL	1.8	<1.80	-

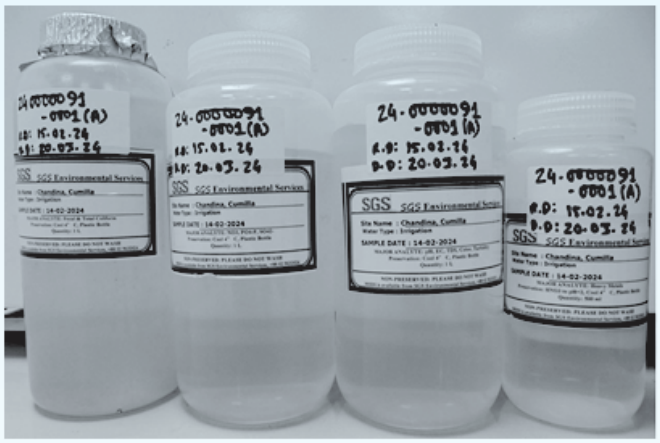
Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Remark: 1) If no evidence of Total Coliform observed in the tested sample, as per 5 tube MPN table result expressed as <1.8 MPN/100ml.
2) If no evidence of Fecal Coliform observed in the tested sample, as per 5 tube MPN table result expressed as <1.8 MPN/100ml.

Signed for and on behalf of:

SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager



SAMPLE AS RECEIVED

Folder Number : DHF24-0000091

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Appendix-3. MRL analysis report for Yardlong bean

MRL Analysis Report of yard long bean pod

Customer Provided Information

Sample Name	:	YARD LONG BEAN (CHANDINA,CUMILLA) VILLAGE: BORKOT
Customer Name	:	F500101 SGS BANGLADESH LTD
Customer Address	:	6th to 9th & 13th Floors, NOOR TOWER
	:	110, Bir Uttam C.R. Datta Road, Dhaka
Postal Code	:	1205
Country	:	BANGLADESH
Sample Qty. Recd.	:	APPROX. 500G
SGS Internal No.	:	DHF24-0000272-0002(B)

Lab Provided Information

Sample Type	:	YARD LONG BEAN
Received on	:	31/05/2024
Registered on	:	31/05/2024
Test Start-End Date	:	31/05/2024 - 03/06/2024

Product Group / Sub-Group	:	Food & Agricultural products	/	Vegetables & vegetable products

NABL Accredited Tests

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Cypermethrin	SO-IN-MUL-TE-085 by GC-MS/MS	BLQ (LOQ:0.005)	mg/kg
Carbendazim	SO-IN-MUL-TE-085 by LC-MS/MS	0.024	mg/kg
Abamectin	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Carboxin	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Spinosad	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Propiconazole	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Matrine	SO-IN-MUL-TE-086 by LCMS/MS	BLQ(LOQ : 0.010)	mg/kg

Technical Report of Bangladesh GAP Validation Trial: Pointed Gourd

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Abstract

A trial on Good Agricultural Practics (GAP) Validation for Pointed gourd was conducted at Borohybotpur village under Jashore district. Three progressive farmers who are trained earlier were involved in this activity with 85 decimal (0.34 hectare) of land. The initial soil and water samples were collected and analyzed in a certified laboratory. All the activities were done following the Bangladesh GAP protocol for pointed gourd and all the necessary information were recorded in a register book with the help of Sub-Assistant Agriculture Officer (SAAO), DAE. From 0.34 hectare of land 3.9MTpointed gourd fruit yield was obtained. The average individual fruit weight was 60g. This translated to fruit yield of 11.47MT/ha, which is significantly higher than the national average yield of 1.21 MT/ha. The total production cost was 150000 Taka, while the market price per kg pointed gourd was 60 Taka, generating total revenue of 234000 Taka. The Benefit-cost ratio (BCR) was calculated to be 1.56. Farmers expressed their satisfaction with the results.

Introduction

Pointed gourd (*Trichosanthes dioica* Roxb.) is an important dioecious vegetable crop belonging to the family Cucurbitaceae. Fruits are rich in vitamins and minerals and contain 9.0 mg Mg, 2.6 mg Na, 83.0 mg K, 1.1 mg Cu, and 17.0 mg S per 100g edible part (Gopalan *et al.,*1982). It has also high industrial value as different types of jam, jelly, and pickles can be made from this vegetable (Hossain *et al.,* 2018). Pointed gourd has a good medicinal value. It is easily digestible, diuretic, and laxative, invigorates the heart and brain and is useful in the disorder of the circulatory system. It was reported that pointed gourd possesses the medicinal property of lowering the total cholesterol and blood sugar (Malek, 2009). The total production of pointed gourd during 2022- 2023 was 12567 MT from the area of 10432 hectares of land (BBS, 2024) and the average yield is 1.21 MT/ha.

The agriculture sector of Bangladesh is gradually changing from 'Subsistence Agriculture' to Commercial Agriculture. In view of producing more food as well as increasing crop production for growing population, high yielding and hybrid varieties of crops are being used with excessive chemical fertilizers and pesticides. Safe food is becoming increasingly important, in terms of human health and economic aspects. Safe food production is urgent because of competition in the global export market, as well protecting people from food bound illness. Indiscriminate use of pesticides and chemicals, presence of heavy metals, infection of microorganisms etc. from the early stages of production to the various stages of food chain made food unsafe. For these reasons considering the availability of safe food, it is very important to follow GAP protocols from the beginning of the production system, harvest and postharvest management. GAP represent a comprehensive set of guidelines designed to promote the production of safe, high-quality, and environmentally sustainable agricultural products (FAO, 2003). These practices cover various aspects of farming, including soil management, water use efficiency, pest and disease control, and postharvest handling (FAO, 2016). By implementing GAP, farmers can enhance productivity, reduce environmental impacts, and meet both local and international market standards (FAO, 2003). The adoption of GAP is critical for improving crop yields, ensuring food safety, and supporting sustainable agricultural development (World Bank, 2007). Very recently Bangladesh government authorized Bangladesh GAP in 2023 and Bangladesh GAP Protocol: Pointed gourd in

2024 (Bokhtiar *et. al.,* 2024b), which will help the producers to grow quality pointed gourd for the consumers. As a part of this activity, a validation trial was chalked out with a farmer with 84 decimals (0.34 ha) of land area to grow quality and safe pointed gourd for the consumers at Borohybotpur, Jashore, Bangladesh.

Materials and methods

Site selection and justification

Three progressive farmers (Md. Raju Ahmed, Md. Anisur Rahman and Md. Jillur Rahman) who were trained earlier (10 February, 2024) are involved in this GAP validation trial with 85 decimal (0.34 hectare) of land.

The trial was conducted in Borohybotpur village under Jashore Sadar upazila in Jashore district. This region was selected due to its favourable climatic and edaphic conditions, which aligned well with the requirements of the pointed gourd. Jashore is renowned for its optimal growing conditions for pointed gourd, including temperature, soil type, and water availability as in AEZ 11 (High Ganges River Flood Plain). The site is located at 23.9459171ºN latitude and 90.1300177ºE longitude.

Previous crop history

Information on previous crop history was collected from the farmers. They reported that the land was occupied with teasle gourd, country bean, mustard, pumpkin, and radish for previous two seasons. Specifically, before growing pointed gourd, teasle gourd and country bean was grown in Raju's plot, while mustard, pumpkin and radish were grown in Anisur Rahman and Jillur Rahman's field respectively.

Land Preparation

The land was cleared of previous crop residues, weeds and debris. The soil was then ploughed and harrowed 4 times to a fine tilth to ensure optimal condition for root development. Soil samples were collected and tested for pH, nutrient levels, and organic matter content. Based on the results, appropriate soil amendments were applied to correct deficiencies according to FRG (2018).The trial spanned an area of 0.34 hectare (85 decimals) with land preparation beginning on 02 April, 2024.

Fig. 1. Land preparation

Fencing the trial field

To protect the GAP validation trial, a sturdy fence was constructed around the 0.34 hectare land area using nylon netting and bamboo sticks. This fencing served as a physical barrier to safeguard the crop from animals and unauthorized access, ensuring the integrity of the trial. In addition to the fencing, three signboards were strategically placed at the entrance of the trial area. These signboards provided essential information about the validation trial, including details such as the crop variety, the objectives of the trial and the implementation of GAP. The signboards also served as a communication tool to inform visitors and passersby about the research being conducted, reinforcing the importance of sustainable farming practices in enhancing crop yield and quality.

Fig. 2. Fencing around the trial

Sapling preparation

Normally pointed gourd saplings are produced by the selected farmers. The farmers prepared a separate shade to produce saplings. Mature stems were put in to the well-prepared polythene pot. The 25-30 days were required for sapling production. After that saplings were transplanted to the main field. For this validation trial the local variety of pointed gourd was used.

Transplanting

Saplings were transplanted into the field after 25-30 days of growth. This allows the plants to establish a strong root system and become robust enough to handle field conditions. Saplings were carefully removed from the polythene pots and transplanted into pre-prepared pits (50 x 50 x 50 cm) in the field, maintaining proper spacing one meter in both the ways. The prepared saplings were transplanted during 18 April to 02 May, 2024.

Intercultural operations

The successful cultivation of pointed gourd involved a series of intercultural operations aimed at optimizing plant growth and yield.

Fertilizer application

Prior to planting, a base application of well-decomposed compost or manure was incorporated into the soil to improve fertility. This organic manure helps in enhancing soil structure, moisture retention, and nutrient availability. A balanced fertilizer mix, including essential nutrients such as nitrogen (N), phosphorus (P), potassium (K), sulphur (S), calcium (Ca), magnesium (Mg), zinc (Zn) and boron (B) was applied at the recommended rates of N-P-K-S-Mg-Zn-B at 135-36-60-22-12-2.1-1.4 kg per hectare. Entire compost, P, S, Mg, Zn, and B, and one-third of K were applied during the final land preparation. The well decomposed mustard oil cake was used @150g/pit. Full doses of nitrogenous fertilizer and two-thirds of the potassium fertilizers were applied at 20-25 days interval by split application (Bokhtiar *et al.,* 2024b).

Irrigation

Irrigation was provided fifteen to sixteen times from 18 April 2024 to November 2024, ensuring consistent soil moisture levels essential for healthy crop development. The drainage system was well designed and no water log situation was prevailing. After each irrigation, the soil was loosened around the plants to enhance aeration and root development. Efficient drainage systems were also implemented to remove excess water following heavy rains, preventing water logging and root rot.

Weeding

Weeding was performed ten times from 18 April to November 2024 to keep the field free of competitive weeds, which could otherwise impact plant growth and nutrient uptake.

Other intercultural operations

A trellis system was constructed using bamboo and nylon rope to support the climbing nature of the pointed gourd vines, facilitating better air circulation and exposure to sunlight. Water suckers were regularly removed from the stem. Additionally, artificial pollination was carried out to increase the fruit set, ensuring a higher yield of quality pointed gourds (Bokhtiar *et al.,* 2024b). These intercultural practices were crucial for maintaining the health and productivity of the crop throughout the growing season.

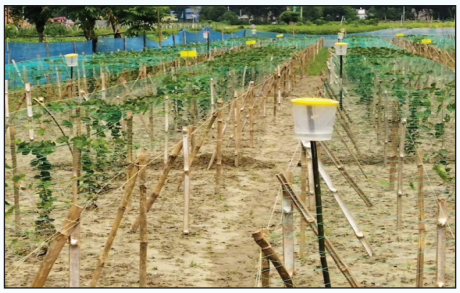

Fig. 3. Supporting the plants

Soil and water analysis result

After conducting soil and water analysis, it was confirmed that no hazardous materials were present in the trial site. Based on these analyses, adjustments were made following the Fertilizer Recommendation Guide (FRG) 2018, with guidance from a soil scientist. The adjusted fertilizer doses, including nitrogen (N), phosphorus (P), potassium (K), sulfur (S), calcium (Ca), magnesium (Mg), zinc (Zn), and boron (B), were applied to the field. Soil and water test results are shown in Appendix-A and Appendix-B.

Maintaining register book and documentation

A comprehensive register book was meticulously maintained for the GAP validation trial, documenting all relevant information and activities conducted throughout the project. The register included the names of the three participating farmers, and recorded crucial details such as the crop and variety name, soil and water test results, and the precise location of the trial site. The register also tracked the dates of key operations, including irrigation, weeding, pesticide and fungicide applications, and other intercultural activities such as loosening the soil, removing water suckers, and hand pollination. Additionally, the number of labourers used for each task was documented to ensure accurate records of resource utilization. This detailed register served as an essential tool for monitoring the trial's progress and ensuring the integrity of the data collected (Bokhtiar *et al.,* 2024a).

Pest Management

During the GAP validation trial for local variety of pointed gourd, a variety of integrated pest and disease management practices were employed to ensure crop health and optimize yield. To control the red pumpkin beetle, the insecticide Bioclean was used, which contains a combination of Terpineol, Chloroxylenol, Ethyl alcohol, Castor oil soap, Caramel colour, and Purified water. For fruit fly management, sex pheromone traps were strategically placed to attract and capture the pests, reducing their population and impact on the crop. Additionally, yellow sticky traps were deployed across the field to target a range of other insect pests, providing an eco-friendly method of pest control.

Table 2. List of pesticides to control insect and diseases

Sl. No.	Generic Name	Trade Name	Application Dose	Purpose
1.	Carbendazim	Autostin WDG	1g/L of water	Foot and root rot diseases
2.	Mandipropamid	Revus 250 SC	1ml/L of water	Downy Mildew
3.	D-limonene	Bioclean	1.0 ml/L of water	Red pumpkin beetle

Worker health safety

Worker health, safety, and environmental stewardship were prioritized throughout the GAP validation trial for pointed gourd. To ensure the safety and well-being of all workers, they were provided with protective gear including aprons, masks, hand gloves, caps, and shoes. Additionally, a comprehensive farm instrument manual was issued to guide the proper use of tools and machinery. Pure drinking water was made available to all workers and their working hours were restricted to a maximum of eight hours per day to prevent fatigue. Training sessions were

conducted to educate workers on health safety protocols, the correct use of pesticides and the provision of first aid treatment. These measures not only ensured a safe and healthy working environment but also reinforced the importance of environmental responsibility and the ethical treatment of workers within the framework of GAP (Bokhtiar *et al.,* 2024a).

Fig. 4. The pesticides were sprayed by the concerned farmer using standard protective measures

Harvesting based on maturity

Attractive green colour fruits are usually harvested and around 12-15 days after anthesis, more the harvest more the bearing fruits, harvest must be with sharp knife, harvest cooler time of the day early morning or evening, harvesting pot was plastic crate instead of bamboo pot, harvested fruit were kept in shady place.

Fig. 5. Harvested and graded pointed gourd

Postharvest management

Harvested fruits were kept in shady places on a flat mat to avoid soil contact. Then fruits were sorted and graded properly followed by cleaning with fresh water. The graded fruits were packed using packaging materials. The place of harvesting, date and other relevant information were mentioned on the packet.

MRL analysis results

Pointed gourd sample was collected by the assigned authorities on 18 August, 2024. The analysis report indicated that there were no health hazardous materials detected in the products. The MRL level was below the harmful level. Result on MRL analysis is shown in Appedix-3.

Table 3: MRL Analysis Report of Pointed gourd

Test	Method	Result	Unit
Mandipropamid	SO-IN-MUL-085by LC-MS/MS	BLQ(LOQ:0.005)	mg/kg
Carbendazim	SO-IN-MUL-085by LC-MS/MS	BLQ(LOQ:0.005)	mg/kg

Farmers Training

The training on pointed gourd production technology following GAP protocol was conducted in RARS, Jashore on 09 February2024 with 25 participants in attendance. These sessions focused on equipping farmers with the knowledge and skills needed to implement GAP effectively, thereby enhancing the quality and yield of their pointed gourd crops.

Yield

From 0.34 hectare of land total yield was 3.9 MT. The average individual fruit weight was 60g. This translated to a fruit yield of 11.47 MT/ha, which is significantly higher than the Regional yield (Jashore) average yield of 8.7 MT/ha. These results highlight the effectiveness of the cultivation practices implemented, particularly the use of GAP standards, in substantially improving productivity.

Table 4: Yield of GAP produced pointed gourd compare with national average

Practice	Area (ha)	Yield (kg)	Yield (MT/ha)	Income (Tk.)	Total Cost of Production (Tk.)	BCR
GAP	0.34	3900	11.47	234000/	150000/-	1.56
Regional yield (Jashore) District	1.00	8520	8.52	-	-	-

Benefit-Cost analysis

The production of pointed gourd on 0.34 hectare of land adhering to GAP resulted in a total yield of 11.47 MT. The total production cost was 150000 Taka, while the market price per kg pointed gourd was 60 Taka, generating total revenue of 234000 Taka. The Benefit-cost ratio (BCR) was calculated 1.56. The total production cost will be reduced in 2nd year cultivation because in 2nd year the pointed gourd will be cultivated as ratoon crop.

Farmer's profile and reaction

Raju Ahmed, Anisur Rahamn and Jillur Rahaman, residents of Borohybotpur in Jashore Sadar, Jashore successfully cultivated pointed gourd following GAP protocol. Raju Ahmed and Jillur Rahaman are HSC passed farmers but Anisur Rahman passed SSC. They expressed satisfaction with the results, noting that the optimum use of compost, fertilizers, insecticides, fungicides, and irrigation water significantly improved their yield. Compared to their previous farming methods, adopting GAP led to better crop performance and higher profitability, confirming the advantages of these sustainable farming practices.

Export opportunity

GAP produced pointed gourd meets international standards for quality and safety, making it highly competitive in global markets. The adherence to GAP enhances the crop's appeal to foreign buyers, offering farmers the chance to access lucrative export opportunities. This not only boosts income but also strengthens Bangladesh's presence in the international agricultural market.

Marketing

Pointed gourd producers were able to establish the level of reliability of safeness of products. As a result, consumers acceptance has been increased to purchase GAP produced product. Therefore, it may be marketed as a premium, safe, and sustainable product. Strategies include targeting health-conscious consumers, supermarkets, emphasizing its compliance with international safety standards, and positioning it for export to high-demand markets. Leveraging certifications and promoting the benefits of GAP can also attract buyers looking for quality and traceable produce. The involvement of the Department of Agricultural Marketing (DAM) can establish better marketing channels.

Challenges and Way forward

During vegetative stage, drought conditions led to the death of some plants. Scarcity of prescribed insecticides and fungicides at local market.

To overcome the challenges faced during the GAP validation trial, several steps can be taken for moving forward. Efficient irrigation methods, such as drip irrigation or mulching, should be introduced to mitigate the effects of drought during the seedling stage. The issue of labour scarcity and high costs during peak periods, particularly in April and May, can be addressed through mechanization or community labour-sharing initiatives. Additionally, training should be provided to the Sub-assistant Agriculture Officer (SAAO) on record-keeping and data management for GAP trials, ensuring more accurate tracking and reporting. These measures will enhance productivity and sustainability, leading to better outcomes in future GAP standards.

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Appendix-1. Soil analysis report for Pointed gourd

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000281	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	18.02.2024
		Date of analysis:	18.02.2024 - 04.03.2024
		BOSS Order:	1030841

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Soil (Jashore Sadar)
Type of sample	Soil
Sample Condition	Soil in Two Plastic Bag
Sample Quantity	2 Kg

Parameter	Method of Analysis	Unit	Test Result	Test Requirements
Total Nitrogen as N	IS 14684: 1999	%	0.10	0.0-0.36
Phosphorus as P	ASTM D6349-13 (by ICP-OES)	mg/kg	1229.75	0.0-30
Sulfur as S	ASTM D6349-13 (by ICP-OES)	mg/kg	197.66	0.0-43.20
Total Organic carbon C:N=13.5:1.0	Walkely and Black, 1934	%	0.92	

Remark: This test has been subcontracted from SGS India Private Limited,Test report number: KE24-000376.001 , Dated at 01-03-2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000098

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Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000313	Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	18.02.2024
		Date of analysis:	18.02.2024 - 25.02.2024
		BOSS Order:	1030818

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Jashore Sadar)
Type of sample	Soil
Sample Condition	Soil in Two Plastic Packet
Sample Quantity	2 Kg

Physical & Compositional tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Moisture	APHA 2540 G, 23rd edn.: 2017	%	0.5	14.09	

Chemical tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Arsenic (As)	US EPA 3052	mg/kg	1	<1.00	20
Cadmium (Cd)	US EPA 3052	mg/kg	1	<1.00	3
Chromium (Cr)	US EPA 3052	mg/kg	1	17.53	100
Lead (Pb)	US EPA 3052	mg/kg	1	7.18	85
Mercury (Hg)	US EPA 3052	mg/kg	1	<1.00	0.02-0.06
Nickel (Ni)	US EPA 3052	mg/kg	1	15.80	100
Zinc (Zn)	US EPA 3052	mg/kg	1	101.07	0.0-1.60
Boron (B)	US EPA 3052	mg/kg	1	<1.00	0.0-0.61
Potassium (K)	US EPA 3052	meq/100g	2.5	**5.91**	0.0-0.36
Magnesium (Mg)	US EPA 3052	meq/100g	2.5	**34.23**	0.0-1.62
Conductivity (EC)	APHA 2510 B, 23rd edn.:2017	dS/m		0.29	<8.0

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Folder Number : DHF24-0000097

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Appendix-2. Water analysis report for Pointed gourd

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TEST REPORT

DHF240000280

Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	18.02.2024
		Date of analysis:	18.02.2024 - 25.02.2024
		BOSS Order:	1030818

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Water (Jashore Sadar)
Type of sample	Water
Sample Condition	Water in Three Plastic Bottle
Sample Quantity	3.5 litre

Chemical tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Arsenic (As)	APHA 3500 (CrVI) B, 23rd edn.:2017	mg/L	0.01	<0.01	0.1
Calcium (Ca)	APHA 3500 (CrVI) B, 23rd edn.:2017	mg/L	0.05	72.80	401
Iron (Fe)	APHA 3500 (CrVI) B, 23rd edn.:2017	mg/L	0.05	1.85	1.0-5.0
Magnesium (Mg)	APHA 3500 (CrVI) B, 23rd edn.:2017	mg/L	0.05	15.36	61
Potassium (K)	APHA 3500 (CrVI) B, 23rd edn.:2017	mg/L	0.05	3.05	2
Sodium (Na)	APHA 3500 (CrVI) B, 23rd edn.:2017	mg/L	0.05	7.86	920
Taste	APHA 2160 A, 23rd edn.:2017	-	-	Agreeable	--
Colour	Visual Examination (APHA 2120 B, 23rd edn.:2017)	Pt-Co	5	5	--
Turbidity	APHA 2130 B, 23rd edn.:2017	NTU	5	20.48	--
Odor	Sensory Evaluation(APHA 2150 B, 23rd edn.:2017)	-	-	Unobjectionable	--
Conductivity	APHA 2510 B, 23rd edn.:2017	µS/cm	-	772.00	3000
Total Dissolved Solid (TDS)	APHA 2540 C, 23rd edn.:2017	mg/L	1	492.00	2000
Temperature	APHA 2550 B, 23rd edn.:2017	°C	1	27.0	--
Chloride	APHA 4500-Cl- B & D, 23rd edn.:2017	mg/L	0.5	10.00	600
pH	APHA 4500-H+ B, 23rd edn.:2017	-	-	6.80	6.5-8.8
Nitrate	APHA 4500-NO3 B, 23rd edn.:2017	mg/L	0.05	0.17	1-10.0
Total Phosphorus	APHA 4500-P-J, B & E, 23rd edn.:2017	mg/L	0.1	< 0.10	2
Sulfate	APHA 4500-SO4 2- E, 23rd edn.:2017	mg/L	5	6.58	1000

Folder Number : DHF24-0000097

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Microbiology tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Total Coliform	APHA 9221B_23rd Edition 2017	MPN/100 mL	1.8	<1.80	--
Fecal Coliform	APHA 9221E_23rd Edition 2017	MPN/100 mL	1.8	<1.80	--

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Remark: 1) If no evidence of Total Coliform observed in the tested sample, as per 5 tube MPN table result expressed as <1.8 MPN/100ml.
2) If no evidence of Fecal Coliform observed in the tested sample, as per 5 tube MPN table result expressed as <1.8 MPN/100ml.

Signed for and on behalf of:

SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

SAMPLE AS RECEIVED

This electronically generated test report has been checked and approved. It is also valid without handwritten signatures.

Folder Number : DHF24-0000097

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Appendix-3. MRL analysis report for Pointed gourd

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TEST REPORT

DHF240001510

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	05.09.2024
		Date of analysis:	05.09.2024 - 15.09.2024
		BOSS Order:	1031427

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Pointed Gourd Jessore, Hoibotpur
Type of sample	Vegetable
Sample Condition	Vegetable in One Plastic Packet
Number of Container/Packet	01
Sample Quantity	250 gm

NABL Accredited Tests

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Mandipropamid	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Carbendazim	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg

Remark: This test has been subcontracted from SGS India Private Ltd.,Test report number: CG24- 023053.001 , Dated at 14.09.2024

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000545

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Technical Report of Bangladesh GAP Validation Trial: Green Papaya

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Abstract

In order to verify the Bangladesh GAP protocol in green papaya, a validation trial was conducted at Atgharia village (24º6'51" N latitude and 89º14'48"E longitude) in the Atgharia upazila of Pabna district. In January 2024, the trial was initiated in accordance with the Bangladesh GAP Standard 2020 and concluded in November 2024. On 25 March 2024, papaya (var. Green Lady) seedlings were transplanted into the main field. Flower was initiated in the first week of May 2024. Data were accurately recorded in the field record book, and all intercultural operations were conducted in accordance with the Bangladesh GAP protocol: Green papaya. Field monitoring and training were conducted effectively. The harvesting process commenced in September 2024 and persisted until November 2024. Total 15.5 tons green papaya was harvested from one acre (37 t/ha) of land and total return was Tk. 4,50,000/- with BCR 1.71. The SGS Bangladesh Limited conducted MRL tests on the harvested produce, and no substantial residues of the applied chemicals were detected.

Introduction

Bangladesh is moving from 'Subsistence Agriculture' to 'Commercial Agriculture'. Since Bangladesh's independence, cropping intensity has been increased from 143% (1971-72) to 214% (2021-22) (BBS, 2023). High yielding hybrid crops and excessive chemical fertilizers and pesticides are being used to boost agricultural production and feed a growing population. However, food safety is a big concern nowadays due to its health and environmental impacts. Crop production is difficult and requires careful consideration of many elements to ensure successful production and consumer delivery. To ensure crop success, a holistic approach should include all production points. Internationally recognized GAP covers all elements of crop production, storage, and transportation for safe and nutritious crops. The Bangladesh government passed the "Bangladesh Good Agricultural Practices Policy 2020" to produce safe food.

Papaya (*Carica papaya*) is a global crop. Green papaya is one of the 54 important vegetables in Bangladesh exported to international markets. Its taste and nutrition make it essential for desserts and vegetables. Bangladesh's climate and soil are ideal for green papaya production. Papaya grows in many well-draining soils. They prefer 21º to 32ºC temperatures, full sun, well-drained soils, moist in hot weather, and dry in cold weather. Papayas prefer soil pH between 6.0 and 7.0 (Evans *et al.,* 2012). Bangladesh uses green papaya to replace potatoes, salads, and other foods. Light, neutral-flavoured green papaya is comparable with a carrot-like texture. Young papayas are better as vegetables and go well in savory salads and dishes. Due to its delicate harvest before ripening, producers can grow it year-round in the field and at homesteads with less work than ripe papaya. Compared to ripe papaya, green papaya has higher protein, calcium, iron, phosphorus, and three times more potassium (Singh *et al.,* 2010). In 2022–23, Bangladesh produced 316156 MT of green papaya from 8839 ha of land (BBS, 2023). According to a recent report by the Bangladesh Fruits, Vegetables and Allied Products Exporters' Association, exports of fresh fruits and vegetables to Europe declined by 23% in 2023 compared to 2014, due to lack of traceability of agricultural products from production to export along with lack of Good Agricultural Practices (GAP), efficient packaging, and technology to extend shelf life and remove bacteria as a hindrance to agricultural

exports from Bangladesh (The Business Standard, 21 October, 2023). Hence, this validation trial was conducted in the farmer's field to investigate the farmer's reaction, challenges, and yield of green papaya in accordance with Bangladesh GAP Standard.

Methodology

Site selection

Land selection was done by physically visiting the area by the personnel of competent authorities (BARC, DAE and BARI) during January 2024. The selected land was located at Atgharia village (24º6'51" N latitude and 89º14'48"E longitude) in the Atgharia upazila of Pabna district which belongs to the Lower Atrai Basin (AEZ-5). The soil of the selected land is classified as Vertisols, which are characterized by high clay content and the ability to crack deeply during dry periods. One acre (100 decimals) land was selected which belongs to Mr. Hassan of mentioned village. The selected land was easily accessible from road and adjacent to local market. The trial was started following all steps described in Bangladesh GAP protocol: Green Papaya (Bokhtiar *et al.,* 2024a). Soil and water samples of the selected land were collected and tested (Laboratory of SGS Bangladesh Ltd.) prior to inputs application in the field.

Seedling raising

Seedlings were raised in plastic cups (12.5x10 cm) filled with coco peat and vermicompost (1:1). Seeds were sown in cups on 15 February 2024. One seed was sown in one cup. After sowing all cups were placed in nursery bed and covered with transparent polyethylene to keep warm inside the cup. Gentle irrigation was provided twice a week until seedling transplantation. After about two weeks seeds were germinated polyethylene cover was removed. Seedlings were sprayed with Ridomil Gold @ 2 g/L and Imitaf 20 SL @ 0.5 ml/L water at an interval of 15 days.

Fig. 1. Seedling raising in plastic cup

Land preparation

The selected one-acre land was ploughed and laddered thoroughly by tractor. The weeds were cleaned before making 2 m wide and 25 cm rise bed. On the bed 60 × 60 × 45 cm pit was prepared at 2 m distance. In between two beds 25 cm wide and 25 cm deep drain was prepared for ensuring well drainage system. Land and bed preparation was started on 01 March 2024 and completed on 10 March 2024.

Fertilizer application

Each pit was fertilized on 10 March 2024 with 10 kg well decomposed cow dung, 1 kg vermicompost, 300 g TSP, 250 g gypsum, and 20 g boric acid (FRG, 2018). All of the fertilizers were mixed thoroughly with the soil and pits were irrigated after one day of fertilization. After two weeks all the fertilized pits were spaded properly for releasing gases and filled again with the same soils lightly.

Fencing around the trial

The entire field was fenced by three feet height synthetic net supported by bamboo poles for protecting domestic and wild animals in the papaya field before one day of seedlings transplantation.

Fig. 2. Fencing around the trial plot by nylon net (mesh 60) before seedling plantation.

Seedling transplantation

Seedlings were transplanted in the pit on 25 March 2024 at the age of 40 days after two weeks of pit preparation. Seedlings were transplanted maintaining 2 × 2 m spacing and altogether 1012 seedlings were transplanted. Seedlings of the Green Lady variety of papaya were bought from local registered nursery, used in the validation trial. This variety is well-known for green papaya originated from India. It was a F1 generation of monoecious variety.

Fig. 3. Seedling transplantation

Previous crop history

The selected field was fallow for last one year.

Intercultural operations

Irrigation: Regular manual irrigation was provided after seedling transplantation at an interval of 2 days up to two weeks. Flood irrigation was provided after seedling establishment (two weeks after transplantation) at an interval of 15 days. Irrigation frequency was increased from mid-April as the area was affected by severe drought and heat wave (about 43ºC).

Fig. 4. Irrigation application

Weeding

Weeding was started after two weeks of seedling transplantation, and it was continued every month. Mechanical and manual weeding was executed in the trial plot.

Fig. 5. Mechanical and manual weeding in the trial plot

Top dressing

Top dressing of urea and MoP were done at an interval of one month starting from one month after seedling transplantation. The quantity of urea and MoP were 50 g per plant up to flowering stage and after flowering the quantity of both the fertilizers were increased to double.

Fig. 6. Top dressing of Urea and MoP

Bamboo stalking

Each plant was held straight with two bamboo poles that were tied together with jute rope. The poles were 5 feet above the ground.

Soil and water analysis result

As per soil testing report, no hazardous materials were detected but the soil was rich with phosphorous and Sulphur. The water quality was good without any contamination. Soil and water quality was tested by Laboratory of SGS Bangladesh Ltd and the detailed results are given in Appendix-1.

Maintaining of register book and documentation

A comprehensive register book was meticulously maintained for the GAP validation trial, documenting all relevant information and activities conducted throughout the project. The register included the name of participating farmer. It recorded crucial details such as the crop name, variety name, soil and water test results, and the precise location of the trial site (Bokhtiar *et al.,* 2024a). The trial spanned an area of 100 decimals, with land preparation beginning on 01 March 2024 and completed on 10 March 2024. Seedlings were transplanted on 25 March 2024, and fencing was completed on 24 March 2024, using nylon net and bamboo sticks. The register also tracked the dates of key operations, including irrigation, weeding, pesticide and fungicide applications, and other intercultural activities such as loosening the soil and removing side suckers. A signboard was used to mention the important information regarding the GAP validation trial. Additionally, the number of labourers used for each task was documented to ensure accurate records of resource utilization. This detailed register served as an essential tool for monitoring the trial's progress and ensuring the integrity of the data collected.

Pest control

The following pesticides were applied in the field by wearing proper attire.

Commercial Name	**Generic name**	**Application frequency and amount**	**Initial date of application and application times**
Rugby 10 (Soil Application)	Cadusafos (Organophosphate)	10 g in each pit during pit preparation	23 March 2024 One time during pit preparation
Ridomil Gold	Mencozeb+ Metalaxyl	Started after two weeks of seedling transplantation at an interval of 10 days (2 g/L)	08 April 2024 and 24 times

Commercial Name	Generic name	Application frequency and amount	Initial date of application and application times
Autoistin 50 WDG/ Sandomil	Carbendazim	Started after one month of seedling transplantation at an interval of 15 days (2 g/L) alternatively	25 April 2024 and 21 times
Imitaf 20 SL	Imidacloprid	Started after two weeks of seedling transplantation at an interval of 10 days (0.5ml/L)	08 April 2024 and 24 times
Fytoclean	40% Potassium salt of fatty acid	Started after two months of seedling transplantation at an interval of 15 days (10 ml/L)	25 May 2024 and 18 times

Fig. 7. Pesticides application by maintaining proper attire.

Worker health safety issues as well as environmental issues

To ensure the safety and well-being of all workers, they were provided with protective gear including aprons, masks, hand gloves, caps, and shoes. Additionally, a comprehensive farm instrument manual was issued to guide the proper use of tools and machinery. Worker health, safety, and environmental stewardship were prioritized throughout the GAP validation trial for papaya. The pesticides were sprayed by the concerned farmers using standard protective measures (Fig. 7) viz., apron, gum boot, hand gloves, mask, goggles, etc. (Bokhtiar *et al.,* 2024b). The spraying direction was in favour of wind and especially the spraying nozzle was kept towards the concerned pest locations or habitats. These measures not only ensured a safe and healthy working environment but also reinforced the importance of environmental responsibility and the ethical treatment of workers within the framework of Good Agricultural Practices (GAP).

Harvesting based on maturity

Green papaya is harvested earlier when the flesh is firm, crunchy, neutral in taste with smooth dark green skin and a hollow core filled with white seeds (Fig. 8). Typically weighing between 650g and 1kg. Harvesting time in the trial field was determined by observing the skin colour and seed. Five older fruits were selected at random from five different plants following five months of seedling transplanting at an interval of 10 days. After that, fruits were cut into transverse sections to examine the colour of the seeds. The skin was noticed smooth and deep green. All seeds were found white in colour and none of the seeds were turned into black or grey colour (Bokhtiar *et al.*,

2024a). Finally, harvesting was started on 20 September 2024 and lasts up to November 2024. Harvesting was done in the afternoon by hand and fruits were kept on tarpaulin (to avoid direct contact with soil) just after harvest and marketed in the plastic crate after sorting and grading. Fruits were picked at an interval of 10 days and altogether 8 picking times were recorded.

Fig. 8 Cross section view of green papaya at harvest.

MRL analysis results

No significant residues of applied fungicides and insecticides were found in the harvested green papaya (Appendix-2). MRL analysis was performed by the Laboratory of SGS Bangladesh Limited.

Postharvest management (sorting, grading, packaging)

After harvesting, fruits were kept on tarpaulin to avoid direct contact with soil. No flaws, wounds, or physical damage were found in the harvested fruits. Harvested fruits were washed with clean water followed by air drying. Then fruits were graded as per size and loaded in the plastic crate by putting soft paper at the bottom of it to avoid physical injury. Then fruits were marketed in the local market by battery-driven open three-wheelers.

Farmers' training

Training on papaya production technology following Bangladesh GAP protocol was provided to the selected farmer along with neighbouring papaya growing farmers on 15 May 2024 at the meeting room of Atgharia Upazila Agriculture Office (Appendix-3). Total 25 farmers were attended in the training. Training of trainers was also conducted for extension and research personnel.

Yield (MT/ha)

The recorded yield of 37 MT/ha was bit higher than the average yield of Pabna district 35.77 MT/ha. This yield is based on harvesting through November 2024, however, it may increase if harvesting were extended up to February 2025. No. of plants per acre, yield per plant and yield in recorded in the trial plot are given in the following table with national average yield.

Practices	Plants/ha	Yield/plant (kg)	Yield (MT/ha)
GAP	1012	14.00	37.00
Pabna district (Non-GAP)	1012	13.00	

Benefit-cost analysis

Total cost involved in this validation trial was 263000 taka and return was 450000 taka. Therefore, BCR was calculated to 1.71. As BCR > 1, hence the GAP in green papaya production is considered financially viable, as benefits outweigh costs.

Farmer's profile and reaction

Mr. Hassan, Village: Atgharia, P/O. Atgharia, Upazila: Atgharia, District: Pabna, is a gentleman and a practicing farmer who has gained extensive crop production knowledge from his own farms. He is able to write and read. Besides papaya, he also cultivates other high-value crops like rice, tomatoes, cauliflower, cabbage, mustard, and yard long beans on his own land. He is married and father of two sons and one school-going daughter. His elder son took his diploma degree in marine engineering from China, and his younger son is a Hafez in Quran.

He is delighted and honoured to participate in this prestigious trial of GAP. Before involving in this trial, he did not know about GAP and its benefits. Many enthusiastic farmers visited his field to learn about GAP, which motivated them to implement it in their own fields. He added, "Papaya is a crop that requires a periodic harvest and additional time in the field to achieve the highest possible yield." Hence, need more fertilizers and labour for weeding and crop management. Before practicing GAP, it was unknown to him. However, he also added it is difficult to maintain all information in the record book, and GAP allowed more basal fertilizers than normal cultivation. Proper sources of papaya seedlings are rare with authentic and registered nurseries. He expresses no interest in covering the costs associated with soil and water testing. He also emphasizes the importance of setting up marketing channels for GAP crops in the local area.

Export opportunity

The validation trial was executed maintaining all standards of Bangladesh GAP, so it has huge potentiality of export to the mainstream supermarkets of Europe and Middle East. As they prefer agricultural products with traceability and credibility which is given by GAP certification.

Marketing

All harvested green papaya was sold in local wholesale markets on the same day of harvesting. Consumers and wholesale buyers showed eagerness to buy GAP followed green papaya in the local markets with higher price (Tk. 25-30/kg) than green papaya produced by traditional method (Tk. 10-15/kg).

Challenges and way forward

There is a shortage of labour during the weeding season, which spans from May to September. Unpredictable weather conditions, such as severe drought, excessive rainfall, and heat waves, often result in high costs for soil, water, and MRL testing facilities. Farmers have a tendency to use excessive amounts of insecticides and fungicides. Sanitation facilities, such as a toilet adjacent to the field, are not available. Growers lack knowledge or education about GAP and the marketing channel. The absence of awareness and monitoring activities regarding GAP is also a contributing factor. The farmer's unwillingness to maintain records is also a contributing factor.

Community GAP farming for one crop or specific crop in an area should be established. Warehouse or packhouse facilities should be established in the nearby area of papaya field. Marketing channel should be developed from village to supermarkets. Direct linkage should be established between papaya growers and wholesale buyers/supermarkets. Sanitation facilities should be established in the farming area. In house and on farm training should be provided to the growers. Mulching film can be considered as a good alternative of irrigation and weeding. Low/nominal charge for soil, water

and MRL testing facilities. Awareness and monitoring activities should be strengthened for minimizing excessive use of insecticides and fungicides. To reach more consumers, advertisements on popular social media should highlight the advantages of GAP produce over conventional produce.

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Appendix-1. Soil analysis report for Green papaya

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000311	Page 1 of 2

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	22.02.2024
		Date of analysis:	22.02.2024 - 10.03.2024
		BOSS Order:	1030837

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Atghoria, Pabna)
Type of sample	Soil
Sample Condition	Soil in One Plastic Bag
Sample Quantity	2 Kg

Parameter	Method of Analysis	Unit	Test Result	Test Requirements
Total Nitrogen as N	IS 14684: 1999	%	0.12	0.0-0.36
Phosphorus as P	ASTM D6349-13 (by ICP-OES)	mg/kg	691.48	0.0-30
Sulfur as S	ASTM D6349-13 (by ICP-OES)	mg/kg	202.77	0.0-43.20
Total Organic carbon C:N=13.5:1.0	Walkely and Black, 1934	%	1.21	

Remark: This test has been subcontracted from SGS India Private Ltd.,Test report number: KE24-000401.001 , Dated at 09-03-2024.

Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

Folder Number : DHF24-0000112

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Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000340	Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	22.02.2024
		Date of analysis:	22.02.2024 - 03.03.2024
		BOSS Order:	1030836

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Soil (Atghoria, Pabna)
Type of sample	Soil
Sample Condition	Soil in One Plastic Packet
Sample Quantity	2 Kg

Physical & Compositional tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Moisture	APHA 2540 G, 23rd edn.: 2017	%	0.5	11.39	

Chemical tests

Parameter	Method of Analysis	Unit	RL	Test Result	Test Requirements
Arsenic (As)	US EPA 3052	mg/kg	1	<1.00	20
Cadmium (Cd)	US EPA 3052	mg/kg	1	<1.00	3
Chromium (Cr)	US EPA 3052	mg/kg	1	30.42	100
Lead (Pb)	US EPA 3052	mg/kg	1	14.61	85
Mercury (Hg)	US EPA 3052	mg/kg	1	<1.00	0.02-0.06
Nickel (Ni)	US EPA 3052	mg/kg	1	27.83	100
Zinc (Zn)	US EPA 3052	mg/kg	1	91.82	0.0-1.60
Boron (B)	US EPA 3052	mg/kg	1	<1.00	0.0-0.61
Potassium (K)	US EPA 3052	**meq/100g**	2.5	**9.50**	0.0-0.36
Magnesium (Mg)	US EPA 3052	**meq/100g**	2.5	**61.39**	0.0-1.62
Conductivity (EC)	APHA 2510 B, 23rd edn.:2017	dS/m		0.10	<8.0

Note:
RL = Reporting Limit
< = Less than
Less than reporting limit = Not detected

Folder Number : DHF24-0000111

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Appendix-2. Water analysis report for Green papaya

Laboratory of SGS Bangladesh Ltd.	TEST REPORT DHF240000243	Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	14.02.2024
		Date of analysis:	14.02.2024 - 22.02.2024
		BOSS Order:	1030808

THE FOLLOWING SAMPLE WAS DRAWN AND TESTED BY SGS BANGLADESH LTD.

Sample Description	Water (Bhaluka, Mymensingh)
Type of sample	Water
Sample Condition	Water in Three Plastic Bottle
Sample Quantity	3.5 litre

Chemical tests

Parameter	Method of Analyses	Unit	RL	Test Result	Test Requirements
Arsenic (As)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.01	<0.01	0.1
Calcium (Ca)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	9.76	401
Iron (Fe)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	0.12	1.0 - 5.0
Magnesium (Mg)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	4.64	61
Potassium (K)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	1.02	2
Sodium (Na)	APHA 3030 & 3120, 23rd edn.:2017	mg/L	0.05	9.31	920
Taste	APHA 2160 A, 23rd edn.:2017	-	-	Agreeable	-
Colour	Visual Examination (APHA 2120 B, 23rd edn.:2017)	Pt-Co	5	<5	-
Turbidity	APHA 2130 B, 23rd edn.:2017	NTU	5	<5.00	-
Odor	Sensory Evaluation(APHA 2150 B, 23rd edn.:2017)	-	-	Unobjectionable	-
Conductivity	APHA 2510 B, 23rd edn.:2017	µS/cm	-	184.30	3000
Total Dissolved Solid (TDS)	APHA 2540 C, 23rd edn.:2017	mg/L	1	132.00	2000
Temperature	APHA 2550 B, 23rd edn.:2017	°C	1	27.0	-
Chloride	APHA 4500-Cl- B & D, 23rd edn.:2017	mg/L	0.5	4.00	600
pH	APHA 4500-H+ B, 23rd edn.:2017	-	-	6.20	6.6 - 8.8
Nitrate	APHA 4500-NO3 B, 23rd edn.:2017	mg/L	0.05	1.85	1.0 - 10.0
Total Phosphorus	APHA 4500-P-J, B & E, 23rd edn.:2017	mg/L	0.1	< 0.10	2
Sulfate	APHA 4500-SO4 2- E, 23rd edn.:2017	mg/L	5	< 5.00	1000

Folder Number : DHF24-0000088

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Appendix-3. MRL test report for Green papaya

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TEST REPORT

DHF240001812

Page 1 of 3

Analyses ordered by:	**GAP PARTNER BARC** BANGLADESH AGRICULTURAL RESEARCH COUNCIL (BARC) KHAMARBARI RD, DHAKA, 1215 BANGLADESH	**Date of sample receipt:**	20.10.2024
		Date of analysis:	20.10.2024 - 25.10.2024
		BOSS Order:	1031581

THE FOLLOWING SAMPLE WAS SUBMITTED AND IDENTIFIED BY THE CUSTOMER AS

Sample Description	Green Papaya Alghoria, Pabna
Type of sample	Vegetable
Sample Condition	Vegetable in one plastic packet
Sample Quantity	250 gm

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Metalaxyl	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Carbendazim	SO-IN-MUL-TE-085 by LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
ORGANOPHOSPHORUS			
Acephate	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Azinophos ethyl	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Azinophos methyl	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Carbophenthion	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Chlorfenvinphos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Chlorpyrifos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Chlorpyrifos methyl	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Diazinon	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Dichlorvos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Dimethoate	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Edifenphos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Ethion	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Etrimfos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Fenithrothion	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Fenthion	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Iprobenphos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg

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Test/Parameter	Method	Result	Unit
Malathion	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Malaoxon	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Methamidophos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Methidathion	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Mevinphos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Monocrotophos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Omethoate	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Oxydemeton methyl	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Parathion ethyl	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Parathion methyl	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Paraoxon methyl	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Phenthoate	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Phorate	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Phosalone	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Phosphamidon	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Pirimiphos methyl	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Profenophos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Propetamphos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Quinalphos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Temephos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Thiometon	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Triazophos	SO-IN-MUL-TE-085 By LC-MS/MS	BLQ(LOQ : 0.005)	mg/kg
Imidacloprid	SO-IN-MUL-TE-085 by LC-MS/MS	0.010	mg/kg

Test/Parameter	Method	Result	Unit
DISCIPLINE: CHEMICAL			
Mancozeb as CS2	SO-IN-MUL-TE-112 by GC-MS/GC-MS/MS	BLQ (LOQ :0.010)	mg/kg

Remark: This test has been subcontracted from SGS India Private Ltd.,Test report number: CG24-026696.001 A&B, Dated at 25-10-2024.

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TEST REPORT

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Signed for and on behalf of:
SGS BANGLADESH LIMITED

Rafiqul Islam
Chemical Lab Manager

PICTURE

This electronically generated test report has been checked and approved. It is also valid without handwritten signatures.

---------- End of Report ----------

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Appendix-3

(Farmers Training Session in Atgharia, Pabna)

(A)

(B)

Fig. 9. Lecture session about production technology of green papaya by following GAP (A) and Certificate giving ceremony after completion of training (B) at the Atgharia Upzilla Agriculture Office training room.

Acknowledgement

We gratefully acknowledge the financial support from the Program on Agricultural and Rural Transformation for Nutrition, Entrepreneurship, and Resilience in Bangladesh (PARTNER) Programme, which is essential for the successful implementation of the GAP validation trials. Special thanks to providing all sorts of logistic support. We also extend our sincere appreciation to Bangladesh Agricultural Research Institute (BARI) authority for allowing its scientists to contribute their expertise to this initiative. Finally, we acknowledge the dedicated efforts of the Department of Agricultural Extension (DAE), whose field-level support was crucial in carrying out the trials across various locations. All of them, who have successfully executed the trials and prepared technical reports, deserve appreciation. All the farmers who participated in the validation trial with their lands and positive attitudes are highly acknowledged.

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