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Effect of adoption of IPM solutions, including improved cultural practices on overall revenue generation and gross return in banana

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Abstract

Banana is an important cash crop in Bangladesh. Despite potential to increase its acreage, banana faces a range of different threats, including Panama wilt, bunchy top and sigatoka diseases, and insect pests. The Feed the Future Bangladesh Integrated Pest Management Activity (IPMA) project developed an Integrated Pest Management (IPM) package for banana to support farmers in combating production threats. The IPMA has introduced a business model aimed at creating demand for IPM solutions by providing farmers with capacity-building training, facilitating business-to-business (B2B) connection between IPM solution providers and local input dealers to reach last-mile farmers, and establishing field trials to showcase the results of IPM solutions. The IPMA has systematically collected data to measure the adoption of IPM solutions, including improved cultural practices, and assessed their impact on overall production and gross return. Farmers who adopted these practices obtained 33% and 36% higher revenue and gross margin, respectively, in 2024 compared to 2022, while farmers secured a 23% and 27% higher revenue and gross margin, respectively, in 2024 compared to 2023. Cumulative effects of improved fertilization, cultural practices, and adoption of bio-based IPM solutions contributed to achieving higher revenue and gross margin.

Keywords: Banana, integrated pest management, revenue, Bangladesh

Introduction

The banana, *Musa sp.* (Musaceae) is one of the best-known tropical fruits. In the Asia-Pacific region, bananas have great socio-economic significance. Available data indicate that between 2000 and 2017, global production of bananas grew at a compound annual rate of 3.2 percent, reaching a record of 114 million tons in 2017, up from around 67 million tons in 2000 (FAO, 2020) [2]. Bangladesh is an agro-based country and about 75 percent of the population lives in rural areas. The majority of inhabitants are directly or indirectly involved in agricultural activities for their livelihood (BBS, 2018) [1]. Nearly half of all of Bangladesh's workers and two-thirds in rural areas are directly employed by agriculture, and about 87 percent of rural households rely on agriculture for at least part of their income (World Bank Group, 2016) [15]. Banana is mainly cultivated for its ripe fruit, unripe fruit when cooked, and for leaves in India and other countries, including Bangladesh (Khanum *et al.*, 2000) [9]. It is the second largest fruit produced after citrus, contributing to about 16% of the world's total fruit production (Kumari *et al.*, 2022) [10]. Bananas are highly nutritious (Sharrock and Lustry, 2000) [13], a rich source of carbohydrates, potassium, phosphorus, calcium, magnesium, and vitamins, particularly vitamin B (Hossain, 2014) [4]. It is more easily digestible than many other fruits such as apples (Mohapatra *et al.*, 2010) [11]. Haque (1988) [3] found that per hectare cost and net return of

banana cultivation were Tk 103,614.88 and Tk 1,61,386.12, respectively, in Bangladesh. According to him, net return from banana cultivation was much higher than any other field crop.

In 2020-2021, Bangladesh produced 8,26,151.76 metric tons of bananas planted in an area of around 49,470.52 ha (Statistical Yearbook Bangladesh, 2021) [14]. Specifically, banana constitutes around 40.7% of the total fruit production in the country and 22.1% of the total fruit area (Islam and Hoque, 2004) [5]. Banana is cultivated in the highlands in a variety of soil types, mostly in a pH range of 4.5 to 7. However, a soil pH range of 6.0 to 7.0 is more conducive for banana cultivation. Rainfall of 127 cm to 254 cm per year is optimum for bananas and reduced rainfall necessitates irrigation. Banana is basically a tropical crop, growing well in the temperature range of 13°C - 38°C with RH regime of 75-85%. There are many varieties of banana in Bangladesh. Among them, Sabri, Sagar, Chini-champa, and Champa are very popular. Major banana growing districts are Narsingdi, Gazipur, Rangpur, Bogura, Natore, Pabna, Noakhali, Faridpur, and Khulna (Mukul and Rahman, 2013) [12].

Banana is available throughout the year and although the consumption rate is higher (per capita consumption by per person per year is about 4.7 kg) than other fruits in Bangladesh, it is much lower than that consumed in Europe, including Belgium (26.7 kg), Sweden (16.7 kg), UK (10.5

kg), Germany (14.5 kg), as well as the USA (13.1 kg) (Islam *et al.*, 2019) [6]. Its cultivation plays a vital role in providing nutrition, income, and employment in Bangladesh (Kamal *et al.*, 2014) [7]. Bangladesh ranks 14th among the top banana producing countries in the world. In spite of having the potential to increase production, it remains in a static position in terms of acreage and production. In this article, we present introduction of the banana Integrated Pest Management (IPM) package and improvements in its adoption as well as increasing the yield of banana in Bangladesh.

Materials and Methods

Before and After Comparison (BACO) design with the Simple Random Sampling (SRS) method was used for this assessment. The proportional distribution of samples (208) across different subdistricts disaggregated data was maintained on age and sex. Shailakupa subdistrict in Jhenaidah district had the highest count with 113 farmers, where 10 were 15 to 29 years of age (eight males, two females) and 103 were age older than 30 (83 males, 20 females). In Kaligonj subdistrict in Jhenaidah district, there were 55 individuals, all above the age of 30 (52 males, three females). Magura Sadar subdistrict under Magura district had 40 farmers, with two between 15 and 29 years of age (1 male, 1 female) and 38 above the age of 30 (31 males, seven females). Overall, males (178) significantly outnumbered females (30), and 193 out of 208 were above 30 years of age across all subdistricts. Samples were drawn from 450 banana farmers across 10 out of 14 villages in three subdistricts (Shailakupa, Kaligonj and Magura Sadar) of two districts (Jhenaidah and Magura). Each village also had a backup list of five farmers for replacement, if needed. A structured interview schedule was developed and used as a data collection tool. Data was collected through in-person interviews using the Kobo tool kit. The collected data was processed, tabulated, classified, and analyzed using Excel and SPSS software.

Tillage, fertilizer, sucker, irrigation, plant protection and transportation costs were collected for production cost determination. The sales price was collected and simplified gross margin was calculated by subtracting the production cost from sales price.

Results and Discussion

The stagnation of production for three consecutive years is due to different threats, such as Panama, sigatoka and bunchy top diseases, nematodes, and insect pests, shown in Table 1.

The Feed the Future Bangladesh Integrated Pest Management Activity (IPMA), a project funded by the USAID Mission in Bangladesh and implemented by Virginia Tech, has developed an IPM package for banana. IPMA trained 981 farmers (320 in 2022, 450 in 2023, and 211 in 2024), supported private sector marketing of IPM solutions by creating a business-to-business (B2B) network with local input dealers as a strategy to make IPM solutions available at the proximity of last-mile farmers, and established field trials to demonstrate the effectiveness of IPM solutions in addressing specific threats to banana cultivation. The IPMA collected baseline information from farmers trained in 2023 on recall data and also collected

data in 2023 and 2024 with the objective to measure the adoption of IPM solutions, including improved cultural practices, and to assess the impact on overall production and gross returns. The IPM package for banana is given in Table 2.

Adoption of balanced fertilization: Application of balanced fertilizers is crucial for banana plants because it ensures they receive the necessary nutrients in the right proportions throughout their growth cycle, leading to optimal production, quality fruits, and overall plant health, especially considering banana's high potassium requirement and rapid growth rate. An imbalanced fertilization can hinder fruit development and reduce the yield.

The data revealed that farmers applied all required nutrients without following doses recommended by Bangladesh Agricultural Research Institute in 2022, which gradually got adopted to the recommended doses in 2024. A striking point is that the farmers were habituated using micronutrients like zinc sulphate, boric acid, and magnesium oxide. In addition, farmers followed recommended doses of fertilizers in 2024, which had a greater influence on both the quantity and quality of production. The fertilization pattern is shown in Fig. 1.

Adoption of improved cultural practices: The data revealed that the adoption of improved cultural practices, including weed management, cleaning the corm before planting, earthing up, and following the spacing of 1.8X1.8 m recommended by BARI significantly improved in 2024 over 2022 and 2023. The comparison of the adoption of different improved management practices is shown in Fig 2.

Crop protection measures: There was a major shift towards increasing availability of biopesticide-based solutions at the proximity of the last-mile farmers in 2023 and 2024 compared to 2022. In 2023, 36% of farmers responded that biopesticide-based solutions were available in their locality, while it increased to 56% in 2024. None of the farmers adopted any IPM-based solutions in 2022. There was a positive trend in adoption of biopesticide-based solutions in terms of treatment of suckers, soil amendment, and pest management by spraying different bio-based solutions in 2024 compared to 2022. The data revealed that the adoption of sucker treatment with a solution of *Trichoderma harzianum*, *Trichoderma viride*, *Metarhizium anisopliae*, *Beauveria bassiana* @ 3 g per liter water and *Bacillus amyloliquefaciens* @ 2 g per liter water was 37% in 2023, which increased to 40% in 2024. Similarly, the adoption of soil treatment with *Trichoderma* increased from 37% in 2023 to 44% in 2024, while adoption of biopesticide-based solutions for addressing different insects also increased from 67% in 2023 to 73% in 2024. This shift corresponds with the technology adoption cycle, where 16% is typically considered as slow (Khadim, 2023) [8]. Both sucker and soil treatment contributed to combating Panama and sigatoka diseases and banana corm weevil, which had a greater impact on increasing production. Fig. 3 summarizes the adoption and the availability of IPM-based solutions.

Economics

The data revealed that the land size under the production of

banana was 51.87 (± 3.538) decimals per farmer, with production cost remaining nearly the same in both 2023 and 2024 (BDT 20,053 in 2023 and BDT 20,883 in 2024). There was a significant increase in fruit sales and profit in 2024 compared to 2022 and 2023. Revenue and gross margin were 33% and 36% higher in 2024 compared to 2022, and 23% and 27% higher compared to 2023, respectively. The cumulative effects of improved fertilization, cultural practices, and the adoption of bio-based IPM solutions

contributed to achieving higher revenue and gross margins. The revenue generated is shown on Fig. 4.

Table 1: Acreage and production for three consecutive years

Particulars	Year 2021	Year 2022	Year 2023
Acreage (in ha)	49,470	49,630	49,637
Production (in Metric Ton)	826,152	826,180	840,362

Table 2: Integrated Pest Management package for banana

Improved cultural practices

- Use of pest free healthy suckers.
- Deep ploughing to expose pathogens, and nematodes to sun.
- Providing good drainage and periodic weeding.
- Use of balanced fertilizers¹ (for each banana plant or pit, 10 kgs of organic manure, 0.5 kg of urea, 0.4 kg of TSP, 0.5 kg of muriate of potash (MOP), 0.2 kg of gypsum, 0.0015 kg of zinc sulphate, and 0.002 kg of boric acid). Full amount of cow manure, tricho-compost, triple super phosphate (TSP), gypsum, zinc sulfate, boric acid and half of MOP should be applied during pit preparation. Urea and remaining half of MOP should be applied 2-3 times at two-month intervals and at the time of flowering.

For Panama diseases

- Soak suckers overnight in the solution of *Trichoderma harzianum* @ 3 g per liter water and *Bacillus amyloliquefaciens* @ 2 g per liter water.

For Sigatoka

- Spray *Trichoderma harzianum* @ 3 g per liter water and *Bacillus amyloliquefaciens* @ 2 g per liter water at two months interval.

For Bunchy top disease

- Plant disease free suckers.
- Uproot and burn infected plants.
- Control aphid (*Pentalonia nigronervosa*) vector by spraying azadiractin and set up six yellow sticky traps (for 33 decimals) at 10 m intervals.

For fruit beetle

- Bagging with polybag.
- If bagging is not possible, spray *Metarhizium anisopliae*, *Beauveria bassiana* @ 1 g per liter of water: first time one week before the emergence of inflorescence, second time just after the emergence of inflorescence, third time just after the emergence of first bunch of bananas, and fourth time after the emergence of all bananas.

For banana corm weevil

- Remove weevil grubs from the corm before planting. Set up banana corm weevil pheromone traps.

¹ Recommended by Bangladesh Agricultural Research Institute (BARI)

Table 3: Distribution of sample farmers

Locations	Village name	Male			Female			Grand total
		Age 30+	Age 15-29	Total	Age 30+	Age 15-29	Total	
Magura sadar	Kalinagar	11	1	12	6	0	6	18
	Kosundi	12	1	13	7	1	8	21
Sub-total		23	2	25	13	1	14	39
Kaliganj	Aruashulva	8	2	10	-	-	-	10
	Bethuli	23	2	25	-	-	-	25
	Chaprail	8	0	8	-	-	-	8
	Mollikpur	12	1	13	-	-	-	13
Sub-total		51	5	56	0	0	0	56
Shailakupa	Berbari	10	3	13	5	0	5	18
	Podomdi	14	4	18	-	0	0	18
	Sherpur	15	3	18	2	0	2	20
	Sreerampur	40	6	46	11	0	11	57
Sub-total		79	16	95	18	0	18	113
Grand total		153	23	176	31	1	32	208

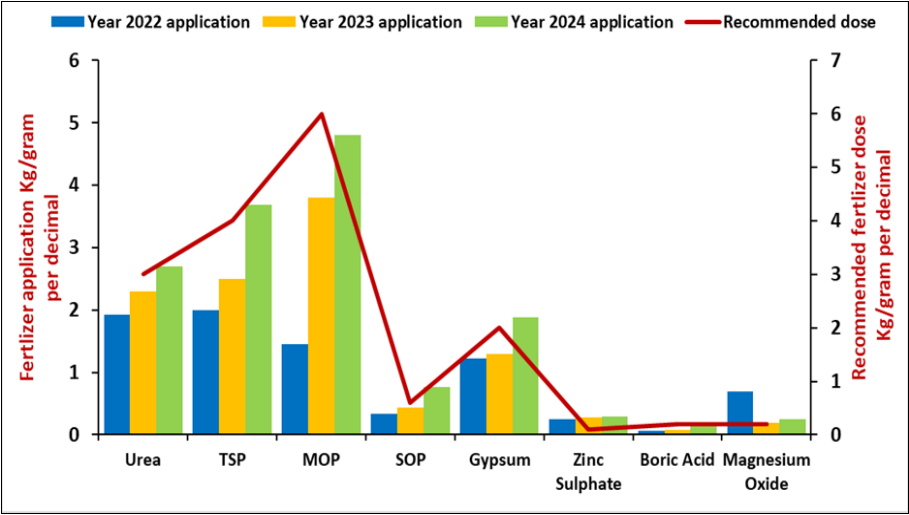


Fig 1: Fertilizer application adoption in 2022 and 2024

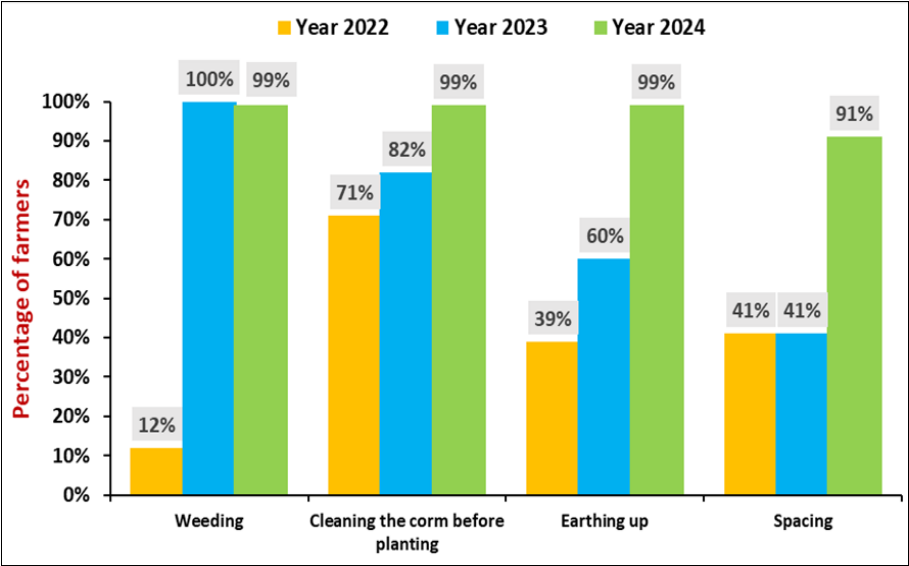


Fig 2: Adoption of cultural practices from 2022 to 2024

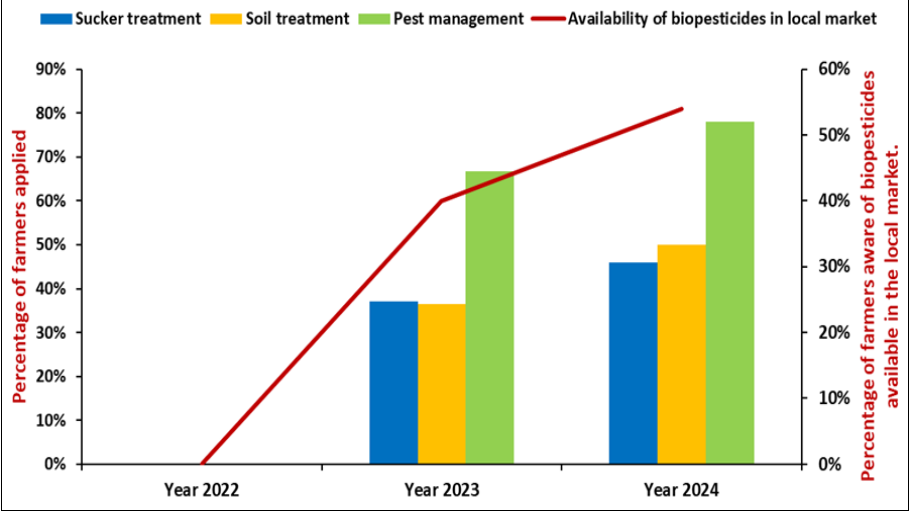


Fig 3: Biopesticide usage from 2022 to 2024

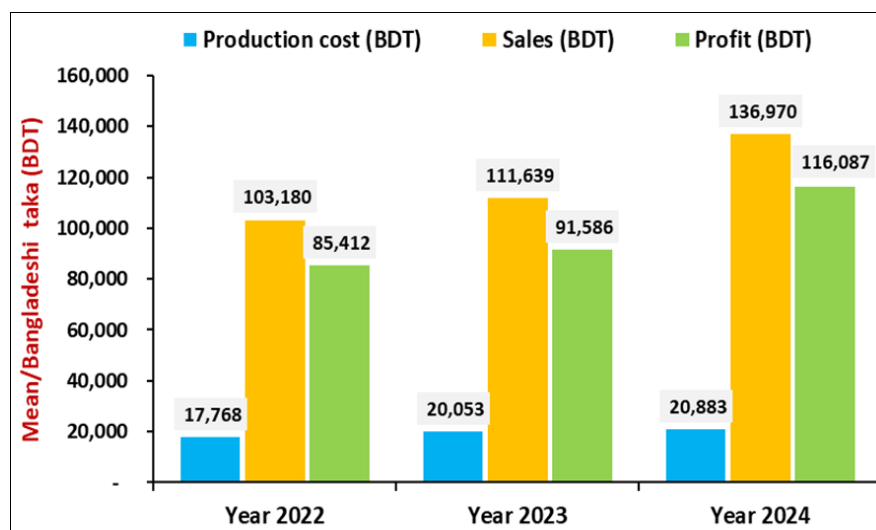


Fig. 4: Revenue generated from 2022 to 2024 in banana production

Conclusion

This study has clearly indicated that there is a positive relationship between the availability of IPM-based products at the doorstep of farmers and the rate of adoption of IPM-based solutions. Training on IPM-based solutions, followed by the increased availability of IPM-based products for last-mile farmers are important factors in accelerating the adoption of the technologies. The adoption rate of IPM-based technologies reached 73% within a year from 2023 to 2024. The cumulative effect of improved fertilization, cultural practices, and the adoption of bio-based IPM solutions contributed to achieving higher revenue and gross margins.

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