Prospect of profitability and socio-technological status of banana production in Rajshahi region in Bangladesh

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ABSTRACT

This study seeks to evaluate the socio-technological conditions of banana growers and to document the technologies adopted in banana production in Puthia and Charghat Upazila in Rajshahi. For primary data collection, a survey was conducted among 53 banana producers. To fulfill the study's aims, descriptive analysis and multiple regression analysis were applied as analytical tools. The study reveals that both education and total input cost affect on total income; Total input has a strong positive correlation with total input cost (r=0.719), while the correlation with education is weak (r=0.178). A significant majority of farmers cultivate the Anupom variety (18.86%) and face issues with the banana fruit and scarring beetle (60.38%), alongside major problems like high fertilizer prices (86.79%). Most farmers primarily use irrigation (75.47%) for soil management, yet a large percentage are unaware of digital ICT tools (79.25%) and few use improved technology. Governmental support is virtually non-existent, with only 1.87% of respondents receiving assistance. Consequently, the most desired support from the government is a reduction in prices (75.47%), followed by the availability of seedlings, weather-resistant varieties, and financial aid. The study's outcomes lead to the following recommended policies and actions are useful for improving banana production and achieving the SDG's goal, including making HYV suckers more accessible, improving extension services and transportation, promoting Good Agricultural Practices (GAP), and integrated pest management and Strengthening extension support and promoting ICT-based training could enhance productivity and sustainability.

Keywords: socio-technological, profitability, production, recommendations.

Introduction

Banana (Musa paradisiaca, family Musaceae) is recognized as one of the world's

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oldest cultivated fruit, and remain staple across many cultures due to its medicinal, economic value, nutrition (Kumar et al., 2012) . Despite the difficulty in pinpointing its exact origin, this tropical native is now an extensively cultivated crop in tropical and subtropical zones worldwide. (MF Alam et al 2014).

It evolved from one of the first cultivated fruits into the most heavily exported fresh fruit in the world (ITC News, 2018; Reay, 2019; WorldAtlas, 2020). Banana is grown not only for eating fresh but also for cooking, and its leaves are widely used in countries such as India and Bangladesh (Khanum et al., 2000). In Bangladesh, banana cultivation is a significant year round agricultural activity and preferred as a second most important fruit crop after mango. Bangladesh is ranked among the world's top 20 banana producers, with an annual output of 833,309 tonnes (AtlasBig.com, 2021). While banana produced all over the country, certain districts such as Narsingdi , Gazipur , Tangail , Rangpur, Khulna, Noakhali , Faridpur are The main areas of banana cultivation in Bangladesh (Bhuiyan et al 2021). Its cultivation plays a vital role in providing nutrition, extra income, and employment in Bangladesh (Kamal et al., 2014).

Rajshahi a region known for its favorable agro-climatic zone. Commercial farming of banana has been gaining ground in the region including its vast Barind tract with farmers reaping a sound profit from the cropping (dailyasianage,2018). In recent years, Rajshahi has undergone noticeable transformation in banana farming. At present Puthia, Durgapur and Charghat upazilas ,(DAE) with a total contribution of approximately 35,000 metric tonnes from around 2,000 hectares of land. Despite of this growth, productivity remain low with average yield is much lower compared to significantly higher outputs in other countries. Furthermore, government-sponsored initiatives to promote banana farming and commercialization in Bangladesh are currently limited .As a result, banana production faces a wide range of challenges that hinder productivity and threaten the sector's sustainability. These include rising production costs, pests and diseases, yield uncertainties, and labor issues such as scarcity and high wages. Farmers also struggle with lack of quality suckers, inadequate power, high input costs,water shortages in summer, limited credit access, price manipulation by commission agents, and insufficient cold storage. (Jalaluddin et al., 2022,Sakthiganesh et al., 2022 & Jomanga et al., 2022).These factors not only affect the livelihoods of smallholder farmers but also leads to erosion of banana genetic diversity and gradual decline of regional supremacy in producing bananas . Therefore to unlock its full potential ,it is crucial to understand the socio-economic and technological conditions under which farmers operates. However, there is limited empirical evidence on how existing socio-technological conditions and production constraints affect the profitability of banana cultivation in the Rajshahi region.The objective of this study is to

assess farmer knowledge, challenges faced by farmers, and the profitability conditions of banana cultivation, and provide recommendations for sustainable banana production.

Some available studies have been conducted on banana for providing policy guide line (Kamal et al 2014) , guideline the sustainable solution to farmers(Sarma et al 2021), improving profitability and productivity(Phulara et al 2020;Bhatta et al 2020) ,postharvest handling(Woldu et al 2015) ,identify factors affecting profitability and value chain (Mahalaksmi et al 2016;Fonsah et al 2018;Muthee et al 2019;Lucas et al 2021), adaptability of new technology(Jhariya et al 2019;Pradhan et al 2017),analyze profitability (Munia et al 2019) but there are no previous studies have been carried out in our study area. This study contributes to the literature by providing location-specific evidence on socio-technological status and farm-level profitability of banana cultivation in Rajshahi, Bangladesh. However The findings will provide valuable insights for researcher, policy maker and other stake holders interested in advancing banana production. This study also highlights aspects relevant to Sustainable Development Goal 12 by supporting responsible consumption and production through improved food security, environmental sustainability, and livelihoods of marginal farmers. This study aims to bridge the knowledge gap by examining the socio-technological status and identify the profitability challenges of banana cultivation, faced by banana growers in one of major banana production area in Bangladesh3. Materials and Methodology

3.1 Study area: The present study was conducted in Puthia and Charghat upazila between June and July 2025 ; Specially Raghurampur , Jhalmalia , Banneshwar, Nandangahi.

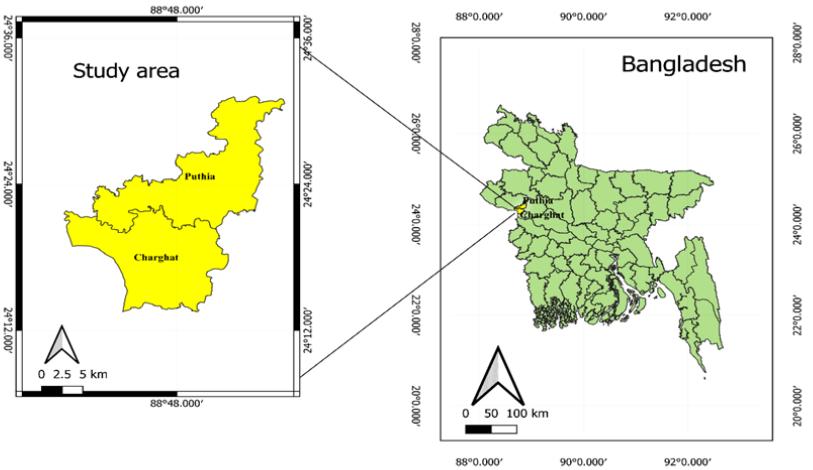


Figure 1: Maps of study area in Rajshahi region ; Puthia, Charghat.

3.2 Data collection:A total of 53 banana farmers were interviewed for primary data collection. The respondents were selected using a purposive sampling technique, focusing on active banana growers in the selected areas. Data were collected directly from the field through face-to-face interviews at farmers' houses and local haats (markets). The sample size of 53 farmers was considered adequate to represent the active banana growers in the selected study areas within the time and resource constraints of the study. For secondary data collection, information was gathered from various reliable sources, including peer-reviewed research publications, academic journals, magazines, newspapers, research articles, internet sources, and relevant government websites.

Study materials: Major challenges faced by farmer, total input cost, total income, cultivated area, main source of income. pest and diseases, government help, preferred support.

3.4 Analysis: By using SPSS descriptive analysis done among age, experience and cultivated area , Correlation and regression is done between education, total input and total income.

4.Result

4.1 Producers age, experience and cultivated area

As shown in Table 1, producers' ages range from 25 to 70 years, indicating a wide variation in age among the respondents. Based on a survey of 53 farmers, cultivation experience ranged from 1 year to 55 years, showing considerable variation among producers. Similarly, cultivated areas ranged from a minimum of 1 ha to a maximum of 16 ha.

Table 1: Descriptive statistics of producers age, experience and cultivated area

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Age (Year)	53	25	70	44.13	11.561
Experience	53	1	55	20.11	12.367
Ciltivated area(ha)	53	1	16	2.64	2.932
Valid N (list wise)	53				

4.2 Producer's education, total input cost effects on total income

Table 2 shows how education and input cost affect farmers' income. Income was highest (200,000 Tk) with higher education and input cost (81,000 Tk).

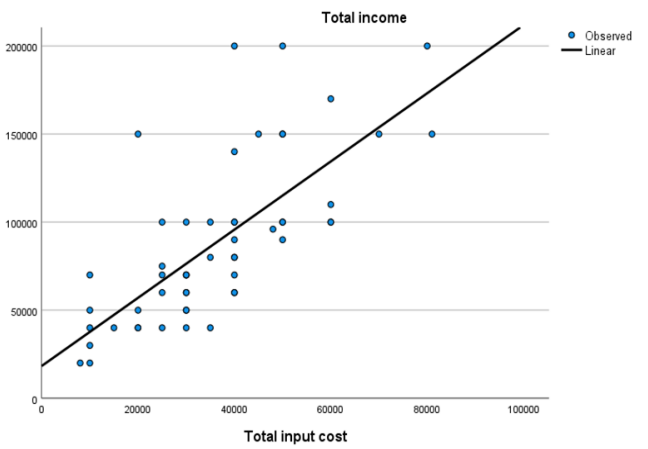
Lower education and inputs led to less income.A strong positive correction existed between input cost and income ($r = 0.719$, $p < 0.05$).Education had a weak link with income ($r = 0.178$), meaning input use influenced the income more than education.

Table 2: Relationship between education and total input cost with total income

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Education	53	0	13	6.26	5.167
Total input cost	53	8000	81000	36169.81	17287.986
Total income	53	20000	200000	88320.75	46556.737
Valid N (list wise)	53				

Correlations (Total input cost and total income)			
		Total input cost	Total income
Total input cost	Pearson Correlation	1	.719**
	Sig. (2-tailed)		.000
	N	53	53
Total income cost	Pearson Correlation	.719**	1
	Sig. (2-tailed)	.000	
	N	53	53

Linear relationship between total input cost and total income



4.3 Relationship between Benefit cost ratio, profitability and total area

Profitability increases against the total cultivable area. Maximum profit shows 160,000 taka with a benefit cost of 7.50. Whereas minimum profitability shows 5000 taka with a benefit-cost ratio of 1.33. Though in both cases it's confirming overall profitability, a higher standard deviation (36185.631 taka) confirms increasing cultivable land plays a significant role in the benefit-cost ratio (minimum 1.33 to maximum 7.50). This observation shows similarity with the findings that banana production increases with increased cultivable land

Table 3: Descriptive analysis of Profitability and Benefit cost ratio

Descriptive Statistics					
	N	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Profitability	53	5000	160000	52150.94	36185.631
Benefit Cost Ratio (Income/ input)	53	1.33	7.50	2.6374	1.24353
Valid N (listwise)	53				

Table 4 represents clear differences in profitability and economic efficiency across farm sizes. Small farms recorded the highest mean profitability (Tk. 52,586.96) and the highest B:C ratio (2.7033), indicating that they generated the greatest return per unit of investment. Medium farms performed moderately (profitability Tk. 51,000.00; B:C ratio 2.2200), On the other hand large farms reveal comparatively lower profitability (Tk. 45,000.00) and B:C ratio (2.1650).

Table 4: Differences in profitability and economic efficiency across farm sizes

Total Area (Begha)		**Profitability**	**Benefit Cost Ratio(Income/ input)**
Large	Mean	45000.00	2.1650
	Std. Deviation	7071.068	.23335
medium	Mean	51000.00	2.2200
	Std. Deviation	37148.351	.57896
small	Mean	52586.96	2.7033
	Std. Deviation	37238.317	1.31232
Total	Mean	52150.94	2.6374
	Std. Deviation	36185.631	1.24353

4.4 Cultivated banana varieties

Table-5 shows the distribution of banana varieties grown by farmers. Several single and mixed varieties were reported here .The lowest share (1.88%) was found in combinations like Chinchampa + Honuman and Gin + Chapa.The highest percentage was for Anupom (18.86%).Overall, Anupom and Gin were the most preferred varieties.

Table 5: Percentage of cultivated banana varieties

Variation	Item	Percentage
Anupom+ rongila	4	7.55
Rongila+ Sagor	3	5.66
Chinichampa +honuman	1	1.88
Anupom	10	18.86
Gin+ anaji+ anupom	1	1.88
Rongila+ anupom+gin	3	5.66
Rongil + chapa	2	3.77
Gin+ chapa	1	1.88
Gin	9	16.98
Gin+ rongila	3	5.66
Rongila	6	11.32
Gin + anupom	3	5.66
Chapa + anupom	1	1.88
Gin+ manik + chapa	1	1.88
Chapa	5	9.43

4.5 Fertilizers types used by farmers

Table-6 represents the percentage of fertilizer types used by farmers. The combination of fertilizers appears to vary by type. poultry manure and only MP are rarely used (1.88%), whereas TSP and MP are the most preferred (32.08%).

Table 6: Percentage of fertilizer types used by farmer

Types	Item	Percentage
TSP	9	16.98
MP	1	1.88
TSP+MP	17	32.08
TSP+ MP+ Urea	13	24.52
TSP + Urea	2	3.77
MP + Urea	4	7.55
TSP + MP+ Boric acid	2	3.77
TSP+ MP+ Zinc	2	3.77
Poultry	1	1.88
Zinc+ MP	2	3.77

4.6 Main input cost

Figure-2 shows the main input costs arise during banana cultivation. However, these costs may change over time due to fluctuations in market prices and farming practices. Labor cost is the lowest for farmers with a percentage of 1.88%, while fertilizer cost occupies the largest share at 52.83%.

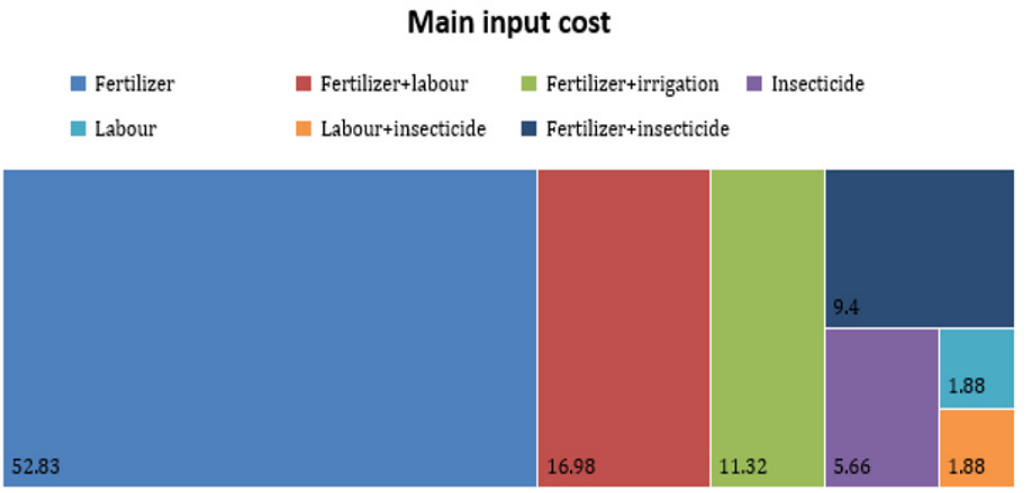


Figure 2: Main input cost arise during Banana cultivation

4.7 ICT tool and improved technology

Figure 3(A) and Figure 3(B) illustrate the percentage of farmers using ICT tools and improved technologies in banana production respectively. In the case of ICT tool usage, it is observed that most farmers are not familiar with using such tools, showing a difference of 58.5% between users and non-users. Similarly, a comparable pattern is evident in the use of improved technologies, where 81.13% of farmers do not adopt them, while only 10.86% make use of such technologies.

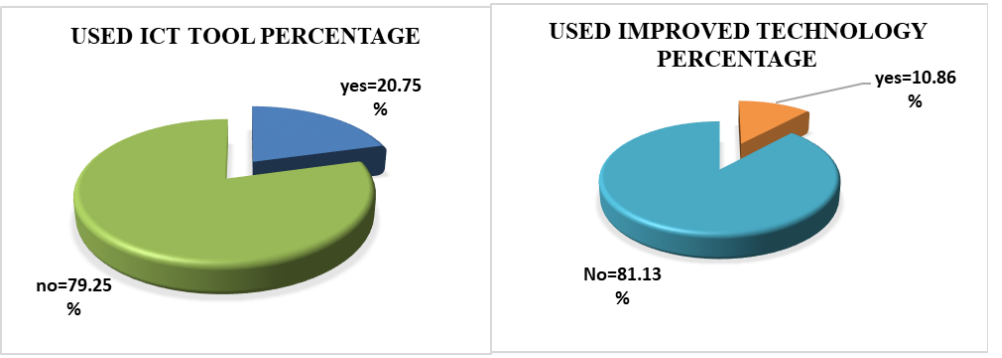


Figure-3: Percentage of ICT tools (3.A) and improved technology (3.B) used by banana cultivars

4.8 Disease and pest attack in banana field:

Table-7 presents the various disease and pest that farmers believe are responsible for reducing banana production.It is observed that the most common pest causing production loss is the banana thrips. In contrast, the least common pests are the cutworm and earthworm. Comparing their prevalence, banana thrips account for 60.38%, which is 58.49% higher than that of cutworm and earthworm.

Table 7: Percentage of disease and pest attack on banana

Variation	Item	Percentage(%)
Virus	9	16.98%
Banana thrips	32	60.38%
Hopper	1	1.89%
Banana weevil	3	5.66%
Cutworm	1	1.89%
Earthworm+ banana thrips	1	1.89%
Banana thrips+ virus	1	1.89%
None	5	9.43%

4.9 Techniques of managing soil health

Figure 4 represents the percentage of techniques adopted by farmers to manage soil conditions. Though the soil management techniques depend on variable factors like environmental conditions, plant growth stages and resource availability. About 3.77% of farmers suggested using organic compost, cow dung or no treatment for better soil health. In comparison, About 75.47% of farmers considered irrigation as a necessary practice for maintaining healthy soil.

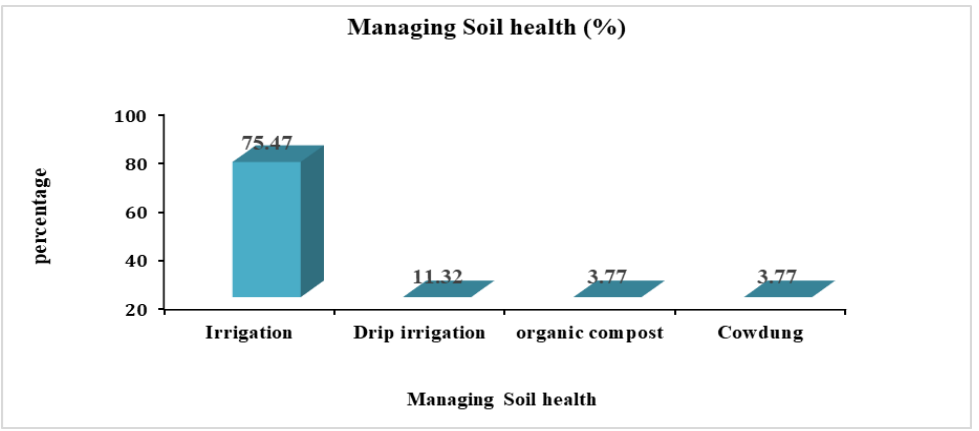


Figure 4: Percentage of techniques adopted by farmer for managing soil condition

4.11 Member of incorporation and government support

Pie chart 5.A illustrates the percentage of banana producers involved in cooperatives. only 7.54% of banana producers are member of different incorporation while the remaining 92.45% are not members of any incorporation. This indicates a very low level of incorporation participation. Pie chart 5.B illustrates the government's assistance to farmers. They reported that only 2% of them receiving support whereas 98% are deprived of any assistance.

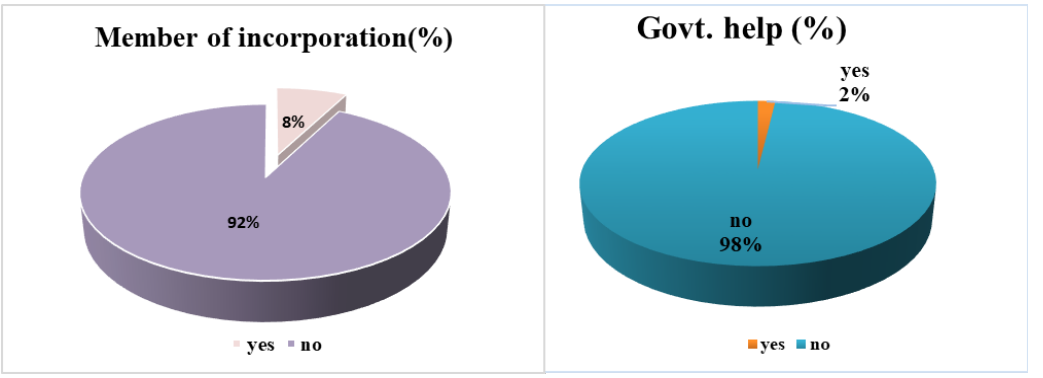


Figure 5: Percentage of farmers who's are attach to incorporation (5.A) and Govt. help they received (5.B).

4.12 Challenges faced by farmers and preferred support by them

Chart 6.A illustrates the primary challenges faced by farmers. Most of them (86.79%) attributed their problems to the high cost of fertilizer. On the other hand, root damage was a significant challenge for only 13.21% of banana production. Pie chart 6.B illustrates the government's assistance to farmers. They reported that only 2% of them receiving support whereas 98% are deprived of any assistance.

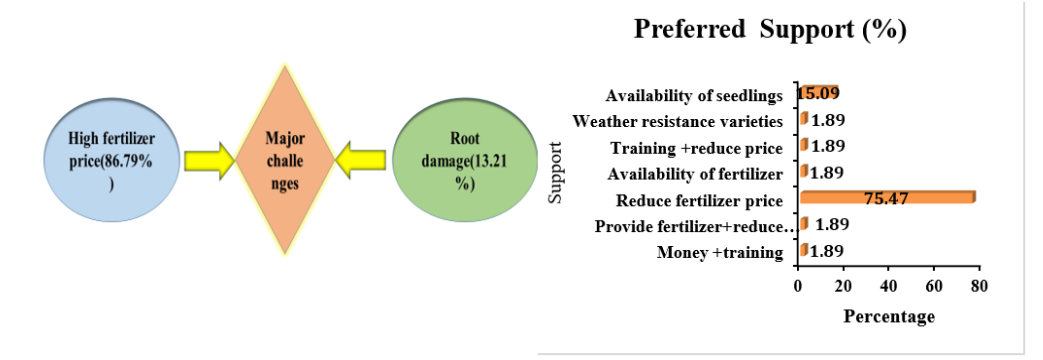


Figure 6: Major challenges faced by farmers (6.A) and support preferred (6.B) by farmer.

5 Discussion:

The results of the study here farmers with higher levels of education, particularly up to honours level (13 years), attained higher incomes, with the maximum reported income reaching 200,000 Tk, while the maximum input cost was 81,000 Tk. Descriptive statistics indicated that the mean input cost was 36,169.81 Tk (SD = 17,287.98) and the mean income was 88,320.75 Tk (SD = 46,556.73). The statistics positive association between total input cost and total income ($r = 0.719$, $p < 0.01$), here greater input investment regularly improved income. And the union between education and income was weak ($r = 0.178$, $p = 0.201$), that show education alone did not having a major impact on income. This observation we saw previous evidence from Sylhet, where education had a positive yet relatively weaker effect on banana returns compared to input-related variables (Islam et al., 2017).

Profitability increases against the total cultivable area. Maximum profit shows 160,000 taka with a benefit cost of 7.50. Whereas minimum profitability shows 5000 taka with a benefit-cost ratio of 1.33.Though in both cases it's confirming overall profitability, a higher standard deviation (36185.631 taka) confirms increasing cultivable land plays a significant role in the benefit-cost ratio (minimum 1.33 to maximum 7.50). This observation shows similarity with the findings that banana production increases with increased cultivable land .

The higher profitability executed among small farms supports the inverse relationship (IR) hypothesis, It implies that smaller holdings make more effective and intensive use of available labor. Similar findings were reported in studies on (Madhur Gautam 2018) This paper seeks to determine whether small farms continue to exhibit higher productivity in Bangladesh or if ongoing agricultural changes have modified the pattern. The observed benefit cost (BCR) greater than one implies that the total return transcends total production cost ensuring positive net income for farmers. This finding claim that banana farming remains a financial sustainable agricultural enterprise. Familiar results were represented in documents on (Z.T. Munia 2019 and M. MOHIUDDIN 2020) this evidence reveals that profitability in banana farming depends not only on farm size but also on effective management of critical inputs. Banana farming exhibits structural differenences in return across farmer catagories highlightes the importance of scale execution and less resource use.

Some condition of Choice of variety, the majority of farmers cultivated Anupom (18.86%), Gin (16.98%), Rongila (11.32%), and Chapa (9.43%), and while mixed combinations such as Chinchampa + Honuman, Gin + Chapa, and Gin + Manik + Chapa were adopted (1.88%). Overall, the study shows that farmers have balance between productivity (as in Anupom and Gin) and market-driven

preferences (as in Chapa and Rongila). That means they have deep knowledge about the environmental condition on their local area and also market demands and personal needs. This strategy of maintaining varietal diversity plays a crucial role in ensuring both livelihood security and resilience in smallholder farming systems (Miah et al., 2016).

In this study, most of the farmers (32.02%) mentioned that they usually apply a mix of triple super phosphate (TSP) and muriate of potash (MP). The second most common practice among farmers was applying a combination of TSP, MP, and urea. According to Munia et al. (2019), farmers commonly used five types of fertilizers: urea, MP, TSP, gypsum, and zinc sulphate . For better banana growth, Islam et al. (2020) reported that applying 500 g of urea and 450 g of MP per plant, either alone or combined, can improve yield. According to (Zhang et al 2020) the application of organic fertilizer significantly promoted soil organic matter content and banana yield and quality .However, previous paper showed that most farmers hardly used organic fertilizers, so they had to depend more on chemical fertilizers. The rising dependence on chemical fertilizers, combined with their limited availability, has gradually driven up market prices. Also this is very harmful for health and environment. Proper steps should be taken to encourage farmers to use organic fertilizers, fixes fertilizers dose by examing the soil and Integrated pest management method must be trained.

According to our study, the percentage of farmers using and not using ICT tools is 20.75 and 79.25 respectively which are shown in the figure (3.A). Similar results were obtained by a previous study by Simon L. Mwombe et al. (2011). According to Kabirigi et al. (2021), ICT tools, including mobile phones, have the potential to offer many benefits. The use of improved technology in the banana production are also shown in the figure (3.B) which indicate that the majority percentage is 81.13 which reveals the negative result in using improved technology. And the another percentage means that 10.86% banana grower used improved technology by many ways. Parallel results were observed by AZM Shafiullah Prodhan et.al (2017) and G Alagukannan et.al (2015). Based on the findings of the present study as well as previous records, it can be inferred that an increased utilization of ICT tools and improved technologies could enable growers to substantially enhance, even multiply their production.

In the present investigation, a substantial proportion of farmers (60.38%) identified banana thrips (Chaetanaphothrips signipennis) as the predominant pest constraining banana cultivation. This pest is chiefly implicated in the manifestation of conspicuous black lesions on the upper epidermal surface of banana fruits, thereby diminishing both their market value and consumer appeal. Similar findings were obtained by KD Bisane et al. (1967), further substantiating

the consistency of these findings across different contexts. Furthermore, 16.98% of the surveyed farmers indicated the presence of virus-induced diseases in their plantations. These findings are consistent with the reports of D.R. Jones (2009) and M.N. Islam et al. (2018). Overall, pest infestations in banana cultivation were found to hinder plant growth, while different types of diseases contributed to a significant decline in production, ultimately resulting in substantial economic losses for growers. Government extension services should be focused on developing and implementing Integrated Pest and Disease Management (IPDM) which includes biological control, using resistant varieties , cultural practices, regular monitoring, technology adoption .

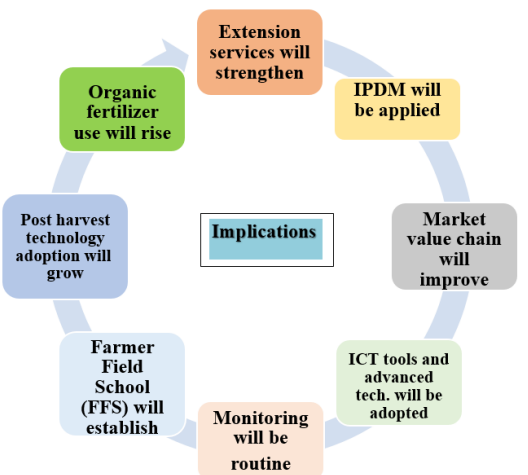
The survey showed that most farmers in the study area still relied on conventional irrigation methods, while only a smaller number had switched to drip irrigation, and just a few used compost or other organic materials to keep their soil healthy .These findings aligned with the previous studies, which showed that all farmers used irrigation for their cultivation and that, along with other components, irrigation also had a momentous impact on increasing banana production (Munia et al., 2020). Yet, research also made it clear that drip irrigation could offer even greater benefits. Pramanik and Biswas (2012) found that drip irrigation was more profitable than surface irrigation because it led to higher banana yields. Similarly, Ghosh et al. (2018) pointed out that drip irrigation delivered water directly to the root zone, reduced losses, made better use of water, and ultimately boosted production. Even with these clear benefits, many farmers still had not adopted drip irrigation, mainly because they lacked proper technical knowledge and felt that the initial setup costs were too high.Government and NGO's should offer subsidies for overcoming cost and knowledge barriers.Farmer Field School (FFS) should be established for hands on training. Extension workers or local technicians should employed for onsite techonological support.

In the study, nearly all farmers (98.1%) stated that they had not received any direct government support for banana cultivation. Many of these farmers typically relied on traditional method and weren't proactive in seeking training or advisory services . Farmers often believed that government help was difficult to obtain and not consistently dependable.so they focused on immediate needs, like lowering input costs, instead of asking for broader support. These findings point to the need for more active government involvement. Previous studies indicate that carefully designed policies can boost productivity (Samadder et al., 2017), and that changes in policy can have a direct impact on crop yields (Akcaoz et al., 2009). Supporting this, Uddin and Dhar (2018) found that when governments provide support for agricultural inputs, it not only increases

productivity and profitability but also raises income by lowering input costs. Such assistance helps strengthen food security and supports efforts to reduce poverty. The findings suggest that providing targeted support could play an important role in improving both the productivity and the livelihoods of banana farmers.

According to the findings, 86.79% of the cultivators claimed high price of the fertilizer as a great challenge for growing banana Similarly most of the farmers suggested to reduce the price of fertilizer according to Anusree samaddar 2017 et al. On the other hand, poor soil fertility, poor market of agricultural produce were accused as a major challenge according to Shija Shilunga Lucas 2021 et al. Pest and diseases, adverse weather were also claimed a major challenge according to C.Y.Li et al (2009).To addressing the challenges in banana cultivation future research should be foused on economy and policy, use of compost and crop rotation, require a deep analysis on value chain of banana production, adoption on postharvest technology.

Implications of the findings



6.Conclusion

The study aims to identify profitability and socio-technological status of banana production in Puthia and Charghut upazila in Rajshahi. From the findings, Anupom and Gin variety were one of the most cultivated varieties in the region that occupied 18.86% and 16.98% respectively. Farmer faced numerous problem, the major one was high price of fertilizer. Moreover, banana thirps was one of the major pests in banana cultivation (60.38%). Farmers deal with the pest every year during the cultivation season. The pest decreases the quality of banana because of that it reduces the market price. Farmers rarely received the government

support or NGO support (1.87%). The study shows that only few farmers used digital tools and improved technology 20.75% and 10.86% respectively. For the development of current status of farmers, using of ICT tools and improved technology is very necessary in 21st century. Training should promote more efficiently by the extension personnels by providing leaflet, booklets, posters etc. Besides this limitation, farmers earned a positive net return from banana cultivation. This increases the possibility of exporting. Educated farmer cultivated more efficiently. The survey dealt with only 53 banana producers. Despite this limitation, the study enlightened the current socio-technological status of banana production. The risk management of banana cultivation has to minimize by creating awareness through the extension personal and also provide the knowledge of integrated pest management (IPM). Opportunities for future studies may include the identification of the particular reasons of not enriching the modern tools, high price of fertilizer, insecticide etc. To control the attack of pest and virus, integrated pest management and modern technology should introduced by extension officers. The study emphasizes on improving food security, economic growth, environmental sustainability which connects to the goals no 12 of sustainable development goals (SDGs).

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