RESEARCH ARTICLE

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First Report on Homestead-Based Black Pepper (*Piper nigrum*) Gardening at Jaintiapur of Sylhet District in Bangladesh

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ABSTRACT

Black pepper (*Piper nigrum*), famous as "Black Gold" and also called the "king of spices," is widely used as a spice throughout the country. It is mainly cultivated in the North-Eastern part of Bangladesh, where the gardening features, beneficiary output, and situational analysis of black pepper in the homestead areas are less explored. Hence, a study was conducted from August 2018 to July 2019 in the Nijpat and Jaintiapur unions of the Jaintiapur upazila of the Sylhet district in Bangladesh to investigate existing gardening features of black pepper cultivation and how it could be a potential option for rural farmers to improve their living standards. A structural questionnaire was prepared after the pilot test containing six aspects, *viz.* demographic features (age, education, homestead size, family size, annual family income), black pepper pre-plantation features (variety, seedling source, propagation method, seedling age, planting time, plant density per supporting plant, preferred pit size), post plantation practices or features (watering, nutrition supply, pruning, use of a fence, the pattern of the garden, the occurrence of pest infestation, pesticide use, supporting plants), flowering and fruiting information (first flowering time, flowering month, fruit harvesting time, harvesting method, yield range), post-harvest information (processing, marketing channel, pricing), valuation survey (beneficiary output, possible constraints, SWOT analysis). Data were collected through personal interviews with 70 randomly selected respondents who have direct/indirect experience in black pepper gardening. A SWOT analysis was conducted to analyze the growers' strengths, weaknesses, opportunities, and threats. Most respondents (57.14%) collected seedlings from their own output; 94.29% utilized stem cuttings for black pepper multiplication and planted primarily between July and August (54.29 %). The majority of responders (71.43%) transplanted two to three seedlings per supporting tree, keeping a pit size of primarily 45×45×45 cm^3 (54.29%). It was found that farmers preferred neither chemical fertilizer nor manure (54.29%), watering (65.71%), no use of fence (91.43%), standards (100%), no pruning and weeding (100%), pesticide use (77.14%) in black pepper garden, generally. The first flowering took 3 to 4 years (65.71%), May to June (91.43%) was the flowering month, fruit harvesting time was found to be November to December (100%), harvesting method was done manually (100%), and yield was 2.0 kg supporting $plant^{-1}$ (62.86%). Respondents followed the conventional method of processing. The analysis showed that there was about Tk. 682.5 kg^{-1} pricing difference between farmers and Megashops. The constraints were the lack of appropriate knowledge, government assistance, soil moisture during the dry season, and high-quality planting materials. Farmers acknowledged the beneficiary output of black pepper, where 88.57% were satisfied with their generated outcomes as they believed it could provide environmental benefits (100%), medicinal value (77.14%), and no health hazards (100%). Farmers believed that in terms of environmental benefits, black pepper gardening provided soil improvement, increased amenities, oxygen release, and carbon dioxide release. Situational analysis revealed a vast scope of black pepper gardening, which could be a potential option for achieving Sustainable Development Goals. Hence, this ground needs more focus and further research initiatives to increase its potential to be effective.

Keywords: black pepper, *Piper nigrum*, homestead gardening, SDGs.

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I. INTRODUCTION

On the global market, spices are in high demand due to their powerful flavor, medicinal value, texture, and perfume. The increasing use of pepper in food and other products, such as pharmaceuticals and cosmetics, enhances the export potential of the leading pepper-producing nations. In terms of quantity and value, pepper represents a significant proportion of all spices exported. The plant is largely cultivated for its fruits, which are used as a spice, food flavoring, seasoning, fragrance, and condiment worldwide. It has been dubbed the "King of Spices" or "King of Medicinal Agents" due to its commercial and monetary importance in the global spices market [1] and pharmacological and neutraceutical application [2].

Just 3% of the world's arable land is used for organized spice farming, which covers 374 thousand hectares. In Sylhet, Habigonj, and Bogura districts, black pepper is grown in only around a 5-ha area producing only six metric tons annually [3]. Each year, Bangladesh imports more than 120,000 tons of black pepper, turmeric, and cinnamon, according to reports. The local demand for black pepper in Bangladesh is substantial [4]. Black pepper has been an important source of revenue for many farmers in Bangladesh, notably in the Sylhet region. In the majority of black pepper-producing nations, it is an essential smallholder crop for farmers' ability to improve their livelihood. There are many levels of cultivation, ranging from expansive home gardens to dense monoculture. Using black pepper, agroforests, and household gardens can become more resistant to climate change. Black pepper is cultivated naturally as part of an ecological farming strategy to supply safe, high-quality food while enhancing the soil's quality and health [5]. The production takes up little extra area, does not compete with other trees, and adds to livelihoods by offering a second, valuable source of income. Black pepper is a great agroforest plant since it grows well in the shade and thrives in humus-rich soils. Estimates indicate that the country's 16.7 million households occupy around 0.3 million hectares of land, which continues to rise as the population grows (BBS, 2018). Therefore, growing black pepper within an agroforestry framework offers great promise. In addition, the climate and soil conditions in the Sylhet region are ideal for the growth and development of black pepper. Due to a paucity of planting materials and post-planting mortality, black pepper can only be cultivated in the Sylhet area and Chittagong Hill tracts in Bangladesh [6]. Since the spices industry employs thousands of people, including local merchants, exporters, producers, and laborers, scientific techniques and processes for successfully marketing spices and related products will benefit a country's overall economic growth. Sadly, several circumstances have led to the demise of our spice industry. Farmers have adopted black pepper production, but their production technique is still backdated; in some cases, the production technique is still not under documentation where marketing channel is still unknown. This also shows that the production and marketing system is unexplored. In Jaintiapur, people are engaged in black pepper production in their homestead area from where they fulfill their spices requirement. But people are still lack of knowledge and information regarding plantation techniques that can broaden their productivity in a small area. Another factor is that the black pepper producer is encouraged to expand the production, but the prevalence of limitations hinders the enlargement of the scope. Climatic change is problematic that faced during production. The government and other agencies are exerting great effort to improve production and export, while manufacturers exert great effort to raise output and productivity. Bangladesh's spices are of the greatest quality. However, the spice industry is doomed.

Despite the fact that different researchers have documented various aspects of black pepper cultivation and production, a comprehensive study of agronomic factors such as production-related planting materials, plant spacing, pruning, plant supports, training, irrigation, weeding, nutrition, mulching, cropping system and harvesting are still lacking [1]. There is a scarcity of data on the effects of natural agricultural practices or modern production activities on black pepper farms, particularly in Sylhet.

There is very little research on black pepper-based homestead gardening for improving rural livelihood in Bangladesh. All of these considerations pushed the researcher to investigate the production methods, challenges, and future possibilities of pepper cultivation in Jaintiapur in the Sylhet area. This study will provide the researcher with an understanding of the baseline information regarding the pepper plantation and its development problems in Jaintiapur. The specific objectives of this study were to document the conventional gardening practices of black pepper at Jaintiapur upazila, to outline the beneficiary outputs that black pepper growers consider concerning black pepper production, to document the existing processing, marketing, and pricing of black pepper in the study area and finally to investigate the constraints and situational analysis (SWOT) of black pepper production in the homestead. The study would help by providing information on production activities that followed at Jaintiapur upazila and its potentiality assessment to be a future smart option for improving the livelihood status of farmers. This can help the policymakers focus more on this ground.

II. MATERIALS AND METHOD

A. Study Site:

The research was done in the Jaintiapur upazila which is located between latitudes 24°59' and 25°11' north and 92°03' and 92°14' east in the Sylhet district. The Indian state of Meghalaya surrounds it to the north, Kanaighat and Golapganj upazila to the south, Kanaighat upazila to the east, and Gowainghat and Sylhet Sadar upazilas to the west (Fig. 1). The survey study was conducted in Nijpat and Jaintiapur unions during August 2018 to July 2019. The baseline information is outlined in Table I.

B. Population and Sample

The population of the research consisted of directly and indirectly experienced peoples from the two selected unions. The sample for the research was selected at random from 35 respondents of each union. Consequently, the sample size was 70 repondents. The researcher conducted in-person interviews to obtain data for this study.

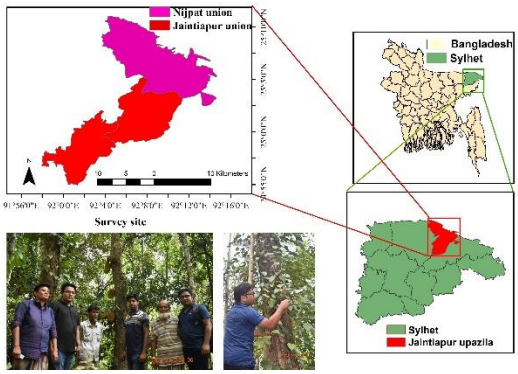

Fig. 1. Survey Site.

TABLE I: DEMOGRAPHY AND BASELINE INFORMATION OF JAINTIAPUR UPAZILA, SYLHET DISTRICT, BANGLADESH

Items	Area/Number
Area	263 m^2
Number of villages	182 no.
Total no. people	1,61,744 no.
Male	80769 no.
Female	80975 no.
Density	470 per m^2
Family no.	25,113
Tribal Family	349
Tea garden	06
Total land	25,880 Ha
Total agricultural land	17,883 Ha
Total uncultivable land	6546 Ha
Total Forest area	1,447 Ha

The interview schedule established by the researcher was utilized to collect data. Following the aims of the study in mind, a structured interview schedule was devised to collect pertinent data. There were both open-ended and closed-ended questions on the agenda of the interview questionnaire considering six aspects as Demographic features (age, education, homestead size, family size, annual family income), black pepper pre-plantation features (variety, seedling collection source, propagation method, seedling age, planting time, plant density per supporting plant, preferred pit size), post plantation information and activities (watering, nutrition supply, pruning, use of a fence, standards, the pattern of the garden, the occurrence of pest infestation, pesticide use), flowering and fruiting information (first flowering time, flowering month, fruit harvesting time, harvesting method, yield range), post harvesting information (processing, marketing channel, pricing), Valuation survey (beneficiary output, possible constraints, SWOT analysis). Prior to beginning the real data collection, a pilot test was conducted. The required adjustments, additions, alterations, and rearrangements were made in light of the pre-test experience. As a result, the interview schedule was created for usage at the end. A focus group discussion was conducted afterward to confirm the data. Through survey and FGD, a SWOT analysis of the black pepper producers' strengths, weaknesses, opportunities, and threats was conducted.

C. Statistical Analysis

In accordance with the study's goals, the collected data were examined. With the use of appropriate scoring procedures, qualitative data were transformed into quantitative data. Using Microsoft Excel, frequency counts, percentage age distributions, averages, standard deviations, and ranks were utilized to describe the data.

III. RESULT

A. Demographic Information

The age of the respondents ranged from 30–67 years, with an average of 50.54 years and a standard deviation of 11.05. The education level ranges from illiterate to class X, with an average of 4.29. The standard deviation belongs to the farmers' education was 2.57. The findings indicated that most farmers' education status was above the primary level in Jaintiapur upazila.

TABLE II: DEMOGRAPHIC INFORMATION OF THE RESPONDENTS

Characteristics	Unit of measurement	Observed range	Mean	Standard deviation
Age	Year	30-67	50.54	11.05
Education level	Year of schooling	0-10	4.29	2.57
Family size	Number	4-9	6.17	1.54
Homestead size	Hectare	0.3-1.8	0.91	0.38
Annual family income	Thousand Tk. Per month	11.5-28.0	20.27	5.60

The family size of the respondents ranges from 4 to 9 people, with a mean value of 6.17±1.54. The homestead size of the sample farmer ranged from 0.3–1.8 ha with an average of 0.91±0.38 ha. The annual family income of the sample farmer ranged from Tk. 11.5-28.0 thousand with an average of Tk. 20.27±5.60 thousand (Table II).

B. Farmers' Response Regarding Pre-Plantation Activities

Most of the farmers (100%) in the study area planted only Jainta black pepper-1, which is the only variety of black pepper in Bangladesh released by the Bangladesh Agricultural Research Institute (BARI), known as "Jainta black pepper-1." At Jaintiapur upazila, 57.14% of the farmers produce seedlings themselves, 37.14% collect black pepper seedlings from private nurseries, and only 5.71% collect black pepper seedlings from neighbors/or relatives (Table III).

Most farmers adopted the propagation mode of stem cuttings (94.29%), followed by rooted cuttings (5.71%). The seedling ages were found below one year (57.14%), while 34.29% of seedlings were in the one to two years age range. More than half of the farmers preferred planting time between July and August (54.29%), while only minors preferred planting time between May and June (31.43%). Most farmers (71.43%) opined that they transplanted 2-3 seedlings per supporting plant, and 20.00% of farmers practiced single saplings. In comparison, only 8.57% of farmers transplanted more than three seedlings per supporting plant in Jaintiapur upazila. The majority of owners 54.29% and 34.29% preferred pit sizes of 45×45×45 cm^3 and 65×65×65 cm^3, respectively (Table III).

TABLE III: FARMERS' RESPONDENTS REGARDING PRE-PLANTATION ACTIVITIES OF BLACK-PEPPER PRODUCTION

Pre-plantation features	Response	Respondents (%)
Varieties	Jainta Blackpepper-1	100
	Others	0
Seedling collection source	Private nursery	37.14
	Citrus Research Centre	0.00
	Self-production	57.14
	Neighbors/Relatives	5.71
	Others	0.00
Propagation mode	Seedling from Seed	0.00
	Stem cuttings	94.29
	Terminal shoot	0.00
	Rooted cuttings	5.71
Seedling Age	≤1 year	57.14
	1 year–2 years	34.29
	>2 years	8.57
Planting Time	January to February	0.00
	March to April	5.71
	May to June	31.43
	July to August	54.29
	September to October	8.57
	November to December	0.00
Plant density per supporting plant	<2	20.00
	2-3	71.43
	>3	8.57
Pit size (cm^3)	30×30×30	5.71
	45×45×45	54.29
	65×65×65	34.29
	>65×>65×65	5.71

C. Farmers' Response Regarding Plantation Activities

As a source of nutrition supply, most farmers (54.29%) used neither fertilizer nor manure in their black pepper garden for plant nutrient supplements, while 42.86% used only manure. Only 2.86% of farmers used fertilizer and manure in black pepper production at Jaintiapur upazila of Sylhet district (Fig. 2).

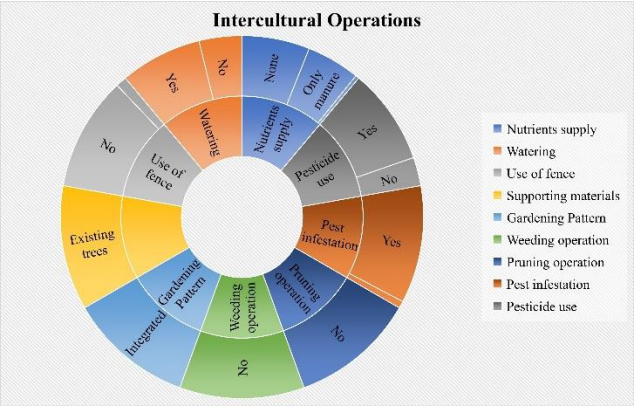

Fig. 2. Overall plantation or intercultural operations practiced in black pepper cultivation in Jaintiapur upazila.

About 65.71% of farmers reported that they practiced watering the black pepper plant during the dry season, while 34.29% did not practice watering. 91.43% of farmers did not practice using a fence as a protection measure, as almost all respondents (100%) had existing trees as supporting materials and followed the integrated pattern of gardening (100%). None of the farmers prefer weeding and pruning operation. 94.29% detected pest infestation in their black pepper cultivation area, and following the infestation, 77.14% opted for pesticide use. Farmers found to integrate supporting plants for greater productivity (Table IV).

TABLE IV: SUPPORTING PLANTS USED BY FARMERS FOR BLACK PEPPER CULTIVATION IN JAINTIAPUR UPAZILA

Plant species	Scientific name
Jackfruit	*Artocarpus heterophyllus*
Kuma	Local species
Tamarind	*Tamarindus indica*
Saitani	Local species
Mango	*Mangifera indica*
Coconut	*Cocos nucifera*
Date palm	*Phoenix dactylifera*
Tal	*Borassus flabellifer*
Betel nut	*Areca catechu*
Dewa	*Phaleria macrocarpa*
Erythrina	*Erythrina variegata*
Jiga	*Garuga pinnata*
Gliricidia	*Gliricidia sepium*

D. Flowering, Harvesting, and Post-Harvesting Activities

Most of the farmers (65.71%) opined that the black pepper plant took 3-4 years to first flower after planting, and 34.29% opined that it took 5-6 years (Table V). It also revealed that the black pepper plant took a maximum of 6 years after transplanting for the first flowering under the climatic condition of the study area. May to June month was reported by 91.43% of farmers as the pick flowering time of black pepper. Few farmers (8.57%) also reported July to August as the time of flowering of black pepper. Most farmers preferred fruit harvesting time (100%) from November-December. All the farmers (100%) reported that they practice the manual harvesting of black pepper through bamboo, climbing by using single pole ladders at Jaintiapur upazila. About 62.86% reported that two kg per plant yield was obtained, while 37.14% obtained a 3 kg yield per supporting plant.

E. Processing of black pepper

Standard methods of black pepper processing are important to ensure safe and quality products. The following flow chart shows different unit operations of standard processing of black pepper comprising threshing, blaching, drying, cleaning, grading, and packaging (Fig. 3) [6]. The research region reported using a traditional processing method that needed to be improved. In the research area, harvesting is supported by a single-pole bamboo ladder. Berries that are fully grown are gathered. If the berries are allowed to become overripe, there will be significant loss from berry drop and animal damage from birds and squirrels. Black pepper easily absorbs moisture from the air, which can lead to mold growth and bug infestation. Farmers used polybags as storage though they did not clean and grade their products (Fig. 4), which differed from standard processing flow (Fig. 3) as described by Dhas & Korikanthimath, 2003 [6].

TABLE V: FARMERS' RESPONSE REGARDING FLOWERING, FRUIT HARVESTING, AND POST-HARVEST ACTIVITIES

Activities	Response	No. of respondents	Respondents (%)
First flowering time after transplanting (years)	<3	0	0.00
	3-4	46	65.71
	5-6	24	34.29
	>6	0	0.00
Flowering Month	January to February	0	0
	March to April	0	0
	May to June	64	91.43
	July to August	6	8.57
Fruit harvesting time	January to February	0	0
	March to April	0	0.00
	May to June	0	0.00
	July to August	0	0.00
	September to October	0	0.00
	November to December	70	100
Harvesting method	Mechanically	0	0.00
	Manually	70	100.00
Yield range (Kg/plant)	1	0	0.00
	2	44	62.86
	3	26	37.14
	4	0	0.00

Fig. 3. Flow chart of standard processing of black pepper [7].

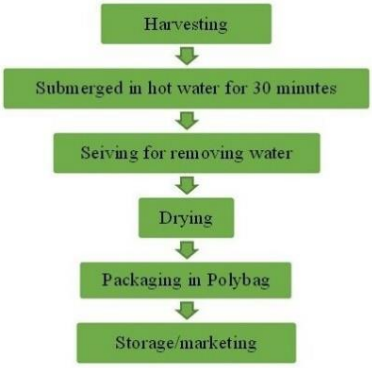

Fig 4. Flow chart of processing of black pepper practiced by farmers in Jaintiapur upazila.

F. Marketing Channel and Pricing

Commercial farmers followed the below (Fig. 5) marketing channel to reach the end products to end users or consumers. The prices of black pepper were reported as Tk. 650-700 per kg when products were sold directly by the producer to the consumer in the local market. In contrast, the price was Tk. 1220-1480 per kg in the retail market or supers-hops (average 1358 Tk/kg) in Sylhet. There is an enormous price gap (approximately 682.5 Tk/kg) between farmhouses and supper shops (Fig. 6).

TABLE VI: PRICE OF BLACK PEPPER IN THE FARMHOUSE AND SUPER SHOP AS PERCEIVED BY THE RESPONDENTS IN JAINTAPUR UPAZILA

Marketing place	Price (Tk/kg)
Farmhouse or producer	675.0±25.0
Super shop	1357.5±110.1
Price gap	~682.5

Poor communication and transport facilities often force small enterprises to sell their products through intermediaries. In this system, the middleman were the main beneficiaries, whereas producers and consumers were the losers.

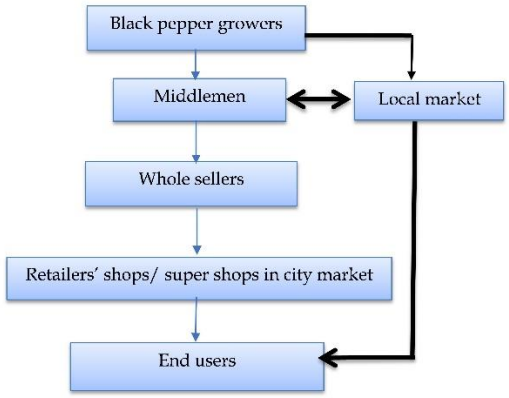

Fig. 5. Flowchart of the marketing channel of black pepper at Jaintiapur upazila.

G. Valuation Survey

About 77.14% acknowledged the medicinal value of black pepper for treating colds, coughs, indigestion, nervous disorder, constipation, pain, etc., and denied any health hazards (Fig. 7). Black pepper production was satisfactory, as respondents (88.57%) acknowledged its overall positive outcome. No health hazards were mentioned by the respondents (100%).

Fig. 6. Year-round retail price of black pepper at super shops in Sylhet.

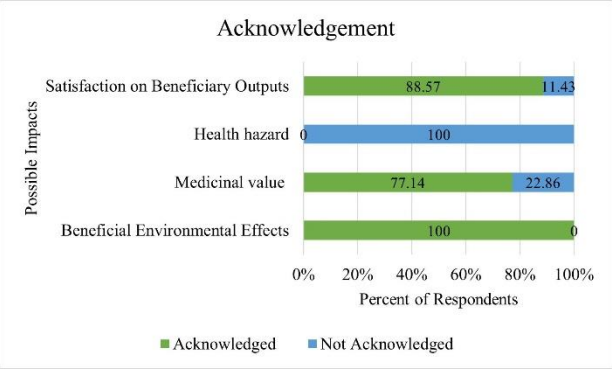

Fig. 7. Farmers' response to the beneficiary output of Black Pepper production.

A positive response from all of the respondents was recorded (Fig. 8) regarding the impact of black pepper contribution to environmental health comprising features of soil improvement (agreed by 97.14%), amenity increase (by 94.29%), oxygen releasing (by 85.71%) and carbon dioxide capturing (by 71.43%).

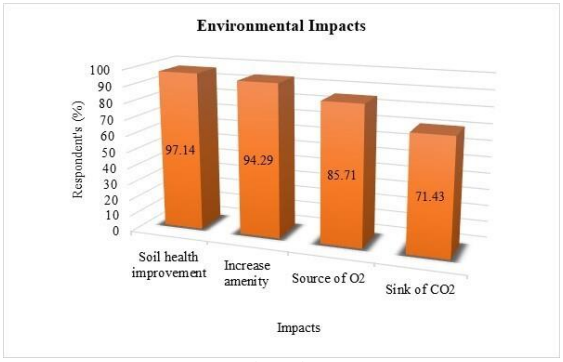

Fig. 8. Positive impact from farmer's perspectives.

Farmers outlined the possible constraints of black pepper production expansion where all respondents (100%) agreed that lack of accurate information hindered them from enhancing their scope and courage to commercialize the product. The majority (97.1%) opined that government support was somewhere lacking, followed by climate change (94.3%) due to variations in rainfall and temperature. Among the other constraints, respondents listed lack of quality planting materials (88.6%), using backdated technology (85.7%), outdated and non-transparent marketing facilities (71.4%), and insufficient capital for investment (62.9%) were major limitations of black pepper production (Fig. 9)

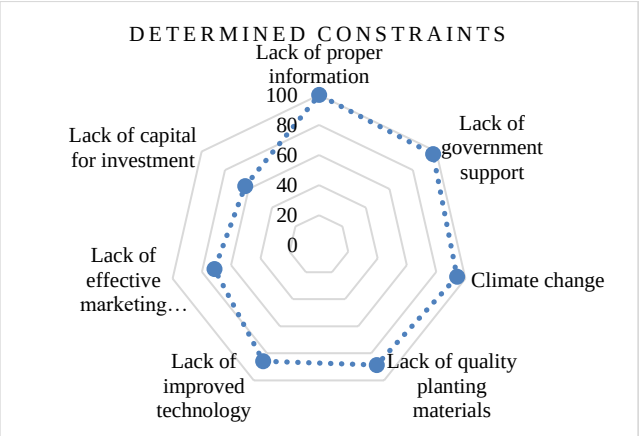

Fig. 9. Outlined constraints from farmer's perspectives for black pepper cultivation in Jaintiapur upazila.

H. SWOT Analysis of Black Pepper as an Enterprise

Based on farmers' perspectives, it was revealed that black pepper production had a huge opportunity as it comprises strengths of being a unique spice with high local demand. Another statement was that black pepper required low intensive care, which they favored cultivating quickly along with other agroforestry systems. They could recognize the beneficial environmental impact, including high value, medicinal value, and others. Farmers outlined that the prevailing constraints were the main factors responsible for black pepper production, which they mentioned as weaknesses. The unique weakness found after the focus group discussion was the lack of irrigation facilities in their homestead area. Again, respondents determined land scarcity, preference for monocropping agricultural production, climate change, pest infestation, and water scarcity as significant threats to black pepper production expansion. It was argued that the expansion area of black pepper cultivation is shrunk as growers possess a lack of knowledge regarding diseases and insects attacks and ways of management [8].

The majority were more willing to utilize their homestead area by cultivating vegetables for self-consumption. Hence, farmers pointed out the opportunities for black pepper integration at their homestead locality. The opportunities were increasing demand globally, generation of value-added products, and environmental amelioration in terms of soil health improvement, oxygen release, and carbon dioxide capture; organic production can encourage the worldwide demand. In terms of SDGs, farmers revealed that it could help food security by expanding commercial production. The livelihood improvement of women could be obtained through income generation opportunities from black pepper produce, as the homestead area is under the authority of females. Both males and females are involved in black pepper cultivation. Females are mainly responsible for the processing of black pepper. Males are mainly engaged in performing marketing, planting, applying manure, and harvesting black pepper. Hence females had the opportunity to be engaged in production activities that can fulfill the gap of gender equality. In the case of climate-smart components, facilitations, soil health improvement, amenity uplifting, and acting as a source of oxygen and sink of CO_2 are prominent features indicating that SDG of climate action is contributed by black pepper gardening in the homestead area. Thus, black pepper production directly or indirectly contributes to achieving SDGs (SDG1, SDG2, SDG3, SDG4, SDG13) (Fig. 10). Consequently, black pepper gardening becomes a significant approach to serving the framework of climate-smart agriculture tool while integrated with agroforest trees in the homestead territory as homestead agroforestry practices keep contributing to the productivity, mitigation and adaptation within the climate-smart agriculture framework [9].

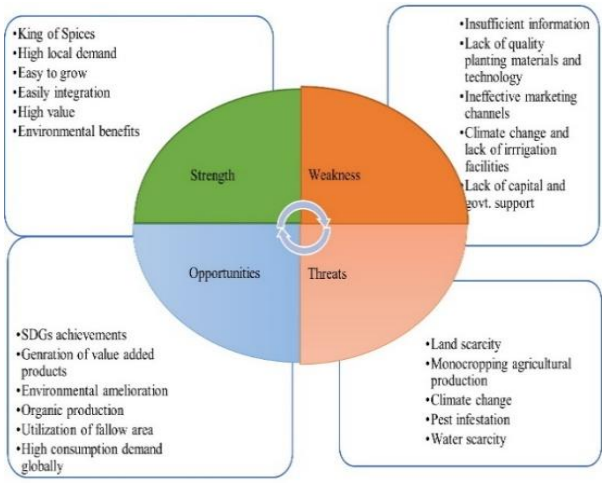

Fig. 10. SWOT analysis of black pepper from farmer's perspectives in Jaintiapur upazila.

IV. Discussion

The respondents had an average of four family members. The majority of responders have completed at least their primary education. In the research area, there were almost no landless farmers' organizations. Most respondents reported having black pepper gardening as a secondary source of income. The farmers receive their income from various sources, including small businesses, services, and agriculture. In this study, different conventional gardening practices of black pepper were documented. Most farmers (100%) in the study area were found to plant only Jaintia black pepper-1, the prominent variety of black pepper in Bangladesh released by Bangladesh Agricultural Research Institute (BARI) known as "Jaintia Golmorich." Farmers could get a good yield per plant by harvesting stems from mother plants with at least three nodes that were free of disease. Even though stem cuttings are the easiest and most economical method of vegetative multiplication, farmers find enhanced production difficult due to the high rate of seedling mortality [6], which demands improvement in production techniques. In order to produce disease-free, genetically stable, and genetically identical black pepper progeny throughout the year, an effective and reliable procedure is needed. Farmers follow conventional planting techniques and activities. Due to their poor success rates, the proliferation of soil-borne diseases, and low survival rates, traditional growing methods face considerable difficulties. But respondents of the Jaintiapur followed systematic pre-plantation, plantation, harvesting, and post-harvesting activities to keep the black pepper production upward. The major observation was that most farmers planted the black pepper seedling mainly in the rainy season, i.e., in July-August. Farmers avoided planting from December to February due to insufficient rainfall and soil moisture. Ripcord was used for controlling spiders and insects in response to managing pest infestations, such as spiders, rotting diseases, etc., during the winter season. On the other hand, the rotting disease was found in the black pepper garden, which was controlled by using Tilt. It means climatic variations led farmers to adopt controlling measures, and it also determined the flowering of plants as black pepper plants took a maximum of 6 years after transplanting for first flowering under the climatic condition of the study area. In the case of harvesting, farmers practiced a manual method of harvesting black pepper at Jaintiapur upazila. In this method, a single-pole bamboo ladder is used to support harvesting. As harvesting is done manually, cost-effectiveness prevailed in the study area. Different homestead tree species were reported as supporting plants for black pepper at Jaintiapur upazila. Typically, black pepper vines are cultivated by allowing them to climb on non-living supports (termed as standard) such as deadwood poles, teak poles, concrete posts, granite stones, brick constructions, and so on, or on living supports such as *Erythrina* spp., mango, jackfruit, coconut trees, and so on. Growers encountered various challenges, including a lack of living support, a high risk of disease on supports, and the eventual collapse of the vine. Because of non-living supports, such as concrete poles and granite stones, become hot in the summer and hurt black pepper vines, it necessitates early investments. Various trees have been reported to be used as supporting plants, including *Erythrina indica, Garuga pinnata, Erythrina lithosperma, Gliricidia maculate and Gliricidia sepium* [10]. Living supports are responsible for increasing productivity. Meanwhile, *Ailanthus malabarica* and *Garuga pinnata are* mentioned as the best-supporting plants [11]. Living standards are more expensive to purchase initially than non-living standards, such as reinforced granite pillars, concrete poles, and teak poles. Another way to grow black pepper is trellising [9], which is less successful. No weeding and pruning operations were reported in the study area. But pruning is essential for increasing or establishing vines of black pepper[1]. Weeds pose a significant obstacle to the production of black pepper [4]. Hence, respondents were frequently engaged in weeding operations. Considering weed management, cover crops can be raised to smother the weeds. Various organic materials and green leaves could be used as mulch. In the study area, watering was only done at the early stage of establishing black pepper. But irrigation is essential in the dry season to maximize the output. When pepper vines are irrigated from November or December until the end of March and stopped being irrigated until the end of the monsoon season, pepper yield is enhanced by 50% [13]. As a nutrition supplement, biofertilizers and vermicompost can enhance further productivity[13]. Nodes number per vine and vine length showed accelerated performance *P. nigrum* cutting treated with biochar [14].

The traditional processing technique of black pepper was reported in the study area. But modern harvesting and processing technology is required to produce quality pepper [15]. Nevertheless, a significant price gap of black pepper between the farmhouse and the super shop was reported in the study area. The respondents reported that mediators and retailers get more profit considerably from black pepper farming. This is due to the ineffective marketing system and the farmers' lack of market expertise and information. The farmers' dispersed distribution, meager financial standing, and small-scale operations provide significant marketing challenges. Marketing challenges also severely hampered the development of businesses like black pepper cultivation. Trading is more profitable for intermediaries than original growers because of highly segregated marketplaces and uneven bargaining power between buyers and sellers. When questioned about their concerns with black pepper, the

respondents mentioned a variety of things, but the most frequently mentioned were the lack of correct information, government support, soil moisture during the dry season, and high-quality planting supplies. One of the biggest issues black pepper growers confront is the shortage of readily available planting material [16]. Homestead area utilization can enrich black pepper gardening as the appropriate utilization of homestead areas facilitates large-scale production through the appropriate utilization of marginal areas [17]. Thus, SDGs could be achieved by introducing a black pepper garden within the homestead boundary.

V. Conclusion

Jaintiapur upazila has built a black pepper-based homestead agroforestry system, notwithstanding the need for further development in the study area. Farmers in the research area reported no other varieties than Jaintia gol morich. It is necessary to introduce additional high-yielding varieties. Precision agriculture needs to standardize area-specific production packages for black pepper, as the technology used in one region may not be suitable for another region. Even though numerous popular cultivars are cultivated, just a few produces consistently high yields. There is a shortage of knowledge regarding cultivars suited to a certain region. To fulfill the demand for high-quality planting material, it is essential to disseminate speedy multiplication of black pepper. Research is required to streamline the process at the farm level. There is a dearth of information regarding the necessity for multicultural management strategies, intense care in various places, and drought management challenges. To manufacture black pepper, a clear marketing infrastructure must exist between the producer and consumer. The government must prioritize pepper quality since failure can affect the global market success of pepper products. The research is restricted to a certain region of Jaintiapur. Additional research should be performed to evaluate the production procedures and the benefits, drawbacks, possibilities, and risks involved with black pepper production. Thus, black pepper can contribute profoundly to the achievement of Sustainable Development Goals (e.g., SDG 1,2,3,5 and 13).

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Conflict of Interest

The authors declare that they do not have any conflict of interest.

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