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Farmers’ Perceptions and Knowledge of Country Bean (*Lablab purpureus* L.) Insect Pests, and Diseases, and Their Management Practices, in Bangladesh

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Abstract: Country bean (*Lablab purpureus* L.), a popular vegetable in Bangladesh, is severely affected by insect pests and diseases. Farmers’ perceptions of insect pests, diseases, and their management are critical constraints to the establishment of an effective and sustainable pest management approach for this crop. A comprehensive survey was conducted with 300 country bean farmers from six districts of Bangladesh to assess farmers’ perceptions and knowledge of the insect pests and diseases of country bean, and their management practices. The survey results show that country bean farmers have been facing varying pest problems for more than ten years. They could identify eight pests and only one beneficial insect species in their fields, including thrips and jute weevil, as new pests. Among the pests, aphids and pod borers were common in all surveyed areas. More than 80% of farmers said their bean plants were severely affected by *bean yellow mosaic virus* and white mold diseases. Farmers also mentioned that insect pests and diseases together caused 30–40% yield losses of this crop. About 76% of the farmers solely depended on different chemical pesticides for the production of country bean. Growers frequently used insecticides from the organophosphorus and neonicotinoid groups, and fungicides from the triazole group, to manage pests associated with this crop. Farmers start applying pesticides from the seedling stages, at three-day intervals, maintaining only two- to four-day pre-harvest intervals (PHI). Our findings provide insight into the importance of developing sustainable pest management approaches for country bean production in Bangladesh.

Keywords: *Lablab purpureus* L.; insect pests; diseases; Bangladesh; pesticides

1. Introduction

Country bean (*Lablab purpureus* L.), which belongs to the Leguminosae family and is popularly known as “Sheem”, is a common and popular vegetable in Bangladesh, grown mainly during the winter (Rabi) season, and more recently also in the summer (Kharif) [1]. Bangladesh’s overall land area under bean cultivation is 61,628 acres, with a production of 169,735 metric tons in 2019–2020 [2]. Almost every household grows country beans in their homestead [3–6]. It is cultivated all over the country; however, the major growing areas are Dhaka, Cumilla, Noakhali, Chattogram, Bogura, Pabna, Jessore, Gazipur, Habiganj, and Sylhet [7,8].

In Bangladesh, seven types of vegetables occupy 56% of the total cultivated area, and the country bean is one of the most important of these vegetables [9]. Country bean is considered a cheap and readily available source of protein, and it is in high demand. It is a nutritious vegetable and an income-generating crop, which is also grown for fodder and as a cover crop [10]. The green pod of the country bean contains approximately 5%
protein, 0.1% fat, 0.75% lipids, 4.11% ash, and 10% carbohydrates. In addition, bean pods provide vitamins (vit A, vit C, riboflavin, thiamine), and different minerals, i.e., magnesium, calcium, phosphorous, potassium, iron, sulfur, and sodium [11,12]. The pharmacological studies of country bean have shown that it has antifungal, antidiabetic, anti-inflammatory, analgesic, antioxidant, cytotoxic, hypolipidemic, antimicrobial, insecticidal, hepatoprotective, antilithiatic, and antispasmodic effects [13,14]. Moreover, it is also used for iron deficiency and anemia treatment [15].

Country bean also has potential in overseas markets, with a new horizon for the export of this vegetable emerging in recent times [16]. It is one of the main exportable vegetables of Bangladesh, and the farmers have been encouraged to focus on its production [7]. A report from the state-run Export Promotion Bureau (EPB) stated that exports of vegetables such as cabbage, country bean, brinjal, cabbage and potatoes combined contributed USD 128 million in the fiscal year 2020 [17]. During the 2005–2006 fiscal year, Bangladesh earned 22 million Bangladeshi Taka (BDT) by exporting country bean to other countries [18].

Despite being an important crop, the production of country bean in Bangladesh has dramatically reduced due to insect pests and diseases [19,20]. Approximately 55 species of insect pests and mites attack country bean from the seedling stage to harvest [21]. Among the insect pests, aphids, bean bugs, green semiloopers, hooded hoppers, leaf miners, leaf weevils, pod borers, shoot borers, shoot weevils, epilachna beetles and mitesly cause significant economic damage to country bean production [22]. Microbial infection also causes damage to this crop to an extent [23]. Country bean plants are susceptible to a variety of fungal and viral diseases, which are the main reasons for the poor production of country bean in Bangladesh [24]. Viral disease can cause up to 100% yield losses of country bean [25,26]. Akhter et al. [27] reported that insects are the main vector of viral diseases in horticultural crops, including beans.

Farmers prefer chemical pesticides over other management techniques because of their effectiveness, availability, and cost-effectiveness [28,29]. The indiscriminate use of pesticides has harmful effects on the environment, and also causes significant damage to terrestrial biodiversity [30]. It also affects production efficiency by increasing production costs and reducing net returns from vegetable cultivation [31]. During the rainy season, excessive pesticides are washed away through rain water and contaminate rivers, ponds, and water reservoirs, annihilating the aquatic biodiversity [32]. Therefore, efforts are required to develop an Integrated Pest Management (IPM) technique that is eco-friendly, socially and economically viable, and compatible with diverse cropping systems. However, the lack of information regarding farmers’ knowledge, and their perception of pests and their management, is the main constraint in implementing sustainable management technology [33]. The evaluation of farmers’ basic socio-demographic status, knowledge and perceptions, and pest management practices is a prerequisite for establishing sustainable pest management technology [34].

In Bangladesh, inclusive baseline information is necessary for developing the sustainable management of country bean insect pests and diseases; however, very few comprehensive studies have been conducted to explore farmers’ perceptions of country bean insect pests and diseases, and their management practices. We hypothesized that country bean growers do not have proper knowledge for the identification of pests and beneficial arthropods, as well as the IPM of country bean. Therefore, the present study aimed to investigate farmers’ perceptions and knowledge of the insect pests and diseases of country bean, and their current management practices, in major country bean-producing districts of Bangladesh.
2. Materials and Methods

2.1. Sites Selection

We conducted a survey in 2020 to 2021 to generate baseline information on the insect pests and disease status of country bean and their current management practices in Bangladesh. We selected six of Bangladesh’s most significant country bean-producing upazilas (sub-districts) randomly from six districts to complete the survey. These were Sherpur upazila of the Bogura district, Ishwardi upazila of the Pabna district, Jashore Sadar upazila of the Jashore district, Kaliganj upazila of the Gazipur district, Nabiganj upazila of the Habiganj district, and Golapganj upazila of the Sylhet district (Figure 1).

![Country bean (Lablab purpureus L.) Survey areas of Bangladesh 2020-2021](image)

Figure 1. Surveyed upazilas (sub-districts) across six districts of Bangladesh during 2020–2021.

2.2. Data Collection

We collected data through face-to-face interviews with farmers, following a pre-designed open and close-ended questionnaire. This semi-structured questionnaire was prepared for the survey to collect information about the insect pests and diseases of country bean and their management practices. The questionnaire included socio-demographic data such as age, gender, educational level, and farm size, as well as information on country bean cultivation area, farmers’ perception of insect pests and diseases of country bean, and management actions performed to manage the insect pests and diseases. We also provided the farmers with printed laminated photographs of insect pests.
and diseases for clarification. The photographs were shown to the respondents to rank the insect pests and diseases according to the damage they observed in their country bean fields. To select the farmers from the six upazilas, we used the following equation to determine the total number of respondents:

\[ n = \frac{N}{1 + N \varepsilon^2} \]  

where

- \( n \) is the sample size;
- \( N \) is the total number of farmers in each area;
- \( \varepsilon \) is the design margin of error [35].

With a designed number of errors of 6%, a total of 300 farmers, i.e., 50 farmers from each upazila, were interviewed with the assistance of the Sub Assistant Agriculture Officers (SAAOs) of the respective upazilas.

2.3. Data Analysis

All the recorded data from the questionnaire were encoded, imported to a spreadsheet, and checked for data consistency. Data were analyzed by descriptive statistics (means, standard deviation, frequencies and percentages) using SPSS (Version 26, IBM Corporation, Armonk, NY, USA) and R (Version 4.0.3, R Core Team 2020. Vienna, Austria). R packages were used for data visualization [36].

3. Results

3.1. Socio-Demographic Status and Country Bean Cultivation Practices of the Farmers of Six Surveyed Upazilas of Bangladesh

We recorded the socio-demographic characteristics (gender, age, educational level, land type, and country bean cultivation experience) of 300 bean farmers from six upazilas to obtain information regarding their personal and professional lives. The majority of the farmers were male (87%), and 37% of the farmers were in the mid-age group of 31–45 years, followed by 34% aged 46–60 years, with a diversity of educational levels (Table 1). The study showed that nearly one-fourth (24%) of the farmers were able to sign only. The study found that graduates (6%) were also involved in country bean cultivation. The study showed that 67% of farmers had their own land for country bean cultivation, and 32.7% of farmers had 6–10 years of country bean cultivation experience, while 15.3% of farmers had more than 20 years of experience in country bean cultivation, whereas about one-fifth (20%) had 1–5 years of cultivation experience (Table 1). According to this study, approximately 51.33% of country bean farmers were marginal farmers, and they had an average of 0.15 ha of land for country bean cultivation (Table 2).
Table 1. Socio-demographic status of the country bean farmers from six surveyed upazilas (sub-districts) viz. Sherpur of the Bogura district, Ishwardi of the Pabna district, Jashore Sadar of the Jashore district, Kaliganj of the Gazipur district, Nabiganj of the Habiganj district and Golapganj of the Sylhet district of Bangladesh (N = 300).

| Factor                        | Category | Frequency | % of Total Farmers | Mean   | SD    |
|-------------------------------|----------|-----------|--------------------|--------|-------|
| **Age (years)**               |          |           |                    |        |       |
| 15–30                         | 56       | 18        | 25.07              | 3.80   |       |
| 31–45                         | 110      | 37        | 38.60              | 4.27   |       |
| 46–60                         | 101      | 34        | 53.27              | 4.16   |       |
| >60                           | 33       | 11        | 68.36              | 5.09   |       |
| **Gender**                    |          |           |                    |        |       |
| Male                          | 261      | 87        | -                  | -      | -     |
| Female                        | 39       | 13        | -                  | -      | -     |
| **Education level**           |          |           |                    |        |       |
| Illiterate                    | 60       | 20        | -                  | -      | -     |
| Only Signature                | 72       | 24        | -                  | -      | -     |
| Class 1–5                     | 51       | 17        | -                  | -      | -     |
| Class 6–9                     | 51       | 17        | -                  | -      | -     |
| SSC                           | 33       | 11        | -                  | -      | -     |
| HSC                           | 15       | 5         | -                  | -      | -     |
| Graduate                      | 18       | 6         | -                  | -      | -     |
| **Land type**                 |          |           |                    |        |       |
| Own                           | 200      | 67        | -                  | -      | -     |
| Lease                         | 46       | 15        | -                  | -      | -     |
| Borga (Tenant)                | 54       | 18        | -                  | -      | -     |
| **Household size**            |          |           |                    | 5.58   | 1.91  |
| **Experience in country bean**|          |           |                    |        |       |
| cultivation (years)           |          |           |                    |        |       |
| 1–5                           | 58       | 19.3      | 3.28               | 1.44   |       |
| 6–10                          | 98       | 32.7      | 8.64               | 1.38   |       |
| 11–15                         | 52       | 17.3      | 13.83              | 1.45   |       |
| 16–20                         | 46       | 15.3      | 19.24              | 1.39   |       |
| >20                           | 46       | 15.3      | 32.54              | 9.43   |       |

SSC = Secondary School Certificate; HSC = Higher Secondary Certificate; SD = Standard Deviation.

Farmers used to cultivate a wide range of country bean varieties. In Sherpur upazila of the Bogura district, farmers grew Beguni, Irri, Choita, BARI sheem 1, BARI sheem 2, BARI sheem 3, and Chinese verities. The Rupban variety was the most popular and profitable variety in Ishwardi upazila of the Pabna district and Jashore Sadar upazila of the Jashore district. On the other hand, Motor, Katimaiya, BARI sheem 6, IPSHA 1, and IPSHA 2 were the most cultivable country bean varieties in Kaliganj upazila of the Gazipur district. Katimaiya and Puti were the most cultivable variety of Nabiganj upazila of the Habiganj district. Farmers of Nabiganj upazila also preferred Aishna and Kaikka varieties. In Golapganj upazila of the Sylhet district, most farmers chose the local Goyalgadda variety because of its export quality (Table 3). Regardless of the country bean varieties, the yield varied from one upazila to another.
Table 2. Farm size and proportion of land used for cultivating country bean by the farmers from six surveyed upazilas (sub-districts) viz. Sherpur of the Bogura district, Ishwardi of the Pabna district, Jashore Sadar of the Jashore district, Kaliganj of the Gazipur district, Nabiganj of the Habiganj district and Golapganj of the Sylhet district in different farm categories of Bangladesh (N = 300).

| Farm Category | Frequency | Percentage (%) | Mean Total Land Holdings (ha.) | SD | Mean Land Used for Country Bean Cultivation (ha.) | SD |
|---------------|-----------|----------------|-------------------------------|----|-----------------------------------------------|----|
| Large (>2)    | 12        | 4.00           | 3.08                          | 0.89 | 0.58                                          | 1.17 |
| Medium (1.01–2.0) | 44      | 14.67          | 1.46                          | 0.35 | 0.40                                          | 0.09 |
| Small (0.51–1.00) | 90      | 30.00          | 0.68                          | 0.13 | 0.21                                          | 0.34 |
| Marginal (<0.50) | 154     | 51.33          | 0.29                          | 0.12 | 0.15                                          | 0.13 |

SD = Standard Deviation.

Table 3. Country bean varieties cultivated in six surveyed upazilas (sub-districts) of Bangladesh (N = 300).

| Sherpur | Ishwardi | Jashore Sadar | Kaliganj | Nabiganj | Golapganj |
|---------|----------|---------------|----------|----------|-----------|
| Beguni  | Chocolate| Rupban        | Motor    | Katimaiya| Goalgadda |
| Irri    | Hatikani | Katimaiya     | Katimaiya| Puti     | Aishna    |
| Choita  | Kakoli   | Katimaiya     | BARI sheem 6 | Aishna | Puti      |
| BARI sheem1 | Auto | Rahim | IPSHA 1 | Kaikka | Goalgadda |
| BARI sheem2 | Kanchon | BARI sheem 6 | IPSHA 2 |          |           |
| BARI sheem3 | Rupban |              |          |          |           |

The results show that the average yield in the Sherpur district was 12.74 ton per ha. Among the upazilas, the highest average yield was found in Jashore Sadar upazila, at 17.96 ton per ha, and the lowest average yield was in Kaliganj upazila, at 9.13 ton per ha. The average yields of Ishwardi, Nabiganj, and Golapganj upazilas were 15.60, 12.29, and 10.50 ton per ha, respectively (Figure 2).

Figure 2. Average yield of country bean in the six surveyed upazilas (sub-districts) of Bangladesh.

3.2. Farmers’ Observations of Insect Pests and Diseases of Country Bean in Six Surveyed Upazilas of Bangladesh

Bangladeshi farmers have been facing insect pest problems in country bean for several years. Among the farmers, 41% reported facing the issue for more than 10 years. One-
fifth (20.3%) and nearly one-fourth (23%) of the farmers reported experiencing this problem for 5 and 3 years, respectively (Figure 3).

Figure 3. Farmers’ observations of insect pest problems in the six surveyed upazilas (sub-districts) viz. Sherpur of the Bogura district, Ishwardi of the Pabna district, Jashore Sadar of the Jashore district, Kaliganj of the Gazipur district, Nabiganj of the Habiganj district, and Golapganj of the Sylhet district of Bangladesh.

The survey results show that the major country bean insect pests are aphids (*Aphis* spp.), pod borers (*Maruca* spp.), green semiloopers (*Plusia signata* Fab.), field crickets (*Brachytrypes* spp.), bean bugs (*Coptosoma cribratium*), thrips (*Magalurothrips usitatus*), and jute weevils (*Apion corchori*) (Table 4). According to farmers, among the insect pests, aphids and pod borers were the most destructive in all upazilas. More than 90% of farmers from each upazila observed aphids and pod borers in their fields. Bean bugs were the least observed insect pest, observed only in Sherpur, Ishwardi and Jashore Sadar upazila. Very few farmers observed ladybird beetles (*Coccinella* spp.), green semiloopers, and field crickets in their country bean fields. Our data reveal that about 73% and 48% of the farmers of Jashore Sadar upazila noticed thrips and jute weevils, respectively, in their country bean fields for the first time (Table 4).
Table 4. Farmers’ observations of major insect pests of country bean in the six surveyed upazilas (sub-districts) of Bangladesh (N = 300).

| Insect Pests     | Scientific Name       | Family          | Order     | Sherpur | Ishwardi | Jashore | Sadar | Kaliganj | Nabiganj | Golapganj | Mean | SD  |
|------------------|-----------------------|-----------------|-----------|---------|----------|---------|-------|----------|----------|-----------|-------|-----|
| **Harmful Insects** |                       |                 |           |         |          |         |       |          |          |           |       |     |
| Aphid            | Aphis spp.            | Aphididae       | Homoptera | 100     | 100      | 100     | 96    | 100      | 98       | 99.00     | 1.67  |     |
| Pod borer        | Maruca spp.           | Crambidae       | Lepidoptera | 96      | 100      | 90     | 92    | 98       | 98       | 95.67     | 3.88  |     |
| Green semilooper | Plusia signata Fab.   | Pyralidae       | Lepidoptera | 38      | 66       | 54     | 56    | 32       | -        | 98.67     | 13.90 | 0   |
| Field cricket    | Brachytrypes spp.     | Gryllinae       | Orthoptera | 28      | 34       | -      | 6     | 16       | 26       | 22.00     | 11.0  | 5   |
| Bean bug         | Coptosoma cribilatium | Plastapidae     | Hemiptera | 2       | 4        | 2      | -     | -        | -        | 2.67      | 1.15  |     |
| Thrips           | Magalurthrips usitatus| Thripidae       | Thysanoptera | -      | -        | 73     | -     | -        | -        | 73.00     | -     |     |
| Jute weevil      | Apion corchori        | Apionidae       | Coleoptera | -      | -        | 48     | -     | -        | -        | 48.00     | -     |     |
| **Beneficial Insect** |                   |                 |           |         |          |         |       |          |          |           |       |     |
| Ladybird beetle  | Coccinella spp.       | Coccinellidae   | Coleoptera | 20      | 8        | 10     | 6     | 20       | 22       | 14.33     | 7.09  |     |

SD = Standard Deviation.

Bean farmers of different areas of Bangladesh observed various viral and fungal diseases on country bean as well. The viral diseases included bean common mosaic virus (BCMV) and bean yellow mosaic virus (BYMV), while fungal diseases included anthracnose (Colletotrichum lindemuthianum), rust (Uromyces fabae), white mold (Sclerotinia sclerotiorum), and cercospora leaf spot (Cercospora cruenta) (Table 5). The survey results reveal that BYMV and white mold were the most observed diseases. Rust and BCMV were the least recorded diseases. More than two-thirds of farmers (72–86%) from all upazilas observed anthracnose in their country bean fields. Additionally, more than 50% of farmers from Sherpur, Ishwardi, Jashore Sadar, and Kaliganj upazila observed cercospora leaf spot in their fields (Table 5).

Table 5. Farmers’ perceptions of the major diseases of country bean in the six surveyed upazilas (sub-districts) of Bangladesh (N = 300).

| Disease Name       | Causal Organisms              | % Respondents in Different Study Areas | Sherpur | Ishwardi | Jashore | Sadar | Kaliganj | Nabiganj | Golapganj | Mean | SD  |
|--------------------|--------------------------------|----------------------------------------|---------|----------|---------|-------|----------|----------|-----------|-------|-----|
| **Viral Diseases** |                                |                                        |         |          |         |       |          |          |           |       |     |
| Common Mosaic      | Bean Common Mosaic Virus (BCMV) |                                        | 48      | 50       | 24      | 36    | 10       | 30       | 33        | 15.11 |     |
| Yellow Mosaic      | Bean Yellow Mosaic Virus (BYMV) |                                        | 98      | 100      | 96      | 100   | 100      | 98       | 98.67     | 1.63  |     |
| **Fungal Diseases**|                                |                                        |         |          |         |       |          |          |           |       |     |
| Rust               | Uromyces fabae                |                                        | 38      | 12       | 22      | 18    | 8        | 10       | 18        | 11.10 |     |
| White mold         | Sclerotinia sclerotiorum      |                                        | 80      | 100      | 96      | 52    | 86       | 98       | 85.33     | 18.05 |     |
| Anthracnose        | Colletotrichum lindemuthianum |                                        | 72      | 74       | 56      | 86    | 72       | 78       | 73        | 9.86  |     |
| Cercospora leaf spot| Cercospora cruenta             |                                        | 54      | 76       | 62      | 54    | 38       | 24       | 51.33     | 18.23 |     |

SD = Standard Deviation.

Farmers from the surveyed upazilas have been facing yield losses for several years due to insect pests and diseases (Figure 4). The results show that about 31.8% of farmers faced 30–39% yield losses due to insect infestation and 23.1% said that they experienced 40–49% yield losses due to insect pests. Moreover, 13.7% said that the insects could cause
more than 50% yield losses. On the other hand, 31% of the farmers stated that they faced 40–49% yield losses due to disease. Approximately 28.3% of the farmers mentioned that disease could half the total yield. A total of 18%, 12.7%, and 2.7% faced 30–39%, 10–19%, and less than 10% yield losses, respectively, due to disease (Figure 4).

Figure 4. Farmers’ perceptions of yield loss of country bean due to insect pests and diseases of six surveyed upazilas (sub-districts) viz. Sherpur of the Bogura district, Ishwardi of the Pabna district, Jashore Sadar of the Jashore district, Kaliganj of the Gazipur district, Nabiganj of the Habiganj district and Golapganj of the Sylhet district of Bangladesh.

3.3. Management Practices against Country Bean Insect Pests and Diseases Followed by the Farmers of Six Surveyed Upazilas of Bangladesh

The surveyed farmers used chemical and non-chemical methods for physical and mechanical control to manage insect pests and diseases of country bean (Figure 5). The results reveal that chemical methods were more popular than any other methods; 76.3% of the farmers solely depended on chemical pesticides, while 20.4% of farmers used both chemical and non-chemical methods. A negligible number of farmers (4.3%) used non-chemical methods for pest management (Figure 5). The farmers applied a wide range of insecticides and fungicides belonging to different groups (Table 6). Neonicotinoid, organophosphorus, phenyl pyrazole, and synthetic pyrethroid were popular insecticide groups for insect pest control, while dicarboximide, ethylene-bis-di-thio-carbamate, strobilurins, and triazoles were popular fungicide groups to manage diseases of country bean. Under the WHO pesticide classification, most of the pesticides belong to the moderately hazardous class (II), with no acute hazardous class (U) substances reported (Table 6). Most of the farmers from these upazilas applied pesticides more than four times in a single country bean cropping season (Table 7). Surprisingly, during the survey, some of the farmers reported that they applied pesticides about 30–40 times (data not shown in the table or graph) in a single country bean cropping season.
Figure 5. Management of insect pests and diseases by farmers from six surveyed upazilas (sub-districts) of Bangladesh.

Table 6. List of commonly used pesticides in six country bean-growing upazilas (sub-districts) of Bangladesh (N = 300).

| Upazila (s) (Sub-Districts) | Group Name              | Common Name          | Types      | WHO Class (GHS) |
|-----------------------------|-------------------------|----------------------|------------|-----------------|
| Sherpur                     | Benimidazole            | Carbendazim          | Fungicide  | U (5)           |
|                             | Carbamate               | Emamectin Benzoate   | Insecticide| II (3)          |
|                             |                        | Cartap               | Insecticide| II (4)          |
|                             | Ethylenebisdithiocarbamates | Mancozeb         | Fungicide  | U (5)           |
|                             | Neonicotinoid           | Thiamethoxam         | Insecticide| II (4)          |
|                             |                         | Chlorpyrifos         | Insecticide| II (3)          |
|                             |                         | Dimethoate           | Insecticide| II (3)          |
|                             | Organophosphorous       | Fenitrothion         | Insecticide| II (4)          |
|                             |                         | Quinalphos           | Insecticide| II (3)          |
|                             | Phenylpyrazole          | Fipronil             | Insecticide| II (3)          |
|                             | Strobilurins            | Azoxyostrobin        | Fungicide  | U (5)           |
|                             | Synthethic Pyrethroid   | Lambda Cyhalothrin   | Insecticide| II (3)          |
|                             |                         | Hexaconazole         | Fungicide  | III (5)         |
|                             | Triazoles               | Propiconazole        | Insecticide| II (4)          |
|                             |                         | Tebuconazole         | Insecticide| II (4)          |
|                             | Carbamate               | Emamectin Benzoate   | Insecticide| II (3)          |
|                             | Dicarboximide           | Iprodione            | Fungicide  | III (5)         |
|                             | Ethylenebisdithiocarbamates | Mancozeb         | Fungicide  | U (5)           |
| Ishwardi                    | Neonicotinoid           | Thiamethoxam         | Insecticide| II (4)          |
|                             | Organophosphorous       | Chlorpyrphos         | Insecticide| II (3)          |
|                             | Triazoles               | Tebuconazole         | Fungicide  | II (4)          |
|                             | Carbamate               | Carbofuran           | Insecticide| Ib (2)          |
|                             | Ethylenebisdithiocarbamates | Mancozeb         | Fungicide  | U (5)           |
|                             | Neonicotinoid           | Thiamethoxam         | Insecticide| II (4)          |
| Jashore Sadar              | Organophosphorous       | Chlorpyrphos         | Insecticide| II (3)          |
|                             | Strobilurins            | Azoxyostrobin        | Fungicide  | U (5)           |
|                             | Synthetic Pyrethroid    | Beta Cypermethrin (2%) | Insecticide| II (3)          |
| Ia = Extremely hazardous; Ib = Highly hazardous; II = Moderately hazardous; III = Slightly hazardous; U = Unlikely to present acute hazard; GHS = Globally Harmonized System of Classification and Labeling of Chemicals. |

**Table 7.** Frequency of pesticide application to control insect pests and diseases of country bean in six surveyed upazilas (sub-districts) of Bangladesh (N = 300).

| Frequency of Pesticide Application | Sherpur | Ishwardi | Jashore Sadar | Kaliganj | Nabiganj | Golapganj |
|-----------------------------------|---------|----------|---------------|----------|----------|-----------|
| Once                              | -       | -        | -             | 4.2      | -        | -         |
| Twice                             | -       | -        | -             | -        | -        | -         |
| Thrice                            | -       | -        | 2.1           | -        | -        | -         |
| Four times                        | -       | 8        | 8.3           | -        | 16       |           |
| >Four times                       | 100     | 92       | 100           | 85.4     | 100      | 84        |
The results demonstrate that most of the farmers started pesticide application at the flowering stage of the country bean. Almost half of the farmers said they begin to apply pesticides at the flowering stage (Figure 6). About 40% of the farmers began pesticide application at the vegetative stage, while around 30% of the farmers started the application at the seedling stage of the country bean (Figure 6). Approximately 50% of farmers used pesticides three days apart. Nearly 40% of the farmers applied them at seven-day intervals, and 5% of farmers sprayed pesticides at intervals of fifteen days (Figure 7).

Figure 6. Stages of country bean when farmers started pesticide application in six surveyed upazilas (sub-districts) viz. Sherpur of the Bogura district, Ishwardi of the Pabna district, Jashore Sadar of the Jashore district, Kaliganj of the Gazipur district, Nabiganj of the Habiganj district and Golapganj of the Sylhet district of Bangladesh.

Figure 7. Interval of pesticide application for insect pests and disease control in six surveyed upazilas (sub-districts) viz. Sherpur of the Bogura district, Ishwardi of the Pabna district, Jashore Sadar of the Jashore district, Kaliganj of the Gazipur district, Nabiganj of the Habiganj district and Golapganj of the Sylhet district of Bangladesh.

The data show that about 40% of farmers had a pre-harvest interval (PHI) of 2–3 days (Figure 8), while 15% of farmers harvested country bean the day after pesticide application, and 20% of farmers had PHIs of 4–5 days. It is a matter of concern that less than 5% of farmers maintained a PHI of more than 10 days (Figure 8). The results also reveal that
the cost of pesticides (more than BDT 13,000) in Sherpur, Jashore Sadar, and Kaliganj upazilas was comparatively higher than in the other upazilas (Table 8).

![Figure 8](image)

Figure 8. Pre-harvest interval (PHI) followed by farmers in six surveyed upazilas (sub-districts) viz. Sherpur of the Bogura district, Ishwardi of the Pabna district, Jashore Sadar of the Jashore district, Kaliganj of the Gazipur district, Nabiganj of the Habiganj district and Golapganj of the Sylhet district of Bangladesh.

| Upazila (s)   | Mean Pesticide Cost (BDT/ha) | SD     |
|---------------|------------------------------|--------|
| Sherpur       | 13841                        | 107.70 |
| Ishwardi      | 12482                        | 125.57 |
| Jashore Sadar | 13602                        | 180.24 |
| Kaliganj      | 13132                        | 89.18  |
| Nabiganj      | 11249                        | 200.68 |
| Golapganj     | 11900                        | 151.97 |

SD = Standard Deviation.

Unfortunately, the survey results clearly show that the farmers lag far behind in training facilities. The training status of farmers in country bean pest management was not up to the mark (Figure 9). Only 17% of farmers had received training on country bean pest management (Figure 9). According to the survey data, they received training on country bean pest management from government organizations such as the Department of Agriculture (DAE) and the Bangladesh Agricultural Research Institute (BARI).

![Figure 9](image)

Figure 9. Status of training on pest management among the farmers of six surveyed upazilas (sub-districts) viz. Sherpur of the Bogura district, Ishwardi of the Pabna district, Jashore Sadar of the Jashore district, Kaliganj of the Gazipur district, Nabiganj of the Habiganj district and Golapganj of the Sylhet district of Bangladesh.
4. Discussion

The socio-demographic status of the majority of the country bean farmers was mid-aged and with a low educational background. A similar result was found in different studies; approximately 23–25% of farmers were mid-age (31–45 years) and 30–34% of farmers were illiterate, while 32–35% had completed their primary education, 21–29% had completed their secondary school education, and only 2–7% had graduated [37–39]. Our results also show that more than half of the surveyed farmers were marginal farmers, similar to the findings of Qudus and Kroop [39].

Generally, farmers cultivate a wide range of country bean varieties in Bangladesh. Among the local varieties, Puti, Rupban, Auto, Goaligadda, etc., were the most common in the surveyed areas. Mollah et al. [38] stated that numerous varieties of country bean, such as Puti, Suri, and Beta, are cultivated in various locations in Bangladesh. Researchers have also found physio-morphological variations among some local country bean varieties of Bangladesh [40–43].

Most of the surveyed farmers mentioned aphids and pod borers as the most destructive insect pests of country bean. Our results show that over 30 different arthropod species attack country bean, and a few cause economic damage; among them, aphids and pod borers are considered the major insect pests of country bean [19,22,44–46]. Nova et al. [47] found that aphids and pod borers are the major insect pests of country bean in the Jashore district of Bangladesh. Furthermore, researchers from different countries also noted aphid and pod borer infestations in country bean [40,48–51]. In our neighboring country India, the devastating nature of aphids and pod borers in country bean has also been recorded [52]. According to Laizer et al. [53], in Tanzania, the majority of common bean farmers report that the bean aphid is the most destructive insect of the common bean. Aphids can damage bean plants in two ways: direct damage and indirect damage. Direct damage occurs through sucking plant sap, and the secretion of honeydew deposited on leaves can develop into sooty mold, which restricts light interception for photosynthesis [54,55]. On the other hand, indirect damage occurs through the transmission of viruses, such as bean common mosaic virus ( BCMV) and bean yellow mosaic virus (BYMV) [56]. Karim [44] also mentioned that bean aphids and pod borers are found everywhere in Bangladesh, and the infestation of these pests can cause severe economic damage. Few farmers mentioned green semiloopers, bean bugs, field crickets, thrips and jute weevils as harmful pests of country bean. Infestations of these insects have also been revealed in previous studies [19,40,44,47,57]. Only farmers from Jashore Sadar upazilla mentioned thrips and jute weevil infestation in country bean fields. During the survey, it was evident that the farmers of Jashore Sadar upazilla cultivated jute after country bean according to their cropping pattern. Since no other standing crop was available in the crop field, the jute weevil might have used country bean as its alternative host. Panizzi [58] and Pasini et al. [59] reported that insects migrate in search of an alternative host to find shelter when susceptible crops are unavailable in the off-season. The pest spectrum of a crop could vary geographically and temporally, and is dependent on the climatic conditions of cropping season and the availability of host plants. Therefore, there are clear variations in insect pest complexes in different locations [60–63].

The results show that infections with bean yellow mosaic virus (BYMV) and white mold diseases in the country bean plant were severe. Hemipteran insects transmit more than 70% of all known insect-borne viruses. Among them, aphids and whiteflies are important plant viral vectors, spreading about 500 virus species [64]. The presence of aphids in all surveyed areas could explain this finding. There is a positive correlation between the abundance of bean aphids and infection with mosaic virus in lentils [65]. Uddin et al. [66] and Akhter et al. [27] also mentioned that insects are the main vector of viral diseases in horticultural crops, including beans. Insects, especially aphids, carry the virus and cause mosaic in bean [67]. In bean plants, aphids play an important role in transmitting Leaf Roll viruses [68]. In Southeast Asia, the bean yellow mosaic virus (BYMV) is one of the most devastating diseases of mung beans and black grams [69]. Nahar et al. [23] found that
white mold disease infection in country bean is severe in Bogra, Sylhet, and Habiganj districts. Our findings are similar to those of Akhter [70] and Fakir [71]. Country bean growers also face infections of anthracnose, bean common mosaic virus (BCMV), rust, and cercospora leaf spot in their fields [70,71]. Farmers of the surveyed areas face significant yield losses due to insect pests and diseases. Our present results are in agreement with the findings of Islam [72], Ochilo et al. [48], and Uddin et al. [61], who found that bean farmers experience 20–45% yield losses due to insect infestation. Bean aphids can alone be responsible for 40–90% yield losses [52,73–75]. The diseases of country bean also reduce yield significantly [23,76]. According to Singh and Schwartz [77], diseases can cause up to 100% yield losses of common bean. Bean yellow mosaic virus (BYMV) is the most destructive virus that infects beans, and the yield loss due to bean yellow mosaic virus (BYMV) could be as high as 100% [25,26,77].

Our study showed that almost all of the country bean farmers rely on chemical pesticides for insect pest and disease management. Very few farmers used physical and mechanical methods for pest management [71]. Farmers applied a wide range of insecticides and fungicides to manage the insect pests of country bean. Generally, farmers used emamectin benzoate, mancozeb (64%) + metalaxyl (8%), thiamethoxam (20%) + chlorantraniliprole (20%), cypermethrin, organophosphorus, synthetic pyrethroid, etc., to manage pests of country bean [22,47,78,79]. A similar result was found in Kenya among bean farmers who used these pesticides for pest management [80]. Around 77% of Bangladeshi farmers used pesticides at least once, 31% used them twice, and the remainder applied them three to five times throughout a single cropping season [81]. A similar trend was found in Nepal and Kenya, where more than 80% of farmers used chemical pesticides solely to control insect pests in their vegetable crops [82–84]. According to the researchers, vegetable farmers are very dependent on synthetic chemicals for pest control, and the frequency of pesticide application in vegetables was six times higher than in rice in Bangladesh [30,85–87].

Country bean farmers do not follow any judicial instructions for pesticide application. Usually, the frequency of pesticide application is more than 4 times (sometimes up to 30 times) in a single cropping season. Similar findings were reported by Nova et al. [47]. They observed that more than 50% of country bean farmers from the Jashore district apply pesticides around 40 times in a single season. Chowdhury et al. [22] also reported that country bean farmers use pesticide dosages 8–30 times the recommended dose. The results show that the average pesticide cost ranged from BDT 11,000 to 14,000 per ha in the surveyed areas. The indiscriminate use of pesticides has increased vegetable production costs by 30% [88]. Furthermore, the excess and inappropriate use of pesticides has harmful effects on farmers’ health, increases production costs and reduces net returns from vegetable cultivation [30,31,89,90]. According to Mitra and Yunus [90], tomato farmers spend more than BDT 8,000 per cropping season on pesticides alone.

Most of the surveyed farmers started applying pesticides at the flowering stage of country bean. Khan et al. [19] and Miah et al. [78] also reported that infestation generally starts at the flowering stage. Very few farmers were cautious about the waiting period or the pre-harvest interval (PHI) of pesticide application. According to our results, most of the farmers harvest country bean 2–3 days after pesticide application, and the majority of them applied pesticides at three-day intervals. Nova et al. [47] found similar results, with the harvesting of country beans 1–2 days after pesticide application and the application of pesticides at an interval of 3–4 days. A short pre-harvest interval of pesticide application may be responsible for pesticide residues in country bean. Pesticide residues of organophosphate, organochlorine, carbamate, and synthetic pyrethroid groups have been found in country beans and other vegetables [91–95].

5. Conclusions

Country bean is one of the most popular vegetables for its taste and nutrition, and especially its protein content. This study highlights the status of farmers’ perceptions and
knowledge of insect pests and diseases of country bean, as well as their management practices. Most farmers have been encountering pest species of country bean for a long time, along with some recently arrived insect species. According to the farmers, insect pests and diseases cause 30–40% yield loss. Although the farmers identified some pests and diseases, they did not use integrated pest management approaches. They indiscriminately used chemical pesticides without following the proper pre-harvest interval (PHI). Our results also show that only 17% of the farmers received training on country bean insect pests and disease management. The results of our study corroborate the initial hypothesis that bean growers are not acquainted with all of the harmful and beneficial arthropods in the crop field. Thus, the current survey emphasizes the need to develop integrated pest management approaches for this crop, as well as building the capacity of farmers for sustainable country bean production in Bangladesh.

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