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FIELD SURVEY ON PAPAYA VIRAL DISEASES IN MAJOR PAPAYA GROWING DISTRICTS IN BANGLADESH

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Abstract

To investigate the papaya viral diseases in Bangladesh, an extensive survey was conducted at 10 upazilas of 6 selected major papaya growing districts of Bangladesh to collect the information and present status of different virus diseases of papaya in field. With the assistance of DAE, 20 farmers from each upazila were selected for interview on the incidence and severity of viral diseases of papaya crop in the field at seedling, flowering and fruiting stage. Direct personal interview approach was adopted for collection of primary data. Collected data were compiled, analysis and summarized by SPSS Software. Results exhibit that 3 identified different viral symptoms from all over the working area at three distinct growth stage were selected for sample data collection. Ringspot, mosaic and leaf curl symptoms were found as common symptoms which cause severe damage to papaya. Experiment results revealed that from both at farmer's level information and field survey inspection papaya ringspot symptoms were very destructive and cause severe losses of farmer's papaya fields. After papaya ringspot, papaya mosaic and papaya leaf curl were ranked, it was determined that all of them were serious in investigated papaya growing areas. It was observed that ringspot in fruit, leaf curl in leaves and in seedlings, mosaic in fruit and leaves were most destructive.

Introduction

The papaya (*Carica papaya* L.) is one of the important delicious and popular fruit crops grown throughout Bangladesh. It originated in Mexico and has spread to almost all the corners of the tropical and subtropical parts of the world. It is usually cultivated in homestead areas but presently farmers commercially cultivate in different regions of Bangladesh. As a raw fruit, it is popularly used as a vegetable in cooking and some preparations. Papaya fruit is a rich source of minerals, vitamins, and enzymes. Papaya is one of the major fruit crops cultivated in tropical and sub-tropical zones. Over 6.8 million tonnes of fruit were produced worldwide in 2004 on about 389,990 ha [10]. Of this volume, 47% was produced in Central and South America (mainly in Brazil), 30% in Asia, and 20% in Africa [10]. In Bangladesh, 38 thousand acres of land were under papaya cultivation and 489 thousand tonnes of papaya were produced in 2014-15 [7] which is very low compared to neighboring countries like India, Srilanka and Pakistan.

Diseases are the most important limiting production problems of papaya. Although the plant is classified botanically as perennial, virus diseases have reduced the effective crop life to 1-2 years. Insect pest and diseases cause serious damage to papaya crops in our country. It is urgently needed to protect this fruit crop against insect pest and disease infestation. Every year in Bangladesh, about 25% papaya damage was found from insect pest infestation, 30-40% damage was found from disease infestation and only 10% damage was observed from transportation of papaya for marketing [6].

The papaya viral disease may show peculiarity in their prevalence and symptom development throughout the year. Sometimes, masking of the symptom occurs in the infected plants depending upon the seasons [15].

The papaya plant may get infected by PRSV-P at any stage of the growth (seedling to maturity) and yield loss might reach even up to 100% very often [19]. For causing a devastating disease which severely interferes with economic papaya production, *Papaya ringspot virus*-Papaya strain (PRSV-P) is well recognized in all papaya growing countries in tropic and sub-tropic zones [13]. Another researcher [1] stated that all seven symptoms, namely mild mosaic (MM), mosaic (MO), severe mosaic (SM), leaf distortion (LD), fern leaf (FL), vein clearing (VC), chlorotic leaf spot (CS), all reacted positively in DAS-ELISA against the antisera of papaya ringspot virus- papaya strain (PRSV-P).

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Papaya viruses cause diseases of international importance with serious reductions in fruit production that may even totally destroy affected orchards. Until now, more than ten different viruses have been reported in papaya worldwide. PRSV causes the most destructive viral disease of papaya crop, the papaya ringspot, and has been found in many tropical and subtropical areas where papaya is grown, including the USA, South America, Mexico and Japan [2]. PLDMV was first reported in 1954 on the island of Okinawa, Japan. PLDMV emergence in PRSV-resistant papaya transgenic lines was considered as an emerging threat to papaya culture in China [5]. PYLV is restricted to Brazil and its increasing spread is reaching high incidence rates [9]. PapMV was first reported in 1962 in Florida, USA. The disease has spread to other countries, reaching Bolivia, Peru, Venezuela and Mexico. In Mexico, PRSV and PapMV occurred in single or mixed infections and a synergistic interaction between the two independent viruses in the same host can occur and lead to increased symptoms and virus accumulation [18].

The economic production of papaya needs efficient management of the disease caused by papaya viruses. Severe attempts were made like roughing, controlling of insect vectors by spraying mineral oil and insecticides, mulching, inter-cropping with barrier crop (corn), protecting young seedlings with plastic bags, developing papaya varieties resistant to papaya viral disease for managing the disease [22], but none of these measures gave satisfactory results.

Although reports on different virus symptoms of papaya are found elsewhere, reports on those of the papaya are not available in Bangladesh. Thus the present research work was undertaken to fulfill the following objectives:

1. To study the virus infection (disease incidence) of papaya in Bangladesh.
2. To observe the distribution and the intensity of damage (disease severity) of different virus symptoms in major papaya growing districts of Bangladesh.

Materials and Methods

An extensive survey was conducted at 10 upazilas of 6 selected major papaya growing districts of Bangladesh during April 2016 to August 2016 to collect the information and present status of different viral symptoms of papaya in field. The survey area is presented in Table 1.

Table 1. List of districts and upazilas selected for survey of viral diseases of papaya in Bangladesh

Sl. No.	District	Upazila
01	Gazipur	Kapasia
		Sreepur
02	Norsinghdi	NarshingdiSadar
		Jhikargacha
03	Jessore	Monirampur
		Keshobpur
04	Magura	MaguraSadar
		Sripur
05	Jhinaidah	Kaliganj
06	Faridpur	Modhukhali

Primary data were collected from the standing papaya of the selected farmers from each upazila and recorded the incidence and severity of different virus symptoms available in the field.

Respondents of the study
Field activities included interviews with Sub-Assistant Agriculture Officer (SAAO), Upazila Agriculture Officer (UAO) and the Deputy Director (DD), Department of Agricultural Extension (DAE) and also scientists of BARI research stations using a structured questionnaire to record the present status of disease on papaya crops.

Sample size
With the assistance of DAE, 20 farmers from each upazila were selected for interview on the incidence and severity of viral diseases of papaya crop in the field at seedling, flowering and fruiting stage. Primary data were collected from the standing papaya farmer's field of each upazila and the incidence and severity of different virus symptoms available in the field were recorded. Additional information on the area of papaya cultivation

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and production in the selected districts were collected from the DAE office. The total sample size was 275 as shown in Table 2.

Table 2. Sample respondents of the field survey

Respondents	Sample size
District level officials of DAE	5
Upazila level officials of DAE	10
Sub-Assistant Agriculture Officer (SAAO) of DAE	50
Papaya farmers	200
BARI scientists	10
Total	275

Study related indicators and questionnaire
Several study related indicators were selected for field data collection and as follows:
    a) Name of symptoms in the papaya field
    b) Diseases (viral) incidence (%) in the papaya field
    c) Damage status and severity of diseases in the field
The draft questionnaires were pre-tested in the selected study location and finalized with due care to be able to include appropriate questions for collection of necessary information from different levels and types of respondents to reflect the indicators relevant to the objectives of the study.

Methods of data collection
Two types of data were collected for the study such as primary data and secondary data.
Primary data collection
Primary data were collected by direct personal interview and field survey. Direct personal interview approach was adopted for collection of primary data. Then the purpose of the interview and objectives of the study were described to the farmers. Colored photographs of different disease symptoms were shown to the farmers for identification of diseases. The data were recorded only after fully being satisfied that the respondent was able to understand the question and offered any of the probable answers in his own perception. As per sample design the 275 survey respondents had been interviewed for the 10 sampled upazilas of 6 major papaya growing districts.

Personal field survey was made and collected necessary information based on the questionnaire and format from the farmers and concerned officials of 6 major papaya growing districts. Reaching the target areas the virus symptoms of papaya was identified through careful observation of papaya leaves and fruits. Percent infection/severity of papaya virus symptoms was measured based on diseases symptoms on leaf and fruit with degrees of infection. Data were taken from 5 randomly selected plants. Severity of infection was measured based on percentage of infection. Severity was classified as low (below 4.00 percent of infection), medium (above 4.00 to8.00 percent of infection) and high (above 8.00 percentage of infection).

Secondary Data Collection
The secondary information on virus symptoms of papaya was collected from Bangladesh Agricultural Research Institute [4], published reports and Internet. The Internet searching was done to collect information on virus symptoms of papaya worldwide.
Information gathered through secondary sources, three (3) viruses symptoms were selected to take information. On the basis of diseases severity; papaya ringspot, mosaic and leaf curl symptoms were selected to observe infection status for the study.
Data were taken into two ways: farmer's level information and direct field inspection. Data were presented in the table and expressed as major and minor for disease status in both at farmer's level and field survey data [21]. Disease severity status was measured by infection status obtained from field survey data. Considering field survey data, scoring and analysis, percent (%) infection of papaya was classified into two categories: major and minor infection and score ranged with 0 - 3 = minor infection status with low disease severity, 3 – 6 = minor infection status with medium disease severity and 6 – above = major infection status with high disease severity.

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Measurement of %disease incidence and severity

Percent (%) disease incidence was measured from collected data through questionnaire at farmer's information and personal field observation. According to the questionnaire, % disease incidence (based on % infection by virus symptoms) was classified into four categories as 'no and/or very low % disease incidence', 'low % disease incidence', 'moderate % disease incidence' and 'major % disease incidence and score was given by 1, 2, 3 and 4 respectively for data collection. The information taken on the first three statuses ('no and/or very low % disease incidence', 'low' % disease incidence' and 'moderate % disease incidence') were considered as minor infestation. The score was given for the three selected major papaya virus symptoms. According to the questionnaire, the possible highest score was 12.00. The score of 12.00 was divided into two groups as 'minor' and 'major'. So, the score of 0-6 was grouped as 'minor' % infestation and score of 6-12 or above 6 was grouped as 'major' % infestation.

Percent (%) disease severity was measured from collected data through questionnaires at farmer's information and personal field observation. According to the questionnaire, % disease severity was classified into three categories as 'low % disease severity', 'medium % disease severity' and 'high % disease severity' and score was given by 1, 2 and 3 respectively for data collection. The score was given for selected three major papaya virus symptoms. According to the questionnaire, the possible highest score was 9.00. The score of 9.00 was divided into three groups as 'low', 'medium' and 'high'. So, the score of 0-3 was grouped as 'low', 3-6 was grouped as 'medium' and 6-9 or above 6 was grouped as 'high'% disease severity.

Data analyses and interpretation of results

The collected data on virus infection of papaya from different locations were analyzed using the computer software SPSS Package Program. Results were interpreted with the aim to find out variations in respect of incidence, status and severity of virus symptoms of papaya.

Results

In Bangladesh various types of virus symptoms are found in all growth stages of papaya (seedling, leaves, and fruits). Major 3 virus symptoms were selected & viral infection status and disease severity and incidence were collected.

Area under papaya cultivation in study area

The area visited for survey on status of symptoms of papaya, the data under papaya cultivation area was recorded.

Table 3. Average area under cultivation of papaya by the respondents

Sl. No.	Name of district	Name of upazila	No. of respondents	Papaya cultivated area (Decimal)
1.	Gazipur	Kapasia	20	2080
2.		Sreepur	20	2840
3.	Narsinghdi	Narshingdi Sadar	20	2400
4.		Jhikargacha	20	3200
5.	Jessore	Monirampur	20	3440
6.		Keshobpur	20	3120
7.	Magura	Magura Sadar	20	2880
8.		Sripur	20	3040
9.	Jhinaidah	Kaliganj	20	3280
10.	Faridpur	Modhukhali	20	2440
	Total		200	28720

It was observed that the total land area of selected 20 farmers under papaya cultivation was highest at Monirampur upazilla of Jessore district where the lowest was in Kapasia, Gazipur (Table 3).

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Diversity, incidence and severity of different virus symptom in seedling of different location of papaya

Three recorded papaya symptoms, namely Papaya ringspot, Papaya mosaic and Papaya leaf curl, at seedling stage were observed from different locations of Bangladesh. Among all symptoms, the highest incidence was found in Magura sadar compared to all locations.

In the case of Papaya Ringspot, from farmer's and field survey data, the highest incidence was found in Magura Sadar (9.00 and 8.00%, respectively) followed by Keshobpur, Jessore (8.00 and 7.00) whereas the lowest incidence (1.00%) in Narsingdi Sadar. There were no ringspot symptoms found in Kapasia and Sreepur upazilas under Gazipur districts.

In the case of Papaya mosaic, from farmer's data, the highest incidence was found in three locations viz. Magura Sadar, Modhukhali, Faridpur and Monirampur, Jessore (6.00%) and the lowest incidence (3.00%) in Jhikargacha, Jessore, Kapasia, Gazipur and Sripur, Magura. There were no mosaic symptoms found in Kaliganj upazila under Jhinaidah district. From field survey data, the maximum incidence was found in Magura Sadar (7.00%) and minimum incidence found in Keshobpur, Jessore and Kapasia, Gazipur (3.00%). No mosaic symptoms were found in Kaliganj, Jhinaidah. In the case of Papaya leaf curl, from farmer's data, the maximum incidence (11.00%) was found in three locations viz. Kapasia, Gazipur, Monirampur, Jessore and Narshingdi sadar and minimum (7.00%) in Sreepur, Gazipur and Sripur, Magura. From field survey data, the maximum incidence was found in Kapasia, Gazipur (11.00%) and the minimum incidence (6.50%) in Sreepur, Gazipur. There was no leaf curl symptom found in Keshobpur upazilas under Jessore district.

Table 4. Diversity and incidence severity of papaya virus symptom in seedlings of different locations

Upazila and district name	Papaya Ringspot (% incidence)		Papaya Mosaic (% incidence)		Papaya Leaf Curl (% incidence)	
	Farmer's data	Field survey data	Farmer's data	Field survey data	Farmer's data	Field survey data
Jhikargacha, Jessore	3.00	3.00	3.00	4.00	-	-
Kaliganj, Jhinaidah	5.00	6.00	-	-	10.00	11.00
Kapasia, Gazipur	-	-	3.00	3.00	11.00	10.00
Keshobpur, Jessore	8.00	7.00	4.00	3.00	-	-
Magura Sadar,	9.00	10.00	6.00	7.00	8.00	10.00
Modhukhali, Faridpur	3.00	5.00	6.00	5.00	10.00	9.00
Monirampur, Jessore	2.50	3.00	6.00	5.00	11.00	10.00
Narshingdi Sadar,	1.00	1.00	5.00	6.00	11.00	10.00
Sreepur, Gazipur	-	-	5.00	6.00	7.00	6.50
Sripur, Magura	5.00	4.00	3.00	4.00	7.00	7.00

Diversity, incidence and severity of different virus symptom in leaves of different location of papaya

Three symptoms of papaya were recorded in different locations of Bangladesh with their percent of damage and severity in papaya leaves. In the case of Papaya Ringspot, from farmer's data, the highest incidence was found in Kapasia, Gazipur (8.00%) whereas the lowest incidence (3.00%) was found in 5 locations during survey: Kaliganj, Jhinaidah, Magura sadar, Modhukhali, Faridpur, Sreepur, Gazipur and Sripur, Magura. There were no ringspot symptoms found Jhikargacha and Keshobpur, under Jessore district.

In the case of Papaya mosaic, from farmer's data, the highest incidence (10.00%) was found in Modhukhali, Faridpur and the lowest incidence (2.00%) in five locations of surveyed area. They were Kaliganj, Jhinaidah, Kapasia, Gazipur, Keshobpur & Monirampur Jessore and Sripur, Magura. From field survey data, the maximum incidence (11.00%) was in Modhukhali, Faridpur and the minimum incidence (2.50%) was found in five locations of Bangladesh. There were no mosaic symptoms found in Magura Sadar.

On the other hand, in Papaya leaf curl, from farmer's data, the maximum incidence (10.00%) was found in Kapasia, Gazipur and the minimum (3.00%) in Sripur, Magura locations. From field survey data, maximum incidence was found in Kapasia, Gazipur (11.00%) and minimum incidence (3.00%) in five locations of Bangladesh during survey. There were no mosaic symptoms found in Kaliganj, Jhinaidah.

Table 5. Diversity and incidence severity of papaya virus symptom in leaves of different locations

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Upazila and district name	Papaya Ringspot (% incidence)		Papaya Mosaic (% incidence)		Papaya Leaf Curl (% incidence)	
	Farmer's data	Field survey data	Farmer's data	Field survey data	Farmer's data	Field survey data
Jhikargacha, Jessore	-	-	6.00	7.00	4.00	3.00
Kaliganj, Jhinaidah	3.00	2.00	2.00	2.50	-	-
Kapasia, Gazipur	8.00	8.00	2.00	2.50	10.00	11.00
Keshobpur, Jessore	-	-	2.00	2.50	4.00	5.00
Magura Sadar	3.00	2.00	-	-	4.00	3.00
Modhukhali, Faridpur	3.00	2.00	10.00	11.00	4.00	3.00
Monirampur, Jessore	7.00	8.00	2.00	2.50	9.00	10.00
Narshingdi Sadar	5.00	5.00	3.00	3.00	4.00	5.00
Sreepur, Gazipur	3.00	2.00	5.00	4.00	3.00	3.00
Sripur, Magura	3.00	2.00	2.00	2.50	4.00	3.00

Diversity, incidence and severity of different virus symptom in fruits of different location of papaya
Two symptoms of papaya were recorded in different locations of Bangladesh with their percent of damage and severity in papaya fruits. In the case of Papaya Ringspot, from farmer's data, the highest incidence (11.00%) was found in two locations: Kapasia, Gazipur and Jhikargacha, Jessore, whereas the lowest incidence (3.00%) found in Modhukhali, Faridpur location during survey. According to field survey data, the highest incidence (10.00%) was found in the two locations, Kapasia, Gazipur and Kaliganj, Jhinaidah, whereas the lowest incidence (3.00%) found in Modhukhali, Faridpur location during survey. There were no ringspot symptoms in three locations of Bangladesh.

In the case of Papaya mosaic, the highest incidence (9.00% and 10.00%) was found in Jhikargacha, Jessore Modhukhali in all survey data respectively. The lowest incidence (2.00%) was found in 5 locations from farmer's data and 1.50% incidence in four locations of Bangladesh during survey. There were no mosaic symptoms found in two locations that were Kaliganj, Jhinaidah and Keshobpur, Jessore. On the other hand, there were no symptoms found in fruit due to leaf curl symptoms in all locations of surveyed area.

Table 6. Diversity and incidence severity of papaya virus symptom in fruits of different locations

Upazila and district name	Papaya Ringspot (% incidence)		Papaya Mosaic (% incidence)		Papaya Leaf Curl (% incidence)	
	Farmer's data	Field survey data	Farmer's data	Field survey data	Farmer's data	Field survey data
Jhikargacha, Jessore	11.00	10.00	9.00	10.00	-	-
Kaliganj, Jhinaidah	9.00	10.00	-	-	-	-
Kapasia, Gazipur	11.00	9.00	2.00	2.50	-	-
Keshobpur, Jessore	4.00	5.00	-	-	-	-
Magura Sadar,	7.00	8.00	2.00	1.50	-	-
Modhukhali, Faridpur	3.00	3.00	2.00	1.50	-	-
Monirampur, Jessore	-	-	2.00	1.50	-	-
Narshingdi Sadar,	-	-	4.00	5.00	-	-
Sreepur, Gazipur	-	-	2.00	2.00	-	-
Sripur, Magura	4.00	4.00	2.00	1.50	-	-

Average virus infection at different growth conditions
Severe virus infection was found at seedling stage, in leaves and in fruits. Results indicated that all conditions of papaya were affected seriously by papaya ringspot, papaya mosaic and papaya leaf curl. It was found that the highest infection was found in seedling stage and lowest was observed in fruit (Fig. 1).
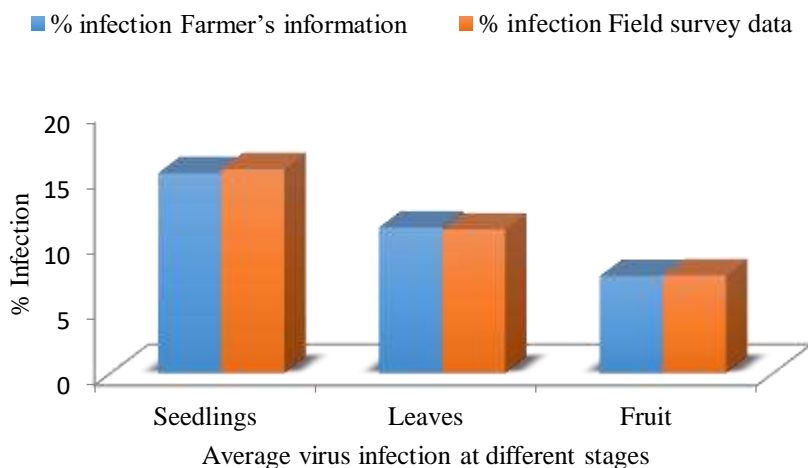
Figure. 1. Average virus infection in seedling, leaves and fruits

Average virus infection at different locations in Bangladesh

Viral infection at different selected areas of Bangladesh was observed and found that considerable infection was occurred in selected papaya growing areas (Table 7). Among the different study areas in Bangladesh, major virus infection was observed in Kapasia, Gazipur and Jhikargacha, Jessore with high level of severity. Minor virus infection with medium level of severity was also found in Sreepur, Gazipur, Narshingdi Sadar, Monirampur, Jessore, Keshobpur, Jessore, Magura Sadar, Kaliganj, Jhinaidah and Modhukhali, Faridpur. Minor virus infection with low level of severity was observed in Sripur, Magura (Table 7).

Table 7. Average virus infection at selected areas in Bangladesh

| Location	% Infection		Severity	Status
	Farmer's information	Field survey data		
Jhikargacha, Jessore	6.00	6.17	High	Major
Kaliganj, Jhinaidah	5.80	6.30	Medium	Minor
Kapasia, Gazipur	6.71	6.57	High	Major
Keshobpur, Jessore	4.40	4.50	Medium	Minor
Magura Sadar	5.57	5.93	Medium	Minor
Modhukhali, Faridpur	5.13	4.94	Medium	Minor
Monirampur, Jessore	5.64	5.71	Medium	Minor
Narshingdi Sadar	4.83	5.00	Medium	Minor
Sreepur, Gazipur	4.17	3.92	Medium	Minor
Sripur, Magura	3.75	3.50	Low	Minor

Distribution, diversity, infection and severity in Bangladesh

About six virus symptoms were identified in 10 Upazila of 6 districts. Among them three are identified as common papaya virus symptoms in growing areas. Three virus symptoms have been identified but there was variation in infection percent, severity and distribution (Fig. 2). Individually each selected papaya was affected seriously which was proved by the present study(Fig. 2). At different locations the same virus symptoms played as major disease and minor disease. Papaya ringspot was recorded as a major virus symptom with high level of infection (farmer's information 12.05 ± 1.62 percent and field survey data 11.90 ± 1.27 percent of infection) and severity. In the case of papaya mosaic, it was also recorded as a major virus symptom of papaya with high level

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of infection (farmer's information 10.00 ± 0.86 percent and field survey data 10.60 ± 1.18 percent of infection) and severity. Papaya leaf curl was also found as a major papaya virus symptom with high severity (farmer's information 11.70 ± 1.16 percent and field survey data 11.45 ± 0.84 percent of infection).
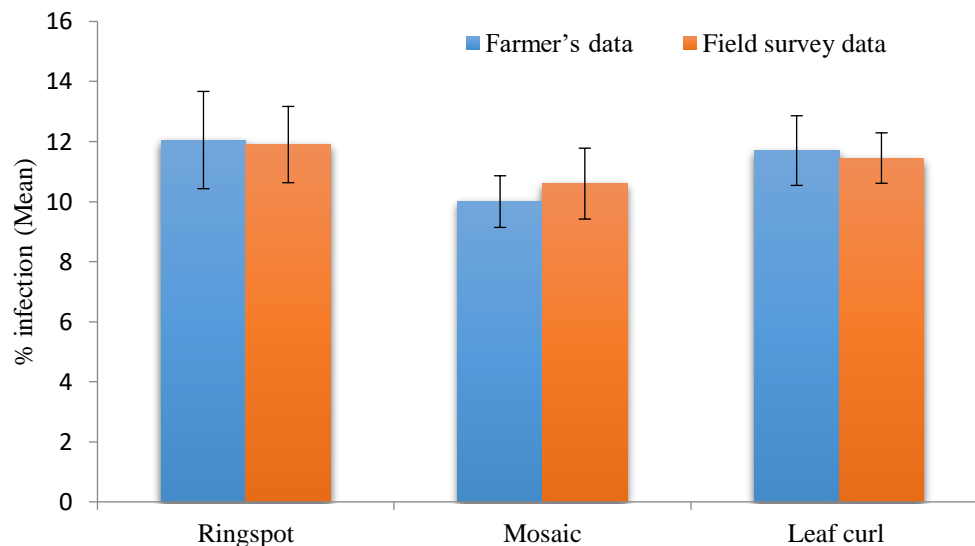
Figure. 2. Infection and severity of papaya virus symptoms in Bangladesh

Discussion

Papaya is one of the major fruit crops cultivated in tropical and sub-tropical zones. The most important virus symptoms that affect papaya are the Papaya ringspot (PRSV), the Papaya leaf distortion mosaic (PLDMV), the Papaya lethal yellowing (PLYV) and the Papaya mosaic (PapMV), which have been known to cause serious damage to the crop production throughout the world. PRSV causes the most destructive viral disease of papaya crop, the papaya ringspot, and has been found in many tropical and subtropical areas where papaya is grown, including the USA, South America, Mexico and Japan [2].

In this survey, ten locations of six districts in Bangladesh were selected to see the incidence of virus symptoms and severity of PRSV-P. The effects of *Papaya ringspot-* papaya strain (PRSV-P) on growth and yield on papaya were showed by [1]. He showed the reduction percentage of growth and yield of the plant due to infection of PRSV-P in different locations in Bangladesh. Under the present study, it was found that the disease's incidence and severity in studied areas were versatile in character. All kinds of viruses are not destructive for all levels of plant growth. It was observed that the ringspot in fruit, leaf curl in leaves and in seedlings, mosaic in fruit and leaves were more destructive.

Seedlings show prominent vein clearing and downward cupping of the young leaves [8]. PRSV caused three types of leaf symptoms on papaya which are mosaic, yellowing and deformation that were established by [13]. Another researcher [20] also found similar symptoms during investigation about PRSV-P. He showed there are seven symptoms which are visible in the infected plants. The reduced percentage of different characteristics of papaya due to PRSV-P infection was also showed in another study [16]. He described different parameters like plant height, flower per plant, fruit per plant fruit weight and fruit yield. In every parameter there was remarkable reduction due to PRSV-P infection.

Papaya virus symptoms can greatly hamper papaya production both in quality and quantity. It reduces the production and effect on commercial papaya production. In Andhra Pradesh of India, in commercial plantation, papaya plants with severe mosaic, leaf distortion and filiform leaves were suspected to be infected with PRSV reported by [15]. Papaya leaf curl caused by PLCV is one of most serious threats to papaya cultivation in most of the papaya-growing countries. Papaya leaf curl is caused by bipartite Gemini virus [14]. The virus symptom was observed on papaya plants of all age groups, but it was most serious on young plants. The infected plant

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showed degeneration and marked reduction in growth. The fruits on diseased plants developed circular water soaked lesions with central solid spots. It is transmitted by several species of Aphids [23].

It was also observed that under the present study, papaya was affected by certain viral diseases which had tremendous effect on growth and yield of papaya and sometimes result 100% crop losses. It was found that the diseases incidence and severity in studied areas were versatile in character. All kinds of viruses are not destructive for all levels of plant growth, yet ringspot in fruit, leaf curl in leaves and in seedlings, and mosaic in fruit and leaves were more destructive.

Conclusion

An extensive survey was conducted at 10 upazilas of selected 6 major papaya growing districts of Bangladesh to collect the information and present the status of different virus diseases of papaya in field. The study areas were in upazila Kapasia and Sreepur under Gazipur district, Narshingdi Sadar upazila under Narsinghdi district, Jhikargacha and Monirampur and Keshobpur upazila under Jessore district, Magura Sadar and Sripur upazila under Magura district, Kaliganj upazila under Jhinaidah district and Modhukhal iupazila under Faridpur district. Primary data were collected from the standing papaya of the selected farmers from each upazila and the incidence and severity of different virus symptoms were recorded that were available in the field. Field activities included interviews with Sub-Assistant Agriculture Officer (SAAO), Upazila Agriculture Officer (UAO) and the Deputy Director (DD), Department of Agricultural Extension (DAE) and also scientists of BARI research stations using a structured questionnaire to record the present status of insect pests on papaya.

With the assistance of DAE, 20 farmers from each upazila were selected for interview on the incidence and severity of virus symptoms of papaya crop in the field at seedling, flowering and fruiting stages. Primary data were collected from the standing papaya farmer's field of each upazila and the incidence and severity of different viral diseases available in the field was recorded. Direct personal interview approach was adopted for collection of primary data. Personal contact was done with the respondents and the desired information was obtained by explaining the objectives of the study to the respondents. Collected data were compiled, analysis and summarized by SPSS Software.

The results exhibits that 6 virus symptoms were identified from all over the working area and three were selected for sample data collection. Ringspot, mosaic and leaf curl were selected as common diseases which cause severe damage. Results revealed that from the present study, all studied papaya symptoms were severe and destructive in papaya fields and there was damage severity in all stages of papaya plant. Among three major virus symptoms, papaya ringspot ranks first for its severity and damage status. Both at the farmers' level information and field survey inspection it was proved that papaya ringspot was very much destructive and caused severe loss for farmers. After papaya ringspot, papaya mosaic and papaya leaf curl were ranked and both of them were also serious. It was also observed that the ringspot in fruit, leaf curl in leaves and in seedlings and mosaic in fruit and leaves was more destructive.

From the above consideration, it can be concluded that papaya viruses in Bangladesh are a great threat for papaya production and the presence of three common papaya virus symptoms viz. Ringspot, mosaic and leaf curl in the field may also result crop failure. Further lab oriented research should be done to have a full scenario of the viral diseases occurred in Bangladesh.

References

[1] Akhter, M. S. and Akanda, A. M. Effect of *Papaya ring spot virus* on growth and yield of papaya. Bangladesh j. crop sci. 19(2), pp. 203-208. 2008.

[2] Azad, M.A.K.; Amin, L.; Sidik, N.M. Gene technology for Papaya ringspot virus disease management. Sci. World J., doi:10.1155/2014/768038. 2014.

[3] Bakr, M.A., Ahmed, H.U. and Mian, M.A.W. (eds.). Proceedings of the national workshop on "Strategic Intervention on Plant Pathological Research in Bangladesh" 11-12 February2007, BARI (Bangladesh Agricultural Research Institute), Joydebpur, Gazipur, pp. 344 2007.

[4] BARI. Annual Research Report (2006-2007). Horticulture Research Centre. Bangladesh Agricultural Research Institute (BARI), Joydebpur. Gazipur, 2007.

[5] Bau, H.J.; Kung, Y.J.; Raja, J.; Chan, S.J.; Chen, K.C.; Chen, Y.K.; Wu, H.W.; Yeh, S.D. Potential threat of a new pathotype of Papaya leaf distortion mosaic virus infecting transgenic papaya resistant to Papaya ringspot virus. Phytopathology, 98, pp. 848–856. 2008.

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[6] BBS (Bangladesh Bureau of Statistics).Yearbook of Agricultural Statistics-1999. Statistics and Informatics Division (SID).Ministry of Planning.Government of the People's Republic of Bangladesh. 2000.

[7] BBS (Bangladesh Bureau of Statistics). Yearbook of Agricultural Statistics-2015. Statistics and Informatics Division (SID).Ministry of Planning.Government of the People's Republic of Bangladesh.

[8] Conover, R. A. 1964. A programfor development of papaya tolerant to the *Distortion ringspot virus*. Proc. Eda. State Hortic. Soc. 89, pp. 229-231, 2016.

[9] Daltro, C.B.; PereiraII, Á.J.; Cascardo, R.S.; Alfenas-Zerbini, P.; Bezerra-Junior, J.E.A.; Lima, J.A.A.; Zerbini, F.M.; Andrade, E.C. Genetic variability of Papaya lethal yellowing virus isolates from Ceará and Rio Grande do Norte States, Brazil. Trop. Plant Pathol. 37, doi: 10.1590/S1982-56762012000100004. 2012.

[10] FAO, World Food Security: the Challenges of Climate Change and Bio-energy. http://www.faopacific.ws/Portals/WFD2008GlobalReport.pdf, FAOSTAT.FAOSTAT Production. Available online: http:// faostat.fao.org/ site/339/default.aspx, 2004.

[11] Gonzalvez, H. V. A. Teliz, O. D. and Nieto, A. D. Effect of *Papaya ringspot virus* on leaf gas exchange rates of pawpaw.Rexista Mexicana de Fitopatologia 12(2): 174-177, 1997.

[12] Goodman, R.M. Geminiviruses.In: Hankbook of Plant Virus Infections. Kurstak, E. (Ed). Amsterdam: Elsevier/North-Holland, pp. 879-910, 1981.

[13] Kiranmai, G. hena, M. and Srunivasulu, P. Identification of a virus causing leaf distortion disease of papaya in Andhra Pradesh, Indian Phytopathology 51(2): 130-135, 1998.

[14] S Mowlick, AM Akanda, AHMA Rahman, Development of Mild Strains of Papaya Ringspot Virus-Papaya Strain, Journal of Agriculture & Rural Development 5(1) pp. 94-97, January 2007.

[15] Noa-Carrazana, J.; González-de-León, D.; Ruiz-Castro, B.; Piñero, D.; Silva-Rosales, L. Distribution of Papaya ringspot virus and Papaya mosaic virus in papaya plants (*Carica papaya*) in Mexico. Plant Dis. 2006, 90, pp. 1004–1011, 2006.

[16] Purcifull, D. E. Edwardson, J. R. Hiebert, E. and Gonsalves, D. Papaya ringspot virus (revised). No. 292 In: Description of plant Viruses. Commonw.Mycol. Inst. / Assoc. Appl. Biol. Kew. Surrey, England, pp. 5, 1984.

[17] Effect of mild strain on severity of prsv-w infection, m. f. Rahman[1], m. a akanda[1] and m. z. a. Sarkar, Bangladesh J. Agril. Res. 35(2), 279 -285, June 2010.

[18] Wakiluzzaman, S.M. Diversity and damage severity of insect pests of citrus in Bangladesh.MS thesis, Sher-e-Bangla Agricultural University, Dhaka, 2014.

[19] Yeh, S. D., Gonsalve, D., Wang, H. L. Namba, R. and Chiu, R. J. Contol of *Papaya ringspot virus* by cross protection. Plant Disease 72(5), pp. 375-380, 1988.

[20] Zettler, F. W. Edwardson, J. R. and Purcifull, D. E. Ultramicroscopic difference in inclusion of *Papaya ringspot virus* correlated with differential aphid transmission. Phytopathology 58, pp. 332, 1968.