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Surveillance of the Disease Incidence and Severity of *Papaya Ringspot Virus* at Four Selected Districts of Bangladesh

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***Abstract*—** *An experiment was conducted to survey the prevalence of disease incidence and severity of Papaya ringspot virus (PRSV) at eight locations of four districts in Bangladesh. Papaya is one of the most popular fruits in the world. It suffers from several diseases including fungi, bacteria, nematodes and viruses. Among them, viral diseases are found to cause considerable yield loss, with the most important one being PRSV. The survey was conducted at three plain districts and one hill tract area from July 2016 to December 2016. During the survey period, six different symptoms were found in the selected fields and were identified as PRSV based on symptomology. These symptoms were mild mosaic (MM), mosaic (MO), severe mosaic (SM), fern leaf (FL), leaf distortion (LD) and vein clearing (VC). The highest disease incidence (36.24%) was found in BSMRAU farm in Gazipur whereas the lowest (12.04%) was found in Panchari, Khagrachari hill tract. The maximum severity (11.53%) was found in BSMRAU campus, Gazipur on the country and the lowest severity (2.50%) was found in Panchari, Khagrachari hill tract. The yield and yield contributing parameters of papaya found to be differ significantly among the surveyed area. The lowest fruit weight (324.3 gm) due to PRSV infection was recorded in BSMRAU, Gazipur while the highest fruit weight (643.6 gm) was conducted in SAU Campus, Dhaka.*

***Keywords*— Survey, Disease incidence, Disease severity, PRSV, Selected districts, Bangladesh.**

I. INTRODUCTION

Papaya (*Carica papaya* L), belonging to the family Caricaceae, is an important fruit of tropical and subtropical regions in the world. It is an important and popular vegetable as well as fruit crop in respect of its food value and taste. Papaya fruit is the second highest fruit that is rich in vitamin A, next to mangos (Aykroyed, 1951). It contains a fair amount of vitamin C, riboflavin and niacin and is a good source of moisture, protein, fat, carbohydrate, calcium, phosphorus and iron (Bosh, 1985). Papaya has also been regarded as medicinal as well as an industrial cash crop. Carpaine, an alkaloid present in papaya, can be used as a heart depressant, amoebicide and diuretic (Burdic, 1971). Papain, extracted from green papaya, can be used in beverage, food, and pharmaceutical industries (Watt, 1989).

Although papaya is successfully grown all over Bangladesh, statistics regarding the papaya production is not satisfactory. In 2009-2010, papaya has been cultivated in 2790 ha of land with a total production of 40.42 t/ha (BBS, 2010) in contrast about 1, 13, 52, 202 tons' production of papaya in 2010 was in the world (FAO, 2010).

Papaya production is greatly hampered due to some constraints, of which diseases play an important role, especially viral diseases. Such as *Papaya ringspot virus, Papaya leaf curl virus, Papaya yellow mosaic* virus, etc. Viral diseases have been recognized as a major limiting factor for commercial papaya production throughout the tropics and subtropics (Jensen, 1949 a and b, Cook and Zettler, 1970). The infected plants produce different types of symptoms on leaves like mild to severe mosaic, vein-clearing, vein-yellowing, chlorotic spots, fern leaf, shoe-sting etc. (Rahaman, 2003). The infected plants produce small flowers and distorted fruits showing stunted growth. The distorted fruits bear conspicuous ringspot symptoms and the taste becomes watery. The disease drastically deteriorates the yield, market value, and quality of the fruits (Purcifull *et al*., 1984). In Bangladesh, the virus causes 70%-100% yield reduction of papaya depending upon the stage of infection as estimated by Akanda (1991). The virus also infects various cucurbitaceous crops like cucumber, bitter gourd, sweet gourd, ash gourd, ribbed gourd etc. and causes tremendous yield losses of those crops (Akanda *et al*., 1991 a, b and c).

The papaya viral diseases may show peculiarity in their prevalence and symptom development throughout the year. Sometimes, masking of the symptom occur in the

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infected plants depending upon the seasons (Kiranmai *et al*., 1998)

A 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% (Purcifull *et al*., 1994). For causing a devastating disease that severely interferes with commercial papaya production, *Papaya ringspot virus*-Papaya strain (PRSV-P) is well recognized in all papaya growing countries of tropic and sub-tropic regions (Gonsalves, 1998). Akhter and Akanda (2008) stated that 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 are reacted positively in DAS-ELISA against the antisera of *Papaya ringspot virus*- papaya strain (PRSV-P).

The economically sustainable production of papaya needs efficient management of the disease caused by papaya viruses. Several 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 bag, developing papaya varieties resistant to papaya viral disease for managing the disease (Yeh *et al*., 1988) but none of the measures gave satisfactory results. Considering the above facts, the present experiment was undertaken to achieve following objectives: (i) to conduct a survey on PRSV disease in papaya field at selected locations of Bangladesh; (ii) to quantify the effect of PRSV disease on the growth and yield contributing parameters of papaya; and (iii) to know the reduction of growth and yield parameters of papaya due to PRSV infection.

II. MATERIALS AND METHODS

2.1 Selection of the survey area: The experiment was conducted to survey the incidence and severity of *Papaya ringspot virus*-papaya strain (PRSV-P) on the basis of symptoms in the field. The survey was conducted at eight locations of four districts in Bangladesh. The locations of survey area are given in Table 1.

Table.1: Selection of eight locations for survey

Districts	Locations
Dhaka	Sher-e-Bangla Agriculture University (SAU) Campus, Dhaka
	Jahangirnagar University (JU) Campus, Savar
Gazipur	Bangladesh Agriculture Development Corporation (BADC), Kashimpur
	BSMRAU Campus, Salna, Gazipur
Narayanganj	Narayanganj Sadar Upazilla
	Sonargaon Upazilla
Khagrachari	Khagracchari Sadar Upazilla
	Panchari Upazilla

2.2 Survey period: Eight surveys were conducted during the period from 25 May 2016 to 14 December 2016.

2.3 Observation of the symptoms: Symptoms of the disease PRSV was identified by visual observation described by Jensen (1949a), Conover (1964), Gonsalves (1997), Akanda (1991) and Rezende *et al*. (1995), Rahaman (2003), Akhter and Akanda (2008).

2.4 Selection of Plants: During the survey, twelve plants were selected randomly in each location with four plants in one replication, resulting in three replications from each location. Following the procedure, twenty-four replications were selected from eight locations in four districts.

2.5 Determination of the disease incidence and severity: Every plant in the field was counted to determine the disease incidence and severity. Then it was expressed in percentage. The disease PRSV was calculated following formula (Agrios,2005)

$$\text{Disease incidence (\%)} = \frac{\text{No. of diseased plant (or parts)}}{\text{No. of total plant (or parts)}} \times 100$$

The disease severity was expressed in PDI. The PDI was computed by using standard formula (Paper *et al*., 1996) is giving below:

$$PDI = \frac{\sum Disease\,grade \times number\ of\ plants\,in\,grade}{Total\,number\ of\ plants \times highest\,disease\,grade} \times 100$$

2.6 Quantitative assessment on the effect of PRSV on growth and yield contributing parameters of papaya: The effect of PRSV infection on growth and yield contributing characters of papaya plants were assessed by collecting the data on six selected parameters: plant height (cm.); number of leaves; petiole length (cm.); leaf area (cm^2); fruit number; and fruit weight (gm.)

Percent reduction of growth and yield parameters was calculated using formula: $\%\ Reduction = \frac{A-B}{A} \times 100$

Where A= any parameter of healthy plant; and B= that parameter of infected plant

2.7 Statistical analysis: Randomized block design (RCBD) was used to analyze the different parameters through computer software MSTAT-C. To calculate the level of significant difference and to separate the means within the parameters, Duncan's Multiple Range Test (DMRT) and Least Significant were performed.

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III. RESULTS

3.1 Survey and identification of PRSV in papaya at eight locations of four districts

For observing the prevalence of disease incidence and severity of PRSV virus in papaya, the disease was identified by symptomology of infected papaya plants and compared with standard literature. It was found that there were six distinct symptoms prevalent at eight locations of four districts in Bangladesh.

The seven different symptoms so far categorized are named as mild mosaic (MM), mosaic (MO), severe mosaic (SM), fern leaf (FL), vein clearing (VC), leaf distortion (LD) and ringspot on fruit. The development of streaking on the young stem and leaf petioles as well as green ringspot developing on leaves was common and consistent with all the seven types of symptom. Yellowing of the leaf and distortion of fruits were observed in association with other symptoms.

3.2 Incidence and severity at eight locations of four districts in Bangladesh

Significant differences were found in disease incidence at eight locations in Bangladesh as shown in Table 2. The incidence ranged from 12.04% to 36.24% and the severity ranged from 2.50% to 11.53%.

3.2.1 Disease incidence: There were significant differences found among different locations. The highest disease incidence (36.24%) was found in BSMRAU, Gazipur and the lowest incidence (12.04%) was found in Panchari, Khagrachari hill tract.

3.2.2 Disease severity: Significant differences were found in disease severity among eight locations in Bangladesh. The highest disease severity (11.53%) was in BSMRAU campus followed by SAU (9.03%), where the lowest disease severity (2.50%) was found in Panchari upazilla preceded by Narayanganj Sadar (3.44%).

Table.2: The disease incidence and severity of PRSV in papaya at eight locations of four districts in Bangladesh

Locations		Disease Incidence (%)	Disease Severity (%)
Dhaka	SAU, Dhaka	29.84 b*	9.03 b
	JU, Savar	30.05 b	7.49 bc
Gazipur	BADC, Kashimpur	17.40 c	3.05 e
	BSMRAU, Salna	36.24 a	11.53 a
Narayanganj	Narayanganj Sadar	17.60 c	3.44 e
	Sonargaon, Upazilla	30.17 b	6.25 cd
Khagrachari hill tract	Khagrachari Sadar Panchari, Upazilla	12.04 d	2.50 e
Coefficient of Variation (CV %)		13.64	17.88
LSD value (0.05)		5.216	2.166

*Values within the same column with a common letter(s) do not differ significantly (P=0.05)

3.3 Comparison of incidence and severity of PRSV at eight locations of four districts in Bangladesh

The comparison of disease incidence and severity of different locations are shown in Figure 1, indicating that the highest incidence and severity was in BSMRAU and the lowest result in Panchari upazilla.

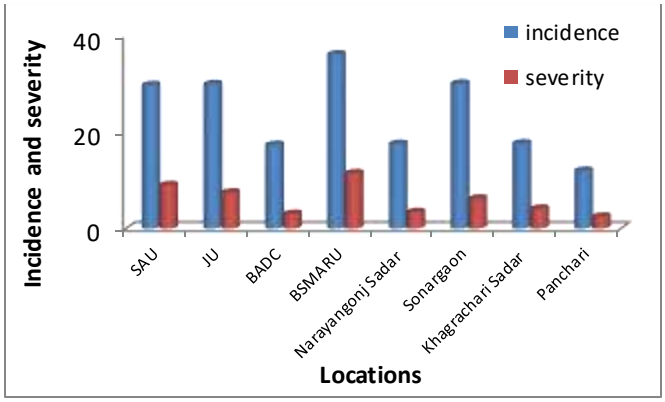

Fig 1: Comparison of disease incidence and severity of PRSV at eight locations of four districts in Bangladesh

3.4 Effect of PRSV on growth parameters in papaya

Significant variation was found in growth parameters due to PRSV infection in papaya, are shown in table 3 and location wise growth parameters in Figure 2-5. The highest plant height (178.6 cm) was found in SAU campus followed by Panchari upazilla (159.6 cm) while the lowest (127.5 cm) was found in Sonargaon upazilla. Maximum number of leaves (20.67) was found in Sonargaon upazilla followed by SAU campus (19.08) while minimum was found in BSMRAU (15.67). Among the eight locations, the longest petiole length (53.66 cm) was found in Khagrachari sadar followed by SAU campus (47.95 cm). On the other hand, the shortest petiole length was found in BSMRAU campus (30.90 cm) that was significantly similar to Narayanganj Sadar. The largest leaf area was found at Panchari upazilla (1330 cm^2) whereas the smallest (535.1 cm^2) at BSMRAU.

Table 3. Effect of PRSV infection on growth parameters at eight locations in Bangladesh

Location	Plant Growth parameters			
	Plant height (cm)	No. of leaf (no.)	Petiole length (cm)	Leaf area (cm^2)

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Dhaka	SAU	178.6 a*	19.08 b	47.95 b	1167 c
	JU	146.9 de	16.08 de	35.39 cd	959.9 d
Gazipur	BADC	146.0 e	16.67 cde	31.86 de	857.4 g
	BSMRAU	150.5 cde	15.67 e	30.90 e	535.1 h
Narayanganj	Narayanganj Sadar	153.1 bcd	17.60 c	30.95 e	887.4 f
	Sonargaon	127.5 f	20.67 a	36.62 c	954.9 e
Khagrachari hill tract	Khagrachari Sadar	155.8 bc	18.58 b	53.66 a	1186 b
	Panchari upazilla	159.6 b	17.08 cd	34.93 cd	1330 a
CV (%)		7.52	9.82	16.93	21.19
LSD value (0.05)		6.314	0.9750	3.543	3.234

*Values within the same column with a common letter(s) do not differ significantly (P=0.05)

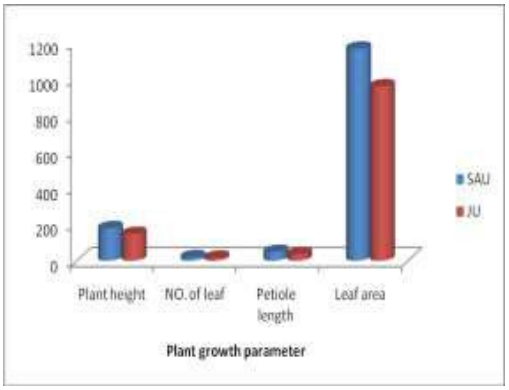

Fig 2: Effect of growth and growth parameters due to PRSV disease in two locations of Dhaka district

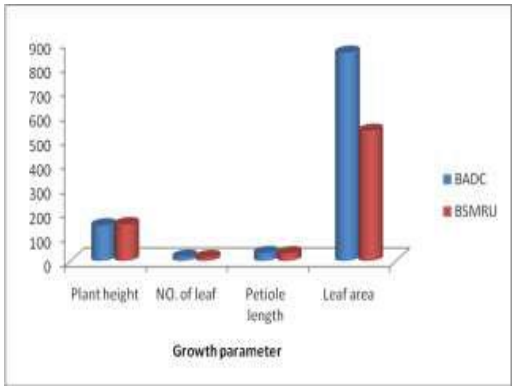

Fig 3: Effect of growth and growth parameters due to PRSV disease in two locations of Gazipur district

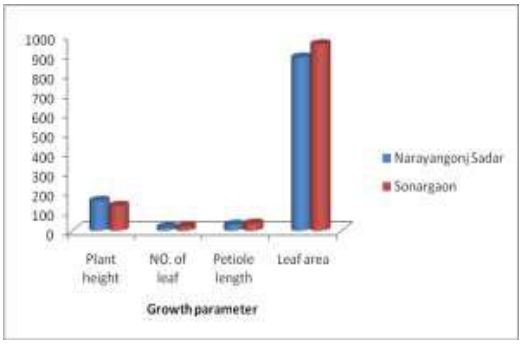

Fig 4: Effect of growth and growth parameters due to PRSV disease in two locations of Narayanganj district

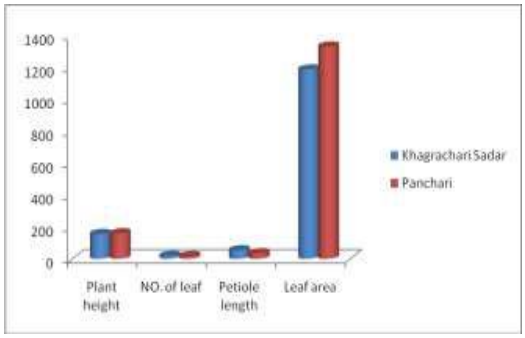

Fig 5: Effect of growth and growth parameters due to PRSV disease in two locations of Khagrachari hill tract

3.5 Effect of PRSV on yield parameters

Yield parameters at eight locations of four districts in Bangladesh were varied significantly due to PRSV infection in papaya as shown in table 4. In terms of fruit number, the range of fruit number was 6.167-4.583. The maximum number (6.167) was found in BSMRAU and the lowest number (4.583) was found in BADC and Panchari which were statistically similar with Sonargaon (4.917). The highest fruit weight (643.6gm) was found in SAU campus and the lowest (324.3gm) was found in BSMRAU. The range of fruit weight was 643.6-324.3 gm.

Table.4: Effect of yield parameters due to PRSV infection

Locations		Fruit /plant	Fruit weight
Dhaka	SAU, Dhaka	5.500 b*	643.6 a
	JU, Savar	5.000 bc	527.7 cd
Gazipur	BADC, Kashimpur	4.583 c	567.8 bc
	BSMRAU, Salna	6.167 a	324.3 e

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Narayanganj	Narayanganj Sadar	5.517 b	515.5 cd
	Sonargaon Upazilla	4.917 c	491.2 d
Khagrachari hill tract	Khagrachari Sadar	5.083 bc	504.6 d
	Panchari Upazilla	4.583 c	584.5 b
CV (%)		8.12	18.11
LSD value (0.05)		0.4859	51.56

*Values within the same column with a common letter (s) do not differ significantly (P=0.05)

3.6 Percent reduction in growth and yield parameters of papaya due to PRSV disease infection

The percent reduction of growth and yield parameters are shown in table 5 & 6 and Fig 6-9. The minimum plant height reduced (1.17%) was in SAU and the maximum (23.85%) in JU. In terms of leaf number, the lowest reduction (5.5%) was found in SAU and the highest reduction (21.9%) was found in Panchari. In Panchari, the lowest reduction (13.04%) of petiole length was found while the highest reduction (38.46%) was found in BADC. The highest reduction in fruit number (70.33%) was found in BSMRAU and the lowest (5.46%) in Khagrachari. But in the case of fruit weight, the maximum reduction (42.93%) was found in BADC while the lowest reduction (12.90%) was in SAU.

Table.5: Percent reduction of growth characters of papaya due to PRSV infection

Locations		% RPH*	% RNL	% RPL	% RLA
Dhaka	SAU	1.17	5.5	21.52	25.19
	JU	23.85	5.63	36.71	11.02
Gazipur	BADC	8.59	12.35	38.46	0.88
	BSMRAU	14.13	11.54	17.50	9.87
Narayanganj	Narayanganj Sadar	8.67	18.82	19.29	6.23
	Sonargaon	2.56	11.62	17.94	12.97
Khagrachari hill tract	Khagrachari Sadar	10.97	12.59	18.44	4.43
	Panchari	10.37	21.9	13.04	25.69

*RPH= Reduction of plant height, RNL= Reduction of number of leaf, RPL= Reduction of petiole length, RLA= Reduction of leaf area

Table.6: Percent reduction of yield characters of papaya due to PRSV infection

Locations		% RNF	% RFW
Dhaka	SAU	12.90	5.5
	JU	26.86	5.63
Gazipur	BADC	42.93	12.35
	BSMRAU	9.87	11.54
Narayanganj	Narayanganj Sadar	41.34	18.82
	Sonargaon	36.61	11.62
Khagrachari hill tract	Khagrachari Sadar	37.62	12.59
	Panchari	17.18	21.9

*RNF= Reduction of number of fruit, RFW= Reduction of fruit weight

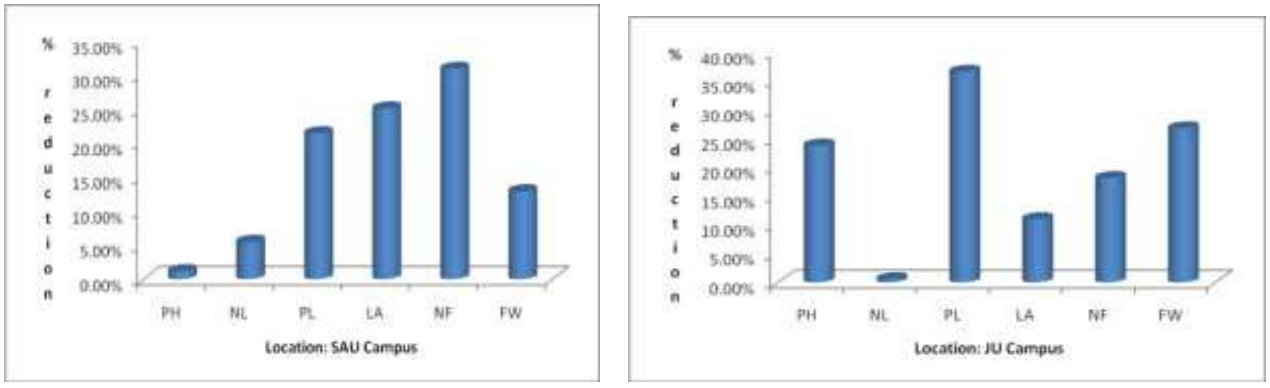

Fig 6: Percent reduction of growth and yield parameters in Dhaka district

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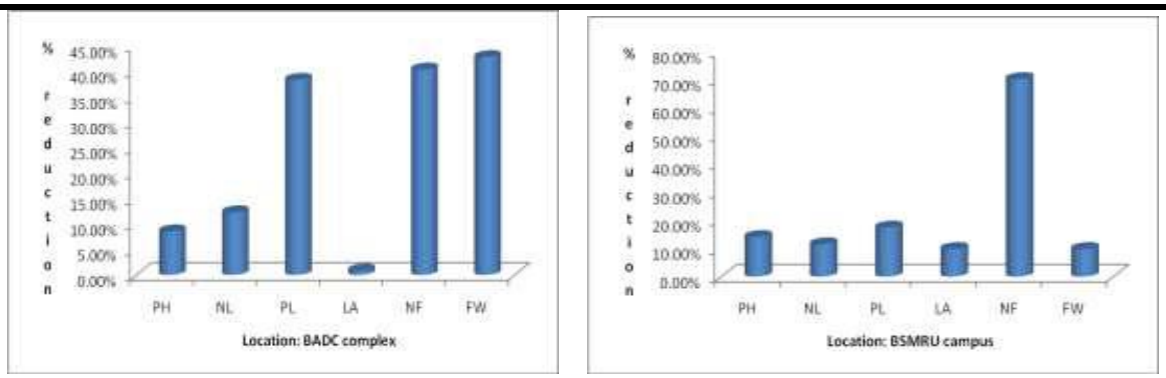

Fig 7: Percent reduction of growth and yield parameters in Gazipur district

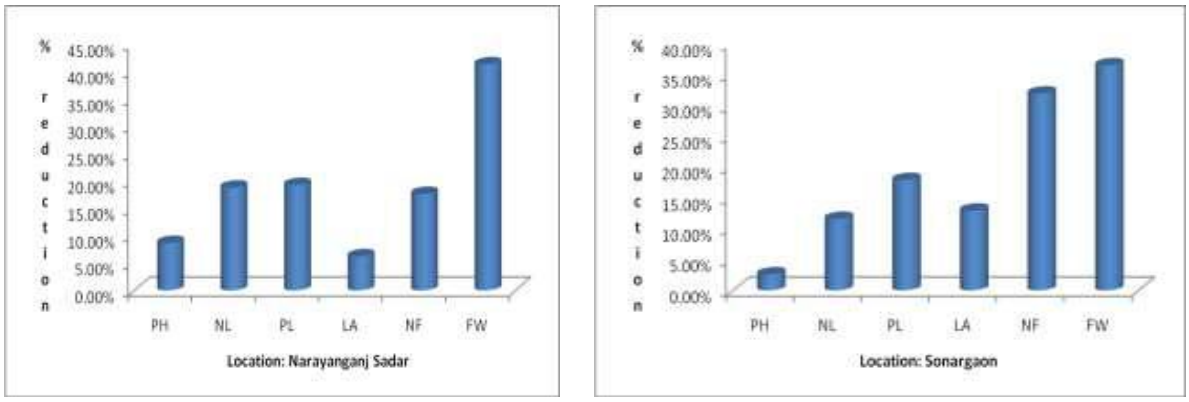

Fig 8: Percent reduction of growth and yield parameters in Narayanganj district

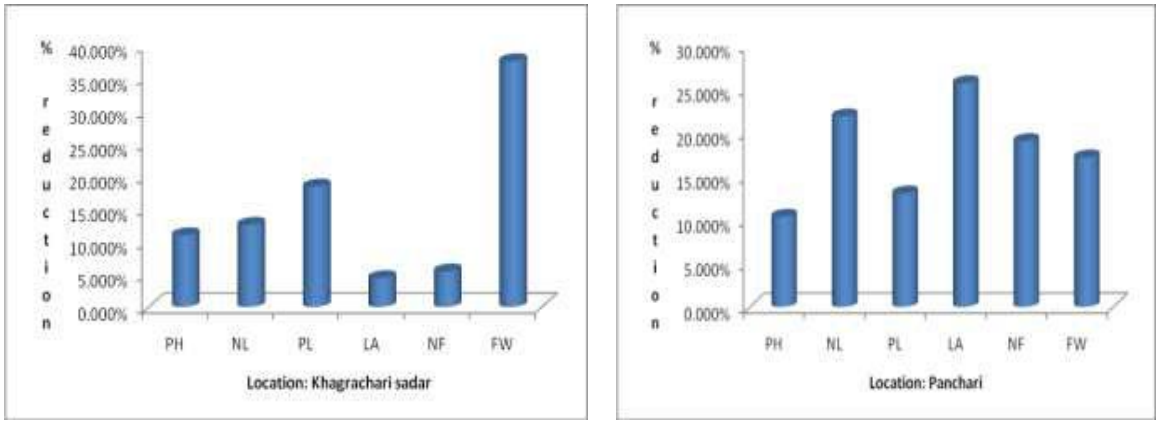

Fig.9: Percent reduction of growth and yield parameters in Khagrachari hill tract

IV. DISCUSSION

Papaya (*Carica papaya* L.) belongs to the family Caricaceae and is grown in Australia, Hawaii, Philippines, Sri Lanka, South Africa, India, Bangladesh, Malaysia and other countries in tropical America (Anuara *et al*. 2008). In 2009-2010, papaya has been cultivated in 2790 ha of land with a total production of 40.42 tons/ha (BBS, 2010) in contrast to about 11352202 tons' production of papaya in 2010 in the world (FAO, 2010). The papaya fruit is very rich in vitamin A, which refers to the second highest among of fruits and comes next to mango (Aykroyed, 1951).

There are several diseases causing damage is papaya cultivation, including fungal, bacterial and viral diseases. The diseases are very harmful for commercial cultivation. Among the viral diseases PRSV causes severe damage in growth and yield. Linder *et al*., 1945 has published a report about PRSV and brought it in literature for the first time. An investigation was done by Jensen (1949a and b) about the virus infecting papaya in Hawaii and named the virus as *Papaya ring spot virus* (PRSV).

In the present survey, the highest (36.24%) incidence was found in BSMRAU in Gazipur, whereas, the lowest value was found in Panchari (12.04%), Khagrachari. The maximum severity was recorded in BSMRAU (11.53%)

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while minimum severity was recorded in Panchari (2.50%). A similar survey was done by Akhter (2007) where he showed the reduction percentage of growth and yield of the plant due to infection of PRSV in different locations in Bangladesh. Seedlings showed prominent vein clearing and downward cupping of the young leaves stated by Conover (1964). Gonzalvez *et al*. (1997) established that PRSV caused three types of leaf symptom on papaya which are mosaic, yellowing and deformation. Rahaman (2003) also found similar symptoms during an investigation about PRSV in Kashimpur farm, BSMRAU farm and nineteen other districts. He showed there are seven symptoms visible in the infected plants. Among them, the maximum number of symptom was observed in BADC, Gazipur. Castro *et al*., (2015) had done similar type of survey to study incidence and severity in the state of Guerrero and found similar results.

During the survey, it was recorded that PRSV had a great influence in growth and yield parameters. PRSV also affected growth-contributing characteristics such as plant height, leaf number, petioles length and leaf area too. A similar experiment was conducted by Akhter, (2007). He had noted the reduction of seedling height due to inoculation of seven symptoms of four locations. A similar experiment was done by Akhter and Akanda (2008). They showed the remarkable effect of *Papaya ringspot virus*- papaya strain (PRSV-P) on growth and yield on papaya.

The yield loss due to papaya viral disease infection can reach up to 100% very often. In this survey, BSMRAU was recorded for maximum fruit number/plant (6.167). On the other hand, the minimum fruit number 4.583 was calculated in BADC and Panchari, respectively. The maximum fruit weight per fruit was found at SAU (643.6 gm) and the minimum was found at BSMRAU (324.3gm). There was similarity found by Akanda (1991) and showed that the virus causes 70%-100% yield reduction of papaya depending upon the stage of infection as estimated in Bangladesh.

During the survey, the minimum plant height reduction was at SAU (1.17%) and the maximum at JU (23.85%). In terms of leaf number, the lowest number was found at SAU (5.5%) and the highest number found at Panchari (21.9%). In Panchari the lowest value of petiole length was found (13.04%) and the highest was at BADC (38.46%). Leaf number reduction was the highest (21.9%) at Panchari and the lowest value (5.5%) was found in SAU campus. Rahaman (2003) also showed similar reduction of different characteristics of papaya due to PRSV-P infection. 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 caused by PRSV-P infection.

V. CONCLUSION

Papaya (*Carica papaya* L.) is a very important fruit all over the world and though its demand is increasing day by day, the production of papaya is not satisfactory. The present experiment was designed to study the surveillance and identification of PRSV disease based on symptomology and to observe the disease incidence and severity of PRSV at eight locations of four districts in Bangladesh. In the survey period among the eight locations, the highest incidence was found at BSMRAU (36.24%) and lowest at Panchari (12.04%). In the case of severity, the maximum severity was found at BSMRAU (11.53%) and minimum was recorded at Panchari (2.50%), BADC (3.057%) and Narayanganj Sadar (3.443%). In the selected locations, the growth parameters were also recorded, including plant height, leaf number, petioles length and leaf blade area. There were significant differences found in different growth parameters at different locations. The highest number of fruit was harvested from BSMRAU campus (6.167) as yield parameters and the lowest number was found at JU and Panchari (4.583). Significant variations also found in percent reduction of growth and yield parameters. From the findings of the study, it may be concluded that the disease incidence and severity and its effects on growth, yield, and yield parameters varied significantly in the surveyed areas by the infection of PRSV in papayas the lowest incidence and severity was found at Panchari (Hill tract area). The farmer may be suggested to cultivate papaya in that region. However, further study need to be continued to have information prissily.

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