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Status of Rice False Smut Disease in Natore District of Bangladesh

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ABSTRACT

Rice false smut has become an emerging disease across the world. Its incidence has become serious in Bangladesh during T. Aman season in the last five years. However, the status of the disease in farmer's field has not been estimated in this country. This study included a survey of 90 fields in four unions of Natore district during ripening stage of T. Aman rice of 2015 in order to estimate the disease incidence, number of smut balls per infected panicle and yield loss, and to ascertain effectiveness of farmer's unregistered foliar fungicide application. The results show that across the fields, disease incidence, number of smut balls per infected panicle and yield loss were 8.06±2.02%, 2.88±0.17 and 0.72±0.18% (± is 95% confidence interval), respectively. Disease incidence (18.71±5.18%), number of smut balls per infected panicle (3.51±0.39) and yield loss (1.75±0.38%) was the highest in Ramananda Khajura union compared to the other three unions surveyed. Among the varieties, BRRI dhan49 incurred the highest disease incidence (18.71±5.18%). The number of smut balls per infected panicle (3.51±0.39) and yield loss (1.75±0.38%) were also the highest in this variety. The crops which flowered during mid October to early November showed significantly higher disease incidence than early flowering crops. Application of unregistered foliar fungicides tended to have reduced the disease, but did not show significant difference with 'no fungicide application'. It is concluded that the strategic management of the disease may be directed to the specific areas of the fields where there is a history of the disease through manipulating genotypes and transplanting time. Farmers should be cautious on adopting chemical option as there is no registered fungicide yet in Bangladesh for tactical management of the disease.

Key words: Disease incidence, flowering time, transplanting time, *Ustilaginoidea virens*, yield loss

INTRODUCTION

Bangladesh is an agro-based country where rice (*Oryza sativa* L.) is the staple food of her 163.65 million people (Kabir *et al*., 2015). Geographic and agro-ecological conditions of Bangladesh are favourable for rice cultivation (Aziz, 2014). The 'food security' of Bangladesh is synonymous to 'rice security'. In addition, rice security is not only an economic issue but also an important parameter to determine social and political stability (Kabir *et al*., 2015). Therefore, keeping up the production of rice as per demand is very important for Bangladesh. The big news is that Bangladesh has recently achieved self-sufficiency in rice. However, more rice will be required in future because of increasing population. Decreasing resources (e.g. land, labour, soil health and water) and increasing climate vulnerability (e.g., drought, salinity, flood, heat, cold, tide and ebb, cyclone and hail storm) appeared as the great challenges to keep the pace of rice production in the background of increasing population (Kabir *et al*., 2015).

Rice yield in Bangladesh, which is on average 4.3 t ha^{-1}compared to 6.0 to 6.5 t ha^{-1} as in other countries like China, Japan, and South Korea (BRRI, 2015b), is influenced by many abiotic and biotic factors. Disease is one of the important biotic factors affecting rice yield in Bangladesh, which costs about 10-15% of annual production (Latif *et al*., 2007).

Rice false smut (RFSm) (anamorph: *Ustilaginoidea virens* (Cooke) Takah.;

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teleomorph: *Villosiclava virens* (Nakata) E. Tanaka & C. Tanaka) is one of the 32 diseases of rice identified in Bangladesh (BRRI, 2015a). It is a fungal disease of rice. Previously the disease was treated as minor disease (Nessa *et al*., 2015b). But the last five years the prevalence of the disease increased drastically in Bangladesh and it is being treated as a major disease (BRRI, 2015a). The typical symptom is the replacement of individual grains into large velvety orange to blackish green balls, commonly known as 'smut balls' (Nessa *et al*., 2015b). Such symptoms are only visible during post-flowering stage (Nessa *et al*., 2015b). The smut balls also known as pseudosclerotia or green balls, which are round or oblong in shape and uneven on their surface (Tanaka *et al*., 2008). The balls begin to appear 10-15 days after rice anthesis. At the beginning, balls consist of white hyphae, which then form a thick yellow, loose outer layer of chlamydospores in summer and early autumn, and an olive to black, hard outer layer in late autumn. Sclerotia often form on the colony surfaces, especially in later autumn, with higher and lower temperature differences between day and night (Zhang *et al*., 2013). The pathogen overwinters as sclerotia (Rush *et al*., 2000). Sclerotia are considered as the primary sources of infection of the disease (Fan *et al*., 2015). The yield losses from RFSm have been attributed to not only the smut ball incidence but also the chaffiness and reduction in individual grain weight (Li *et al*., 2013; Nessa *et al*., 2015a). It has been claimed that in the recent years, the disease can cause huge yield loss, up to 40% under severe incidence (Han *et al*., 2015) and incur significant monetary losses (Zhou, 2012).

High relative humidity (>90%), temperature between 25 and 30°C and rainy-days at the time of flowering are the favourable environmental factors for the disease infection, as mentioned by Atia (2004). However, wide use of high-yielding varieties with semi-dwarf characteristics (Wang *et al*., 2013) and especially hybrids (Han *et al*., 2015) with heavy application of nitrogenous (Li *et al*., 2013) and phosphorus fertilizer (Wang *et al*., 2013) in rice cultivation and late sowing have also favoured the disease. All those claims, hypotheses and speculations have not been tested under Bangladesh conditions.

The attack of the disease is predominant and wide-spread in transplant Aman or T. Aman season (BRRI, 2015a). But the disease is also present in smaller scale in other rice growing seasons like Boro and broadcast Aman or B. Aman and Aus season (BRRI, 2015a). The disease is more prevalent in the north-western part of the country (Unpublished data, B Nessa, SSO, BRRI, Bangladesh).

In this country, the prevalence and distribution of the disease has not been studied yet. In addition, there is no information regarding the status of incidence of the disease and its intensity in field scale. For this reason, the present study was undertaken to determine the level of infection of rice false smut disease in farmers' field, (ii) to evaluate geographic variation of the disease together with yield loss under natural environment, and to explore management options for the disease in farmers' fields.

MATERIALS AND METHODS

This study, as a survey of farmer's fields, was conducted in the north-western region of Bangladesh. This region was chosen as the rice false smut disease had been prevalent in the area in last five years (Unpublished data, B Nessa, SSO, BRRI, Bangladesh). Furthermore, this region has been reported to have much variation and diversification of the disease. Within the region, the Natore district was selected through consultation with the Deputy Directors of the Department of Agricultural Extension (DAE), Ministry of Agriculture, Bangladesh, believing that the district will represent the region in terms of the status of the disease.

Ninety fields from four unions were sampled (Fig. 1). The unions were: Ramananda Khajura and Hatiandah (in Singra upazila), Bagatipara pourasova (in Bagatipara upazila)

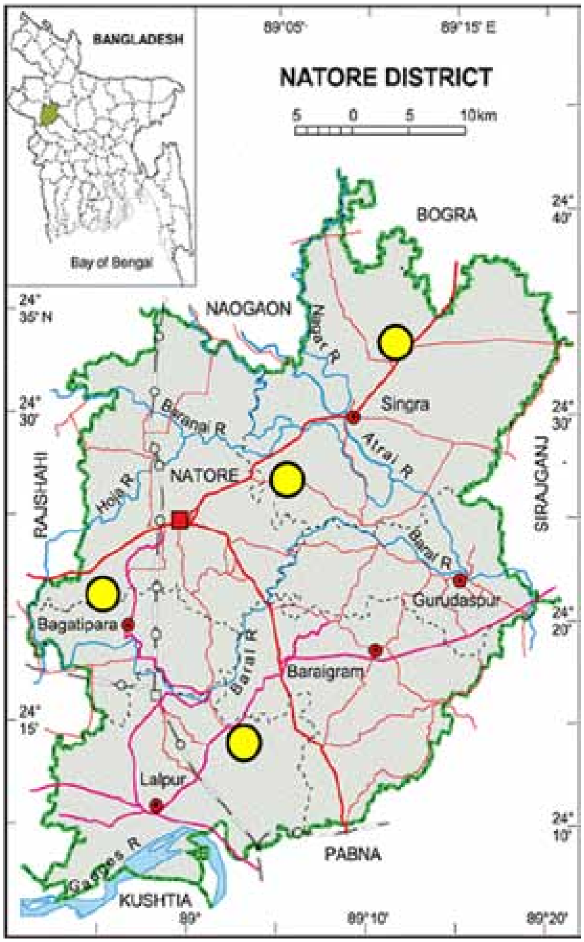

Fig. 1. Map of Bangladesh (inset) and Natore district showing the survey locations (filled circles).

and Gopalpur pourasova (in Lalpur upazila). From Ramananda Khajura union, 25 fields were selected of which 11, 7, 3 and 4 belonged to Koyapara, Koigram, Ajurdorgah and Chora-Vogirpukur villages, respectively. From Hatiandah union, 32 fields were selected and all the fields belonged to Shalikha village. From Bagatipara pourasova, 19 fields were selected of which 12, 5 and 2 belonged to Broypara, Baroygram-Masimpur and Sonapatil villages, respectively. From Gopalpur pourasova, 14 fields were selected of which 2, 6, 1, 1, 1, 2 and 1 belonged to Bhuianpara, Bijoypur, Mohishakhola, Kesobpur, Choknazirpur, Kalupara and Shibpur villages, respectively.

The disease data were collected from five spots, named as blocks, from each field. For this, each of the fields was roughly divided into five blocks located in the upper left side, upper right side, lower left side, lower right side and the middle. From each block, nine hills were randomly selected in a 3×3 matrix.

The field survey was conducted during November 2015. This period was chosen because most of the crops were in mid- to late-flowering stage when the disease was visible. Data on total number of panicles per hill, number of infected panicles per hill and number of smut balls per hill were recorded from each sampling block. In addition, planted variety, date of transplanting, seedling age, date of 50% flowering (anthesis) and status ('yes' or 'no') of foliar fungicide application were recorded for each surveyed field by interviewing farmers.

Measured data from five spots were averaged for representing the field on (i) disease incidence (DI) and (ii) number of smut balls per infected panicle (bp):

(i) DI (%) = (Number of infected panicle(s) / Total number of panicles) × 100

(ii) bp (number of smut balls per infected panicle) = Total number of smut ball(s) / Total number of infected panicles

The yield loss was estimated according to Nessa *et al*. (2015a)

(iii) Yield loss (%) = (DI/100) × [0 + 100 × $(1 - e^{0.03 \times bp})$]

Where, DI is the disease incidence and bp is the number of smut balls per infected panicle.

The flowering times of the crops in the recorded range of 13 September to 1 November were summarized as 5-day interval and corresponding DIs were averaged for each interval. The status of foliar fungicide application was available for 32 fields - 16 each 'with' and 'without' foliar fungicide application. The DIs for 16 'with' and 16 'without' foliar fungicide application were averaged.

The variations in disease incidence, number of smut balls per infected panicle and yield loss for four unions, varieties, times of flowering and effect of foliar fungicide application were statistically analyzed by 95% confidence interval (CI) using Microsoft Office Excel (Nessa *et al*., 2015b).

RESULTS AND DISCUSSION

Status of rice false smut disease in Natore district

The overall disease incidence (%), number of smut balls per infected panicle and yield loss (%) across the 90 fields surveyed in Natore district were 8.06±2.02, 2.88±0.17 and 0.72±0.18, respectively (± is 95% confidence interval) (Table 1). To the best of our knowledge, there is no report in Bangladesh on the status of the disease from farmers' field. In Egypt, the disease incidence and number of smut balls per infected panicle had been reported as 11.76% and 3.66, respectively (Atia, 2004). A survey during 2011 cropping season, the disease incidence of 15.83% was reported from Kashmir of India (Sanghera *et al*., 2012). Kumari and Kumar (2015) published the incidence of the disease from Uttarakhand and Uttar Pradesh of India in the range of 5.00–48.76%. The yield loss reported by the same authors (Kumari and Kumar, 2015) ranged between 0.82 to 17.09%, whereas it was calculated as 3.43% in Egypt (Atia, 2004). Nessa *et al.* (2015a) estimated 3.4 to 13.5% yield loss from rice false smut disease in four fields located in the research station of the Bangladesh Rice Research Institute (BRRI), Gazipur.

Table 1. Status of rice false smut disease in Natore district of Bangladesh, T. Aman 2015.

Union / District	Disease incidence (%)	Number of smut balls per infected panicle	Yield loss (%)
Bagatipara pourasova	5.66±1.41	3.05±0.33	0.52±0.16
Gopalpur pourasova	3.15±0.47	2.48±0.17	0.22±0.03
Hatiandha	3.32±0.70	2.47±0.19	0.25±0.07
Ramananda Khajura	18.71±5.18	3.51±0.39	1.75±0.38
Natore	8.06±2.02	2.88±0.17	0.72±0.18

± is 95% confidence interval

Results further revealed significant difference in the status of the disease and resulting yield loss in the four surveyed unions of Natore district. The measured disease incidence was significantly highest in Ramananda Khajura union (18.71±5.18%) compared to the rest three unions, namely, Bagatipara pourasova (5.66±1.41%), Hatiandah (3.32±0.70%) and Gopalpur pourasova (3.15±0.47%), respectively (Table 1). Table 1 further shows that the highest number of smut balls per infected panicle was observed in Ramananda Khajura union (3.51±0.39, ± is 95% confidence interval) and the lowest in Hatiandah (2.47±0.19). Results also indicate that number of smut balls per infected panicle was statistically similar in the unions of Ramananda Khajura (3.51±0.39) and Bagatipara pourasova (3.05±0.33). Table 1 indicates that Ramananda Khajura union had the highest yield loss (1.75±0.38%) followed by Bagatipara pourasova (0.52±0.16%). The difference in yield loss between the two unions was not statistically significant. The lowest yield loss was recorded in Gopalpur pourasova (0.22±0.03%). The geographical differences in the status of the disease and resulting yield loss were also presented in Egypt by Atia (2004). For example, in 2000, Abou-Hammad district recorded as the highest disease incidence (50.33%) compared to the lowest in Kafer-Saker district (6%). The number of smut balls per infected panicle was also the highest in Abou-Hammad district (8.16) and the lowest (3.14) in Kafer-Saker and El-Ibrahimia districts. Ladhalakshmi *et al.* (2012) presented the disease incidence in the northern Indian states between 2 to 75%. Similar to disease incidence and number of smut balls per infected panicle, the yield loss was reported to vary in different areas of Egypt (ranging from 1.01 to 10.91%) (Atia, 2004) and India (Uttarakhand and Uttar Pradesh, ranging between 0.82 and 17.09%, Kumari and Kumar, 2015).

Status of rice false smut disease on different varieties

Altogether 13 varieties were found in 90 fields surveyed in the study area. This section reports the status of seven varieties. It did not include the rest six varieties (Badshahbhog, Binadhan-7, BRRI dhan34, BRRI dhan39, Dhani Gold Hybrid and Kalijira) as the sample size was small (≤3). Across all 90 fields surveyed, the disease incidence was significantly the highest in BRRI dhan49 (18.71±5.18%, ± is 95% confidence interval) compared to other varieties (Table 2). The rest six varieties had statistically similar disease incidence in the range of 2.92±0.66 to 4.64±2.44%. Like the disease incidence, number of smut balls per infected panicle was the highest in BRRI dhan49 (3.51±0.39) but statistically similar to Swarna (2.91±0.24). In rest of the varieties, the number of smut balls per infected panicle was statistically similar. Numerically, the lowest number of smut balls per infected panicle was recorded in both Guti Swarna (2.24±0.23) and Nepali Swarna (2.24±0.49). BRRI dhan49 showed the highest yield loss (1.75±0.38%) compared to the rest of the varieties. The lowest yield loss was found in Guti Swarna (0.19±0.05%). Varietal difference in the incidence of rice false smut disease and number of smut balls per infected panicle (or severity) and yield was also reported in Egypt (Atia, 2004) and India (Singh and Dube, 1978; Kumari and Kumar, 2015).

Effect of flowering time on incidence of rice false smut disease

When rice flowered during mid October to early November, the incidence of rice false smut disease was higher than early flowering crops (Fig. 2). However, the crops flowered during last week of October showed the highest disease incidence (12.78±4.52%, ± is 95% confidence interval). The crops which flowered during mid-September to early-October showed very low disease incidence (≤0.72±0.92%). Nessa *et al*. (2015c) in Bangladesh also observed increasing incidence of rice false smut from mid October, which reached the peak during early November. The variation in the disease incidence due to planting time, which causes variation in flowering, was also reported in Egypt (Atia, 2004), Nigeria (Ahonsi *et al*., 2000) and USA (Cartwright, 2002; Wamishe *et al.,* 2013).

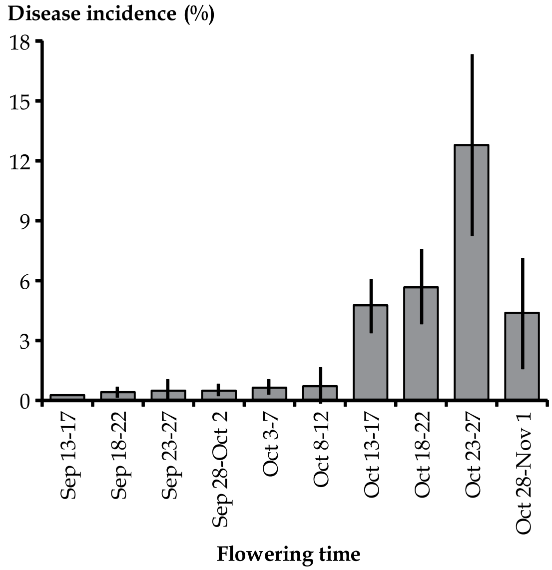

Fig. 2. Effect of time of flowering of T. Aman rice on the incidence of rice false smut disease observed in farmer's fields in Natore district of Bangladesh. A vertical bar indicates 95% confidence interval (CI).

Table 2. Status of rice false smut disease, T. Aman 2015 on different varieties in surveyed areas of Natore district.

Variety	Disease incidence (%)	Number of smut balls per infected panicle	Yield loss (%)
Bijoy Swarna	3.79±3.22	2.36±0.53	0.30±0.31
BRRI dhan33	2.96±0.84	2.60±0.23	0.22±0.05
BRRI dhan49	18.71±5.18	3.51±0.39	1.75±0.38
BRRI dhan52	4.64±2.44	2.48±0.36	0.36±0.27
Guti Swarna	2.92±0.66	2.24±0.23	0.19±0.05
Nepali Swarna	3.92±0.66	2.24±0.49	0.28±0.07
Swarna	4.46±1.05	2.91±0.27	0.40±0.1

± is 95% confidence interval

Table 3. Status of rice false smut disease during T. Aman **season of 2015 on different varieties in surveyed areas of Natore district of Bangladesh.**

Status of unregistered foliar fungicides application	Disease incidence (%)	Number of smut balls per infected panicle	Yield loss (%)
With fungicides	2.8±0.6	2.4±0.3	0.2±0.1
Without fungicide	3.8±1.2	2.9±0.3	0.3±0.1

± is 95% confidence interval

Effect of foliar fungicide application on disease incidence, number of smut balls per infected panicle and yield loss

Use of foliar fungicides, which were unregistered, tended to produce less disease incidence (2.8±0.6%, ± is 95% confidence interval) and number of smut balls per infected panicle (2.4±0.3) and thereby less yield loss (0.2±0.1%) than without fungicide (3.8±1.2%), (2.9±0.3) and (0.3±0.1%), respectively (Table 3). However, the differences were not statistically significant. In Egypt, Atia (2004) recorded a significant variation in disease incidence and number of smut balls per infected panicle due to fungicide use. Ahonsi and Adeoti (2003) in Nigeria recorded a reduced incidence and severity of the disease in the fields with fungicide application. Cartwright (2002) reported Propiconazole, Tilt or Propimax reduced the number of false smut balls in the harvested grain by 50 to 75%. Hegde *et al*. (2000) also found similar results. Raji *et al.* (2016) reported the lowest disease severity, compared to control, with the application of Propiconazole 25 EC (0.1%). Bagga and Kaur (2006) reported good management of the disease by using a number of chemicals. Kumari and Kumar (2015) found spraying of Propiconazole (@ 0.1%) with first spray at booting stage and second at an interval of 10 days was most effective. Similarly, Trifloxystrobin+Tebuconazole (0.04%), Hexaconazole (0.2%), Carbendazim (0.1%) and Kreoxim methyl (0.1%) significantly reduced its incidence compared to the control.

CONCLUSION

Variation in the status (expressed in this study as disease incidence and number of smut balls per infected panicle) of rice false smut disease can occur across geographical locations, even between the fields within a smaller geographical boundary, likely due to the difference in the level of inoculum in soil as indicated by Nessa *et al*. (2015b). Some varieties are less tolerant (otherwise more susceptible) to the disease. The disease is more prevalent during a certain window of flowering time. Application of unregistered foliar fungicides tends to reduce the disease incidence, but the evidence is not statistically supportive. Based on the findings, strategic management of the disease may be directed to the specific areas of the fields where there is a history of the disease through manipulating genotypes and transplanting time. The tactical management of the disease is yet to be investigated. It should be remembered that there is no registered fungicide yet in Bangladesh for management of rice false smut disease.

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