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Disease prevalence and its impact on yield performance of tropical sugarbeet (*Beta vulgaris* L.) genotypes under Bangladesh conditions

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ABSTRACT

Tropical sugarbeet is the most promising alternative sugarcrop in the tropical and subtropical regions. The study's aim was to identify the major diseases that affect tropical sugarbeet growth and yield in Bangladesh. Fifteen tropical sugarbeet genotypes were seeded in the experimental field of the pathology division of BSRI, Ishurdi, Pabna, on November 10th, 2016 in an RCBD design with three replications. All tropical sugarbeet genotypes demonstrated good field emergence, ranging from 82.91 to 93.33% at seven days after sowing (DAS). *Sclerotium* root rot, *Rhizoctonia* crown and root rot, *Cercospora* leaf spot, *Alternaria* leaf spot, and root knot were identified as major diseases and limiting factors for sugarbeet cultivation in Bangladesh. All tropical genotypes were infected by *Sclerotium* root rot, which varied from 5.83 to 35.83%, *Rhizoctonia* crown and root rot was 0-5%, *Cercospora* leaf spot was 10.83-23.75%, *Alternaria* leaf spot disease was 1.25 to 4.20%, and root knot was 0-0.83% disease incidence. Plant height ranged from 60.67 to 77.11 cm at 165 DAS. Similarly, root length differed from 18.60 to 24.00 cm, and root girth diameter varied from 78.38 to 96.77 mm. Individual beet weights differed between genotypes, ranging from 0.626 kg to 0.975 kg. The mean root yield across all the genotypes was 66.22 t/ha when harvested at 165 DAS. The genotypes SZ-35 (87.39 t/ha) and SV-889 (53.07 t/ha) produced the highest and lowest root yields at 165 DAS, respectively. The roots of genotypes SV-35 and SV-893 contained a relatively high amount of pol % beet, at 13.89% and 13.13%, respectively. All the genotypes had more than 11.3 % pol (%) beet and can be considered sugar-producing genotypes.

Key words: *Beta vulgaris,* disease prevalence, sugarbeet, tropical, yield performance

INTRODUCTION

Sugarbeet (*Beta vulgaris* L.) is the second most important sugarcrop after sugarcane. Approximately 20% of white sugar is produced from sugarbeet worldwide (Bruhns 2013). Sugarbeet is a member of the Chenopodiaceous family of plants with high sucrose content in its roots (Draycott 2003, Ford-Lloyd 2005, Hoffmann 2010). Sugarbeet is predominantly and commercially cultivated for sugar production in temperate countries (Islam et al. 2012, Varga et al. 2021). The top sugarbeet producers in the world are the Russian federation, France, Germany, Turkey, and the United States and approximately 278.5 Mt of sugarbeet were produced worldwide in 2019 (FAO 2019). Recently, some tropical sugarbeet genotypes have been developed that can be grown in both tropical and sub-tropical regions of the world and are known as tropical sugarbeet varieties. Tropical sugarbeet is a promising alternative energy crop for sugar and ethanol production in Bangladesh so that Bangladesh sugarcrop research institute (BSRI 2005) conducted a pilot research trail in different sugar mill and non-mill zones for the purpose of sugar, and jagarry production feasibility (Rahman et al. 2007). Currently, only a few farmers are growing vegetable beet in limited areas (Rashid 1999, Islam et al.

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2012). There are numerous advantages to tropical sugarbeet production over sugarcane production. Tropical sugarbeet is a short-duration crop (5–6 months) with high sucrose content (14–20%), whereas sugarcane is a long duration crop (12–14 months) with low sucrose content (10–12%) (Islam et al. 2014). Because of the long duration of sugarcane, farmers are shifting to growing shorter-duration crops to increase profits (Hossain et al. 2021). As a result of the shortage of sugarcane, most of the sugar mills have been idle for a long period of time in Bangladesh (Hossain et al. 2020). In this regard, sugarbeet could be an excellent substitute for sugarcane if processing facilities are developed in sugar mills (Islam et al. 2012).

The introduction of a temperate sugarbeet into a tropical and sub-tropical climate poses many important pathological problems due to the high temperature (Aly 2006). The conditions are suitable for growth and development of the sugarbeet and the succulent nature of its foliage and roots are also favourable for quick development, proliferation, and spread of the diseases (Memon et al. 2004). Globally, diseases are one of the major constraints on the profitable yield of sugarbeet in the form of tonnage and sugar content that can be economically processed into commercial sugar. About 16–20% of the crop is destroyed by diseases every year (Srivastava 2004). The diseases of the sugarbeet have played an extremely important role in the current distribution of the beet sugar industry and sugarbeet crops in most of the sugarbeet growing countries (Pammel 2017). The crop is subject to attack by these diseases from the time of seed sowing until harvest. All parts of the sugarbeet plant (seeds, seedlings, roots, and foliage) are susceptible to attack by a number of diseases which reduce the quantity and quality of roots. World-wide, over 50 diseases are known to affect sugarbeets, of which nearly 20 are of economic importance (Pammel 2017). With the expansion of sugarbeet production worldwide, the diseases have increased in number and severity. So, it is very important to identify the major diseases of tropical sugarbeet and develop their management before beginning commercial cultivation in Bangladesh. To the best of our knowledge, this work is a pioneer study on the investigation of major diseases of tropical sugarbeet genotypes, their incidence, and yield performance in Bangladesh. The results of this present study provide important baseline information about the disease incidence of sugarbeet genotypes and their impact on yield performance.

MATERIALS AND METHODS

The experiment was conducted at the experimental field of the Pathology Division at the Bangladesh Sugarcrop Research Institute, BSRI, Ishurdi, Pabna, from November 2016 to April 2017. For the present study, fifteen tropical sugarbeet genotypes, viz., SZ-35, Aranka, SV-35, SV-891, SV-893, PAC-60008, SV-889, Natura, Belleza, BA_1, BA_2, SV-894, Danicia, Serenada, and SV-892, were collected from Syngenta Bangladesh Limited, Ses Vander Have, and KWS, Germany. The soil in the experimental field was analyzed to determine the nutrient status of the experimental sites (Table 1). The experiment was designed in RCBD, with three replications. Raised beds were seeded on November 10th, 2016 where the unit bed was 5.0 m x 1.0 m in size, considered as one replicate. Each replication had 80 plants with a plant-to-plant and row-to-row distance of 20 and 50 cm, respectively. Two seeds were sown in each pit to ensure germination of the plant. After germination, only one plant was kept to grow. Manures and fertilizers were applied following the doses recommended by the agronomy division of BSRI (Islam et al. 2014). Applications of urea and mop were applied as a top-dressing in two equal installments at 45 and 75 days after sowing (DAS) (Islam et al. 2014). Weeding, irrigation, and other intercultural activities were done on a regular basis. To control the jute hairy caterpillar, the larvae were destroyed by hand soon after infestation. An integrated approach was adapted to control *Spodoptera litura* (a lepidopterous insect). Nitro-505EC (chlorpyriphos + cypermethrin) @ 0.1% was sprayed twice in 7 days. To catch male insects, a pheromone trap (*Spodoptera* pheromone) was also placed in the field. In order to control *Spodoptera litura*, a predator insect (*Bracon hebetor*) was also released into the field. To determine different agronomic traits, including yield and other growth parameters, ten plants were harvested at random from each genotype at 165 days after sowing (DAS). Sucrose was determined using a polarimeter (Model: Atago AP-300), at the Physiology and Sugar Chemistry Division, Bangladesh Sugarcrop Research Institute. The data on each disease parameters was recorded by observing the disease symptoms on individual plants in every week and up to harvest of the plant in the field (Figure 2a-e). Disease incidence was assessed by using the formula described by Rashid (2005) as below.

$$\mathrm{DI} = \frac{\mathrm{NIP}}{\mathrm{TNPA}} \times 100$$

Where
DI= Disease incidence
NIP= Number of infected plants
TNPA= Total number (healthy and infected) of plants assessed

The pathogen was isolated using the method described by Rangswami (1958). The symptomatic plant samples were cut into (5 × 5 mm pieces) and surface sterilized using 1% NaOCl for 1 min, followed by dipping into 70% ethanol for 1 min. The sterilized tissues were rinsed three times with sterilized water and dried on sterilized Whatman filter paper. Thereafter, the samples were placed on Petri plates containing potato dextrose agar (PDA; Merck, Germany). All the plates were incubated at 28–30°C for fungal growth. After five days of incubation, the margins of the fungal hyphae produced by the tissues were transferred to the fresh PDA. The spores' mass was picked up using a sterilized wire loop and streaked on to the water agar. The hyphal tips of single germinated spores were transferred to the PDA slants to keep the pure colonies viable. Pure cultures were maintained on PDA plates with periodic sub-culture and kept at 4±1 °C. The causative agents of those diseases were identified by observing mycelium and conidial typical symptoms under the compound microscope. The generated data was properly compiled and statistically analyzed by the SATS10 software program for interpretation of the results.

Table 1. Analytical data of soil sample

Sample No.	pH	Organic Carbon (%)	Total N (%)	P (ppm)	K (meq/ 100g soil)	S (ppm)	Zn (ppm)
1	7.62	0.46	0.060	15.0	0.18	24.0	0.64
Critical limit	-	-	-	14.0	0.20	14.0	2.0

RESULTS AND DISCUSSION

Field emergence: All the tropical sugarbeet genotypes have demonstrated good field emergence, which ranged from 82.91 to 93.33%. The genotype BA_1 showed maximum (93.33%) field emergence and the genotype SV-35 showed minimum (82.91%) field emergence (Table 1). These results were similar to the findings of Islam et al. (2014), who reported that the tropical sugarbeet germination ranged from 80.0 to 95.0%.

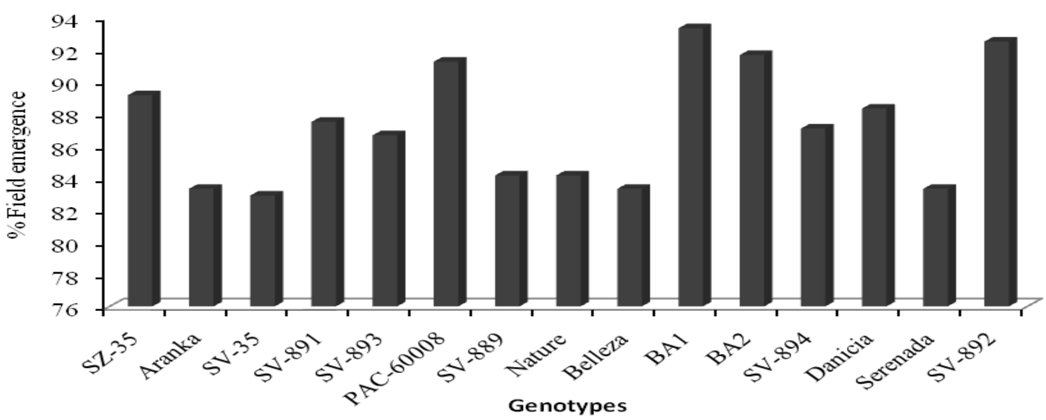

Figure 1. Field emergence percentages of different genotypes for tropical sugarbeet genotypes

Incidence of the diseases: *Sclerotium* root rot (*Sclerotium rolfsii*), *Rhizoctonia* crown and root rot (*Rhizoctonia solani*) *Cercospora* leaf spot (*Cercospora beticola*), *Alternaria* leaf spot (*Alternaria altarnata*), and root knot (*Melodogyne spp*) diseases were identified as the main diseases of tropical sugarbeet genotypes in Bangladesh. The causative agents of these diseases were identified under compound microscopes based on their typical morphological and conidial characteristics (Figure 2). Out of these diseases, two were root diseases (*Sclerotium* root rot and root knot nematode), two were leaf diseases (*Cercospora* leaf spot and *Alternaria* root spot), and one was both leaf and root disease (*Rhizoctonia* crown and root rot) of tropical sugarbeet (figure 2). All tropical sugarbeet genotypes were infected with *Sclerotium* root rot disease, which ranged from 5.83 to 35.83% disease incidence. The genotype PAC-60008 showed the highest (35.83%) and the genotype SV-892 showed the lowest (5.83%) of *Sclerotium* disease incidence. Seven genotypes were infected with *Rhizoctonia* crown and root rot with a disease incidence of 0-5%. All genotypes were infected with *Cercospora* and *Alternaria* leaf spot with disease incidence ranging from 10.83 to 23.75% and 1.25 to 4.20%, respectively. Seven genotypes were infected with root knot disease, having an incidence of 0 to 0.83% (Table 2). This result agreed with the finding of Srivastava et al. (2004), who stated that *Sclerotium* root rot (*Sclerotium rolfsii)*and *Rhizoctonia* root rot (*Rhizoctonia solani)* disease incidences 15–30% to 50% whereas *Cercospora* leaf spot (*Cercospora beticola*) and *Alternaria* leaf spot (*Alternaria alternate*) disease incidence 33–44% and 20–30% in India, respectively. Similar findings were reported by Islam et al. (2012), who stated that the *Sclerotium* root rot disease incidence ranged from 0 to 20% and the *Rhizoctonia* crown rot disease incidence ranged from 0 to 20% in different vegetable sugarbeet genotypes. This study revealed that *Sclerotium* root rot is the most serious disease of tropical sugarbeet in Bangladesh, and all genotypes showed this disease symptom severely. This disease is found in the field generally from February to April, when sugarbeet root formation starts, and at that time, warm weather as well as sporadic rainfall occur. This warm weather and wet conditions might be favour the *Sclerotium* root rot disease development. This assumption is supported by Srivastava et al. (2004) who stated that high temperature and relative humidity enhance the *Sclerotium* root rot disease incidences. On the other hand, all genotypes demonstrated *Cercospora* and *Alternaria* leaf spot diseases infestation mostly in the older leaves that are naturally dropped off. A few genotypes showed *Rhizoctonia* root rot and root knot disease. This might be the most of the genotypes are tolerant to these disease and weather is unfavourable for these diseases.

Table 2. Incidence of major diseases for tropical sugarbeet genotypes in Bangladesh

Sugarbeet genotypes	Disease incidence (%)				
	SRR	RRR	CLS	ALS	Nemic
SZ-35	15.83 ab	0.75 bc	10.83 c	2.91ab	0.00 b
Aranka	10.41 b	0.00 c	19.58 a-c	2.91 ab	0.00 b
SV-35	15.83 ab	0.00 c	19.16 a-c	3.75 ab	0.00 b
SV-891	19.58 ab	0.00 c	14.58 bc	2.50 ab	0.00 b
SV-893	22.50 ab	0.00 c	13.33 bc	2.91 ab	0.00 b
PAC-60008	35.83 a	0.00 c	10.83 c	1.66 ab	0.00 b
SV-889	7.08 b	0.00 c	17.91 a-c	3.33 ab	0.41 ab
Nature	7.91 b	0.00 c	19.58 a-c	4.20 a	0.00 b
Belleza	15.00 ab	0.83 bc	23.75 a	3.75 ab	0.00 b
BA_1	15.00 ab	0.00 c	14.16 bc	2.50 ab	0.00 b
BA_2	12.50 b	1.66 a-c	14.16 bc	3.75 ab	0.00 b
SV-894	10.83 b	4.58 ab	20.83 ab	4.16 a	0.00 b
Danicia	9.16 b	1.66 a-c	15.40 a-c	1.58 ab	0.00 b
Serenada	17.08 ab	1.25 a-c	11.66 c	1.25 b	0.41 ab
SV-892	5.83 b	5.00 a	17.91 a-c	3.33 ab	0.83 a
LSD (0.05)	22.65	4.07	9.06	2.79	0.76
CV	97.51	24.39	46.83	36.03	31.68

In a column, values having different letter (s) diffred significantly at P ≤5 % level of probability by Tukey's test. Note: SSR: *Sclerotium* root rot; RRR: *Rhizoctonia* root rot; CLS: *Cercospora* leaf spot; ALS: *Alternaria* leaf spot; Nemic: Nematode disease

Growth and yield parameters: The major diseases of tropical sugarbeet have significant effects on the growth and yield parameters such as plant height, root length, root girth, individual beet weight, yield, and pol percentage at 165 days after sowing, as presented in Table 3. The height of the plants ranged from 60.67 to 77.11 cm. The genotype BA_2 had the highest plant height (77.11 cm) and the genotype Aranka had the lowest plant height (60.67 cm). Root length and root girth varied among the genotypes. The genotype Belleza produced the longest roots (24.0 cm), while the genotype SZ-35 produced the largest root girth (96 mm). On the other hand, the genotype SV-35 produced the shortest root length (18.60 cm), while Aranka produced the smallest root girth (78 mm). The individual beet weight for genotype SZ-35 was the highest (0.975 kg), and for genotype SV-889 it was the lowest (0.626 kg). The genotype SZ-35 produced the highest yield of 87.39 t/ha, while the genotype SV-889 produced the lowest yield of 53.07 t/ha.

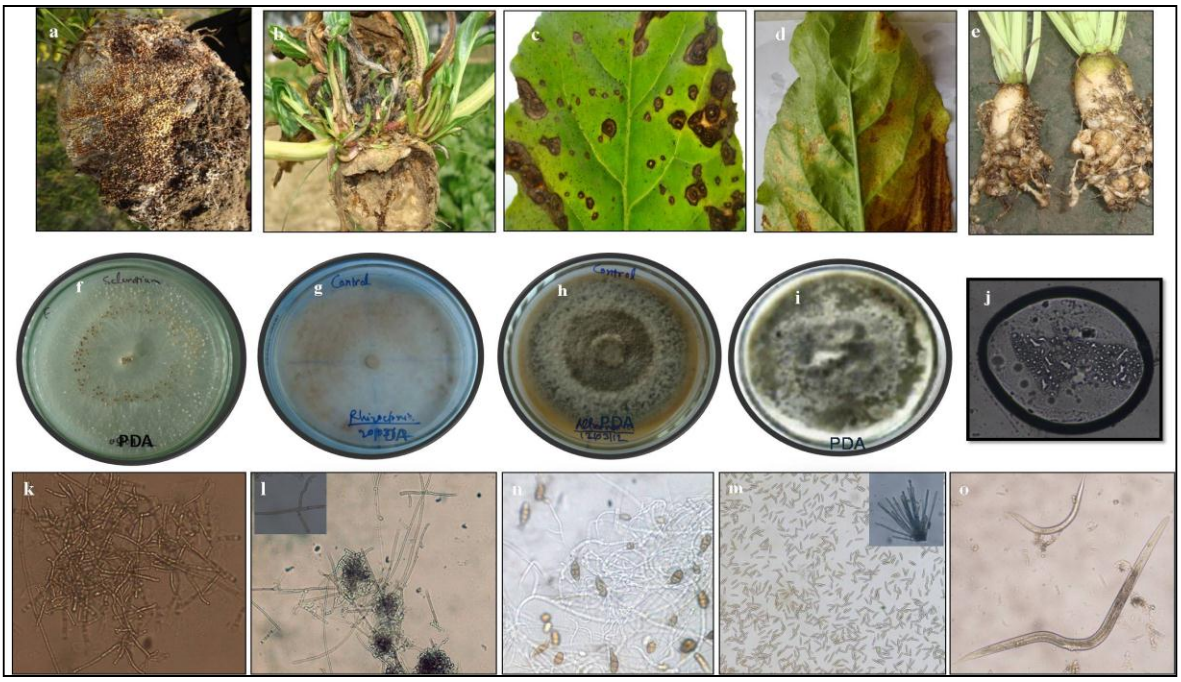

Figure 2: Field symptoms of major tropical sugarbeet diseases (a) *Sclerotium* root rot (b) *Rhizoctonia* crown and root rot (c) *Alternaria* leaf spot (d) *Cercospora* leaf spot (e) Root knot disease; pure culture of (f) *Sclerotium rolfsii* (g) *Rhizoctonia solani* (h) *Alternaria altarnata* (i) *Cercospora beticola* (J) *Melodogyne spp* cyst and microscopic features of (k) Sepetate mycelia of *Scelotium rolfsii* (l) perpendicular mycelia of *Rhizoctonia solani* (n) Muriform conidia of *Alternaria alternate* (m) conidia and conidiophore of *Cercospora beticola* (o) larvae and adult of *Melodogyne* spp nematode.

Table 3. Growth and yield parameters for different genotypes of tropical sugarbeet

Sugarbeet genotypes	Plant height (cm)	Root length (cm)	Root girth diameter (mm)	Individual beet weight (kg)	Yield (t/ha)	Pol %beet
SZ-35	72.33 bc	21.26 a-e	96.77 a	0.975 a	87.39 a	11.32 d-g
Aranka	60.67 f	20.80 a-e	78.38 b	0.848 ab	69.97 a-c	11.51 d-g
SV-35	66.33 de	18.60 e	90.11 ab	0.723 bc	59.65 bc	13.13 ab
SV-891	67.44 de	21.93 a-e	85.72 ab	0.797 a-c	69.79 a-c	12.83 a-c
SV-893	62.89 ef	22.60 a-d	88.66 ab	0.690 bc	59.63 bc	13.89 a
PAC-60008	61.66 f	19.46 de	80.55 ab	0.707 bc	64.24 bc	10.95 g
SV-889	74.55ab	20.73 b-e	91.11 ab	0.626 c	53.07 c	11.01 fg
Natura	70.22 b-d	23.93 ab	84.44 ab	0.748 bc	62.20 bc	12.31 b-d
Belleza	69.00 cd	24.26 a	85.00 ab	0.786 a-c	65.47 bc	12.74 bc
BA_1	60.77 f	20.60 b-e	79.78 ab	0.674 bc	62.84 bc	12.27 b-e
BA_2	77.11 a	20.20 c-e	84.50 ab	0.735 bc	66.60 bc	12.0 b-f
SV-894	74.11 ab	23.40 a-c	88.61 ab	0.846 ab	73.20 ab	12.63 bc
Danicia	63.55 ef	22.06 a-e	82.44 ab	0.778 bc	69.24 a-c	11.19 efg
Serenada	64.33 ef	21.13 a-e	89.72 ab	0.692 bc	67.32 bc	11.04 fg
SV-892	70.78 b-d	22.40 a-d	83.77 ab	0.753 bc	69.71 a-c	11.94 c-g
Mean	67.72	22.90	85.97	0.706	66.69	12.05
LSD (0.05)	4.58	3.53	18.15	0.194	19.76	1.08
CV	4.05	9.79	12.63	15.34	17.90	5.37

In a column, values having different letter (s) differed significantly at P ≤5 % level of probability Tukey's test.

The genotype SV-893 had the highest pol% (13.89%), while PAC-60008 had the lowest (10.95 %) pol% (Table 3). The growth and yield results of this study were consistent with the findings of Islam et al. (2014), who reported that the plant height and beet length were 65 cm and 30 cm, respectively, with an individual beet weight of 0.998 kg, and the beet yield ranged from 62 to 85 t/ha . The beet girth and pol (%) were similar to the findings of Rahman et al. (2007) and Islam et al. (2012). This study's results revealed that sugarbeet disease has an effect on root length, girth, individual beet weight, and pol%. This might be the disease that interrupts the physiological process of sugarbeet genotypes. This hypothesis is supported by Islam et al. (2012), who demonstrated that root length, individual beet weight, and pol (%) were lower in diseased sugarbeet plants than in healthy ones.

CONCLUSION

The diseases of the tropical sugarbeet are one of the major constraints on the profitable commercial cultivation of crops in Bangladesh. Under Bangladesh conditions, all sugarbeet sugarbeet genotypes are affected by different diseases. *Sclerotium* root rot, *Cercospora* leaf spot, and *Alternaria* leaf spot are the major diseases that affect the growth, yield and pol% of tropical sugarbeet genotypes. The genotypes SZ-35, SV894, SV-892, Danicia, and Serenada showed comparatively lower disease incidences and produced higher yields and can be recommended for commercial cultivation in Bangladesh.

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