

Prevalence and Characterization of *Streptomyces* spp. and their pathogenic potentiality associated with common scab disease of potato in Bangladesh

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Potato common scab, caused by *Streptomyces* spp., is one of the major diseases of potato worldwide. A study was conducted to understand the prevalence of common scab disease in the major potato-growing areas of Bangladesh. Recommended medium of International *Streptomyces* Project (ISP) was used for isolation, identification and characterization of the pathogen. Survey results revealed that the Bogura district had the highest disease incidence (62.81%) and severity (28.76%) than others. There was sharp positive correlation between the disease incidence and soil pH. The disease severity recorded higher (22.52- 24.44%) with high soil pH (6.6-7.7). Diamant was the most susceptible potato variety, followed by Cardinal and Granola. *Streptomyces* spp. were isolated from scab-infected potatoes in sixteen distinct locales. On yeast malt extract medium (ISP-2 medium), seven isolates (ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃, and ST₁₆) produced grey to pale grey colonies with grey spores borne in spiral chains, eight isolates produced light to deep brown colonies, while one isolate produced white colonies with brown flexuous spores. On ISP-6 medium, seven isolates, namely ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃ and ST₁₆, were capable of producing melanin pigment, whereas four isolates developed melanin pigment on ISP-7 medium. Except for two isolates (ST₇ and ST₁₁), which could not catabolize raffinose sugar, all *Streptomyces* spp. isolates were capable of utilising eight ISP sugars. Ten isolates (ST₁, ST₂, ST₃, ST₄, ST₅, ST₆, ST₁₂, ST₁₃, ST₁₄ and ST₁₆) were cultured at low temperatures (10°C), with the maximum growth response recorded at 30°C. All the isolates grew vigorously at pH 7.0, and also in highly concentrated NaCl (6%) amended medium. All of the isolates of *Streptomyces* spp. were found pathogenic and produced characteristic symptoms of common scab on potato cultivars, Diamant and Cardinal. Considering all the characteristics, 7 isolates of *Streptomyces* (ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃, and ST₁₆) were similar to *Streptomyces scabies*.

Keywords : Common scab, potato, disease incidence, pathogenicity, varietal susceptibility

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the world's fourth most important food crop after wheat (*Triticum aestivum* L.), maize (*Zea mays* L.), and rice (*Oryza sativa* L.) and provides a balanced source of starch, vitamins, and minerals to many communities in the global village.

Potato is the third-largest crop in Bangladesh after rice and wheat and therefore contributes much to the total food supply of the country. It is used primarily as a vegetable and has the potential as a staple food. A total of 9.254 million tons were produced annually for the 2014–15 crop year from 0.471 million hectares of land (Anonymous, 2016). In Bangladesh, 54 diseases of potatoes were recorded, among them common scab, one of the major diseases of potatoes in Bangladesh (Ahmed *et al.*, 2000). Though the disease does

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not cause an appreciable reduction in yield, it can cause great loss due to a reduction in the market value of tubers. Moreover, infected seed tubers serve as the primary sources of inocula in the next crop (Wang and Lazarovits, 2005). This disease includes many symptoms such as raised, deep pitted, sunken lesions and scab-like surfaces on the tuber (Kers *et al.* 2005). The common scab of potatoes is caused by several *Streptomyces* species and is widely distributed in potato-growing areas; it poses a threat in almost all soils (Loria *et al.* 2006; Stalham *et al.* 2010). *Streptomyces scabies* is a Gram-positive actinobacterial pathogen that causes common scab disease in several crops, particularly in the potato. It is a soil-borne, devastating bacterial plant pathogen and difficult to manage in the field. Due to the higher incidence of common scab disease up to 32% of the total produced potatoes were discarded because of the low-grade consignment and once the pathogen arrives in the field it is difficult to eliminate (Dees and Wanner, 2012; Gouws, 2013). Rauf *et al.* (2007) reported 65-66% common scab disease incidence in Pakistan. *Streptomyces* has several species that cause common scab such as *S. scabies*, *S. acidiscabies*, *S. europaeiscabies*, *S. luridiscabies*, *S. niveiscabies*, *S. puniscabies*, *S. reticuliscabies*, *S. stelliscabies*, *S. turgidiscabies*, and *S. ipomoeae* (Ismail *et al.* 2020). The grey, smooth spores of *S. scabies* are borne in spiral chains. This phenotypic characteristic plus utilization of specific sugars characterize the species. The acid-tolerant strains form the distinct species, *Streptomyces acidiscabies* was also reported to cause the disease. Saha *et al.* (2022) reported twelve isolates of *Streptomyces* spp., among which one was confirmed as *S. scabies* from the northern part of Bangladesh. In Bangladesh, limited information is available on the disease incidence, severity of this disease and the diversity of this pathogen in different agroecological regions of the country. Such information is essential to initiating programs for the development and deployment of varieties with durable resistance. Keeping all these in view, the present investigation was undertaken to satisfy the following objectives: (i) To determine the regional variations in the incidence and severity of potato common scab disease; (ii) To identify the pathogenic species of

Streptomyces from tubers and also study the characteristics of the pathogen.

MATERIALS AND METHODS

Field survey and Sample collection

Scabby tubers were collected from fields of different location of five major potato growing districts viz. Rajshahi, Rangpur, Bogura, Comilla and Munsiganj in Bangladesh. During sampling, one hundred tubers were collected randomly from each field. Tubers were categorized based on 0 – 5 scale (Liu *et al.* 1995) and finally PDI was calculated by the formula suggested by Goswami *et al.* (2002). The following rating scale was used to record the disease viz. = No symptom, 1 = Very small lesions, 2 = Small superficial lesions, 3 = Periderm broken, 4 = pit and 5 = Deep pitted.

Isolation of Streptomyces Species

Isolation of *Streptomyces* spp. was carried out following dilution method (Lindholm *et al.* 1997). Tubers were washed and surface sterilized with 5% sodium hypochlorite (NaOCl). One gram of corky layer tissue (underneath the layer) for each sample was removed by a sterile scalpel and homogenized in sterile water (1g/10ml) in a mortar with pestle. One milliliter of the homogenate was mixed with 9 ml of phenol-water suspension (1:40). Three times diluted homogenate was plated on yeast malt extract (YME –ISP medium 2) agar medium (pH 7.0). Plates were incubated at 30°C for 10 days in BOD. Single colony was transferred to fresh yeast malt extract agar for pure culture. Isolates were maintained on YME slants at 4°C for further use. Cultural, morphological, physiological and pathological properties were considered to identify the isolated pathogens according to Bergey *et al.* (1984).

Morphological characterization

Streptomyces spp. were isolated from deep, raised and superficial scabby tuber lesions from five major potato growing districts in Bangladesh, and were observed for their morphological variability. The isolates were tested according to the ISP method (Shirling and Gottlieb 1966). Each isolate was cultured for 10-14 days in the dark at 30°C in different media viz. YME (Yeast malt

extract, ISP medium 2), OMA (oatmeal agar, ISP medium 3), oatmeal broth and PDA medium. Colony colour and spore colour for each isolate were recorded. The presence or absence of diffusible pigments in the media was also noted.

Physiological characterization

Carbon utilizations

The ability to utilize the International Streptomyces Project (ISP) sugars viz. D-Fructose, D-Glucose, Sucrose, Raffinose, D-xylose, D-mannitol, Rhamnose and Maltose was tested on the standard basal medium (ISP medium 9) according to Shirling and Gottlieb (1966). Plates were incubated for 10-14 days at 30°C and growth was recorded as positive or negative.

Melanin production

Melanin production of different *Streptomyces* spp. were determined after growth on Peptone-yeast extract – iron agar (PYI – ISP medium 6) and tyrosine agar (TA – ISP medium 7) at 38 °C after four, eight and 12 days of incubation. Isolates altering the clear colour of the medium with a dark diffusible pigment were considered as positive for melanin production.

Growth response at different pH

Growth at different pH level 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5 and 8 was determined by growing isolates on YME medium with adjusted pH levels for 14 days in the dark at 30 °C. The pH was altered by adding 1M hydrochloric acid or 1M sodium hydroxide to the media until the desired pH was reached. The minimum and maximum growth rate of each isolate was also recorded.

Growth response at different temperature

To find out the growth response in different temperature for growth the Yeast malt extract medium with triplicate Petri dishes were inoculated with different *Streptomyces* isolates. The isolates were incubated at different temperature (10, 15, 20, 25 and 30 °C) for 14 days. The minimum and maximum growth response of each isolates was recorded.

Pathogenicity test

Pathogenicity was tested according to the procedure provide by Loria and Kempter (1986). Healthy mini-tubers of potato cv. Cardinal and Diamant susceptible to common scab (provide by Tuber crops research center, Bangladesh) were tested for this experiment. The tubers that exhibited common scab lesions were recorded. Isolation of the causal pathogen was made from all lesions to confirm Koch's postulates.

RESULTS

Common scab disease incidence

Under field conditions, the disease was identified through symptomatology. The disease was found to produce different types of symptoms on the surface of the tubers. Survey results revealed that the highest (62.81%) scab disease incidence was recorded in Bogura district followed by Rajshahi (51.14%) and the lowest of that in Rangpur (28.86%). The disease severity was highest at Kahaloo in Bogura district (28.76) and the lowest at Pargacha in Rangpur (3.64). Among the potato variety evaluated, Diamant was highly susceptible against scab disease followed by Cardinal and Granola (Table 1). Potato common scab was positively correlated with soil pH; the disease severity was higher (22.52- 24.44) in high soil pH (6.6-7.7) (Figs. 1 & 2).

Morphological characteristics of different isolate of *Streptomyces* spp.

The isolates of *Streptomyces* spp. were grown on YME (ISP-2) medium showed variation in their colony characteristics (Table 2, Fig.3). Colony color varied from gray to pale gray and light brown to deep brown. A total of 16 isolates were isolated from scab infected potatoes which were collected from different locations of surveyed areas. Among the isolates, eight isolates were found in a light to deep brown color, viz. ST₃, ST₄, ST₅, ST₆, ST₇, ST₁₀, ST₁₂ and ST₁₄ with brown spores, 7 isolates were found in gray to pale gray colonies (ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃ and ST₁₆) with gray spores borne in spiral chains, and one isolate was found in a white colony with brown flexuous spores (Plate 1). Spiral spore chain morphology was

Table 1: Disease severity of common scab disease of potato in different location

District	Location	Soil pH	% Scab disease index	Potato variety evaluated
Rajshahi	Paba	7.5	22.52	Diamant
	Godagari	6.68	15.04	Diamant, Cardinal
	Rajshahi sador	7.7	22.78	Diamant, Cardinal
Bogura	Dhupchaciya	7.6	20.06	Bennela, Diamant, Granola
	Shibganj	7.5	24.44	Granola, Cardinal
	Kahaloo	7.4	28.76	Cardinal
Rangpur	Pirgacha	5.2	3.64	Diamant, Granola, Raja
	Mithapukur	5.9	9.62	Diamant, Granola
	Rangpur sador	6.64	13.02	Granola
Munsiganj	Munsiganj sador	5.6	8.26	Bennela, Cardinal, Diamant
	Tongibari	5.8	11.4	Diamant
	Serajdekhan	6.2	10.82	Diamant
Comilla	Barura	7.06	23.9	Diamant
	Chandina	6.2	12.9	Diamant
	Dabedhar	6.5	24.28	Cardinal, Diamant

Table 2: Morphological Characteristics of 16 isolates of *Streptomyces* spp.

Isolate no.	Location	Potato variety	Colony color on YME (ISP medium 2)	Reverse side color on OMA	Colony surface	Spore color on YME (ISP medium 2)	Spore chain morphology
ST ₁	Munsiganj	Diamant	Gray	Violate	Smooth	Grayish white	Spiral
ST ₂	Comilla	Diamant	Gray	Cream	Smooth	Grayish white	Spiral
ST ₃	Rajshahi	Diamant,	Brown	Red	Powdery	Light brown	Flexuous
ST ₄	Rajshahi	Cardinal	Light Brown	Red	Smooth	Light brown	Flexuous
ST ₅	Comilla	Diamant	Brown	Orange	Powdery	Pink brown	Flexuous
ST ₆	Rajshahi	Diamant	Light Brown	Deep brown	Powdery	Whitish Brown	Flexuous
ST ₇	Rajshahi	Diamant	Deep Brown	Orange	Erupted	Brown	Flexuous
ST ₈	Rangpur	Granola	Gray	Green	Erupted	Grayish white	Spiral
ST ₉	Rangpur	Granola	Pale gray	Green	Erupted	Grayish white	Spiral
ST ₁₀	Bogra	Granola	Parle Brown	Light violate	Powdery	Brown	Flexuous
ST ₁₁	Rangpur	Granola	Gray	Blackish green	Powdery	Grayish white	Spiral
ST ₁₂	Bogra	Cardinal	Brown	Orange	Powdery	Brown	Flexuous
ST ₁₃	Rangpur	Diamant	Pale gray	Yellowish brown	Smooth	Grayish white	Spiral
ST ₁₄	Bogra	Cardinal	Parle Brown	Red orange	Powdery	Cream Brown	Flexuous
ST ₁₅	Munsiganj	Diamant	White	Dark brown	Smooth	Brown	Flexuous
ST ₁₆	Bogra	Bennela	Whitish gray	Deep green	Powdery	Grayish white	Spiral

Table 3 : Growth response of 16 *Streptomyces* spp. isolates in different medium

Isolates of <i>Streptomyces</i> spp.																
Medium	ST ₁	ST ₂	ST ₃	ST ₄	ST ₅	ST ₆	ST ₇	ST ₈	ST ₉	ST ₁₀	ST ₁₁	ST ₁₂	ST ₁₃	ST ₁₄	ST ₁₅	ST ₁₆
PDA	+	+	+++	+	++	+++	+++	+	+	+++	+	+	+	++	++	+
OA	+++	++	+++	++	+	++	+	++	++	+++	+++	+++	++	+++	++	++
YME	++	+++	++	+++	+++	+++	++	+++	+++	+++	++	++	+++	+++	+++	+++

+, ++, +++ represent degree of growth with +++ as maximum (Visual estimation)

Table 4: Physiological characteristic of 16 isolate of *Streptomyces* spp.

Isolate No.	Melanin production		Color secret in OMB (Oat meal broth) medium
	ISP-6	ISP-7	
ST ₁	+	+	Violate
ST ₂	+	+	Brown
ST ₃	-	-	Red Brown
ST ₄	-	-	Cream
ST ₅	-	-	Red Brown
ST ₆	-	-	Blackish green
ST ₇	-	-	Dark Brown
ST ₈	+	+	Light Green
ST ₉	+	+	Green
ST ₁₀	-	-	Golden
ST ₁₁	+	-	Golden Brown
ST ₁₂	-	-	Radish Brown
ST ₁₃	+	-	Olive Green
ST ₁₄	-	-	Red Brown
ST ₁₅	-	-	Light Violate
ST ₁₆	+	-	Brown

"+" = Positive Growth response and "-" = No Growth (Visual estimation)

found in isolates no. ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃ and ST₁₆, and the rest were found to have flexuous chain morphology. Among the isolates, 8 isolates were found in potato variety Diamant, 4 isolates from Granola, 3 isolates from Cardinal and one isolate was collected from Bennela.

Growth response on different medium

The sixteen different isolates of *Streptomyces* spp. were tested for their morphological studies.

Selected strains of *Streptomyces* spp. were grown on YME, OA and PDA medium at 30°C in the dark for 15 days and the pH of this medium was adjusted to pH 7.0. The growth response was observed in a 15-day-old culture when the growth of those isolates reached maximum. Among the three culture mediums, vigorous growth response was found in yeast malt extract (YME) medium, followed by Oat meal agar medium (Table 3). Among the 16 isolates, all of the 11 isolates exhibited vigorous growth response to yeast malt

Table 5: Carbon source utilization of sixteen different isolates of *Streptomyces* spp.

Carbon source utilization	Isolates no. of <i>Streptomyces</i> spp.															
	ST ₁	ST ₂	ST ₃	ST ₄	ST ₅	ST ₆	ST ₇	ST ₈	ST ₉	ST ₁₀	ST ₁₁	ST ₁₂	ST ₁₃	ST ₁₄	ST ₁₅	ST ₁₆
D-Fructose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
D-Glucose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Sucrose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Raffinose	+	+	+	+	+	+	-	+	+	+	-	+	+	+	+	+
D-xylose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
D-mannitol	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Rhamnose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Maltose	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

"+" = Positive Growth response and "-"= No Growth (Visual estimation)

Table 6: Growth response of *Streptomyces* spp. at different temperature

Temp.	Isolates of <i>Streptomyces</i> spp.															
	ST ₁	ST ₂	ST ₃	ST ₄	ST ₅	ST ₆	ST ₇	ST ₈	ST ₉	ST ₁₀	ST ₁₁	ST ₁₂	ST ₁₃	ST ₁₄	ST ₁₅	ST ₁₆
10 °C	+	+	++	+	+	+	-	-	-	-	-	+	+	+	-	+
15 °C	+	+	++	+	+	+++	+	+	+	+++	+	+++	+	+	+	+
20 °C	+	+	++	+	+	++	+	+	+++	++	+	++	+	+	+	+
25 °C	++	+	++	++	+	++	++	+++	++	++	++	++	++	++	++	++
30 °C	+++	+++	+++	+++	+++	++	+++	+++	++	++	+++	++	+++	+++	+++	+++

+, ++ and +++ represent degree of growth where +++ is maximum and + indicates the initiation of colony growth, while - is no growth.

extract medium. The lowest growth response was found on potato dextrose medium. Only four isolates, such as ST₃, ST₆, ST₇ and ST₁₀ showed vigorous growth response on PDA medium.

Physiological characteristics of different isolate of *Streptomyces* spp.

Formation of melanin pigments

The 16 isolates were tested for synthesized melanin pigments on ISP-6 (Peptone Yeast

Extract Iron Agar) and ISP-7 (Tyrosine agar) medium (Table 4). Among the isolates, 7 isolates viz. ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃ and ST₁₆, were capable of producing melanin pigment on ISP-6 medium and 4 isolates produced melanin pigment on ISP-7 medium. In OMB (Oat meal broth) medium, the pathogen produces a variety of coloured colonies (i.e. brown to golden brown, light green to olive green, golden, creamy and violet) indicating the variation in their pigmentation behaviour (Table 4).

Table 7: Growth Response of 16 isolates of *Streptomyces* spp. in different pH level

Isolates No.	Acidic pH						Alkaline pH		
	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0
ST ₁	+	+	+	+	+	+	++	+++	+
ST ₂	+	+	+	+	+	+	++	+++	+
ST ₃	-	-	-	-	+	+	++	+++	+
ST ₄	-	-	-	-	+	+	++	+++	+
ST ₅	-	-	-	-	+	+	++	+++	++
ST ₆	+	+	+	+	+	+	++	+++	+
ST ₇	+	+	+	+	+	+	++	+++	+
ST ₈	-	-	-	-	+	+	++	+++	+
ST ₉	-	-	-	-	+	+	++	+++	++
ST ₁₀	-	-	-	-	+	+	++	+++	++
ST ₁₁	-	-	-	-	+	+	++	+++	+
ST ₁₂	+	+	+	+	+	+	++	+++	+
ST ₁₃	-	-	-	-	+	+	++	+++	+
ST ₁₄	-	-	-	-	-	+	++	+++	+
ST ₁₅	-	+	+	+	+	+	++	+++	+
ST ₁₆	+	+	+	+	+	+	++	+++	+

+, ++ and +++ represent degree of growth where +++ is maximum and + indicates the initiation of colony growth, while - is no growth.

Table 8: Growth response of *Streptomyces* spp. at varied NaCl concentrations

Isolates No.	Control	4% NaCl	5% NaCl	6% NaCl
ST ₁	+	+	+	+
ST ₂	+	+	+	+
ST ₃	+	+	+	+
ST ₄	+	+	+	+
ST ₅	+	+	+	+
ST ₆	+	+	+	+
ST ₇	+	+	+	+
ST ₈	+	+	+	+
ST ₉	+	+	+	+
ST ₁₀	+	+	+	+
ST ₁₁	+	+	+	+
ST ₁₂	+	+	+	+
ST ₁₃	+	+	+	+
ST ₁₄	+	+	+	+
ST ₁₅	+	+	+	+
ST ₁₆	+	+	+	+

+ = Growth and - = No growth, Control = without NaCl.

Carbon Utilization

All of the isolates of *Streptomyces* spp. were capable of utilizing all of the eight ISP sugars except the isolates ST₇ and ST₁₁ that could not catabolize raffinose sugar (Table 5).

Table 9: Pathogenicity of different isolates of *Streptomyces* spp. on potato variety Cardinal and Diamant

Isolates no.	Degree of pathogenic potentiality and severity	
	Cardinal	Diamant
ST ₁	++ (2)*	+(1)
ST ₂	+(1)	+(1)
ST ₃	+++ (3)	+++ (3)
ST ₄	++ (2)	+++ (3)
ST ₅	+(1)	+(1)
ST ₆	+(1)	+(1)
ST ₇	+(1)	++ (2)
ST ₈	+(1)	+(2)
ST ₉	+++ (3)	++ (2)
ST ₁₀	+(1)	+++ (3)
ST ₁₁	+(1)	+(1)
ST ₁₂	+(1)	+++ (3)
ST ₁₃	+(1)	+++ (3)
ST ₁₄	+(1)	+++ (3)
ST ₁₅	++ (2)	+(1)
ST ₁₆	+++ (3)	+++ (3)

+, ++, +++ represent degree of aggressiveness with +++ as maximum (Visual estimation), *Scores on parentheses indicates the disease severity on the basis of 0-3 scale (0= 0%; 1= 1-9%; 2= 10-50%; 3= > 50% of surface area covered)

Growth response in different temperature

The 16 selected isolates of *Streptomyces* spp. were tested for their temperature requirements within the temperature range of 10°C, 15°C, 20°C, 25°C and 30°C. The data obtained from this experiment clearly showed that ten isolates were capable of growing at the low temperature at 10°C but the optimum temperature for most of the isolates was found at 30°C. At the temperature of 15°C-25°C, all isolates were capable to grow in culture medium (Table 6).

Growth response in different pH

The results indicated that among the sixteen isolates of *Streptomyces* spp., nine isolates were not capable of growing at low pH (below 5.0) and seven isolates can be grown at wide range of pH level (3.0 to 8.0). The maximum growth response observed for all of the isolates was at pH level 7.0. All of the isolates grew well between pH 6.0 and 7.0, while it was reduced at pH 8.0. Six isolates viz. ST₁, ST₂, ST₆, ST₇, ST₁₂ and ST₁₆ were capable of growing at as low as pH 3.0, whereas ST₁₅ is unable to grow at pH level 3.0 but can grow at pH 3.5 (Table 7).

Growth response of *Streptomyces* spp. at different concentration of NaCl

The growth response of the 16 isolates was determined in oatmeal agar medium amended

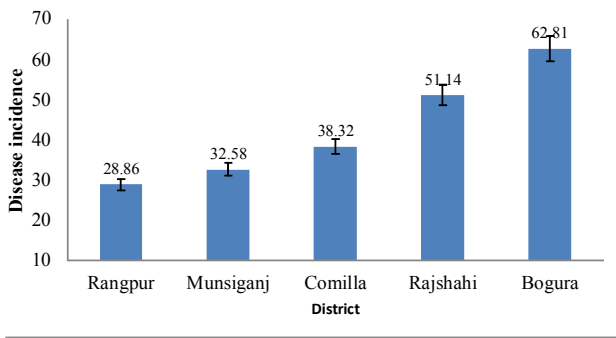


Fig.1. Potato common scab disease incidence found in different district of Bangladesh

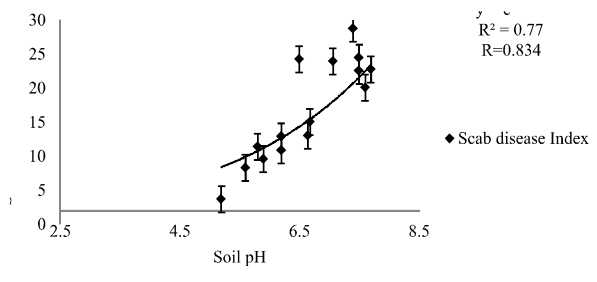


Fig. 2. Correlation between potato common scab with soil pH in different locations

with varied concentration of NaCl (4 to 6%), where they were grown adequately (Table 8). No variation was recorded among the isolates tested.

Pathogenicity test

A total of 16 isolates of *Streptomyces* spp. were obtained from scab lesions of potato cultivars. Isolates were collected from 15 geographic locations in Bangladesh. Selected 16 isolates produced common scab symptoms on potato variety, Cardinal and Diamant. All of the isolates were pathogenic, but there were distinct variations in degree of pathogenicity. Koch's postulates were confirmed for all the isolates that produced symptoms. Seven isolates (ST3, ST4, ST10, ST12, ST13, ST14 and ST16) were found more aggressive than others on the susceptible potato variety, Diamant where they produced symptoms rapidly and covered the whole tuber surface within 3-4 days, while only three isolates (ST3, ST9 and

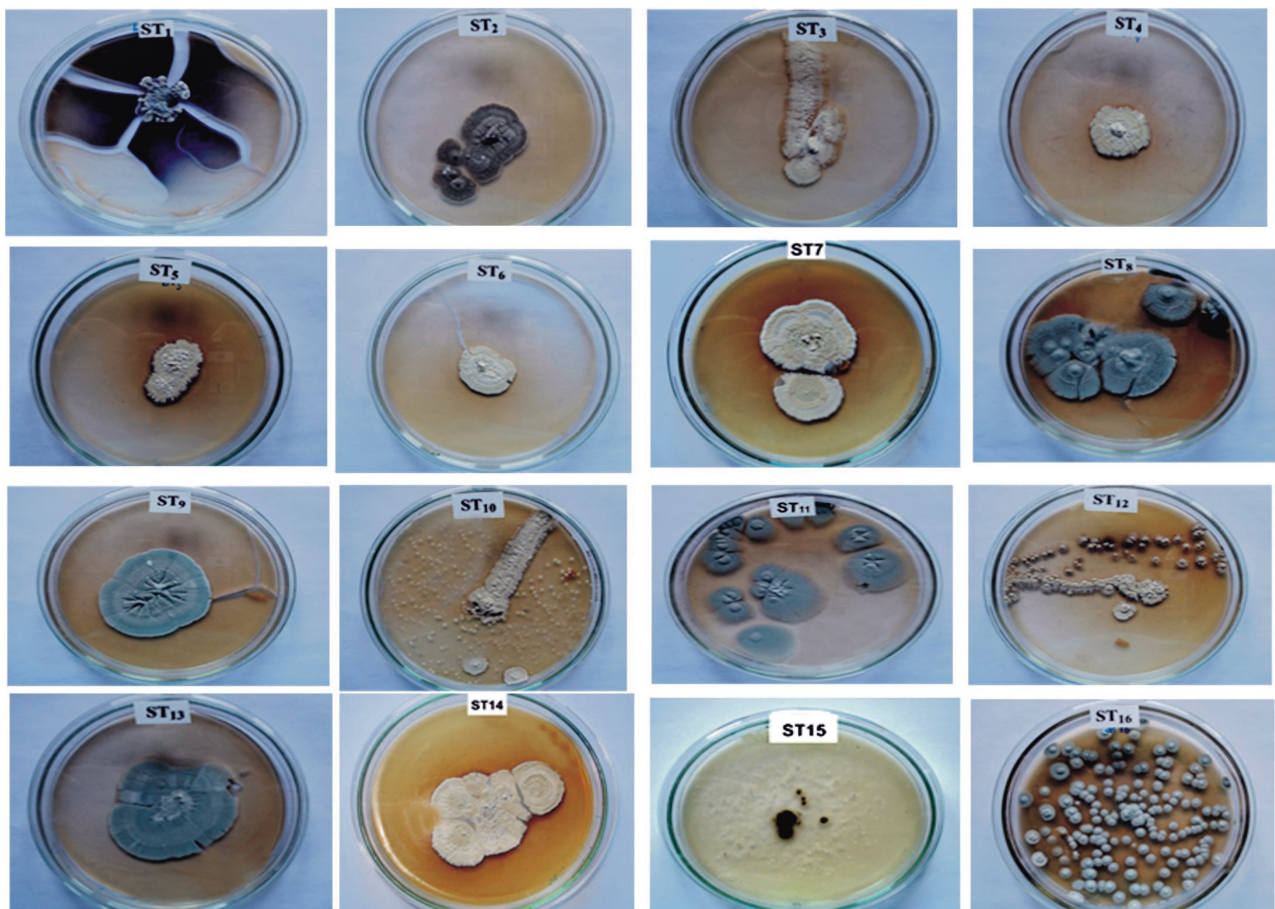


Fig.3 : Colony morphology of sixteen isolates of *Streptomyces* spp. on YME medium.

ST16) showed their aggressivity on potato variety, Cardinal (Table 9).

Identification and confirmation of *Streptomyces scabies*

Among the sixteen isolates, 7 isolates were found in gray to pale gray colonies (ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃ and ST₁₆) with grayish white spores borne in spiral chains, capable of producing melanin in ISP 6 and ISP 7 medium and utilizing eight recommended ISP diagnostic sugars similar to *Streptomyces scabies*. The rest of the nine isolates were unknown though they were all plant pathogenic, and required confirmative tests to identify the species.

DISCUSSION

This paper presents the extensive study of the prevalence and characterization of *Streptomyces* spp. and their pathogenic potentiality associated with the common scab disease of potatoes in Bangladesh. The highest disease incidence recorded in the Bogura district was 62.81% and all the commercially cultivated potato varieties were susceptible against common scab disease. Similar results were reported from Pakistan while disease incidence recorded 69% (Nisa *et al.* 2022). The disease severity was higher in high soil pH level (6.0-7.0) and lower below this limit indicating a positive correlation between soil pH and the disease severity. The result is corroborated with the earlier workers who recorded higher level of disease severity in their studied areas having soil pH around 7.0 (Lacey and Wilson, 2001, Nisa *et al.*, 2022). Hussain *et al.* (2017) reported a decreased level of common scab disease incidence at soil pH level below 5.2. They concluded that this type of soil is not suitable for scab disease incidence but capable of suppressing potato common scab in soils.

Potato scab disease, which is caused by *Streptomyces scabies* has been reported in many countries such as China, South Africa, Pakistan, Iran, Russia, India, the United States and other countries of the world (Zhang *et al.* 2013; Kalantar *et al.* 2006; Lysenko *et al.* 2005; Pasiiecznik *et al.* 2005). Common scab disease

is caused by the pathogen *Streptomyces* spp. is one of the major diseases of potatoes which produces different types of symptoms on the tuber surface. In severe infection, it produces deep pitted scab lesions on the potato tuber surface. If tubers are heavily infected, scab lesions may cover most of the tuber surface and decrease the market value (Fiers *et al.* 2010; Hiltunen *et al.* 2005; Tagawa *et al.* 2008).

From the present investigation seven isolates of *Streptomyces* spp. such as ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃ and ST₁₆ were found in gray to pale gray colonies on yeast malt extract medium and produce gray spores borne in spiral chains which produce scab lesions on potato tuber *in vitro*. Diagnosis of pathogenic strains demands specific and sensitive methods that enable accurate and unambiguous characterization. Morphological, physiological and molecular characteristics have been used for the identification of *Streptomyces* spp. (Boucek-Mechiche *et al.* 2000; Wanner, 2009). *Streptomyces scabies* had been characterized by some previous workers as an organism that has smooth gray spores borne in spiral chains, produces melanin, and is able to utilize l-arabinose, d-fructose, d-glucose, d-mannitol, d-xylose, raffinose, rhamnose, or sucrose as a carbon source.

In the present study, seven isolates of *Streptomyces* such as ST₁, ST₂, ST₈, ST₉, ST₁₁, ST₁₃ and ST₁₆ were considered as *Streptomyces scabies* and capable of producing melanin on ISP-6 (Peptone Yeast Extract Iron Agar) medium. Among them, four isolates (ST₈, ST₉, ST₁₁ and ST₁₃) were not capable of growing below pH 5.0. A novel species of *Streptomyces scabies* sp. nov., nom. rev. which produces melanin on tyrosine agar and peptone iron agar, and does not generally grow on agar medium having pH less than 5.0 was reported earlier. The data obtained from this experiment revealed that all of the isolates of *Streptomyces* spp. were capable of growing at 4-6% concentrated NaCl. Park *et al.* (2003) reported that *S. scabies* strain S33 failed to grow in the presence of 5 - 6% NaCl and the growth of strain S78 was inhibited below pH 3.5 in the presence of 5, 6, or 7% NaCl. At low temperatures (below 20°C), the isolate of *Streptomyces* sp. caused netted scab symptoms

and at higher temperatures deep-pitted lesions produce on susceptible cultivars of potato (Bouček-Mechiche *et al.* 2000).

CONCLUSION

Commercially cultivated all of the varieties of potato were more or less susceptible against the pathogen of common scab disease in Bangladesh. Among sixteen isolates of *Streptomyces*, 7 isolates are comparable as per the description of *S. scabies*, having smooth, grey spores borne in spiral chains, producing melanin and utilizing all of the recommended ISP diagnostic sugars with raffinose as the sole source of carbon, which was based on only morphological identification. All of the isolates of *Streptomyces* spp. were found pathogenic and capable of producing scab symptoms on potato varieties, Cardinal and Diamant. Therefore, it is an utmost need of molecular characterization to identify the *Streptomyces* species or strain which also associated with potato common scab disease. It is also important to find out antagonistic organisms effective against this pathogen.

DECLARATION

Conflict of Interest. Authors declare no conflict of interest

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