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CHEMICAL AND CULTURAL MANAGEMENT OF COMMON SCAB (*Streptomyces scabies*) DISEASE OF POTATO IN BANGLADESH

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Abstract. An attempt has been taken for the management of common scab disease of potato with the integration of chemical and cultural approaches in a same cropping season at different locations of Bangladesh such as Gazipur, Jamalpur, Comilla and Bogra. Among the different seed treating chemical agents against scab disease of potato, Dithane M-45® (Mancozeb) was the best fungicide in terms of disease reduction followed by Provax-200WP® (Carboxin). Potato seed tubers were treated with fungicide solution @ 3g/L of water which was more effective than pelleting @ 3g/kg of potato tuber. Considering the chemical fertilizers, ammonium sulphate @ 650 kg/ha showed significantly lower scab incidence (by number: 27.92% and by weight: 35.37%) and severity (1.26) than Urea, Triple supper phosphate (TSP), Muriate of potash (MOP) and Gypsum at different doses. On the contrary, potato scab disease and yield were varied with the variation of planting time and crop duration. Among the various treatment combinations, early tuber planting dated on 16 November and crop duration 85 Days After Planting (DAP) was given the highest yield 24.76 t/ha followed by longer crop duration i.e. 90 DAP. In the meantime, it was found the positive correlation between raising the tuber production and disease development. It might be happened due to the most congenial environment for growth and development of potato tuber as well as the pathogen.

Keywords: *Common scab, Streptomyces scabies, Chemical & cultural management, Potato.*

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1. Introduction

Potato (*Solanum tuberosum* L.) is the 4th most important food crop after wheat (*Triticum aestivum* L.), maize (*Zea mays* L.) and rice (*Oryza sativa* L.) in the world (Haan& Rodriguez, 2016). In Bangladesh, potato is chiefly used as a vegetable, although in many countries it constitutes the main food and contributes more than 90% as the source of carbohydrate. In the year of 2014-2015, the total potato cultivable land in Bangladesh was 471.06 thousand hectares and tuber yield production was 9.25 million tons with an average yield 19.64 t/ha (Anon., 2016). However, there are many constrains remain for the low production of potato such as seed quality, soil fertility, irrigation facilities, nutrient management, pest infestation and so many. Among of them, plant disease is a drastic problem for marketable tuber production. As many as fifty-

seven diseases in potato have been noted in Bangladesh (Hossain *et al*., 2008). The most important diseases are late blight, stem rot, black scurf, wilt, common scab, potato leaf roll and mosaic etc. (Ahmed *et al*., 2000). Common scab of potato is one of the most economically important worldwide diseases and it was named by Northern American growers in 1991 (Loria *et al.*, 1997). Common scab of potato is caused by several *Streptomyces* spp. (Loria *et al*., 1997), but *S. scabies* is the predominant causal organism (Lambert & Loria, 1989). The symptoms of common potato scab are quite variable and are manifested on the upper surface of the potato tuber. Depending on many factors such as pathogen strain, cultivar susceptibility, environmental conditions, the symptoms of scab can appear as lesions of variable sizes and depth on tuber surfaces (Lorang *et al.*, 1995). The pathogen is disseminated by infected seed tubers or soil and easily can survive in the absence of host plants (Loria *et al.*, 1997; Wang & Lazarovits, 2004). Once established of the pathogen, it's really difficult to eliminate from a field. However, there are a number of possible control methods for common scab, primarily chemical management, cultural controls such as irrigation (Lapwood, 1973), planting dates (Wilson, 2004), crop rotations and cultivar selection (Hiltunen *et al*., 2011). Although, potato common scab was initially a minor disease in Bangladesh but now has become a major one and its incidence and severity is increasing day by day. Therefore, the current study was designed to integrated use of chemical (fungicides and fertilizers) and cultural (optimum planting time and crop duration) approaches for minimizing the common scab disease of potato in Bangladesh.

2. Materials and Methods

2.1. Experiment 1: Effect of different seed treating agents against common scab disease of potato

Experimental site and planting time:

The experiment was conducted at field laboratory of Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur and Comilla during the cropping year 2013-14. Planting time of the experiment was at 19 November 2013 for both locations.

Design and layout of the experiment:

The experiment was laid out in the Randomized Complete Block Design with three replications. The total numbers of plots were 42. The unit plot size was 3 m x 2.4 m where row to row distance was 60 cm and plant to plant distance was 25 cm. Treatments were assigned randomly to 42 plots of each of 3 blocks.

Treatments of the experiment:

There were 7 treatments each had 2 different doses. Treatments were as follows

Treatments	Doses
T_1=Seed treatment with Stable Bleaching Powder (SBP)	D_1@ 0.3% & D_2@ 0.5% solution for 10-15 min.
T_2=Seed treatment with Boric acid	D_1@ 0.3% & D_2@ 0.5% solution for 10-15 min.
T_3=Seed treatment with NaCl	D_1@ 0.5% & D_2@ 0.1% solution for 5 -10 min.
T_4 =Seed treatment with Dithane M-45	D_1@ 3 g/L of water for 10-15 min.& D_2 @ 3 g/kg of tuber
T_5 =Seed treatment with Ammonium sulphate	D_1@ 0.7% & D_2@ 0.5% solution for 10-15 min.
T_6 =Seed treatment with Provax-200WP	D_1@ 3 g/L of water for 10-15 min.& D_2 @ 3 g/kg of tuber
T_7 =Control	No treatment

2.2. Experiment 2: Effect of different doses of fertilizers against common scab disease of potato

Experimental site and planting time:

The experiment was conducted during 2013-2014 at the experimental field of Tuber Crop Research Center (TCRC), Bangladesh Agricultural Research Institute (BARI), Gazipur. Planting time of the experiment was at 9 November 2013.

Design and layout of the experiment:

The design and layout of the experiment was similar as in the experiment one.

Treatments of the experiment

There were 5 treatments each had 3 different doses. Treatments were as follows

Treatments	Dose (kg/ha)
T_1 (Urea)	Low (300), Standard (350) & High (400)
T_2 (Ammonium sulphate)	Low (650), Standard (750) & High (870)
T_3 (TSP)	Low (100), Standard (150) & High (200)
T_4 (MOP)	Low (250), Standard (350) & High (450)
T_5 (Gypsum)	Low (100), Standard (140) & High (200)

2.3. Experiment 3: Effect of planting time and crop duration against common scab disease of potato

Location of the experimental plot:

Field experiment was conducted during in the experimental field of TCRC, BARI, Gazipur, Regional Agricultural Research Station (RARS), BARI, Jamalpur and Agricultural Research Station, BARI, Bogra. Planting time was at16 November 2013 for all the locations.

Design and layout of the experiment:

The experiment was laid out in the Split Plot Design where main plot representing the planting date and sub plot representing crop duration with 3 replications. Planting dates were at 16 November, 26 November, 6 December and 16 December and crop durations were 70, 75, 80, 85 and 90 days. After land preparation the whole experimental area was divided in to three blocks representing three replications. The total number of plots were 54.The unit plot size was 3m x 3m where row to row distance was 60 cm and plant to plant distance was 25 cm. Treatments were assigned randomly to 54 plots of each of 3 blocks.

Treatments of the experiment:

Treatments of the experiment were shown below where main plot representing planting dates and sub plot representing crop duration.

Main plot treatments	Sub plot treatments (Crop duration; DAP=Days After Planting)
T_1=Planting at 16 November	D_1=70, D_2=75, D_3=80, D_4=85 & D_5=90 DAP
T_2=Planting at 26 November	D_1=70, D_2=75, D_3=80, D_4=85 & D_5=90 DAP
T_3=Planting at 6 December	D_1=70, D_2=75, D_3=80, D_4=85 & D_5=90 DAP
T_4=Planting at 16 December	D_1=70, D_2=75, D_3=80, D_4=85 & D_5=90 DAP

2.4. Cultivation method

Land preparation:

The land was first opened by ploughing with a tractor at the beginning of November 2013 and then harrowed, ploughed, and cross ploughed with a power tiller several times followed by laddering to obtain a good tilth. Then, the land was leveled. Weeds and stubbles were completely removed and plots were finally prepared four days before planting.

Application of fertilizers:

Organic fertilizer such as well decomposed cow dung @ 10 t/ha was applied during the land preparation. On the contrary, the chemical fertilizers such as Urea, Triple Super Phosphate (TSP), Muriate of Potash (MP), Gypsum, Zinc sulphate, Boric Powder and Magnesium sulphate were applied according to the standard doses (Chowdhury & Hassan, 2013) and also followed the treatments for particular experiment. Entire quantity of TSP and one third of the MP, one third of Urea and other fertilizers were applied at the time of final land preparation. Rest of the Urea and MP were applied as top dressing at 30 and 50 days after sowing. Top dressing of fertilizer was followed by irrigation.

Preparation of planting material:

The sprouted seed tubers of potato cultivar Diamant has been collected from TCRC and only healthy, disease free and medium size tubers were selected for planting. Seed tubers then treated with different chemicals. After that, whole tuber was planted at 5 cm depth and then tubers were covered with soil.

Intercultural operations:

Weeding, mulching and irrigation were done in the experimental field whenever necessary.

Harvesting:

Tubers were generally harvested 85 days after planting (DAP) when 85-95% plants showed leaf senescence observed visually and also followed the treatments for particular experiment.

2.5. Collection of data

Ten plants were selected randomly from each unit plot to collect the experimental data. The plants in the outer rows and extreme end of the mid rows were excluded to avoid the border effect. The following parameters were recorded during the time of plant growth and harvesting.

Percent emergence:

Percent emergence was calculated by the following formula.

$$\text{Emergence}(\%) = \frac{\text{Total numbers of tubers germinated}}{\text{Total numbers of tubers}} \text{ x } 100$$

Plant height at 60 days after planting (DAP):

Plant height (cm) was recorded at 60 DAP and determined on the basis of average height of ten plants selected randomly from each unit plot.

Scab incidence by number:

After harvest, the number of healthy tubers and infected tubers were separated and counted. Scab incidence by number was calculated by the following formula.

$$\text{Scab incidence by number (\%)} = \frac{\text{Number of scab infected tubers}}{\text{Total number harvested tubers}} \text{ x } 100$$

Scab incidence by weight:

After harvest, healthy tubers and infected tubers were separated and weighted. Scab incidence by weight was calculated by the following formula.

$$\text{Scab incidence by weight(\%)} = \frac{\text{Weight of infected tubers}}{\text{Weight of total harvested tubers}} \text{ x } 100$$

Scab severity (0-5 Scale):

Scab severity was measured by the following scale (Bakr *et al*., 2010).
0=No symptom on potato tubers, 1=1% or less scabby area of tuber, 2=1-10% area affected with sunken scabby lesions, 3=11-20% area affected with dip pitted lesions, 4=21-50% area affected with dip pitted corky lesions, 5=51% or more area affected with severe corky lesions.

Yield:

After harvest, yield of unit plot was measured and then calculated average yield (kg/plot). After the plot yield was converted to t/ha.

2.6. Data analysis

Data were analyzed statistically using Statistix-10 computer program and means were compared by Duncan's Multiple Range Test (Gomez & Gomez, 1984).

3. Results and Discussion

3.1. Experiment 1: Effect of different seed treating agents/fungicides against common scab disease of potato

Presently, common scab disease of potato becoming the most devastating disease in Bangladesh that has severe impact on marketability of potato. However, reduction the quality of seed potato is another important concern by this disease. Therefore, present attempt has been taken to save the potato crop from this disease. Based on previous reports, the first experiment was designed using different seed treating agents and its results were presented below.

3.1.1. Seed treating agents with different doses on common scab disease of potato

Treatments effect were varied significantly on scab disease of potato (Table 1). Among the tested treatments, Dithane M-45, Provax-200WP and Stable Bleaching Powder

(SBP) showed better results than others. The lowest scab incidence by number (13.95%), by weight (14.22%) and severity (1.08) were recorded from Dithane M-45 treated plot when seed tuber treated with 0.3% solution before planting followed by Provax-200WP with same solution. The highest scab incidence and severity was recorded in control treatment. This result partially supported by other researchers (Stevenson & James, 1995; Fischer *et al*., 2005). They reported that scab disease significantly reduced by seed treatment with Dithane M-45. Moreover, both doses of NaCl and ammonium sulphate when compared with control treatment, the non-significant result was observed.

Table 1. Effect of different seed treating agents at different doses against common scab incidence and disease severity of potato in the field

Treatments	Chemical	Dose (% Solution)	Scab incidence		Disease severity (0-5 scale)
			Scab incidence by number (%)	Scab incidence by weight (%)	
T_1	SBP**	0.30	22.95 ^{cd}	25.23 ^{d*}	1.45
		0.50	21.02 ^{cd}	21.23 ^{de}	1.18
T_2	Boric acid	0.30	42.45 ^{ab}	42.44 ^{bc}	1.56
		0.50	49.15 ^{ab}	49.64 ^{abc}	1.63
T_3	NaCl	0.50	43.64 ^{ab}	45.63 ^{abc}	1.60
		0.10	50.22 ^{a}	54.66 ^{a}	1.43
T_4	Dithane M-45	3g/L of water	13.95 ^{d}	14.22 ^{e}	1.08
		3g/kg of tuber	24.35 ^{c}	25.31 ^{d}	1.10
T_5	Ammonium sulphate	0.70	39.71 ^{b}	41.13 ^{c}	1.53
		0.50	45.52 ^{ab}	48.31 ^{abc}	1.46
T_6	Provax-200	3g/L of water	18.40 ^{cd}	20.44 ^{de}	1.27
		3g/kg of tuber	24.41 ^{c}	26.16 ^{d}	1.15
T_7	Control		51.10 ^{a}	51.75 ^{ab}	1.75

* Mean values within a column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (*P=0.05*). **Stable Bleaching Powder

3.1.2. Seed treating agents on yield and yield contributing characteristics of potato

The effect of different seed treating agents with different doses on emergence, plant height and yield of potato presented in Table 2. Among the treatments, percent emergence, plant height and yield were varied significantly. In case of percent emergence, the range was 97.90-100% and lowest percent emergence was recorded in control treatment. Plant height was also differed significantly among the treatments. The highest plant height (56.76 cm) was recorded in Ammonium sulphate 0.70% solution treated plot whereas the lowest (50.37 cm) was observed in Stable Bleaching Powder 0.30% solution treated plot. The range of plant height was 50.37-56.76 cm. However, yield of potato was not differ significantly including control.

Table 2. Effect of different seed treating agents with different doses against yield and yield contributing characters of potato in the field

Treatments	Chemical	Dose (% Solution)	Emergence (%)	Plant height (cm)	Yield (t/h)
T_1	SBP**	0.30	98.61 [ab]	50.37 [c*]	23.12
		0.50	98.96 [ab]	52.83 [bc]	24.29
T_2	Boric acid	0.30	100.0 [a]	52.27 [bc]	22.22
		0.50	99.65 [ab]	54.18 [ab]	23.92
T_3	NaCl	0.10	98.96 [ab]	53.57 [abc]	21.94
		0.50	99.31 [ab]	55.08 [ab]	22.62
T_4	Dithane M-45	0.30	100.0 [a]	52.25 [bc]	23.42
		3g/kg	98.96 [ab]	53.82 [abc]	23.72
T_5	Ammonium sulphate	0.70	99.65 [ab]	56.76 [a]	24.35
		0.50	100.0 [a]	55.42 [ab]	22.66
T_6	Provax-200	0.30	97.92 [b]	53.38 [abc]	21.76
		3g/kg	99.65 [ab]	55.28 [ab]	23.35
T_7	Control		97.90 [b]	53.33 [abc]	23.58

* Mean values within a column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (*P=0.05*). **Stable Bleaching Powder

3.1.3. Interaction effect of locations and treatments of different seed treating agents on common scab disease

Interaction effect of locations and treatments had significant influence on scab incidence of potato (Fig. 1). Among the treatment combinations, the lowest scab incidence (by number and weight) was found in Dithane M-45 treated plot in Comilla followed by Stable Bleaching Powder treated plot in Comilla. Provax-200 another promising treatments that reduced scab incidence (by both number and weight) of both locations as compared to control NaCl, Boric acid and Ammonium sulphate treated plot. However, the highest scab incidence was observed in control treatments.

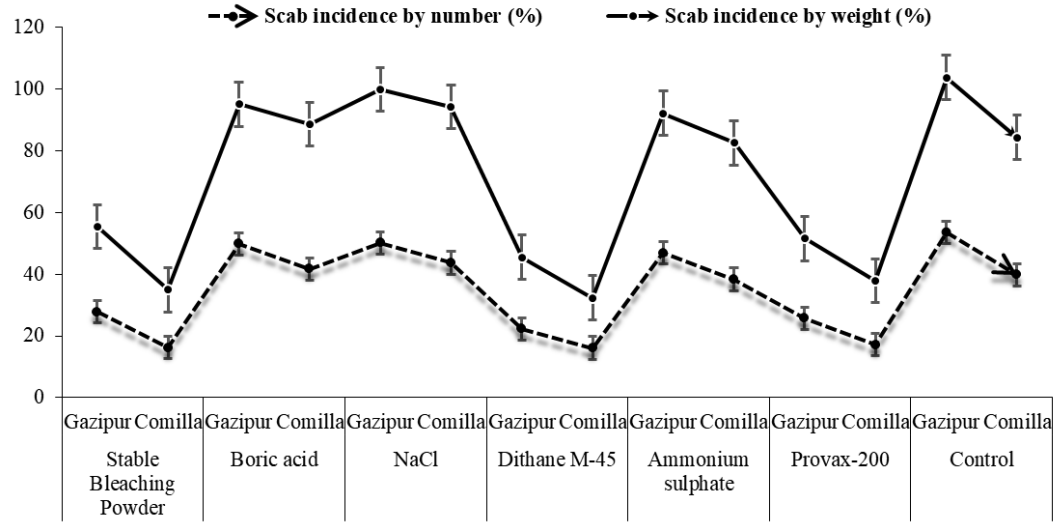

Fig.1. Interaction effect of locations and treatments of different seed treating agents against common scab incidence of potato in the field

3.1.4. Interaction effect of locations and treatments on yield and yield contributing characteristics of potato

Interaction effect of locations and treatments had significant influence on emergence, plant height and yield of potato (Fig. 2). All the tubers were emerged of all the tested treatments in Comilla. The highest plant height was observed in NaCl treated plot in Gazipur and lowest in Stable Bleaching Powder treated plot in Comilla. The highest yield was recorded in control treatment of Comilla and the lowest in control of Gazipur.

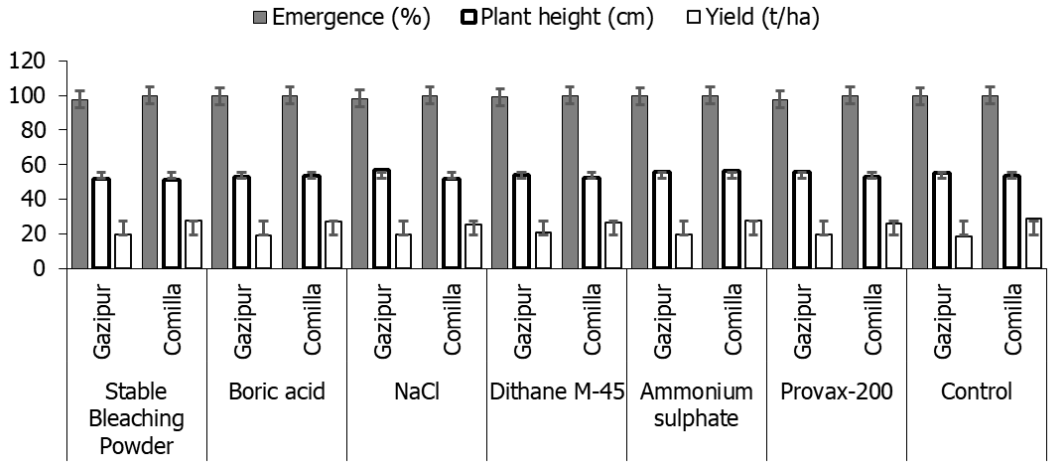

Fig. 2. Interaction effect of locations and treatments of different seed treating agents against plant emergence, plant height and yield of potato in the field

3.2. Experiment 2: Effect of different doses of fertilizers against common scab disease of potato

3.2.1. Effect of different doses of fertilizers against common scab incidence of potato

The incidence of potato scab disease was highly variable at different doses with different fertilizers (Table 3).The potato scab disease incidence by the number and weight were identical and significantly higher in case of treatment T_1 at higher dose 400 kg/ha and standard dose 350 kg/ha, at standard dose in the treatment T_3, T_4 and T_5 in comparison with the other selected doses of different fertilizers at different treatments. The highest scab incidence, still has number and weight was recorded in the urea treated plot at higher dose 400 kg/ha followed by standard dose of urea at 350 kg/ha in the treatment T_1.The lowest scab incidence by number was observed with the treatment T_2 at 650 kg/ha but identical to Ammonium sulphate 870 kg/ha, TSP 100 kg/ha and 200 kg/ha, MOP 250 kg/ha and 450 kg/ha, Gypsum 200 kg/ha and 100 kg/ha (Table 3). All the fertilizers with tested doses had similar trend of scab disease development with the scab incidence by number and scab incidence by weight. However, the interpretation of the results has not synchronized with the increase or decrease dose for scab disease development. The highest disease development by urea in comparison to Ammonium sulphate might be due to decrease in soil pH by Ammonium sulphate as observed by (Tonya *et al.*, 2010). The highest scab incidence by both number and weight in the urea treated plot might be due to formation of excess tuberisation. Lapwood & Dyson (1966)

reported that, nitrogen fertilization may also indirectly affect incidence of potato scab by altering timing of tuberisation. High levels of nitrogen may delay tuberisation to a period when soils are drier and more favorable to crop infection by *S. scabies.*

Table 3. Effect of different doses of fertilizers against common scab disease of potato in the field

Treatments	Dose (kg/ha)	Scab incidence		Disease severity (0-5 scale)
		Scab incidence by number (%)	Scab incidence by weight (%)	
T_1 (Urea)	300	30.89 ^{fg}	32.88 ^{def}	1.53
	350	54.47 ^{abc}	47.57 $^{a-d}$	1.47
	400	63.06 ^{a}	60.53 ^{a}	1.61
T_2 (Ammonium sulphate)	650	27.92 ^{g}	35.37 $^{c-f}$	1.26
	750	45.95 $^{b-f}$	48.52 ^{abc}	1.71
	870	40.23 $^{c-g}$	43.89 $^{b-f}$	1.73
T_3 (TSP)	100	37.47 $^{d-g}$	32.08 ^{ef}	2.05
	150	56.95 ^{ab}	48.38 ^{abc}	1.85
	200	41.77 $^{b-g}$	44.24 $^{b-f}$	1.57
T_4 (MOP)	250	31.81 ^{fg}	35.56 $^{c-f}$	2.18
	350	47.87 $^{a-e}$	52.80 ^{ab}	2.3
	450	42.83 $^{b-g}$	42.76 $^{b-f}$	2.05
T_5 (Gypsum)	100	33.71 ^{efg}	46.77 $^{a-e}$	2.08
	140	50.18 $^{a-d}$	43.87 $^{b-f}$	1.96
	200	42.54 $^{b-g}$	30.06 ^{f}	2.53

* Mean values within a column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (*P=0.05*).

3.2.2. Effect of different doses of fertilizers on potato emergence, plant height and yield of potato

Tested fertilizers at different doses were identical to the emergence of potato (Table 4). The highest plant height was observed in the treatment T_2 at 870 kg/ha treated plot but identical to the treatment T_1 at 400 kg/ha and all doses of the treatments T_2, T_3, T_4 and T_5 except in the treatment T_5 at 200 kg/ha (Table 4).

Table 4. Effect of different doses of fertilizers on yield and yield contributing characters of potato

Treatments	Dose (kg/ha)	Emergence (%)	Plant Height (cm)	Yield (t/ha)
T_1 (Urea)	300	100.0	40.80 ^{d}	19.21
	350	99.31	42.30 ^{bcd}	23.47
	400	98.61	46.30 ^{a}	18.61
T_2 (Ammonium sulphate)	650	99.31	45.40 ^{ab}	16.29
	750	99.31	44.84 ^{abc}	19.21
	870	98.61	46.41 ^{a}	15.78
T_3 (TSP)	100	99.31	45.16 ^{abc}	15.04
	150	98.61	43.97 $^{a-d}$	17.09
	200	98.61	45.20 ^{abc}	15.00
T_4 (MOP)	250	99.31	43.56 $^{a-d}$	14.30
	350	100.0	43.63 $^{a-d}$	18.93
	450	98.61	44.33 ^{abc}	16.80
T_5 (Gypsum)	100	99.31	44.40 ^{abc}	16.75
	140	99.31	44.64 ^{abc}	15.55
	200	97.92	41.87 ^{cd}	16.76

* Mean values within a column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (*P=0.05*).

The highest yield was recorded with the standard dose of urea in the treatment T_1 identical with lower dose of T_1 and standard dose of Ammonium sulphate in the treatment T_2 as significantly higher in comparison to the other fertilizers in all the treatments. The lowest yield was observed with the lowest dose of MOP in the treatment T_4 but the yield at all treatments except low and standard dose of Urea in the treatment T_1 and standard dose of T_2 were identical. The experiment suggests that, nitrogen is the most important and determining factor for the yield of potato. The study results also in agreement with the standard dose (BARC, 1997) of all the applied fertilizers for the yield of potato.

3.3. Experiment 3: Effect of planting time and crop duration against common scab disease of potato

3.3.1. Mean performance of locations on potato emergence, plant height, yield and disease incidence of potato

The mean of scab disease development, percent emergence, plant height and yield were significantly different at three locations (Table 5). Significantly, the highest potato scab disease development, percent emergence, plant height and yield were observed at Jamalpur followed by Gazipur and Bogra. The highest yield obtained from Jamalpur might due to soil type, soil nutrition status, soil pH etc. No clear explanation available for variation in disease incidence over different locations. The variation of the occurrence of scab and its severity in different districts of Bangladesh might be due to cropping system, soil moisture, and soil texture and soil pH .The study revealed that, the maximum development of potato scab disease had no influence on yield of potato. Potato with scab disease abruptly reduces the consumable and market value of the crop. Ultimately, even with higher yield the crop incurred severe economic loss due to the potato scab disease.

Table 5. Mean performance of locations on potato emergence, plant height, yield and disease incidence of potato

Locations	Emergence (%)	Plant Height (cm)	Yield (t/ha)	Common scab incidence (%)	
				by number (%)	by weight (%)
Gazipur	97.31 [b]	53.51 [b]	19.89 [b]	46.54 [a]	50.02 [b]
Jamalpur	99.49 [a]	57.13 [a]	30.46 [a]	49.47 [a]	56.15 [a]
Bogra	93.11 [c]	36.91 [c]	18.42 [c]	35.31 [b]	36.52 [c]

* Mean values within a column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (*P=0.05*).

3.3.2. Effect of planting time on potato emergence, plant height, yield and disease incidence of potato

Potato emergence, plant height and yield of potato differed significantly due to different planting time (Table 6). The highest seedling emergence and plant height were observed with planting at 26 November in the treatment T_2 but identical to the planting at 6 December in the treatment T_3. Significantly, the highest yield was recorded in planting at 16 November in the treatment T_1. On the contrary, the highest common scab incidence by number and weight was also recorded in the treatment T_1. Significantly, the lowest yield was recorded with planting at 16 December in comparison to the other planting dates. The lowest scab incidence also recorded with the treatment T_4. Considering the yield of potato the most suitable planting date was at 16 November,

also the potato scab disease was the highest on the same date. The contradictory results might be due to the most favorable temperature and humidity for tuber growth and development for potato as well as for the pathogen. The nature of potato scab disease has not much direct influence on tuber growth and development rather due to the tuber surface affected with scab abruptly reduce the usable and market economic value of the crop. The study suggests that, potato scab disease will not be minimized by the date of planting rather to control the disease with other methods. Similar observation of early planting increased yield as well as increased potato scab disease where late planting decreased yield as well as reduce scab disease by (Waterer, 2002).

Table 6. Effect of planting time on potato emergence, plant height, yield and disease incidence of potato

Treatments	Planting time	Emergence (%)	Plant height (cm)	Yield (t/ha)	Common scab incidence (%)		Disease severity (0-5 scale)
					by number	by weight	
T_1	16 Nov.	95.93 ^{b}	48.53 ^{bc}	25.06 ^{a}	55.21 ^{a}	60.06 ^{a}	1.64
T_2	26 Nov.	97.78 ^{a}	50.91 ^{a}	23.69 ^{ab}	43.88 ^{b}	48.81 ^{b}	1.45
T_3	6 Dec.	97.30 ^{a}	50.18 ^{ab}	22.79 ^{b}	41.82 ^{b}	45.51 ^{b}	1.56
T_4	16 Dec.	95.54 ^{b}	47.11 ^{c}	20.14 ^{c}	34.18 ^{c}	35.88 ^{c}	1.62

* Mean values within a column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (*P=0.05*).

3.3.3. Effect of crop duration against plant height, yield and disease incidence of potato

The results of the effect of different crop duration on emergence, plant height, potato scab incidence and yield are presented in the Table 7. It was found that, crop duration had no significant influence on plant height. The effect of crop duration on potato scab disease development suggests that, longer duration of the crop resulted maximum potato infection. The highest potato scab incidence was recorded at the 90 days duration of the crop but identical with 85 days duration of the crop. On the contrary, the shortest duration of the crop as well as 70 days crop duration recorded the lowest potato scab disease development and identical at 70, 75 and 80 days of the crop duration. On the other hand, the highest yield was also measured at 85 days crop duration and identical with the yield of the 90 days duration crop. The study suggests that, planting time and the crop duration are not the means to control potato scab disease as decreased potato scab condition also decreased the yield of potato.

Table 7. Effect of crop duration against plant height, yield and disease incidence of potato

Crop duration (Days)	Plant height (cm)	Yield (t/ha)	Common scab incidence (%)		Disease severity (0-5 scale)
			Scab incidence by number (%)	Scab incidence by weight (%)	
70	49.46 ^{a}	19.78 ^{c}	40.15 ^{b}	40.17 ^{b}	1.74
75	49.91 ^{a}	22.88 ^{b}	41.08 ^{b}	40.31 ^{b}	1.59
80	48.75 ^{a}	23.13 ^{b}	42.54 ^{b}	43.56 ^{b}	1.77
85	48.71 ^{a}	24.76 ^{a}	43.96 ^{ab}	48.70 ^{ab}	1.47
90	49.09 ^{a}	24.05 ^{ab}	46.37 ^{a}	49.86 ^{a}	1.82

* Mean values within a column followed by the same letter do not differ significantly according to Duncan's Multiple Range Test (*P=0.05*).

3.3.4. Interaction effect of location and planting time on common scab incidence

Interaction effect of location and planting time had significant influence on common scab development of potato (Fig. 3). The lowest scab incidence by number and weight observed in Bogra when potato planted at 16 December and highest in Jamalpur when planted at 26 November.

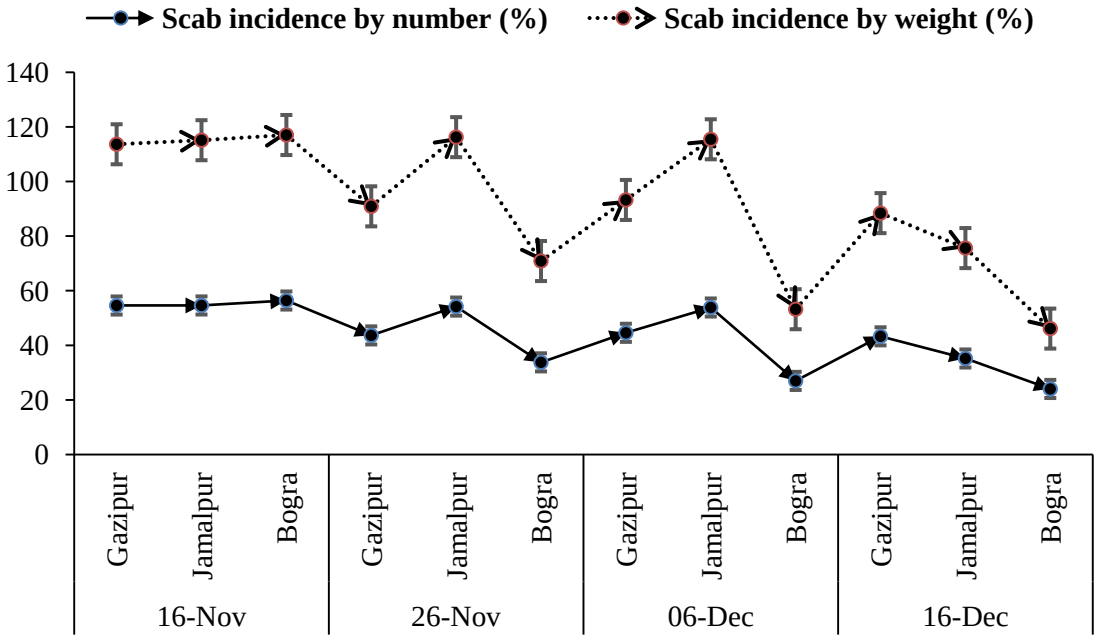

Fig.3. Interaction effect of location and planting time on scab incidence of potato in the field

3.3.5 Interaction effect of location and planting time on yield and yield contributing characters of potato

Interaction effect of location and planting time had significant influence on plant height, plant emergence and yield (Fig. 4). The highest plant height, plant emergence and yield was recorded in Jamalpur when planted at 6 December. The lowest plant height and yield was measured in Bogra when potato was planted at 16 December.

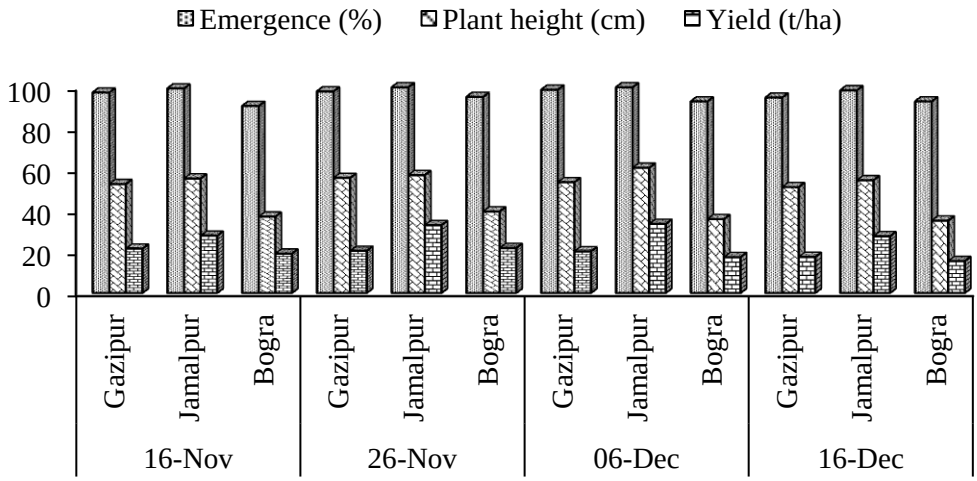

Fig. 4. Interaction effect of location and planting time on yield and yield contributing characters of potato in the field

4. Conclusion

Based on the present study it could be concluded that seed tuber treated with Dithane M-45® 0.3% solution for 10-15 minutes to be the best seed treating agent against common scab disease followed by Provax-200® @ 0.3% solution. On the other hand, seed tuber treated with water solution was more effective than seed pelleting with chemicals. In case of fertilizers, Ammonium sulphate @ 650 kg/ha found to be the best fertilizer for declining scab disease. Early planting (16 November) and longer crop duration (90 days) had positive influence on the development of scab disease and yield increase. Integration of seed treatment with Dithane M-45® 0.3% solution for 10-15 minutes and application of Ammonium sulphate instead of Urea could be the best treatment combination for management of common scab disease of potato.

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