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DETERMINATION OF THE EFFECTIVE MANAGEMENT COMPONENTS AT PRODUCTION STAGE AGAINST *RALSTONIA SOLANACEARUM* CAUSING BROWN ROT OF POTATO IN BANGLADESH

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ABSRACT

Potato is the third most important crop in Bangladesh, following rice and wheat. However, potato production is hampered by various diseases, among which brown rot, caused by *Ralstonia solanacearum*, is particularly significant. Identifying sustainable management techniques can help reduce potato diseases and ultimately improve potato production. Therefore, in this study, twenty-two different organic and inorganic compounds were applied to explore effective management strategies. The results showed that the application of bioactive compounds such as water hyacinth and straw mulch improved the growth and yield-contributing parameters of potatoes while reducing disease incidence and severity caused by *R. solanacearum*. Among the chemicals tested, the application of bleach (100 g) improved the average plant height (52.94 cm), number of stems per hill (5.96), and number of leaves per plant (38.59). Bleach (100 g) also increased potato yield and yield-contributing characters. Further studies are needed to develop alternative techniques to minimize the disease caused by *R. solanacearum* in potato fields.

Keywords: Brown rot, potato, *Ralstonia solanacearum*, management.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is a super vegetable and an important source of carbohydrates that contributes significantly to maintaining national food security. After wheat, rice, and maize, it is the fourth largest crop in the world. (FAOSTAT, 2014) and it is the third most significant crop in Bangladesh after rice and wheat (Rahim *et al*., 2023). In 2016, its average global production estimate was estimated at 380 million tonnes produced on 20 million hectares of land (FAOSTAT, 2018) consumed by over one billion people the world over. Potato "The king of vegetables'' is widely grown throughout the world as a nutritious tuber crop belonging to the In Bangladesh, Munshigonj, Jessore, Jamalpur, Bogura, Rangpur, Pabna, Panchagorh, Cumilla, Nilphamari, and Joypurhat are the major potato-growing regions. According to the Department of Agricultural Extension (DAE), potato cultivation occupies almost 460 thousand hectares (ha) of arable land, and the nation produced 1.09 core tons in 2019.

Solanaceae family. The tuber has a high amount of carbohydrates or starch, making it a nutritional source of vitamins B and C, protein, phosphorus, potassium, and iron (Burgos *et al*., 2020). Furthermore, potatoes have grown in importance as a crop for food security in recent years, particularly during periods of severe monsoon flooding. In the future, potatoes can make a significant contribution to both food and nutritional security. Due to its adaptability to a wide range of climates, it holds significant potential as food for Bangladesh and the world's growing population per unit of time and land.

Bangladesh ranks sixth globally and in Asia the third-

largest producer of potatoes (FAO, 2010). However, Hossain *et al.* (2008) reported that the national average yield of potatoes is very low (19.07 tha^{-1}) compared to its potential yield of 30-40 tha^{-1}, due to lack of quality seed, cultivation of indigenous potatoes (yield 5-7 tha^{-1}) and the high price of quality seed, inadequate supply of quality seeds, poor soil health, different pests, and diseases, etc.

Considering the diseases of potatoes, soil-borne diseases alone can cause a yield loss of as much as 10–20% of potatoes annually (Karim, 2018) and among them wilt or brown rot caused by *Ralstonia solanacearum* is the most destructive one (Yuliar *et al.*, 2015). Therefore, the development of sustainable techniques is important for the management of the brown rot disease of potatoes.

In some areas, naturally suppressive soils have been located but the actual effects are controversial and depend on geographical location, strains (race, biovar) of the pathogen, and crop. In other cases, the disease was most severe on heavy clay-loam soil (Kelman, 1953). Thus, suppressive soil towards brown rot of potatoes may be related to other factors than soil type, such as pH, organic matter content, and microbial communities in soil (Messiha *et al*., 2007). Control of brown rot in areas conducive to the disease is generally very difficult. There are no curative chemicals. Resistance breeding has only been reasonably successful against race 1 of the pathogen in tropical crops like eggplant, tomato, peanut, pepper, and to a very small extent potato in South America. Cultural measures such as the use of healthy (tested) seeds, a wide crop rotation, and the use of certain rotation crops such as corn or rice, rouging and burning of diseased plants, and careful water management also have had only limited success (Kelman, 1953). Inorganic and organic amendments can affect both the survival of the pathogen in soil and the infection of the host. The amendment of soil with compost or manure had a positive effect on the decline rates of the pathogen in the soil (Goldan *et al.,* 2023). Therefore, the main aim of this study was to determine the eco-friendly management components effective against *R. solanacearum* at the production stage and to investigate if eco-friendly management could affect potato brown rot development.

MATERIALS AND METHODS

Experiment site

The experiment was conducted at the farmer's field at Boalkhali, Tulsikhali, union Chitrakot, upazila of Sirajdikhan in the district of Munshiganj, Bangladesh.

Experimental period

The study was conducted from April 2020 to March 2021.

Treatment(s) of the study

Twenty-two (22) treatments were applied for the management of *R. solanacearum* in potato fields listed in Table 1.

Spray Schedule

The bio-control agents

Byocoaa, *Trichoderma harzianum, Bacillus subtilis, Bacillus amyloliquefaciens* were sprayed at 30 DAS (Days After Sowing) as a preventive approach, and for a control approach 3-4 more sprays at an interval of 15 Days, that means (45, 60, 75 DAS).

The botanicals

Neem leaf extract and garlic Bulb Extract were sprayed at 30 DAS (Days After Sowing) as a preventive approach and for a control approach 6-7 more sprays at an interval of 7 days, which means (45, 52, 59, 66, 73, 80 DAS).Sodium bicarbonate and baking yeast Sodium bi-carbonate was sprayed at 30 DAS and 45 DAS and Baking Yeast was sprayed at 33 DAS and 45 DAS.

The pesticides

Migra 72 WP (Mancozeb 64%+Cymoxanil 8%) was sprayed on 30 DAS as a preventive approach and Dithane M-45 (Mancozeb) was sprayed at an interval of 15 DAS means (45, 60, 70 DAS) as a control approach.

Seed tuber treatment

Potato seed tubers were treated with Botanicals like (Neem leaf extract, Garlic bulb extract, and Turmeric powder at the recommended dose), also Copper Oxychloride (Sunvit 50 WP) was used as seed tuber treatment. All the seed treatments were done just before sowing tubers as a preventive approach.

Soil treatments

The soil was drenched with Bio-control agents (Byocoaa, *Trichoderma harzianum, Bacillus subtilis, Bacillus amyloliquefaciens)*, cow dung, and Stable Bleaching powder. These soil treatments were done 4-5 days before sowing of Potato tuber.

Mulching

Mulching was completed with straw and water hyacinth at 10 DAS.

Intercultural operations

Irrigation was applied as per the requirement of the field at regular intervals. Weeding and mulching were done as and when required to keep the crop free from weeds and for better soil aeration and conservation of soil moisture.

Data collection and calculation

Disease incidence and severity, plant growth morphology, and yield and yield-contributing parameters were measured and calculated with respective formulas.

$$\text{Disease Incidence (DI)} = \frac{\text{Number of infected plant}}{\text{Total number of plant}} \times 100$$

$$\text{Disease Severity (DS)} = \frac{\text{Sum of all disease ratings}}{\text{Total number of observations} \times \text{Maximum grade in scale}} \times 100$$

Statistical analysis

The collected data were statistically analyzed using the computer package program of Statistrix 10 software. Treatment means were compared by LSD at a 0.05 level of significance. The data obtained in the present investigation for various parameters were subjected to ANOVA for a completely randomized design.

RESULTS AND DISCUSSION

Effect of different treatments on plant height of potato

The highest plant height at 40 days after sowing was observed in mulching with water hyacinth (47.53 cm) followed by Straw mulch (46.50 cm), and Bleach 100 g (42.69 cm). Statistically, no difference was found between *Trichoderma* Soil and Bleach 120gm (41.55 cm). A similar observation was also found at 55 and 70 days after sowing. Thus, average plant height was also observed in mulching with water hyacinth (56.71 cm) followed by Straw mulch (55.49 cm), and Bleach 100 g (52.94 cm) (Table 2).

Effect of different treatments on the number of stems per hill of potato

The highest number of stems per hill at 40 days after sowing was observed in Bleach 100gm (5.58) followed by Neem Seed (5.26) and Bleach 120gm (5.24) which were statistically similar. At 55 days after sowing, the highest number of stems per hill was observed in Neem Spray (6.15) while, at 70 days after sowing, the highest result was observed in *Trichoderma* Spray (6.68). Finally, the highest average number of stems per hill was observed after the application of Bleach 100 g (Table 3).

Effect of different treatments on the number of leaves per plant of potato

The highest number of leaves per plant at 40 days after sowing was observed in Bleach 100 g (25.66) which was statistically similar to water hyacinth (25.38), followed by straw mulch (24.64) and Bleach 120 g (23.59). At 55 days after sowing, the highest number of leaves per plant was observed in water hyacinth (39.84) which was statistically similar to straw mulch (39.45). At 70 days after sowing, the highest result was observed in straw mulch (57.16). Finally, the highest average of leaves per plant was observed after the application of straw mulch (Table 4).

Effect of different treatments on Yield Attributing characteristics of potato

The highest dry matter of potato tuber was found after application of *B. subtilis* soil (23.69%) followed by Bleach 100 g (22.88%) and water hyacinth (22.84%) and those were statistically similar. The highest number of tuber per hill was observed in Byocoaa Spray (8.64), while the highest average weight of tuber/hill and the average weight/3m^2 were observed after application of straw mulch and those were 444.7 g and 9.72 kg, respectively (Table 5). Finally, the highest yield was observed after the application of straw mulch followed by water hyacinth and garlic spray (Fig.1).

Effect of different treatments on disease incidence and severity

The highest disease incidence and severity were observed in the control plant followed by neem seed and garlic seed and those were statistically similar. On the other hand, the lowest disease incidence and severity were observed after the application of water hyacinth (Fig. 2).

Varietal effect on disease incidence and severity

The highest disease severity was observed in the Asterix variety of potato followed by Diamant and Cardinal. However, the lowest disease severity was observed in Carollas which was statistically similar to Prada. On the other hand, the highest disease incidence was observed in the Diamant variety followed by Asterix, and the lowest disease incidence was found in the Carollas variety (Fig. 3).

The survey study tried to explore all of the information of farmers related to potato cultivation and storage conditions. The study involved surveying 180 potato production farmers in 6 major potato-growing districts of Bangladesh. Several traditional control strategies viz. quarantine, breeding for resistance, biological control, and chemical control have been applied worldwide, but no single management practice could control *R. solanacearum* successfully in potato crops (Karim *et al.,* 2018). To control the disease infection in the potato field, farmers used different types of chemicals and bioactive compounds that had been effective in inhibiting the growth of *R. solanacearum*. This study found that the growth and yield contributing parameters of potatoes were improved by the application of bioactive compound water hyacinth and straw mulch. These compounds also reduced the disease incidence and severity in the potato field. That might be due to the presence of any active compounds that help to enhance plant growth and inhibit the growth of *R. solanacearum*. Among the chemicals bleach 100gm showed better results to minimize disease infestation that might be due to the presence of chlorine. Karim *et al*. (2020) also studied the management of *R. solanacearum* and found that the

bioactive compound cow dung, propolis, and turmeric powder reduced the disease severity index by 28.89, 26.67, and 22.22%, respectively compared to the control. Khanuja (2002), Waziri and Suleiman (2013) and Shrivastava *et al.* (2014) found it to contain antibiotic agents showing higher effectiveness against both Gram- negative and Gram-positive type bacteria). The presence of K, Na, Mg, and many other elements at higher levels in cow dung was described by Waziri and Suleiman (2013). Those elements act as enzymatic cofactors in different biochemical processes concerning antibacterial activity which was also revealed by Gupta *et al.* (2016).

Table 1. Name and doses of treatments applied in a potato field for management of *R. solanacearum*

Treatment No.	Treatment	Dose
1	Soil drenched with Byocoaa solution	1%
2	Spray of Byocoaa solution	1%
3	Soil drenched with *Trichoderma harzianum*	2%
4	Spray of *Trichoderma harzianum*	2%
5	Soil drenched with *Bacillus subtilis*	1%
6	Spray of *Bacillus subtilis*	1%
7	Soil incorporation with Cowdung	2kg/plot
8	Seed treatment with Turmeric Powder	10% for 30 sec
9	Seed treatment with Garlic Bulb Extract	3% for 20 min
10	Spray of Garlic Bulb Extract	3%
11	Soil incorporation with Stable Bleaching Powder (90g/decimal)	6.75 g/plot
12	Soil incorporation with Stable Bleaching Powder (100g/decimal)	7.5 g/plot
13	Soil incorporation with Stable Bleaching Powder (120gm/decimal)	9 g/plot
14	Soil drenched with *Bacillus amyloliquefaciens*	1.5%
15	Spray of *Bacillus amyloliquefaciens*	1.5%
16	Seed treatment with Neem Leaf Extract	3% for 20 min
17	Spray of Neem Leaf Extract	3%
18	Application of Pesticides (Migra 72 WP)	3%
19	Spray of Sodium bi carbonate+ Baking Yeast	2%+2%
20	Mulched with Straw	
21	Mulched with Water Hyacinth	
22	Control	

Table 2. Effect of different treatments on plant height on the different days after sowing

Sl. No	Treatments	Plant height (cm)			
		40 DAS	55 DAS	70 DAS	Average
1.	Byocoaa Soil	35.69 n	54.03 de	54.59 j	48.10 kl
2.	Byocoaa Spray	37.35 m	51.03 gh	52.49 l	46.96 m
3.	*Trichoderma* Soil	41.55 d	54.01 de	55.38 i	50.31 f
4.	*Trichoderma* Spray	37.47 m	53.66 e	61.51 c	50.88 e
5.	*B. subtilis* Soil	40.59 e	50.63 hi	54.44 j	48.55 ij
6.	*B. subtilis* Spray	35.32 no	50.20 i	53.61 k	46.38 n
7.	*B. amylo* Soil	38.70 ij	50.57 hi	55.65 hi	48.31 jk
8.	*B. amylo* Spray	35.50 n	52.62 f	57.47 g	48.53 ij
9.	Turmeric	38.24 k	53.89 e	59.59 d	50.88 e
10.	Garlic Seed	39.09 hi	54.53 d	57.45 g	50.36 f
11.	Garlic Spray	37.96 l	50.60 hi	57.65 g	48.74 i
12.	Neem Seed	40.04 f	51.55 g	56.01 h	49.20 gh
13.	Neem Spray	39.38 gh	52.50 f	58.30 f	50.06 f
14.	Bleach 90 g	38.27 jkl	51.51 g	57.56 g	49.11 h
15.	Bleach 100 g	42.69 c	55.51 c	60.60 d	52.94 c
16.	Bleach 120 g	41.76 d	51.62 g	60.47 d	51.28 d
17.	Cow dung	39.46 gh	50.60 hi	53.58 k	47.88 l
18.	Pesticides	38.47 jk	52.68 f	57.35 g	49.50 g
19.	$NaHCO_3$ spray	39.80 fg	50.57 hi	55.55 hi	48.64 ij
20.	Straw mulch	46.50 b	56.44 b	63.52 b	55.49 b
21.	Water H.	47.53 a	58.10 a	64.49 a	56.71 a
22.	Control	34.91 o	45.58 j	48.58 m	43.02 o
23.	CV (%)	0.69	0.67	0.56	0.39
24.	$LSD_{(0.05)}$	0.4513	0.5826	0.5314	0.3170

Table 3. Effect of different treatments on the number of stems per hill on different days after sowing

Sl. No.	Treatments	Number of stems per hill			
		40 DAS	55 DAS	70 DAS	Average
1.	Byocoaa Soil	4.46 ef	5.37 cdef	5.68 efgh	5.17 fgh
2.	Byocoaa Spray	4.46 ef	5.65 bcd	5.81 def	5.31 defg
3.	*Trichoderma* Soil	4.98 bc	5.57 bcd	5.61 efgh	5.38 def
4.	*Tricoderma* Spray	4.80 cde	5.49 bcde	6.68 a	5.66 bc
5.	*B. subtilis* Soil	4.84 cde	5.32 def	5.77 defg	5.31 defg
6.	*B. subtilis* Spray	4.76 cde	5.29 defg	5.75 defg	5.27 efg
7.	*B. amylo* Soil	4.49 ef	5.06 efgh	4.74 k	4.77 j
8.	*B. amylo* Spray	4.27 fg	5.72 bcd	5.64 efgh	5.21 fg
9.	Turmeric	4.52 ef	5.88 ab	6.15 bcd	5.52 cd
10.	Garlic Seed	5.01 bc	5.31 def	5.27 hij	5.19 fg
11.	Garlic Spray	4.80 cde	5.38 cdef	5.51 fgh	5.23 fg
12.	Neem Seed	5.26 ab	5.77 abc	6.43 ab	5.82 ab
13.	Neem Spray	4.93 bcd	6.15 a	6.39 abc	5.82 ab
14.	Bleach 90 g	4.96 bc	5.51 bcd	5.99 cde	5.49 cde
15.	Bleach 100 g	5.58 a	5.77 abc	6.55 ab	5.96 a
16.	Bleach 120 g	5.24 ab	5.29 defg	5.41 fghi	5.31 defg
17.	Cowdung	4.65 cdef	4.89 gh	5.09 ijk	4.88 ij
18.	Pesticides	4.57 def	4.75 h	5.36 ghi	4.89 ij
19.	$NaHCO_3$	4.79 cde	5.00 fgh	5.06 ijk	4.95 hij
20.	Straw mulch	4.34 fg	5.38 cdef	5.59 efgh	5.10 ghi
21.	Water H.	4.47 ef	4.74 h	4.92 jk	4.71 j
22.	Control	4.07 g	4.25 i	4.21 l	4.18 k
	CV (%)	4.28	4.13	4.05	2.47
	$LSD_{(0.05)}$	0.3336	0.3647	0.3757	0.2148

Table 4. Effect of different treatments on the number of leaves per plant on different days after sowing

Sl. No.	Treatments	Number of leaves per plant			
		40 DAS	55 DAS	70 DAS	Average
1.	Byocoaa Soil	21.54 k	31.98 bcd	46.51 e	33.34 efg
2.	Byocoaa Spray	20.31 l	29.93 cd	34.54 o	28.26 j
3.	*Trichoderma* Soil	22.72 ef	37.17 ab	43.46 g	34.45 de
4.	*Trichoderma* Spray	22.50 fgh	37.16 ab	54.05 b	37.90 bc
5.	*B. subtilis* Soil	22.81 def	37.74 ab	41.36 h	33.97 ef
6.	*B. subtilis* Spray	22.25 hij	35.62 abc	37.70 k	31.85 fg
7.	*B. amylo* Soil	21.97 j	32.46 bcd	34.27 o	29.57 ij
8.	*B. amylo* Spray	20.12 l	30.51 cd	38.77 i	29.80 hij
9.	Turmeric	21.39 k	21.74 e	45.33 f	29.49 ij
10.	Garlic Seed	22.56 fg	35.30 abc	38.29 j	32.05 fg
11.	Garlic Spray	22.29 ghi	34.64 abc	36.77 l	31.23 ghi
12.	Neem Seed	23.56 c	38.30 ab	43.43 g	35.10 de
13.	Neem Spray	23.04 d	33.19 abcd	52.75 c	36.32 cd
14.	Bleach 90 g	22.94 de	37.71 ab	35.12 n	31.92 fg
15.	Bleach 100 g	25.66 a	38.42 ab	51.70 d	38.59 ab
16.	Bleach 120 g	23.59 c	34.62 abc	36.76 l	31.66 gh
17.	Cowdung	22.09 ij	32.55 bcd	41.45 h	32.03 fg
18.	Pesticides	22.23 hij	29.35 cd	35.52 m	29.04 j
19.	$NaHCO_3$	22.81 def	29.43 cd	33.44 p	28.55 j
20.	Straw mulch	24.64 b	39.45 a	57.16 a	40.42 a
21.	Water H.	25.38 a	39.84 a	54.19 b	39.80 ab
22.	Control	20.16 l	27.53 d	30.20 q	25.97 k
	CV (%)	0.76	10.09	0.44	3.48
	$LSD_{(0.05)}$	0.2806	5.627	0.3038	1.882

Table 5. Effect of different treatments on yield attributing characteristics of potato

Sl. No.	Treatments	Yield attributing characteristics			
		Dry matter of tuber (%)	Number of tubers/hill	Average weight of tuber/hill (g)	Average weight/3m^2 (kg)
1.	Byocoaa Soil	19.62 k	6.43 f	375.7 c	8.66 cd
2.	Byocoaa Spray	22.16 cd	8.64 a	318.0 fg	8.29 d
3.	*Trichoderma* Soil	22.28 c	8.52 ab	358.0 cd	7.43 e
4.	*Trichoderma* Spray	21.49 fg	7.23 e	253.0 j	7.49 e
5.	*B. subtilis* Soil	23.69 a	8.28 b	414.3 b	8.44 cd
6.	*B. subtilis* Spray	20.31 j	6.50 f	302.7 gh	6.78 f
7.	*B. amylo* Soil	18.63 l	4.62 i	337.7 def	7.28 e
8.	*B. amylo* Spray	19.67 k	8.51 ab	271.7 ij	7.63 e
9.	Turmeric	17.33 m	7.28 de	354.3 cde	7.65 e
10.	Garlic Seed	21.00 h	6.47 f	326.7 fg	8.79 c
11.	Garlic Spray	20.45 ij	7.29 de	292.3 hi	9.36 b
12.	Neem Seed	18.84 l	7.33 de	333.3 ef	7.54 e
13.	Neem Spray	20.65 i	7.58 cde	342.3 def	8.38 d
14.	Bleach 90 g	22.29 c	7.58 cde	373.3 c	7.59 e
15.	Bleach 100 g	22.88 b	5.85 g	273.7 ij	8.29 d
16.	Bleach 120 g	21.45 g	7.64 cd	357.3 cd	8.48 cd
17.	Cowdung	21.94 de	5.54 gh	269.7 ij	7.52 e
18.	Pesticides	19.42 k	5.37 h	319.7 fg	7.50 e
19.	$NaHCO_3$	22.39 c	8.18 b	323.3 fg	8.46 cd
20.	Straw mulch	21.72 ef	7.47 cde	444.7 a	9.72 a
21.	Water H.	22.84 b	7.75 c	326.3 fg	9.71 a
22.	Control	17.25 m	5.30 h	275.3 ij	6.61 f
	CV (%)	0.69	2.77	3.96	2.46
	$LSD_{(0.05)}$	0.2388	0.3212	1.47	0.3296

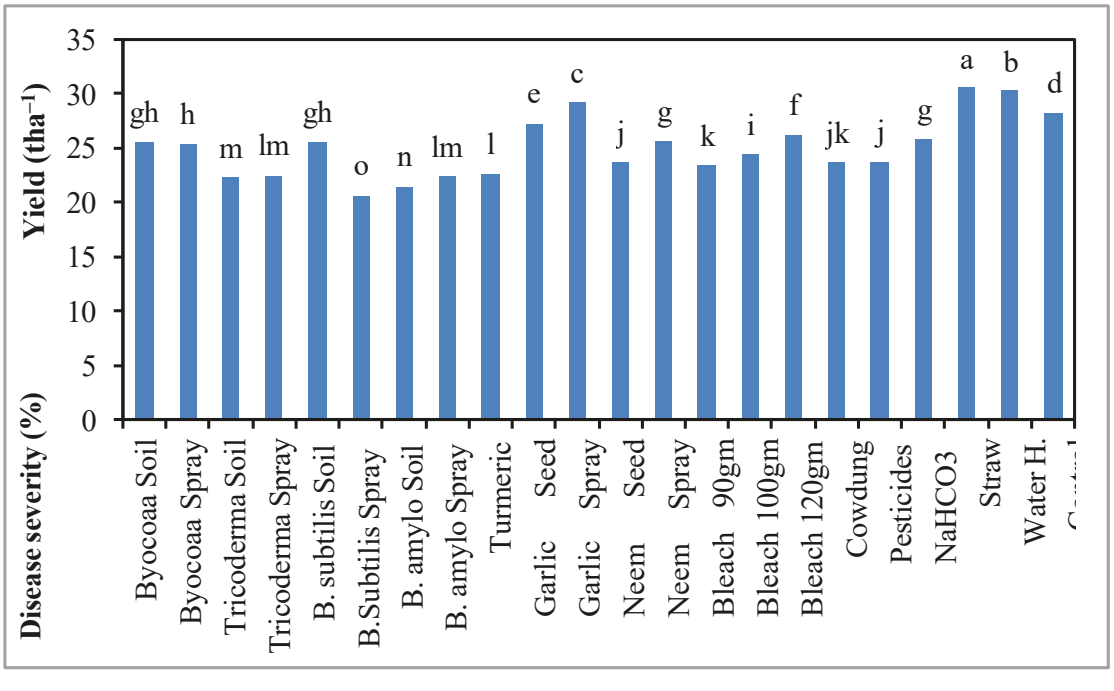

Fig. 1. Effect of different treatments on the yield of potato

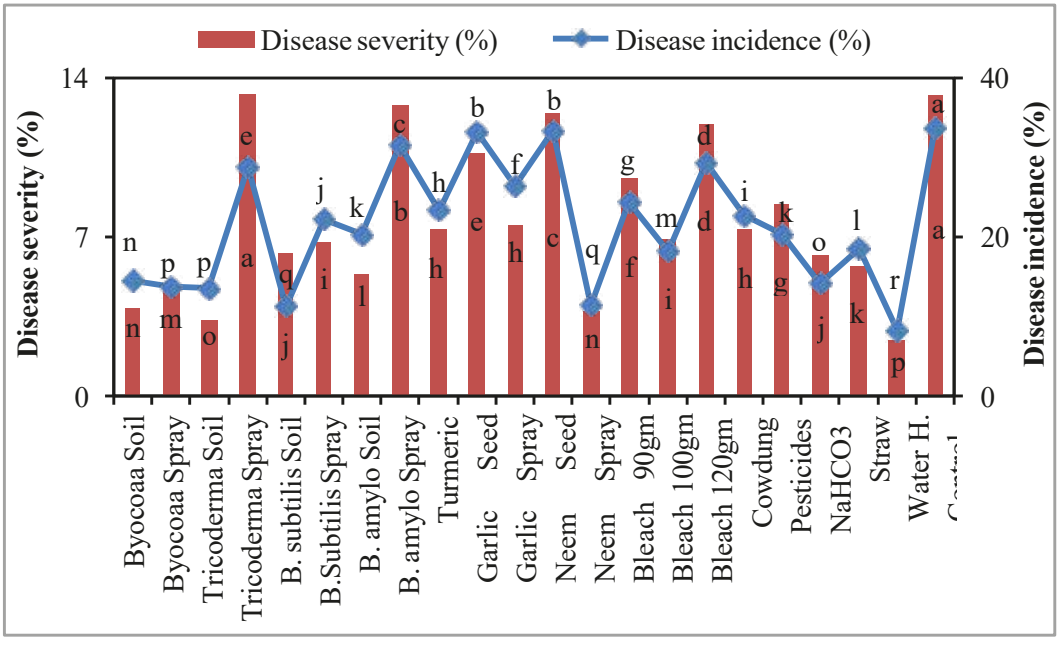

Fig. 2. Effect of different treatments on disease incidence and disease severity of brown rot of potato caused by *Ralstonia solanacearum*

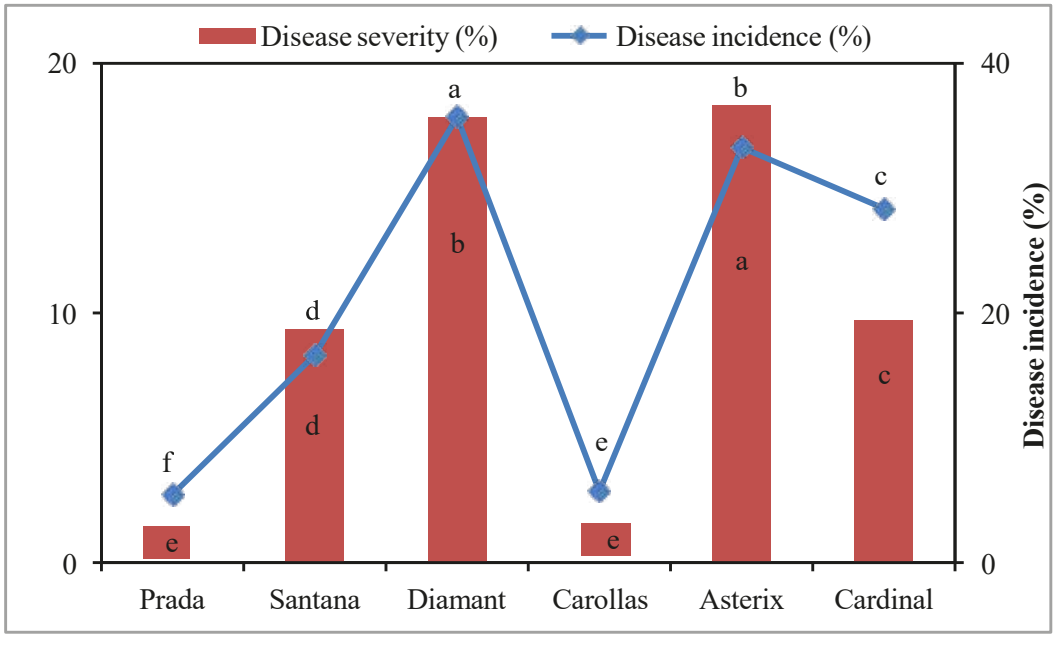

Fig. 3. Effect of different varieties on disease incidence and disease severity of brown rot of potato caused by Ralstonia solanacearum

CONCLUSION

The production of potatoes in Bangladesh is significantly hampered due to the infection of *R. solanacearum* and poor storage conditions. The study on potato production and storage practices among farmers provides valuable insights into various dimensions of potato farming in the country. After the application of different treatments, we found that the growth and yield contributing parameters of potatoes were improved by the application of bioactive compound water hyacinth and straw mulch. These compounds also reduced the disease incidence and severity in the potato field. We found that the application of water hyacinth and straw as a mulch material decreased the disease infection by *R. solanacearum*. Among the chemicals, the application of bleach 100 g showed significant results in minimizing brown rot of potato disease infection by *R. solanacearum*.

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