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Organic Management: An Alternative to Control Late Blight of Potato and Tomato Caused by *Phytophthora infestans*

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ABSTRACT: An experiment was conducted in the field laboratory, Department of Plant pathology, Bangladesh Agricultural University, Mymensingh to evaluate the efficacy of compost tea and poultry litter extract in controlling late blight of potato and tomato under natural infection condition. Significant effects of different organic amendments were observed on the incidence and severity of late blight in potato and tomato as compared to control. The results showed that the minimum late blight incidence, per cent late blight infected leaves per plant and per cent leaf area diseased per plant were recorded in T_3 (compost tea applied as foliar spray) followed by T_2 (foliar spray of Ridomil) while these parameters of late blight assessment were recorded maximum in control treatment (T_1). Application of IPM lab Biopesticide and BAU-Biofungicide performed better as compared to remaining treatments used in the study. All other components such as soil application of poultry litter, mustard oil cake, soil drenching of compost tea and poultry litter extract resulted significantly lower late blight incidence and severities as compared to untreated control (T_1). Foliar application of compost tea showed best performance in increasing the plant height and yield as compared to all other treatments although soil application of mustard oil cake and compost produced tallest plant and highest number of plants, respectively in potato while the maximum plant height, number branches per plant, and fruit yield in tomato were recorded in case of compost tea applied as soil drench as compared to control. The other treatments showed significant effect in increasing all the growth and yield parameters of both potato and tomato as compared to control. Benefit cost analyses revealed that foliar spray of compost tea showed highest BCR (65.20) followed by T8 (Soil application of IPM Lab Biopesticide) with BCR 54.38 in case of potato while the highest BCR (28.32) was calculated in plots received compost tea as soil drenching followed by T_9 (BAU-Biofungicide as foliar spray) in case of tomato. The other treatments showed comparatively higher BCR as compared to untreated control in both vegetables. The results indicated that an investment of Tk. 1.00 may lead to a profit up to Tk. 65.20 by foliar application of compost tea in potato and may lead to a profit of Tk. 28.32 with soil drenching of compost tea in tomato which are maximum profit in the present study.

Key words: Organic management, late blight, *Phytophthora infestans*, potato and tomato

I. INTRODUCTION

Potato and tomato are two important vegetables in Bangladesh and has been contributing to the nutrition of poor peoples of the country who have been suffering from malnutrition. These two vegetables have also been contributing to the recent development of Agro and Food industries in Bangladesh. However, the production of these two major vegetables in Bangladesh is far below as compared to the other growing countries of the World. The main limiting factors for production of potato and tomato in Bangladesh are the poor quality seeds, the management factors and insect-pest and diseases. Late blight caused by the oomycete pathogen, *Phytophthora infestans* (Mont.) deBary, a destructive disease of major concern all over the world which costing the billion-dollar losses every year in potato (Kamoun *et al*., 2001). The causal pathogen can also infects tomatoes (Judelson, 1997).The disease causes 'Irish potato famine' in the middle of 19th century (Salaman, 1985). Severe epidemics were also reported in Great Britain, Holland and Belgium during the same years it caused the Irish potato famine (Andrivon, 1996). Changes in populations of the pathogen have been creating a great challenge for the researchers to develop an effective control strategy against the disease worldwide. At present there is no tolerant and/or resistant potato and tomato cultivar available against late blight pathogen, *P. infestans* worldwide. New fungicides are introducing in the country every year against late blight pathogen but none of them found effective due to the dynamic changes of population structures of *P. infestans*.

Moreover, indiscriminate use of systemic fungicides especially metalaxyl (Ridomil) provides chance to develop resistant strain of the fungus has been reported from home and abroad (Ali and Dey, 1999; Gupta *et al*., 1999; Singh, 2000). Metalaxyl resistant strains of *P. infestans* have also been reported in the country around more than a decade ago.

Therefore, to formulate an eco-friendly integrated control approach and to screen out or to develop the tolerant/resistant cultivars of potato and tomato, a comprehensive information on the late blight incidence and prevalence of the disease and information related to *P. infestans* populations structures from all over the country are necessary. Although some preliminary studies on late blight disease and its pathogen are available, but there is no comprehensive information on the disease and on the population of its pathogen are available in Bangladesh. To address the issues on late blight disease, a comprehensive field survey is required to know the information on the status of late blight of potato and tomato and performance of the existing popular potato and tomato cultivars to the most aggressive and prevalent isolates of *P. infestans* in Bangladesh in the incoming years. However, in a mean time use of some organic approaches to control late blight would be the best option considering the availability to the farmers and environmental issues.

Organic manures and compost tea or organic tea in agriculture and horticulture has been emerging as a new technology in plant disease management during the last decade. These organic products act as sources of plant nutrients as well as beneficial microbes and organic compounds that possess the ability to suppress plant pathogens (Anonymous, 2004). It is a well established fact that certain soil microbes have the capacity to suppress plant diseases (Cook and Baker, 1983; Adams, 1990). Several earlier studies revealed that organic tea or special compost extracts when applied as foliar spray have controlled certain plant diseases including apple collar rot, apple scab, grey mold, downy mildew, powdery mildew and damping-off (Weltzien and Ketterer, 1986; Budde and Weltzien, 1988; Chen *et al*., 1988; Andrews and Harris, 1992; Boehm *et al*., 1993; Elad and Shtienberg, 1994; Bio-Cycle Staff, 1997). Common preparation of compost extracts involves mixing of mature compost with tap water in an open container in varying ratios followed by filtered and later applied to foliage or drenched into the soil (Abbasi *et al*., 2002). Compost tea is mixed with additives which are added with a view of increasing microbial population densities during production (Scheuerell and Mahaffee, 2002). It is reported that the dominant microbial population in both aerated (Weltzein, 1991) and non-aerated (Ingham, 2000) compost tea is bacteria which could be a useful parameter that could help in the measurement of plant disease. It is generally believed that higher level of disease suppression can be achieved by increasing the population of total and active bacteria in compost tea (Ingham, 2000). Considering the above facts on late blight disease management and complex genetic structures of its pathogen, *P. infestans*, the present research was carried out to know the efficacy of different organic approaches against late blight disease of potato and tomato.

II. MATERIALS AND METHODS

A. Experimental site, material, design and treatments

An experiment was conducted in the field laboratory, Department of Plant pathology, Bangladesh Agricultural University, Mymensingh during October, 2011 to March, 2012. The land was firstly ploughed with a power tiller and was exposed to sunlight for at least 7days. Then the land was ploughed and cross-ploughed until the soil had a good tilth followed by laddering to level the land and to remove and weeds and break up clods. After each plough, weeds and rubbish were removed. Finally, spade was used to prepare plots.

B. Collection of seed potato tubers

Potato tubers of a Deshi variety (Lal Pakri) was collected from a farmer house located nearby the Bangladesh Agricultural University and the seeds of tomato variety Ruma VF was bought from the Local market..

C. Treatments, design and layout of the experiment

The experiment was laid out in the Randomized Complete Block Design (RCBD), with four replications. Distance between the blocks was 1 m and between the plots was 0.5m. The size of unit plot was (1 m X 1 m). A total of 10 treatments were used viz. T_1 (Control with no spray), T_2 (Control with fungicide spray), T_3 (Compost tea or extract as foliar spray), T_4 (Compost tea or extract as soil drenching), T_5 (Poultry litter extract as soil drenching), T_6 (Compost as soil application), T_7 (Poultry litter (soil application), T_8 (Biopesticide as soil application), T_9(BAU-Biofungicide as foliar spray) and T_{10} (Mustard Oil Cake as soil application).

D. Soil application of compost, poultry litter, IPM Lab Biopesticide and Mustard Oil Cake as treatment

Compost, poultry litter, IPM Lab Biopesticide and Mustard oil cake were applied to the soil of the respective plot at least seven days before final land preparation @ 10 ton/ha, 10 ton/ha, 64 kg/ha and 3.0 ton/ha, respectively.

E. Planting of potato tubers and transplanting of tomato seedlings along with intercultural operation

Potato tubers were planted in the plots in two rows at 30 cm distance on November 11, 2011 using six tubers row and four seedlings of tomato were transplanted at row to row distance 30 cm. After planting, gap filling was done within a week. General field sanitation was maintained throughout the growing period. Water was applied to the plots in between the two rows in case of potato and in individual plant for tomato.

F. Preparation and application of compost tea and poultry litter extract

Compost teas or extracts were prepared by mixing compost with tap water at a ratio 1:5(w/v) followed by fermentation for at least one week. A cup of molasses was added in the mixture during fermentation to enhance the microbial growth in the compost tea. Then it was stirred once every day and allowed to ferment outdoors around at 25°C. After 7 days, the solution was filtered through cheese cloth and diluted (1:1). Then the prepared compost tea was applied with ordinary sprayers. Poultry litter extracts were prepared similarly for soil drenching.

*Foliar spray: C*ompost tea was sprayed on the foliage with a sprayer at 15 days interval to the assigned plots @ 1000 L/ha.

Soil drenching: Both compost tea and poultry litter extract were drenched at the base of the plant @ 1L/m^2 i.e. 10, 000L/ha.

G. Preparation and application of BAU-Biofungicide

BAU- Biofungicide was collected from Eco-friendly Plant Disease Management Lab, Department of Plant Pathology, Bangladesh Agricultural University, Mymensingh. BAU-Biofungicide was prepared by mixing 20 g with 1L water at a final concentration of 2% taken in a beaker and mixed with a stirrer. Then it was sieved with cheese cloth and 2-3 drops Tween-20 was added to it. Then the prepared BAU-Biofungicide was sprayed at 2% concentration @ 1000 L/ha. The first spray was given 30 days after transplanting (DAT).

H. Data collection and analysis: The data were collected on the various growth and yield parameters of potato and tomato at the time of harvesting. The data were analyzed statistically using analysis of variance to find out the variations resulting from experimental treatments and the treatment means were compared by DMRT (Duncan's Multiple Range Test).

I. Cost-benefit analysis and Benefit Cost Ratio (BCR)

The cost-benefit analysis was done based on gross returns and cost of each treatment to compare the profitability among the treatments. The gross return, gross margin and gross margin over control under each treatment were calculated as follows:

Gross return (TK/ha) = Fruit Yield (kg/ha) × Price (TK/kg)

Gross margin (TK/ha) = Gross return (TK/ha) - Cost of the treatment (TK/ha)

Gross margin over control (TK/ha) = Gross return under each treatment (TK/ha) - Gross return under control (TK/ha)

The BCR was calculated by slight modification of the formula of DAS (Anonymous, 1996/97) as used by Rahman (1998) is shown below:

$$\text{BCR} = \frac{\text{Yield of treated plot} - \text{Yield of control plot}}{\text{Cost of treatments}} \times \text{Price of product}$$

J. Identification of late blight infection and its pathogen, P. infestans

Late blight of potato and tomato was identified based on the symptoms appeared as young lesions which are small, dark, water-soaked spots and a white mold growth in the infected areas under cool, wet conditions. Stems are similarly affected and complete defoliation (browning and shriveling of leaves and stems) can occur within 14 days from the first symptoms (http://www.hgic.umd.edu/content/documents/hg38late blight7_09_001.pdf).

The severity of late blight of potato and tomato was assessed using the following formula:

$$\% \text{ late blight incidence in potato/tomato} = \frac{\text{No. of infected plants per plot}}{\text{Total number of plants per plot}} \times 100$$

$$\% \text{ late blight severity of potato} = \frac{\text{No. of blighted leaves in per plant}}{\text{Total no. of leaves per plants}} \times 100$$

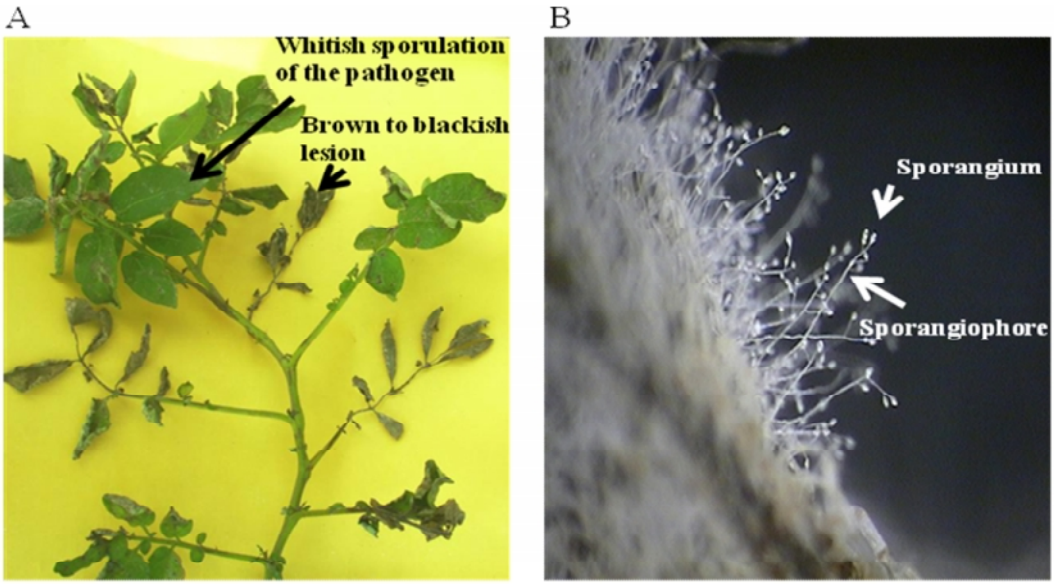
The late blight pathogen, *P. infestans* was identified by observing sporangiophores and sporangia grown on the surface of the collected diseased leaves from the experimental plots after incubation at low temperature over night or slightly more with the aid of a steriobinocular microscope.

Photograph was taken with the digital camera equipped with the microscope.

III. RESULTS AND DISCUSSION

A. Identification of late blight infection and its pathogen, P. infestans

Late blight infections were diagnonized in the field based on the symptoms as shown in Fig. 1A and the organism, *P. infestans* was identified based on the sporangiophores and sporangium produced on the surface of the infected potato leaf after over night incubation at around 18±2°C (Fig. 1B).



A. **B.**

Fig.1. Infected potato plant showing late blight symptoms (A) and Sporangiophores and sporangia of *P. infestans* (B).

B. Organic approaches reduced the incidence and severity of late blight of potato and tomato

Several recent reports proved that compost and poultry litter are effective in controlling a wide range of plant pathogens many economically important crop plants. To test the possibility of using compost tea and poultry litter extract in controlling late blight of potato, incidence and severities of late blight were monitored at different days after transplanting in the field. Significant effect of different treatments was observed on the incidence, percent leaf infection and percent leaf area diseased due to late blight infection as compared to control (Table 1).

The results showed that the minimum late blight incidence, per cent late blight infected leaves per plant and per cent leaf area diseased per plant were recorded in T_3 (compost tea applied as foliar spray) followed by T_2 (Foliar spray of Ridomil) while these parameters of late blight assessment were recorded maximum in control treatment (T_1) (Table 1). Application of IPM lab Biopesticide and BAU-Biofungicide performed better as compared to remaining treatments used in the study.

All other components such as soil application of poultry litter, mustard oil cake, soil drenching of compost tea and poultry litter extract resulted significantly lower late blight incidence and severities as compared to untreated control (T_1) (Table 1).

On the contrary, although the different treatments reduced significantly the late blight incidence and severity in tomato as compared to control treatment, the minimum late blight incidence were recorded in T_4 (compost tea applied as soil drenching) and in T_5 (poultry litter extract applied as soil drenching) while the minimum late blight incidence and severity were noticed in the plot received T_4 (Compost tea applied as soil drenching) and T_9 (BAU-Biofungicide as foliar spray) as compared to control and other treatments. However, in general soil application of compost (T_6), Poultry litter (T_7), IPM Lab Biopesticide (T_8) and Mustard Oil Cake (T_{10}) enhancing the plant responses in reducing the late blight incidence and severity in tomato as compared to control and other treatment (Table 1). Interestingly, from the results it was observed that foliar spray of compost tea performed best in potato and soil drenching of compost tea performed best in tomato. The differential responses of compost tea in potato and tomato might be due to different host factors and signaling pathway activated. However, the possibility of these phenomena needs to be tested.

Table 1. Effects of different organic management approaches on the incidence and severity of late blight of potato and tomato.

Treatment	Potato			Tomato	
	% incidence	% infected leaves per plant	% Leaf area diseased	% Incidence	Severity
T1	60.33a	38.23a	65.00a	100.00	8.87a
T2	14.24f	18.53d	27.00e	100.00	6.06d
T3	12.88f	18.75d	27.00e	100.00	8.33abc
T4	42.29b	38.23a	53.33bc	91.67	6.06d
T5	44.43b	26.19bc	54.00bc	91.67	7.51a-d
T6	26.59d	30.56b	48.33c	100.00	7.52a-d
T7	60.30a	21.70cd	60.00ab	100.00	7.06cd
T8	18.67e	25.73bc	38.67d	100.00	8.71ab
T9	22.74de	23.27cd	38.67d	100.00	6.20d
T10	37.48c	27.00bc	49.33c	100.00	7.20bcd
LSD	4.088	6.285	6.472	-	1.435
Level of significance	*	*	*	NS	*

T_1 (Control with no spray), T_2 (Control with fungicide spray), T_3 (Compost tea or extract as foliar spray), T_4 (Compost tea or extract as soil drenching), T_5 (Poultry litter extract as soil drenching), T_6 (Compost as soil application), T_7(Poultry litter as soil application), T_8 (Biopesticide as soil application), T_9(BAU-Biofungicide as foliar spray) and T_{10} (Mustard Oil Cake as soil application)

* Means with the same letter in the column do not differ significantly at 5% level of probability, NS-Not significant.

A number of previous reports showed some positive impact of organic manures in reducing the incidence and severity of many diseases of some economically important crop plants (Aryantha *et al.* 2000, Nelson *et al.* 2002, Shaikh and Ghaffar 2004; Ben Jenana *et al.* 2009; Saadi *et al.* 2010; Pane *et al.* 2011 and Ahmed *et al.* 2012). Several mechanisms were reported to be involved behind the process how the organic manures reduce inhibit the progress of the disease causing pathogens. First, compost derived beneficial microbes compete for nutrients with plant pathogens in the rhizosphere (De Brito et al. 1995 and Hoitink and Boehm 1999). Secondly, production of antibiotic compounds by beneficial microorganisms may inhibit the various plant pathogens, a process known as antibiosis (Hoitink et al. 1996), the third the Parasitism and predation of soil inhabiting pathogens by compost inhabiting beneficial microorganisms (Hoitink and Boehm 1999) and the fourth one involves in inducing of systemic resistance in plants by microorganisms from composts or soils (Zhang *et al.* 1996). Compost tea added living microorganisms on plant surfaces or roots and provides food for beneficial microbes that ensure diversity and healthy food web community where symbiotic bacteria and fungi provide protection of the plants. Application of organic tea or compost tea extractions have been shown to result in modest to major control of several plant diseases including potato late blight (Ketterer and Weltzein, 1988; Weltzein, 1991; Bio cycle Staff, 1997; Hoitink and Boehm, 1999; Abbasi *et al*., 2002; Stone *et al*., 2004; Al-Dahmani *et al*., 2005; Scheuerell and Mahaffee, 2006). Modest control of powdery mildew and *Botrytis* on grapes was observed by application of aerated compost tea and non aerated compost tea (Travis *et al*., 2003). In other studies, aerobic compost had a lesser effect in controlling apple scab, downy mildew, brown fruit rot and peach leaf curl (Wittig, 1996). Composted pine bark mix fortified with the biocontrol agent *Trichoderma hamatum* reduced the severity of bacterial leaf spot on radish, lettuce and tomato under controlled environmental conditions (Al-Dahmani *et al*., 2005). Plots amended with composted cannery wastes reduced the incidence of anthracnose fruit rot in tomatoes compared to non amended plots and resulted in a 33% increase in marketable yield (Abbasi *et al*., 2002). In another study, Al-Dahmani *et al*. (2003) reported the marginal effective of compost tea against bacterial spot on fruits under high disease pressure.

C. Influence of organic approaches on the growth and yield parameters of potato and tomato

Organic manures were reported to be the potential enhancer of the growth and yield parameters of many vegetable crop plants. To explore the possible effect of the organic approaches used in this study, data were taken on the different growth and yield parameters and analyzed. Significant effects of the treatments were observed on the plant height and yield of potato except number of plant raised per tuber (Table 2). However, foliar application of compost tea (T_3), soil application of compost (T_6) and poultry litter (T_7) showed better performance in increasing the plant height and yield as compared to all other treatments although soil application of mustard oil cake (T_{10})and compost produced tallest plant and highest number of plants, respectively. The results showed that all other treatments resulting comparatively higher plant height, number of plants and yield as compared to control.

The effects of compost tea and poultry litter extract on the growth and yield parameters of tomato were observed significant as compared to control and other positive control treatments such as soil application of compost (T_6), poultry litter (T_7), IPM Lab-Biopesticide (T_8) and mustard oil cake (T_{10}) (Table 2). The results revealed that the maximum plant height, number of branches per plant, number of fruits per plant and fruit yield were recorded in T_4 (soil drenching of compost tea) and the minimum plant height, number branches per plant, number of fruits per plant and fruit yield were recorded in control treatment (T_1). The other treatments showed significant effect in increasing all the growth and yield parameters of tomato as compared to control.
These higher growth and plant vigour may be due to the nutrient elements along with other growth promoting substances provided by different organic components used. Organic teas also increase vigour and hardness on the plant were reported due to both micronutrients (building blocks of plant enzymes, vitamins and hormones) and the organic chelating agents that make them available other humic substances (Merrill et al. 1998). Cheuk (2005) also reported significant increase in tomato yield with compost amendment. Besides, significant yield increase in eggplant was observed as a result of disease suppressiveness and growth promoting effect of compost (Paplomatas, 2005) *Trichoderma* lead to increase nutrient availability and uptake results stronger nutrient uptake by plant and thereby develops the root system. Besides, it makes better support for shoot growth and development.

These are important because improvement of plant vigor to overcome biotic and/or abiotic stresses results in the production of stronger plants and increase in plant productivity and yields (Azarmi 2011).

D. Analyses of Benefit Cost Ratio (BCR) for each organic approach in controlling late blight of potato and tomato

It has been observed that foliar application of compost tea showed highest BCR (65.20) followed by T_8 (soil application of IPM Lab Biopesticide) with BCR 54.38 (Table 3). The treatments T_2 (foliar spray of Ridomil) and T_9 (Foliar spray of BAU-Biofungicide) resulted 35.31 and 38.88 BCR, respectively as compared to untreated control. These treatments showed higher BCR because of low treatment cost as shown in Table 3. The results indicated that an investment of Tk. 1.00 may lead to a profit up to Tk. 65.20 by foliar application of compost tea and may lead to a profit of Tk. 54.38 in case of soil application of IPM Lab Biopesticide which showed the maximum profit in the present study.
On the other hand, soil drenching of compost (T)resulted highest BCR (28.32) as compared to control and other treatments followed by foliar spray of BAU-Biofungicide (T_9) which showed a BCR of 27.84 (Table 4). Foliar spray of Rovral (T_2), foliar spray of compost tea (T_3) and soil application of IPM Lab Biopesticide (T_8) showed comparatively better BCR 16.80, 22.50 and 23.77, respectively (Table 4). An investment of Tk. 1.00 may lead to a profit up to Tk. 28.32 by the he four times soil drenching of compost tea that gave the maximum profit in the present study. The second highest benefit resulted from the treatment with BAU- Biofungicide where the investment Tk. 1.00 returned a profit of Tk. 27.84. The higher economic return for each treatment performed better may be because of lower disease severity with vigorous plant growth which in turn increases the yield in both vegetables.

CONCLUSION

Compost tea as foliar spray in case of potato and as soil drenching in tomato may be the best alternative approach to control late blight of potato and tomato with higher economic return. However, the suitability of compost tea as a technology to control plant diseases needs to be evaluated against wide range of pathogens in other crop plants as compared to other biological means of plant disease control.

Table 2: Effects of different organic management approaches on the major growth and yield parameters of potato and tomato.

Treatments	Potato			Tomato		
	Plant height (cm)	Number of plants	Yield per ha (t/ha)	Plant height (cm)	Number of branches per plant	Fruit yield per ha (t)
T1	21.77abc	3.61	12.20f	78.00d	3.83c	43.40e
T2	21.06bc	2.91	22.40bcd	84.41bc	4.99bc	53.70c
T3	23.50abc	3.80	28.50a	79.33d	4.00c	49.70d
T4	19.63cd	3.89	17.40e	97.75a	8.20a	90.60a
T5	22.00abc	3.76	20.80cde	95.50a	5.65bc	65.60b
T6	15.87d	4.04	25.50abc	86.33b	4.50c	57.60c
T7	24.90ab	3.26	22.00b-e	76.50d	4.66c	49.40d
T8	21.46abc	3.72	18.00de	82.41c	5.15b	47.00de
T9	20.33c	3.44	23.00bc	85.67b	5.17b	55.00c
T10	25.57a	3.25	26.43ab	78.25d	4.79bc	48.80d
LSD	3.832	-	4.470	2.842	0.856	3.978
Level of significance	*	NS	*	*	*	**

T_1 (Control with no spray), T_2 (Control with fungicide spray), T_3 (Compost tea or extract as foliar spray), T_4 (Compost tea or extract as soil drenching), T_5 (Poultry litter extract as soil drenching), T_6 (Compost as soil application), T_7 (Poultry litter (soil application),
T_8 (Biopesticide as soil application), T_9 (BAU-Biofungicide as foliar spray) and T_{10} (Mustard Oil Cake as soil application)
* Means with the same letter in the column do not differ significantly at 5% level of probability, NS-Not significant.

Table 3. Cost-benefit analysis of different treatments used for managing late blight disease of potato in the field.

Treatment	Average yield (t/ha)	Gross return (Tk/ ha)	Production cost of tomato (Tk/ha)	Total cost of treatment	Gross margin	Increase of gross margin over control	Gross margin over control	BCR
T1	12.2	2,19,600	1,00000	-	2,19,600	-	-	-
T2	22.4	3,45,600		5200	3,40,400	35.48	1,26,000	35.31
T3	28.5	4,03,200		4500	3,98,700	44.92	1,83,600	65.20
T4	17.4	5,13,000		20,000	4,93,000	55.46	2,93,400	4.68
T5	20.8	3,74,400		60,000	3,14,400	30.12	1,54,800	2.58
T6	25.5	4,59,000		50,000	4,09,000	46.30	2,39,400	4.79
T7	22.0	3,90,000		150,000	2,40,000	8.50	1,70,400	1.18
T8	18.0	3,24,000		1920	3,22,080	31.82	1,02,480	54.38
T9	23.0	4,14,000		5000	4,09,000	46.30	1,94,400	38.88
T10	26.1	4,69,800		90,000	3,79,800	42.80	2,50,200	2.78

Potato: Tk 18/kg Compost: Tk 5/kg, Poultry litter: Tk 15/kg BAU Biofungicide: Tk 100/kg IPM Lab Biopesticide Tk 30 kg/ha and Mustard oil cake Tk. 30/kg

T_1 (Control with no spray), T_2 (Control with fungicide spray), T_3 (Compost tea or extract as foliar spray), T_4 (Compost tea or extract as soil drenching), T_5 (Poultry litter extract as soil drenching), T_6 (Compost as soil application), T_7 (Poultry litter (soil application), T_8 (Biopesticide as soil application), T_9 (BAU-Biofungicide as foliar spray) and T_{10} (Mustard Oil Cake as soil application)

Table 4 Cost-benefit analysis of different treatments used for managing late blight disease of tomato in the field.

Treatment	Average yield (Ton/ha)	Gross return Tk/ ha	Production cost Tk / ha	Total cost of treatment	Gross margin	Increase of gross margin over control	Gross margin over control	BCR
T1	43.40	5,20,800	1,00000	-	5,20,800	-	-	-
T2	53.70	6,44,400		5200	6,39,200	18.52	1,18,400	23.77
T3	49.7	5,96,400		4500	5,91,900	12.01	71,100	16.80
T4	90.6	10,80,000		20,000	10,60,000	26.96	5.39,200	28.32
T5	65.6	7,80,000		60,000	7,20,000	27.67	1,99,200	4.42
T6	57.6	6,91,200		50,000	6,41,200	18.78	1,20,400	3.40
T7	49.4	5,92,800		150,000	4,42,800	-	-	0.48
T8	47.0	5,64,000		1920	5,62,080	7.34	41,280	22.5
T9	55.0	6,60,000		5000	6,55,000	20.49	1,34,200	27.84
T10	48.8	5,85,600		90,000	4,95,600	-	-	0.72

Tomato: Tk 12/kg, Compost: Tk 5/kg, Poultry litter: Tk 15/kg BAU Biofungicide: Tk 100/kg IPM Lab Biopesticide Tk 30 kg/ha and Mustard oil cake Tk. 30/kg

T_1 (Control with no spray), T_2 (Control with fungicide spray), T_3 (Compost tea or extract as foliar spray), T_4 (Compost tea or extract as soil drenching), T_5 (Poultry litter extract as soil drenching), T_6 (Compost as soil application), T_7(Poultry litter (soil application), T_8 (Biopesticide as soil application), T_9(BAU-Biofungicide as foliar spray) and T_{10} (Mustard Oil Cake as soil application)

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