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Vol. 27, Issue 01: 2252-2257
Journal of Bioscience and Agriculture Research
Journal Home: www.journalbinet.com/jbar-journal.html

Impact of Trichoderma application as bio-stimulator on disease suppression, growth and yield of potato

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Article received: 02.04.2021; Revised: 16.04.2021; First published online: 30 April, 2021.

ABSTRACT

Excess use of chemical fertilizers and synthetic chemicals to increase the growth and yield as well as controlling disease often reduced soil fertility, adversely affect human health and environment. That's why an experiment was accomplished in the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during the period from November 2016 to March 2017 to study the impact of Trichoderma application as bio-stimulator on potato production. The study comprised of three Trichoderma treatments, (i) T_0= No Trichoderma application, (ii) T_1= 10^6spores/ml and (iii) T_2= 10^8spores/ml. Trichoderma 1ml/L (1000 ppm) solution was applied two times in each plot at 15 and 45 days after planting (DAP). Data on growth yield and disease suppression parameters showed significant variation. The results elluciated that application of Trichoderma increased the growth attributes positively and produced 23.82% and 11.33% higher yield in T_2 and T_1 compared to no application of Trichoderma, respectively. Trichoderma (10^8spores/ml) improved tuber yield by optimizing the dry matter content. Furthermore, application of Trichoderma decreased the disease infestation and the best result (1.60%) recorded in T_2. Therefore, 10^8spores/ml of Trichoderma application can be considered the potential bio-stimulator for prospective potato production with higher growth, yield and suppress of disease.

***Key Words**: Bio-stimulator, bio-control agent, dry matter content and spore concentration*

Cite Article: Rakibuzzaman, M. Akand, M. H. Siddika, M. and Uddin, A. F. M. J. (2021). Impact of Trichoderma application as bio-stimulator on disease suppression, growth and yield of potato. Journal of Bioscience and Agriculture Research, 27(01), 2252-2257.
Crossref: https://doi.org/10.18801/jbar.270121.274

I. Introduction

Potato plant growth and tuber yield are affected by several fungal diseases, which reduce the yield as well as market value. *Phytophthora spp*, *Rhizoctonia solani* are the serious fungal pathogen for the production of potato. Late blight of potato caused by *Phytophthora infestans* is one of the most important diseases in potato growing areas worldwide, and crop losses due to this disease can reach 50% (Goodwin et al., 1994). Farmers used various fungicides to control the fungal affect in the potato field, which increases chemical hazardous situation. To control the fungal diseases as well as to improve crop growth and development, application of fungicides and chemicals against pathogen is

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not cost effective and environment friendly (Uddin et al., 2017). On the other hand, biological control agents may combat the disease (Yanpo et al., 2015) and enhance plant growth and development (Sani et al., 2020). Trichoderma is a free living fungi, contains many strains and species, of which some are saprophytic while others are pathogenic to other fungi such as pythium, phytophthora (Mohsin et al., 2010). It is used in agricultural biotechnology and widely used as biological control agent against important aerial and soil-borne pathogen. It is also used as a bio-stimulants (Yanpo et al., 2015). Trichoderma is formulated and marketed as biological agent to control different fungal pathogen and have significant effect on growth and yield. By application of *Trichoderma spp*. on crops, yields were increased significantly (Elad et al., 1981; Jamal Uddin et al., 2020). Trichoderma has a substantial direct influence on plant development and crop productivity (Harman, 2006). Application of Trichoderma to the soil as a biological agent not only resulted in to reduce disease severity but also enhanced plant growth and development as a stimulator (Inbar et al., 1994) based on other studies (Purwantisari et al., 2018; Molla et al., 2012). Trichoderma is used as a bio-fertilizer for reducing potato disease and increasing nutrients availability of potato root zone to promote growth, yield attributes and quality of potato. Therefore, this study aims to determine the bio-stimulating impact of Trichoderma on growth and yield of potato production as well as disease suppression.

II. Materials and Methods

Experimental site

The field experiment was conducted at Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka, during the period from November 2016 to March 2017. The location of the experimental site is $23^{0}74$ N latitude and $90^{0}35$ E longitudes and at an elevation of 8.2 m from sea level in Agro-Ecological Zone of Madhupur Tract (AEZ 28). The soil pH of the studied area was slightly acidic and ranged from 5.5-6.0.

Seed tuber plantation and crop management

Uniform sized healthy and disease free seed tuber of Cardinal potato variety was collected from Bangladesh Agricultural Research Institute (BARI) and cut into smaller pieces with two or more sprouts. Then, they stored at room temperature and allowed them to firm up, which ensured to reduce the rotting and planted them the next day. The land was well prepared and divided into 9 plots. The size of each plot was 2.4 m × 1.5 m and spacing was maintained at 60cm × 25cm. On average, seed tubers were planted at 4-5 cm depth in soil. Standard management practices for production of potatoes were practiced.

Experiment design and treatment

The field experiment was accomplished with three replications following Randomized Complete Block Design (RCBD). This study was conducted with three Trichoderma spore concentrations: T_0= No Trichoderma application, T_1= 10^6 spores/ml, T_2= 10^8 spores/ml.

Preparation and application Trichoderma spore solution

Trichoderma harzianum were prepared and collected from the Advanced Seed Research and Biotech Centre (ASRBC), ACI Limited. New cultured spore was counted under light microscope. Stock spore culture was mixed in autoclaved water to make the target solution for field trial. Target Trichoderma spore of 1 ml was mixed with 1 liter water and then applied in the field two times in each plot at 15 and 45 days after planting (DAP).

Vegetative growth and yield observation

Data collections were done at each plot from randomly selected potato plants by skipping border effect. Data on plant height (20, 35, 50, 65 and 80 DAP), leaf number (20, 40, 60 and 80 DAP) were collected. SPAD value was measured at 60 days after planting (15 days after two time application). Spad values of potato leaves were determined using an automatic SPAD meter (Minolta SPAD-502 meter). Three apical leaflets of a young fully extended leaf were taken for the SPAD value. Number of stem per hill counted before harvesting. Harvested potatoes were counted, weighed, and yield was figured out. Yield difference over control was calculated using following formula,

$$\text{Yield difference (\%)} = \frac{\text{Yield of treatment plot - Yield of control}}{\text{Yield of control}} \times 100$$

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Determination of dry matter content in potato tuber

For dry matter determination, 100g of sun dried potato tuber cut into pieces and were dried for 48 hours at 70-80°C in an oven. Then the dried pieces were weighted and were recorded as percentages (%).

Determination of disease infestation

Daily visual observations were carried out to investigate potato plant diseases. If there were any symptoms found on leaves or stems, the plants were tagged and counted them as the diseased plant. Incase of tuber, observation was done during potato tuber harvest. Disease symptoms were monitored daily based on disease scale ranges from 0 to 2, where 0: No disease symptom, 1: partial infection, 2: severe infection. In the end, scale 1 and 2 were merged and recorded them as percentages.

Statistical analysis

The data recorded for different parameters were statistically analyzed using MSTAT-C computer package programme to find out the significance of variation among the treatments and treatment means were compared by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

III. Results

Plant vegetative growth, SPAD value and tuber dry matter content

Application of different Trichoderma spore concentrations significantly enhances the plant height, number of leaves and stem number per hill. The maximum plant height (23.2, 39.3, 52.2, 63.4 and 72.6 cm) was recorded at the higher concentration of Trichoderma solution (T_2) and the minimum height (17.5, 30.4, 43.5, 54.5 and 60.2 cm) was found from control condition (T_0) at20, 35, 50, 65 and 80 days after planting respectively (Figure 01). In case of number of leaves per plant, the maximum number of leaves (8.3, 19.2, 32.0 and 42.2) was found from T_2 and minimum (7.0, 15.1, 26.7 and 36.3) from T_0 with 20, 40, 60 and 80 days after planting (Figure 02). The maximum number of stem per hill (5.11) was recorded in T_2 treatment, which was (4.61) statistically similar with (T_1) and the lowest number (3.76) was recorded in T_0 (Table 01) at the same DAP. The maximum SPAD value (46.96%) and tuber dry weight (19.99%) were achieved in T_2 treatment. However, the lowest SPAD value (37.64) and dry matter content (18.50) observed in T_0 (Table 01).

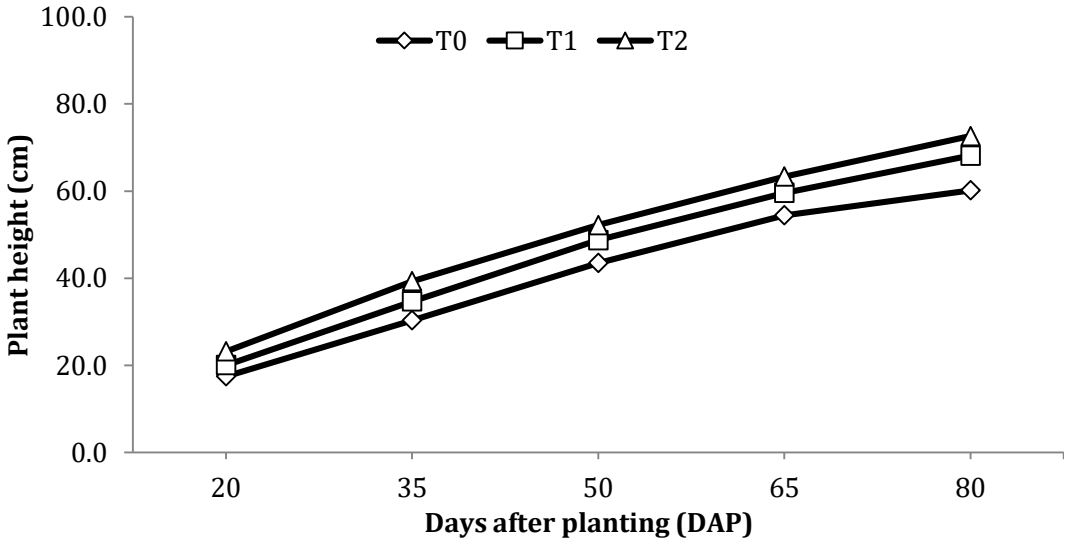

Figure 01. Effect of Trichoderma application on plant height of potato at different days after planting.

Disease parameters

The disease infected plants were counted and infestation percentages were calculated. The higher spore concentration of Trichoderma revealed the best results in disease infected plants. So, less infestation (1.60%) was recorded in 10^8 spores/ml of Trichoderma. Furthermore, where Trichoderma applied either 10^8 spores/ml or 10^6 spores/ml there was prominent impact on suppressing diseases, either 10^6 or 10^8 spores/ml compared to the no application of Trichoderma. On the other, maximum disease infestation plant (23.81%) was observed in the control plant (Table 01).

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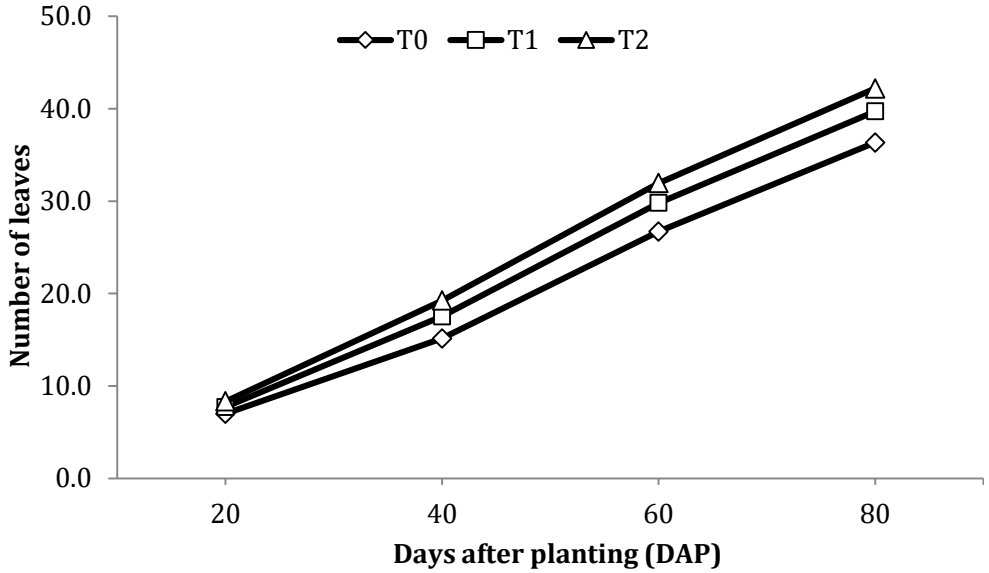

Figure 02. Effect of Trichoderma on number of leaves per hill of potato at different days after planting

Table 01. Significant effect of Trichoderma spore concentration on growth and disease infestation parameters of potato plant.

Treatment	Stem number hill^{-1}	SPAD value	Dry matter content	Disease infestation (%)
T_0	3.76 b	37.64 c	18.50 c	23.81 c
T_1	4.61 a	44.49 b	19.12 b	4.77 b
T_2	5.11 a	46.96 a	19.99 a	1.60 a
CV %	6.84	2.86	0.86	9.39
$LSD_{(0.05)}$	0.70	0.76	0.10	2.14

Here, T_0= No Trichoderma application, T_1= 10^6spores/ml, T2= 10^8spores/ml

Yield attributes and yield observations

The yield-contributing variables showed significant variation among the different spore concentrations of Trichoderma application (Table 02). Application of 10^8 spores/ml of Trichoderma showed better performance in enhancing the number of tuber per hill (5.10), the weight of individual tuber (106.8 g), yield per hill (0.51 kg) and yield per hectare (34.31 t). However, the lowest result was observed in no application of Trichoderma (Table 02). Increased yield over control was calculated and the results showed that application of Trichoderma increased the yield and produced 23.82% and 11.33% higher yield in T_2 and T_1 compared to no application of Trichoderma respectively (Table 02).

Table 02. Effect of Trichoderma application on yield attributes of potato

Treatment	Number of Tuber per hill	Individual tuber weight (g)	Yield per hill (kg)	yield/hectare (t)	Yield difference (%)
T_0	4.10 c	102.9 c	0.42 c	27.71 c	_
T_1	4.60 b	104.5 b	0.46 b	30.85 b	11.33
T_2	5.10 a	106.8 a	0.51 a	34.31 a	23.82
CV %	3.97	0.69	7.34	0.77	
$LSD_{(0.05)}$	0.41	0.45	0.02	0.15	

Here, T_0= No Trichoderma application, T_1= 10^6 spores/ml, T2= 10^8 spores/ml, LSD: Least Significant Difference

IV. Discussion

Trichoderma has been recognized plant growth promoter due to stimulating effect of the growth and promotion of a large number of different plant species, including fruit, vegetable and forestry crops (Lynch et al., 1991; Dorais, 2007). The impact of Trichoderma on plant height of potato plant was in harmony with the findings of Uddin et al. (2016); Uddin et al. (2015) and illustrated that vegetative

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plant growth promoted due to the effect of Trichoderma application. Different Trichoderma concentrations positively impact plant growth promotion and increasing yield (Uddin et al., 2017; Jamal uddin et al., 2020). Trichoderma has the ability to synthesize antibiotics, parasitize other fungi, and compete with harmful fungal microorganisms, which exhibits positive effects on plant growth and development (Harman et al., 2004). Trichoderma stimulates plant growth by several mechanisms such as mycoparasitism, antibiosis, degradation of toxins, inactivation of pathogenic enzyme pathways, resistance against pathogens, increase nutrient uptake, solubilization, sequestration of inorganic nutrients and enhanced root development (Lorito et al., 2010). Lo and Lin (2002) showed that chlorophyll concentrations in leaves were more in Trichoderma treated plants than the untreated plants in cucumber. Trichoderma acts as a biological control agent that can combat the disease of potato studied by Yanpo et al. (2015) also had an antagonistic effect on phytophthora disease (Fatima et al., 2015). The yield in Trichoderma is supported by the study, which shows a significant increase in the yield of wheat of about 29% in Jaipur and 36% in Kota (Sharma et al., 2012). *Trichoderma harzianum* can solubilize phosphate and micronutrients that could be made available to plants which promoted to increase the plant height (Li et al., 2015). Mohsin et al. (2010) showed that Trichoderma increased the efficacy, protected the potato plant and ultimately increased yield compared to control conditions. Trichoderma not only enhanced vegetative growth and yield also increase the quality. It optimizes the tuber shape and size that promote potato production. The increase in the total dry matter due to Trichoderma treatment can be attributed to the cumulative effect of increased leaf area index, SCMR values, increased nutrient uptake and increased rate of photosynthesis (Yemineni et al., 2019).

V. Conclusion

Application of Trichoderma 10^8 spores ml^{-1} L^{-1} increased not only growth but also 23.8% higher yield compared to no application of Trichoderma. It also suppressed different diseases as well as increased tuber quality. So, it can be said that Trichoderma has bio-stimulating effect on growth, yield and suppression of disease. Therefore, Trichoderma 10^8 spores/ml can be considered as the optimum spore concentration for potato production.

Acknowledgement

We gratefully thank the Ministry of Science and Technology of Bangladesh for providing financial support for the research work. Also thank Horticulture Innovation Lab for providing experimental materials support.

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