OCCURRENCE AND DISTRIBUTION OF TOMATO DISEASES AND EVALUATION OF BIO-EFFICACY OF *Trichoderma harzianum* ON GROWTH AND YIELD COMPONENTS OF TOMATO

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ABSTRACT

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Extensive survey was carried out to find out occurrence and distribution of tomato diseases on farmers' fields in six (6) Local Government Areas of Niger State. Pot experiments were also conducted in the screen house of Department of Crop Production, Faculty of Agriculture, Ibrahim Badamasi Babangida University, Lapai to evaluate the bio-efficacy of Trichoderma harzianum on growth and yield parameters of tomato crops. The means of each growth parameter were calculated and significant means were separated using Duncan's Multiple Range Test ($p \leq 0.05$). A total of twenty four (24) different taxonomic group of plant pathogens identified which were seventeen (17) fungal, three (3) bacterial, three (3) viral and one (1) nematode pathogens. The maximum disease incidence of 39.81% was observed in early blight disease followed by 35.37% in root-knot nematode, 33.51% Fusarium wilt, 27.96% tomato mosaic virus and 20.92% bacterial wilt disease respectively, whereas, the minimum incidence of 2.40% was observed in sour fruit rot while 2.77%, 2.96.6% and 3.14% were recorded in corky rot, Septoria leaf spot and leaf mold and Rhizoctonia fruit rot diseases respectively. However, the distribution of these diseases was found maximum in Lapai (20), followed by Kontangora (18) and Borgu (17), whereas, the minimum diseases were found in Mokwa (12). Maximum tomato seed germination (84.40%) was recorded in pots treated with T. harzianum in comparison to untreated pots (24.60%). Similarly, the maximum enhancement in growth parameters viz shoot length (142. 20cm), root length (25.20cm), fresh weight of shoot (89899.60mg), root (4906.60mg), dry weight of shoot (23373.60mg), root (1206.20mg), diameter of stem (4.60cm), number of fruits (12.80) and yield (786.00g) were recorded when the tested bio-control agent was mixed with cow dung manure at the rate of 10%, whereas, the minimum was recorded in control in the soil which were shoot length (41.00cm), root length (11.60cm), fresh weight of shoot (34041.40mg), root (1699.00mg), dry weight of shoot (11016.40mg), root (576.60mg), diameter of stem (2.20cm), number of fruits (5.60) and yield (228.60g) respectively. Use of mass culture of T. harzianum was effective in controlling soil-borne diseases of seedlings and improving the growth and yield parameters of tomato crops.

Keywords*: Vegetable, tomato, pathogens, Trichoderma, bio-control*

INTRODUCTION

Vegetables are essential requirements of human diet, which nourish growth, development and reproduction of human beings and highly medicinal (Swaider and Ware, 2005). Among the vegetables, tomato is highly appreciated and consumed in African countries especially in Nigeria for the purpose of diet and healthcare (Varela *et al.*, 2003). Tomato (*Lycopersicon esculentum* Mill. L) belongs to the *Solanaceae* family and it is relatively short duration crop which gives a high yield, and is economically attractive. It is grown extensively in many parts of Nigeria and almost all the year around. Nigeria ranks as the 13th largest tomato producing country in the world and second highest producer in Africa (FAO, 2011) but unfortunately, the country is not able to export tomato and its products because of inadequate production and high demands of domestic consumers. The major constraints in tomato production in this country are due to inadequate supply of good quality seeds, inadequate storage facilities, lack of proper diseases and pests management and lack of sufficient processing facilities (Ugonna *et al.*, 2015). Among all these constraints, lack of poor managements of pests and diseases are major concern leading to low production of this vegetable crop in the Northern part of the country especially in Niger State. Tomato is incited by taxonomic diverse groups of phytopathogens among which are fungi, bacteria, viruses and parasitic nematodes (Agrios, 2005). There are about 200 known diseases of tomato, of which 30 are economically important (Jones *et al.*, 1997). Among the diseases of this crop, fungal diseases are economically important and the most common diseases in vegetable production throughout the world (Kutama *et al.*, 2007; Shehu *et al.*, 2014; Sobia *et al.*, 2016). They cause huge losses in terms of yield, reduce quality and also damage tomato in storage (Agrios, 2005). They also affect primarily the leaves, stems, flowers and fruits of annual plants, especially vegetables and ornamentals (Gabor and Wiebe, 1997; Blancard, 2000; Agrios, 2005).

Chemical control is one of most common methods and frequently used by farmers for the management of plant diseases. However, synthetic chemicals are highly toxic, hazardous and have negative impacts on the ecosystem including non-target organisms (Hayes and Laws, 1991; Agrios, 2005). Negative impacts and ecosystem concern over the use of these synthetic chemicals led to an increased interest in biological control in its widest sense, in order to achieve eco-friendly method of controlling and reducing crop damages (Cook, 2000; Harman 2000; Zareen *et al.*, 2003; Meah, 2010). *Trichoderma* is one of the most common filamentous imperfect saprophytic fungus and present in all sort of agricultural soil and in other habitats such as decaying substrates and rhizosphere ecosystem (Chet, 1987). It is a fast growing, light to dark green coloured, potent bio-control agent and used against plant diseases of various crops (Barnett & Binder, 1973; Boland, 1990; Agrios, 2005). There are several different types of species that have been isolated and identified from different substrates worldwide (Samuel, 1996; Harman, 2000). Several workers have reported that species of *Trichoderma* can be utilized for multi-purposes in the areas of crop production viz., promoting plant growth (Chang *et al.*, 1986; Boland, 1990; Baker, 1991; Bjorkman *et al*., 1994; Harman *et al.*, 2004; Ozbay and Newman, 2004), improving nutrient uptake (Monte, 2001) and as well as heightened plant defense level against biotic and/or abiotic stress (Yedidia *et al.*, 1999; Howell, 2003) and protection viz., controlling soil-borne (Elad *et al.*, 1983; Chet *et al.*, 1987; Dantoff *et al*., 1995; Waudo *et al*., 1995; Ozbay and Newman, 2004; Montealegre *et al.*, 2005; Ngo *et al.*, 2006), air-borne (Elad, 2000) and post-harvest diseases in a wide range of crops by different mechanisms. The effect of *Trichoderma* isolates on plant growth and development is important, especially in nursery, 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 (Boland, 1990; Nemec *et al.*, 1996; Lo and Lin, 2002; Harman *et al*., 2004). Therefore, the use of *Trichoderma* spp. is beneficial in enhancing plant growth and development, which is highly desirable in order to reduce or eliminate the use of synthetic chemical fertilizers from the point of the view of sustainable agricultural system because application of synthetic fertilizer is not economical in the long run, as they cause environmental pollution and having harmful residues in the soil and food-web system. Recently, some research works have however, reported the effect of *Trichoderma* isolates directly on the plant growth parameters in some commercial crops (Howell, 2003; Harman *et al.*, 2004; Agrios, 2005; Srinon, *et al.*, 2006; Sundaramoorthy and Balabaskar, 2013). Therefore, the objectives of this study were to find out the occurrence and distribution of tomato diseases in six Local Government Areas of Niger State, also to evaluate the bio-efficacy of *T. harzianum* in seedlings growth and yield components of tomato crops.

MATERIALS AND METHODS

Experimental site

An extensive survey work was carried out in Six (6) Local Government Areas of Niger State and pot experiments were conducted in the laboratory and screen-house of the Department of Crop Production, Ibrahim Babangida University Lapai, Niger State. Lapai Local Government Area lies at Longitude 09° 03'58.998 N and Latitude 006° 34'13.808 E of the equator. The area is located in the vegetative zone of Guinea Savannah, middle belt of Nigeria. It has an average temperature of 23 °C - 34.4 °C, with a mean annual rainfall between 1100 mm – 1600 mm. The soil is ferruginous. The main occupation of people is farming with much abundant land, only a few people go into trading.

Sampling of tomato plants in study area

Survey was carried out in six Local Government Areas of Niger State, Nigeria to determine occurrence and distribution of tomato diseases. The infected tomato plants were collected from framers' fields in these Local Government Areas; the data were recorded on identification of diseases and their occurrence and distribution on tomato crops. In this survey work, sampling of infected plants of tomato were done carefully, each infected plant collected into polyethylene bags separately and brought into the laboratory, Department of Crop Production, Faculty of Agriculture, Ibrahim Badamasi Babangida University, Lapai for proper identification of tomato diseases. With the help of the A Colour Atlas of Tomato Diseases: Observation, Identification and Control (Blancard 2000) and Tomato Disease Guide: A Practical Guide Seedsmen, Growers and advisors (Garbor and Wiebe, 1997), tomato diseases were identified. Moreover, some microscopic observations of spores and fruiting bodies of the fungi were also done for the proper identification of fungal diseases of the crop. Also isolation and purification of some fungi were done in the laboratory on potato dextrose agar (PDA) medium from infected parts of tomato plant for proper identification of fungus. Based on identification, a list of causal organisms of tomato diseases was prepared accordingly. Occurrence and distribution of these identified diseases of the crop in these Local Government Areas were also recorded. Occurrence and distribution of the recorded diseases was estimated by following the method given by Singh (2002). The farmers' fields were visited during the raining season from the transplanting of the tomato seedlings to the harvesting of the crop.

Occurrence and distribution of tomato diseases

The % incidence of individual tomato disease was determined as follows:

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

(%) incidence of tomato diseases were recorded diseases was estimated by following the method given by Singh (2002). The distribution of tomato diseases in each Local Government Area was recoded based on the particular disease observed in particular Local Government Area.

Isolation, purification and maintenance of *Trichoderma harzianum*

Isolation of *T. harzianum* was done from agricultural soil collected from Ibrahim Badamasi Babangida Research Farm. The fungus was cultured, purified and identified based on microscopic studies of their morphology of mycelia and spores. *T. harzianum* was maintained by regular sub-culturing at interval of 10 days on potato dextrose agar (PDA) medium in Petri plates and in slant test tubes at low temperature (4-5 °C). All media were sterilized and autoclaved at 15 lbs per inch^2 pressure for 20 minutes. Each medium melted but cooled to 50 ^{0}C was poured into several sterilized Petri-plates. The Petri-plates were incubated at 28±10 °C and observation on radial growth of the fungus was recorded at interval of 24 hours up to full growth of fungus in Petri-plates. The compositions of media were as follows: Composition of Potato Dextrose Agar (PDA) Medium: (Peeled potato 200.0 g, dextrose 20.0 g, agar-agar 20.0 g, distilled water 1000 ml), Composition of Selective medium: ($MgSO_4.7H_2O$ 0.20 g, $K2HPO_4$ 0.90 g, KCl 0.15 g, Glucose 1.0 g, Chloramphenicol 0.25 g, P-dimethyl amino benzene diazo sodium 0.30 Sulphonate-Penta chloro nitro benzene 0.20 g, rose bengal 0.15 g, agar-agar 18.0 g, distilled water 1000 ml).

Mass production of *Trichoderma harzianum*

Locally available sorghum (*Sorghum bicolor*) grains were used for the mass production of *T. harzianum*. Sorghum grains were parboiled and autoclaved to sterilized and supplemented with 5% anhydrous dextrose. The conical flask containing sterile 250 g sorghum grains were inoculated with 5mm disc from 7 days old culture of *T. harzianum*. The conical flasks were incubated at 28±1 °C for 15 days for colonization of grains with mycelia and spores of the fungus. Colonized sorghum grains were air dried, powdered and sieved through 80 mesh sieve for further experiment (Whitehead 1957).

Evaluation of bio-efficacy of *Trichoderma harzianum* on performance of tomato plants

Pot experiments were set up to evaluate the bio-efficacy of *T. harzianum* on seed germination, seedling growth and yield parameters of tomato plants. Soil from Ibrahim Badamasi Babangida Research Farm was used for the experiment purpose and experiment was conducted in plastic pots in the screen house of the Department of Crop production, Faculty of Agriculture, IBB University, Lapai. Six (6) treatments viz., control, fertilizer (NPK), cow dung manure (CDM), *T. harzianum* alone, *T. harzianum*+CDM@5% and *T. harzianum* +CDM@10% were used and for each treatment five replications were done. Observations on growth parameters viz., shoot and root length, fresh and dry weight of shoot and root, diameter of shoot, number of nodes, leaflets/leaf, flowers/bunch and yield/plant were recorded. The means of each parameter were calculated and significant means were separated using Duncan's Multiple Range Test ($p \leq 0.05$). Soil was thoroughly mixed by hand with CDM and mass culture of *T. harzianum* for uniform mixing of inoculums of the fungus and CDM. The inoculums of the fungus were mixed properly in soil at 0.75 g per kg of soil, then one kg of soil was filled in pots and one tomato seedling was sown in each pot. Adequate moisture level was maintained throughout the experiment period by watering the pots alternate day.

In another set of experiment, the evaluation of bio-efficacy of *T. harzianum* on seed germination and tomato seedling was done using nursery soil having the problem of damping off diseases. The inoculums of the fungus were mixed properly in the soil at 0.75g per kg of soil, it was filled in pots and fifteen (15) tomato seeds (Ife-Brown) were sown in each polythene bag. Proper moisture was maintained till the completion of the experiment watering the pots alternate day. Observations on germination percentage (%), shoots and root length, fresh and dry weight of shoot and root of tomato seedling were recorded. All the treatments were done in five replications along with control in which soil were not inoculated with inoculums of *T. harzianum*. The means of each parameter were calculated and significant means were separated using Duncan's Multiple Range Test ($p \leq 0.05$).

RESULTS AND DISCUSSION

Data collected from the survey of six Local Government Areas of Niger State clearly revealed the occurrence and incidence of tomato diseases in these areas and a taxonomically diverse group of causal organisms of tomato diseases were observed (Table 1). A total of twenty four (24) different taxonomic group of plant pathogens were identified, including seventeen (17) fungal, three (3) bacterial, three (3) viral and one (1) nematode disease. Among the fungal diseases, primarily eight (8) foliar, three (3) fruit, two (2) each of stem and wilting, one (1) each of root and seedling diseases were recorded (Table 1). Diseases are the major obstacle in tomato cultivation which often causes heavy losses ranging from minor to 100%. Tomato plants are prone to attack by numerous diseases caused by fungi, bacteria, viruses and nematodes (Agrios, 2005), but Stone *et al*. (2000) and Sobia *et al*. (2016) reported that fungal pathogens constitute major cause of yield reduction because they attack tomato at all stages of growth and are carried by air, soil, water, seed and vector which support the present work. Similar observations were reported by several workers ((Erinle 1986, ElAbyad *et al.* 1993, El-Shanshoury *et al*. 1996).

Estimation of (%) incidence of tomato diseases in six (6) Local Government Areas is presented in (Table 2).

It is apparent from the data that different kinds of tomato diseases had different percentage incidence. The maximum incidence (39.81%) was observed in early blight disease followed by (35.37%), (33.51%), (27.96%) and (20.92%) in root-knot nematode, *Fusarium* wilt, tomato mosaic virus and bacterial wilt disease respectively, whereas, the minimum incidence (2.40%) were observed in sour fruit rot closely followed by (2.77%), (2.96.6%) and (3.14%) in corky rot, *Septoria* leaf spot and leaf mold and *Rhizoctonia* fruit rot diseases respectively (Table

2). Erinle (1986) reported that wilt of tomato in the savanna zone of northern Nigeria was caused by *F. oxysporum* f.sp. *lycopersici*, *Sclerotium rolfsii* and *P. solanacearum*, with Fusarium wilt being the most prevalent disease in the field. Leaf spots of tomato plants in Nigeria have been associated with *Sclerotium rolfsii*, *Alternaria solani*, *Septoria lycopersici*, *Xanthosomonas vesicatoria* and *Pseudomonas syringae* (Erinle, 1986).
The distribution of tomato diseases in six (6) Local Government Areas of the State is presented in (Table 3).

Table 1: Occurrence of tomato diseases and their causal organisms in the study area

Disease	Causal organism
Damping-off of tomato seedling	*Pythium spp.*
Early blight	*Alternaria solani*
Alternaria stem canker	*Alternaria alternate f.sp. lycopersici*
Fusarium wilt	*Fusarium oxysporum f.sp. lycospersici*
Gray leaf spot	*Stemphylium solani*
Gray mold	*Botrytis cinerea*
Cercospora leaf mold	*Cercospora fuligena*
Leaf mold	*Cladosporium fulvum*
Didymella stem rot	*Didymella lycopersici*
Southern blight	*Sclerotium rolfsii*
Corky root rot	*Pyrenochaeta lycopersici*
Rhizopus fruit rot	*Rhizopus stolonifer*
Rhizoctonia fruit rot	*Rhizoctonia solani*
Verticillium wilt	*Verticillium albo-atrum*
Target spot	*Corynespora cassiicola*
Sour fruit rot	*Geotrichum candidum*
Septoria leaf spot	*Septoria lycopersici*
Bacterial spot	*Xanthomonas vesicatoria*
Bacterial wilt	*Ralstonia solanacearum*
Bacterial soft rot	*Erwinia carotovora subsp. carotovora*
Tomato yellow leaf curl disease	*Tomato yellow leaf curl virus*
Tomato mosaic disease	*Tomato mosaic virus*
Curly top disease	*Curly top virus*
Root-knot disease of tomato	*Meloidogyne spp.*

Table 2: Estimation of % incidence of tomato diseases collected from the study area.

Disease	No. of infected plants	Incidence (%)	
		Mean	Range
Damping-off of tomato	66	12.22	40-60
Early blight	215	39.81	60-80
Alternaria stem canker	63	11.66	5-15
Fusarium wilt	181	33.51	45-75
Gray leaf spot	18	3.33	1-8
Gray mold	24	4.44	2-10
Cercospora leaf mold	21	3.88	1-8
Leaf mold	17	3.14	1-8
Didymella stem rot	22	4.07	2-11
Southern blight	36	6.66	3-16
Corky root rot	15	2.77	0-8
Rhizopus fruit rot	101	18.70	3-22
Rhizoctonia fruit rot	17	3.14	2-18
Verticillium wilt	89	16.48	4-20
Target spot	81	15.00	2-12
Sour fruit rot	13	2.40	0-7
Septoria leaf spot	16	2.96	1-5
Bacterial spot	67	12.40	10-33
Bacterial wilt	113	20.92	30-40
Bacterial soft rot	37	6.85	10-18
Tomato yellow leaf curl	99	18.33	25-48
Tomato mosaic virus disease	151	27.96	30-50
Curly top disease	31	5.74	10-30
Root-knot disease of tomato	191	35.37	60-80

Among all the six Local Government Areas visited the maximum diseases were found in Lapai (20), followed by Kontagora (18) and Borgu (17), whereas, the minimum diseases were found in Mokwa (12), closely followed by Chanchaga (14) shown in (Table 2). Irrespective of Local Government Areas, some of the diseases such as

Fusarium wilt, early blight, bacterial wilt, *Rhizopus* fruit rot, tomato mosaic virus and root-knot diseases were found more frequently and in all Local Government Areas of the State. Mokwa and Chanchaga had the minimal occurrence of tomato diseases; it might be due to the fact that the growers in these Local Government Areas were adopting proper pests and diseases managements during the growing seasons of the crop. The production of tomato in Niger State has been reduced by diseases whose relationships with host crop was unknown to the farmers and virulence of these pathogens has not been fully studied in the State. The observations on the effect of mass culture of *T. harzianum* on seed germination and seedling growth parameters are presented in Table 4.

Table 3: Distribution of tomato diseases in the study area

Local Gov. Area	Occurrence of Diseases
Lapai	*Meloidogyne spp, Pythium spp, Tomato yellow leaf curl virus, Alternaria solani, Sclerotium rolfsii, Fusarium oxysporum f.sp. lycospersici, Cercospora fuligena, Cladosporium fulvum, Didymella lycopersici, Pyrenochaeta lycopersici, Rhizopus stolonifer, Verticillium albo-atrum, Corynespora cassiicola, Septoria lycopersici, Xanthomonas vesicatoria, Ralstonia solanacearum, Erwinia carotovora subsp. Carotovora, Curly top virus,. Tomato mosaic virus, Rhizoctonia solani,*
Mokwa	*Pythium spp, Alternaria solani, Tomato mosaic virus Fusarium oxysporum f.sp. lycospersici, Cercospora fuligena, Cladosporium fulvum, Rhizopus stolonifer, Rhizoctonia solani, Corynespora cassiicola, Geotrichum candidum, Xanthomonas vesicatoria, Erwinia carotovora subsp. Carotovora,*
Paikoro	*Tomato mosaic virus, Erwinia carotovora subsp. Carotovora, Pythium spp, Alternaria solani, Alternaria alternate f.sp. lycopersici, Fusarium oxysporum f.sp. lycospersici, Cercospora fuligena, Rhizopus stolonifer, Rhizoctonia solani, Corynespora cassiicola, Geotrichum candidum, Septoria lycopersici, Xanthomonas vesicatoria, Ralstonia solanacearum, Tomato yellow leaf curl virus*
Chanchaga	*Alternaria solani, Alternaria alternate f.sp. lycopersici, Fusarium oxysporum f.sp. lycospersici, Botrytis cinerea, Sclerotium rolfsii, Rhizopus stolonifer, Rhizoctonia solani, Verticillium albo-atrum, Septoria lycopersici, Xanthomonas vesicatoria, Ralstonia solanacearum, Tomato yellow leaf curl virus, Tomato mosaic virus, Meloidogyne spp.*
Borgu	*Fusarium oxysporum f.sp. lycospersici, Rhizopus stolonifer, Pythium spp, Alternaria solani, Alternaria alternate f.sp. lycopersici, Pyrenochaeta lycopersici, Stemphylium solani, Botrytis cinerea, Cladosporium fulvum, Didymella lycopersici, Sclerotium rolfsii, Geotrichum candidum, Septoria lycopersici, Ralstonia solanacearum, Cercospora fuligena, Tomato yellow leaf curl virus, Tomato mosaic virus*
Kontagora	*Rhizoctonia solani, Meloidogyne spp. Ralstonia solanacearum, Pythium spp, Alternaria alternate f.sp. lycopersici, Fusarium oxysporum f.sp. lycospersici, Stemphylium solani, Cercospora fuligena, Cladosporium fulvum, Didymella lycopersici, Pyrenochaeta lycopersici, Rhizopus stolonifer, Botrytis cinerea, Corynespora cassiicola, Alternaria solani, Xanthomonas vesicatoria, Tomato mosaic virus, Curly top virus,*

Table 4: Evaluation of bio-efficacy test of *Trichoderma harzianum* on tomato seedlings

Parameter	Treated	Untreated
Germination (%)	84.40a	24.60b
Height of seedling (cm)	15.20a	5.60b
Length of root (cm)	4.60a	1.20b
Fresh weight of shoot (g)	18.20a	3.60b
Fresh weight of root (g)	2.20a	0.60b
Dry weight of shoot (g)	4.00a	1.20b
Dry weight of root (g)	0.96a	0.11b

Means with different letters show significant difference within a row at $p \leq 0.05$ using Duncan's Multiple Range Test (DMRT)

In treated pots 84.40% germination percentage was recorded, as against 24.60% in untreated pots. Similarly, pots treated with *T. harzianum* showed significant effect on height of seedling (15.20cm), root length (4.60cm), fresh weight of shoot (18.20g), root(2.20g), dry weight of shoot (4.00g) and root (0.96g) as compared to untreated pots with height of seedling (5.60cm), root length (1.20cm), fresh weight of shoot (3.60g), root(0.60g), dry weight of shoot (1.20g) and root (0.11g), respectively. The observations on effect of mass culture of *T. harzianum* with or without cow dung manure (CDM) on growth and yield parameters of tomato plants are presented in (Table 5). From the results it is evident that all the growth and yield parameters of tomato plants were increased significantly especially when mass culture of *T. harzianum* was mixed with CDM in comparison to control. The maximum enhancement occurred in growth parameters when the tested bio-control agent was mixed with CDM at the rate of 10%, whereas, the minimum was recorded in control. Irrespective of the growth parameters, the maximum increase was obtained in pots treated with mass culture of *T. harzianum*+ 10% CDM and closely followed

Trichoderma + 5%. CDM. However, efficacy of *T. harzianum* alone on growth parameters of tomato was better than the CDM alone. In the past Papavizas (1985) and Harman (2000) reported that species of *Trichoderma* have the faster growth and competitive abilities to restrict the colonies growth of pathogens in glass house and *in vitro* test qualifies the fungus to be an efficient bio-agent. This wide spread antagonism exhibited by the species of *Trichoderma,* suggest its use for multiple disease control and may serve as additive component in IPM system (Dantoff *et al*., 1995; Altomare *et al.,* 1999; Cook, 2000; Howell, 2003). Most of the bio-control studies involving the use of *T. harzianum* used is inoculants is applied either to foliage or more frequently to soil for the control of plant pathogenic fungi (Kleifeld and Chet, 1992; Elad, 2000). However several comprehensive studies have been reported that *T. harzianum* are important in natural bio-control of pathogenic fungi in pot and field experiments that confirmed the present findings. (Chet *et al*., 1987; Baker, 1989; Windham *et al*., 1986; Harman *et al*., 2004; Verma *et al*. 2007; Kaewchai *et al.* 2009; Akrami and Yousefi, 2015).

Table 5: Bio-efficacy test of *Trichoderma harzianum* on the growth and yield components of tomato plants

Parameters	Control	Fertilizer	CDM	*T. harzianum*	*T. harzianum* +CDM 5%	*T. harzianum* + CDM 10%
Length of shoot (cm)	41.00a	45.60b	60.20c	62.60c	113.60d	142.20e
Length of root	11.60a	12.20a	16.60b	17.20b	24.40c	25.20c
Fresh wt. of shoot (mg)	34041.40a	38991.00b	39058.20b	39140.60b	78608.00c	89899.60d
Fresh wt. of root (mg)	1699.00a	1706.60a	2098.60b	2176.40b	4578.60c	4906.60d
Dry wt. of shoot (mg)	11016.40a	11538.20a	119237.60a	17772.00b	22010.20c	23373.60d
Dry wt. of root (mg)	567.60a	572.00a	589.60a	862.60b	1192.40c	1206.20c
Dia. of Stem (cm)	2.20a	2.40a	3.40b	3.60b	4.20c	4.60c
No. of fruits	5.60a	6.60b	6.40b	7.00b	10.00c	12.80d
Yield/Plant (g)	228.60a	308.00b	318.40b	346.20b	510.60c	786.00d

Means with different letters show significant difference within a row at $p \leq 0.05$ using Duncan’s Multiple Range Test (DMRT)

CONCLUSION

Several tomato diseases were apparent in six Local Government Areas of Niger State, Nigeria, however, fungal diseases were predominate. Conclusively, *Alternaria solani* and *Fusarium oxysporum* f sp. *lycopersici* were isolated more frequently among all the fungal pathogens from leaves and roots of tomato samples, whereas *Rhizopus* fruit rot predominated in fruits of tomato. Furthermore, the occurrence of root knot nematode, tomato mosaic virus and bacterial will diseases on tomato caused adverse effect on its growth and production. The uses of *Trichoderma* can be highly effective in controlling damping off disease and improving growth and yield components of tomato plants.

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