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COMPARATIVE EFFECTS OF TRICHODERMA SPECIES ON GROWTH PARAMETERS AND YIELD OF *ZEA MAYS* (L.)

***C. W. Worlu, A. B. Nwauzoma, E. C. Chuku and M. G. Ajuru**

Department of Plant Science and Biotechnology, Faculty of Science, Rivers State University, Port Harcourt, Rivers State, Nigeria.

Corresponding author: *C. W. Worlu
Email : cworlu1@gmail.com

ABSTRACT

The effects of two *Trichoderma* species (*T. harzianum* and *T. koningii*) on number of leaf, stem height, leaf length, leaf area and yield of maize was investigated at the Department of Plant Science and Biotechnology, Rivers State University. *Trichoderma* species were isolated from a contaminated mushroom at Dilomat Farms and Services Limited, Rivers State University. The species were applied on maize as follows: *T. koningii* combine with *T. harzianum, T. koningii* only *and T. harzianum* only; they were replicated thrice at 10^{-3} spores/ml, 10^{-5} spores/ml and 10^{-7} spores/ml levels of concentration. The results showed significant differences in the number of leaf, stem height, leaf length, and leaf area at 5ml and 10ml at six weeks after planting, but no significant difference was recorded on the growth parameters at 10^{-3} spores/ml concentration. The highest percentage yield (%Y) increase was observed at 10^{-7} spores/ml in *T. koningii+T. harzianum* combination with 61% increase in yield followed by10^{-3} spores/ml in *T. harzianum* with (40%) yield increase when compared to the control that had 18% yield increase. *Trichoderma species* have positive effects on all the growth parameters at the various concentration levels. For best results, combination of *T. koningii* and *T. harzianum* should be used to promote high yield in maize.

KEYWORDS

Growth parameters, Maize yield, Spore concentration, Trichoderma harzianum, Trichoderma koningii

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INTRODUCTION

The impacts of *Trichoderma* spp on growth and development of plants have important agronomical and economical implications such as shortening the plant growth period and time in nursery, as well as improving plant vigor to overcome biotic and abiotic stresses, resulting in increase plant productivity and yields (Adeniran, 1999; Harman, 2006; Behzad, 2010). The use of *Trichoderma* isolates for solubilization of mineral nutrients in the soil is essential in sustaining plant growth, improvement and yield because application of synthetic fertilizer in agriculture is not economical but highly hazardous to plants and environment (Chuku, 2020). Recent researchers have made attempt to undertake several surveys on *Trichoderma* spp. promotion of seedling establishment, enhancement of plant growth and elicit plant defense reaction in some crops such as cotton, vegetables, bean and corn (Lynch *et al.*, 1991 Inbar *et al.*, 1994; Rabeerdran *et al.*, 2000; Celar and Valic, 2005; Hoyos-Carvajal *et al.*, 2009; Shanmugaiah *et al.*, 2009).

Species of *Trichoderma* possess the capacity to solubilize mineral elements by altering the pH of the soil apart from their diverse biocontrol, growth promoting and biocatalystic activities (Illmer *et al*., 1995, Vassilev *et al*., 2006; Anil and Lakshmi 2010 Santos *et al*., 2010; Machado *et al*., 2011). For example, *T. harzianum* and *T. koningi* had enhanced the growth and productivity of chickpea (*Cicer aritinum*), maize (*Zea mays*) tomato (*Solanum lycopersicum*) and rice (*Oryza sativa*) in a greenhouse study by solubilizing macronutrients especially phosphate in the soil (Reyes *et al*. 2002; Brandy and Weil, 2002).

Literatures have shown that seed germination can be positively influenced by the use of antagonists and beneficial fungi where they also increase plant growth and productivity (Harman, 2006: Manju and Mall, 2008). Studies by Hanson, (1999), Mishra and Sinha, (2000), Oyarbide *et al.*, (2001) and Mukhtar (2008) on different *Trichoderma* spp promoted early germination as well as high germination percentage. *T. longipile* and *T. tomentosum* have been reported to promote different plants and numerous plant growths (Rabeendran, *et al.*, 2000; Lo *et al.*, 2001; Yedidia *et al.*, 2001). Benitez *et al.*, (2004) had also reported that there was increase in crop productivity of about 300% in fields after treatment with *T. koningii* and *T. hamatum.* Reports have also shown that *T. harzianum* and *T. viridi* promoted seed germination, root elongation and shoot length as well as increasing the vigour of plants, thereby boosting yield (Rojoa *et al.*, 2007; Dubey *et al.*, 2007; Mukhtar *et al.*, 2012).

Furthermore, several researchers have shown that seeds pretreated with *Trichoderma sp.* (*viride, T. harzianum* and *T. pseudokoningii*) inoculant extracts, increased the rate of seed germination, seedling vigour, reduced the incidence of seed-borne fungal pathogens and reduced loss of yield of okra and other plants compared to untreated experiments (Zheng and Shetty, 2000; Bharath *et al.*, 2006: Prasad and Anes 2008; Mukhtar, *et al.*, 2012; Isitekhale, 2014). The releases of nutrients and organic matter from the soil, increased uptake and translocation of minerals have been attributed to the presence of *Trichoderma sp* in the soil. Furthermore, auxins produced by *Trichoderma* are able to trigger plant root development, growth and yield quality (Engel *et al.*, 2001; Contreras - cornejo *et al* 2009). Vargas *et al* (2009) has also observed that *Trichoderma* cells are provided with plant derived sucrose that enhance their root colonization and defensive mechanisms which increased uptake of oxygen in leaves resulting in increased rate of leaf photosynthesis. Therefore, this study is aimed at examining the effects of two *Trichoderma* isolates (*T. harzianum and T. koningii*) on growth parameters and yield of maize by analyzing the number of leaf, stem height, leaf length, leaf area and fresh weight of corn.

Materials and Methods

Study Area and Sample Collection

This work was carried out in the Department of Plant Science and Biotechnology demonstration plot, beside the screen house at the Faculty of Science, Rivers State University, Port Harcourt, Nigeria, which lies within latitudes 4^0 43’0743’07’’ and 4^0 54’3254’32’’ N and longitudes 6^0 56’0456’04 and 7^0 03’2003’20’’E. The mean annual rainfall of the area is 2000mm and mean temperature of 29^0 C (Tubonimi and Udonna 2015).

Collection of Maize Seed

Certified maize seeds (Name: O.P. maize seed, Variety: SAMMAZ, Moisture Content: <12%) were obtained from Premier Seed Nigeria Limited located in Zaria, Nigeria on the 15th of November 2019. Following physical examination, the maize seeds were properly sorted and checked for infection, dryness or any form of fungal growth. The seed samples were taken to the experimental site where further viability test was done by dropping the maize seeds into a basin of water. The ones that sank were collected for planting while the ones that floated where discarded.

Collection of *Trichoderma* species

Trichoderma species were isolated from contaminated mushrooms at Dilomat Farms and Services Limited, Rivers State University.

Planting Operation and Experimental Design

A completely randomized design was adopted. Four viable maize seeds were planted in a polythene bag containing 6kg of soil which amounted to a total of 144 viable seeds used. Two weeks after germination (2 WAG), 3 of the seedlings were uprooted from each bag such that only one would be treated with *Trichoderma spp*. This was to maximize the efficiency of the treatments on the seedlings.

The experiment consisted of four treatments namely: *T. koningii* +*T. harzianum, T. koningii* only, *T. harzianum* only and Soil only which were replicated thrice at three different levels of concentration (10^{-3} spores/ml, 10^{-5} spores/ml and 10^{-7} spores/ml) giving a total of 48 sample size.

Trichoderma spp were grown in potato dextrose agar (PDA) and incubated for seven days at 30±2°C, and the spores were harvested and diluted with distilled water. Thereafter, 5 ml, 10ml and 15ml each of *Trichoderma sp* (*T. harzianum* and *T. koningii*) spore suspension was measured, poured and spread into the plastic bags containing 6kg of soil respectively. These were applied at two weeks interval for a period of twelve (12) weeks.

Growth parameters

The leaf length, plant height and leaf area (leaf length x width) were measured using meter rule while the number of leaves per plant were accounted weekly for 7 weeks.

Yield Assessment

Assessment of yield loss was carried out based on yield comparisons between the treatments at the various concentrations (Cooke, 2006). Percentage yield loss (%YL) in terms of grain weight was calculated as follows (Mousanejad *et al.*, 2010).

$$\% \text{ YL} = \frac{\text{Yield in intensive protected bag} - \text{Yield in particular treatment X 100}}{\text{Yield in intensive protected bag}}$$

Data Collection

Data collected were growth parameters (number of leaf, leaf length, stem height and leaf area) and yield of maize.

Data Analysis

All data collected were subjected to analysis of variance (ANOVA) using SPSS (version 20.0) to assess effects of treatments. Means were separated for comparing using Duncan multiple range tests at 5% probability level.

Results

The effects of *Trichoderma sp* on Growth Parameters (number of leaf, leaf length, stem height and leaf area)

The mean comparison of growth parameters of *Zea mays* amongst the treatments at 10^{-3} spores/ml, 10^{-5} spores/ml and 10^{-7} spores/ml concentrations and the control are shown in Tables 1, 2 and 3. There were significant differences in the number of leaf, stem height, leaf length and leaf area of *Zea mays* amongst the various treatments at 5ml and 10ml concentration when compared to the control at 6 WAP (Tables 1 and 2) but there was no significant difference in the growth parameters of maize treated with 10^{-3} spores/ml (Table 3).

Table 1. Means Comparison of the effects of Treatments at 10^{-7} spores/ml concentration on Growth Parameters of *Zea mays* (6 WAP).

Treatment (spores/ml)	No. of leaf	Stem height (cm)	Leaf length (cm)	Leaf area (cm^2)
T. koningii + T. harzianum	9.67 ± 0.58^{b}	$37.33\pm9.30^{a\text{-}b}$	$70.33\pm5.60^{a\text{-}b}$	$365.67\pm67.80^{a\text{-}c}$
T. harzianum	$8.67\pm0.58^{a\text{-}b}$	$34.00\pm5.20^{a\text{-}b}$	$69.00\pm2.65^{a\text{-}b}$	$355.67\pm68.30^{a\text{-}b}$
T. koningii	10.67 ± 0.58^{b}	$33.00\pm6.30^{a\text{-}b}$	$62.33\pm2.52^{a\text{-}b}$	$404.33\pm15.04^{a\text{-}c}$
Soil Only	7.00 ± 0.00^{a}	28.67 ± 4.04^{a}	59.00 ± 14.73^{a}	231.67 ± 98.40^{a}

Means with different letters down the column are significantly different

Table 2. Means Comparison of the effects of Treatments at 10^{-5} spores/ml concentration on Growth Parameters of *Zea mays* (6 WAP).

Treatment (spores/ml)	No. of leaf	Stem height (cm)	Leaf length (cm)	Leaf area (cm^2)
T. koningii + T. harzianum	$9.67\pm0.58^{b\text{-}c}$	$33.33\pm5.86^{a\text{-}b}$	$62.67\pm11.68^{a\text{-}b}$	$348.67\pm94.35^{a\text{-}b}$
T. harzianum	$8.00\pm1.00^{a\text{-}b}$	$37.33\pm8.74^{a\text{-}c}$	$67.33\pm6.43^{a\text{-}b}$	$344.33\pm50.36^{a\text{-}b}$
T. koningii	$9.67\pm0.58^{b\text{-}c}$	$38.33\pm8.20^{a\text{-}c}$	$68.67\pm4.16^{a\text{-}c}$	$445.33\pm24.11^{b\text{-}d}$
Soil Only	7.00 ± 0.00^{a}	28.67 ± 4.04^{a}	59.00 ± 14.73^{a}	231.67 ± 98.40^{a}

Means with different letters down the column are significantly different

Table 3. Means Comparison of the effects of Treatments at 10^{-3} spores/ml concentration on Growth Parameters of *Zea mays* amongst (6 WAP).

Treatment (spores/ml)	No. of leaf	Stem height (cm)	Leaf length (cm)	Leaf area (cm^2)
T. koningii + T. harzianum	6.67 ± 5.86^{a}	24.00 ± 21.63^{a}	50.00 ± 43.86^{a}	297.67 ± 257.83^{a}
T. harzianum	9.00 ± 0.00^{a}	42.00 ± 14.42^{a}	72.33 ± 6.43^{a}	370.33 ± 55.20^{a}
T. koningii	10.67 ± 0.58^{a}	39.33 ± 13.65^{a}	70.67 ± 5.86^{a}	457.67 ± 15.04^{a}
Soil Only	7.00 ± 0.00^{a}	28.67 ± 4.04^{a}	59.00 ± 14.73^{a}	231.67 ± 98.40^{a}

Means with different letters down the column are significantly different

The effects of *Trichoderma sp* on Yield of *Zea mays*

There was exponential and differential percentage yield increase in all the treatments at all levels of concentration when compared to the control (Fig 1). From the result, *T. koningii+T. harzianum* had the highest percentage yield increase (61%) at 10^{-7} spores/ml followed by 10^{-3} spores/ml, (30%) and 10^{-5} spores/ml (10%). *T. harzianum* had the highest percentage yield increase (40%) at 10^{-3} spores/ml followed by 10ml (31%) and 10^{-7} spores/ml (26%). Finally, *T. koningii* had the highest percentage yield increase (37%) at 10^{-3} spores, followed by 10^{-7} spores/ml (32%) then, 10^{-5} spores/ml (31%). However, the highest percentage yield (%Y) increase was observed at 10^{-7} spores/ml *T. koningii+T. harzianum* with 61% increase in yield followed by10^{-3} spores/ml *T. harzianum* with (40%) yield increase when compared to the control that had 18% yield increase.

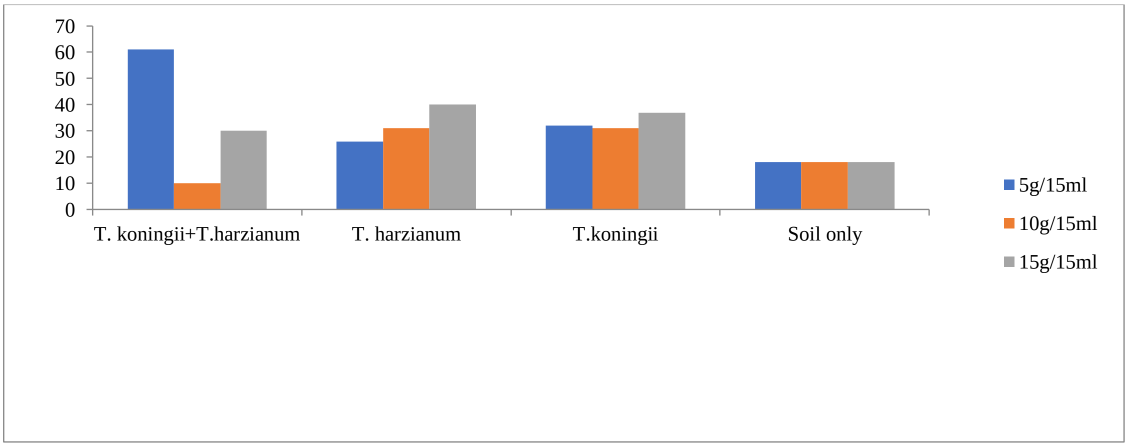

Fig. 1: Effects of treatments on yield of *Zea mays*

Discussion

Combination of *Trichoderma* species in soil cultivated with maize had a significant effect on the growth and yield of maize in relation to the controls (Tables 1, 2 and 3). Such improved performance over the control with respect to growth parameters (number of leaf, stem height, leaf length and leaf area) was due to appreciable amount of some essential mineral nutrients contained in the treatments (*Trichoderma* species). The above observations were also noted by Lo *et al.,* (2001), Yedidia *et al.,* (2001), Harman (2006) and Mukhtar (2008) reported that *Trichoderma* spp were being employed widely in plant agriculture thereby increasing yields in plants. The non significant effect observed on the number of leaf compared to the controls at 1 & 2 WAP could be lack of additives materials (*Trichoderma spp*) to solubilize and modify the climatic and edaphic stresses. Harman (2006) stated that plants that suffer from scarcity of essential nutrients such as NKP are prone to environmental stresses especially the soil factors. Such seedlings fail to grow and consequently result in drastic reduction or total loss of yield in certain plants. Engel *et al.,* (2001) and Brandy and Weil, (2002) also reported that plants that are Phosphorus deficient appear weak with usual delay in maturity.

However, the decreases on the leaf length and leaf area in the control experiment at 7WAP were expected due to low amount of essential mineral elements in the untreated maize soil. They were also suspected to have been caused by diminishing soil nutrients in the untreated soils. In addition, it was also observed that there was high and accelerated growth rate which influenced and reflected on the growth parameters of maize seedlings that were treated with combination of *Trichoderma spp* between 2 WAP and 6 WAP respectively. This however, resulted in early production of florescence (flowering) and teaseling which stalled the whorles and eventually reduced the leaf lengths and leaf areas of the treated maize at the various concentrations. This is in agreement with the findings of Behzad, (2010) who stated that the impacts of *Trichoderma* spp on growth and development of plants have important agronomical and economical implications such as shortening the plant growth period and time in nursery, as well as improving plant vigor to overcome biotic and/or abiotic stresses, resulting in increase plant productivity and yields.

In addition, the long-term residual effects of combination of *Trichoderma* species also contributed to their ability for the continual supply of nutrients to maize plant throughout the growing period. The works of Adeniran *et al.,* (1999) and Isitekhale *et al.,* (2014) confirmed the above observation that gradual and long-lasting effects of organic matters was attributed to its ability to supply nutrients to waterleaf plant all through the growth season.

Also, the significant impacts on the growth and yield associated with combination of *T. konngii* and *T. harzianum* at 10^{-7} sores/ml concentration could be due to enhanced photosynthetic activities which impacted on yield significantly. This finding is supported by Rojoa *et al.,* (2007) and Prasad and Anes (2008) who reported that *Trichoderma* species increased the frequency of healthy plants, significantly improved various growth parameters and boosted yield of okra.

Similarly, there was a direct correlation between combination of *Trichoderma* species, improved soil and healthy maize which significantly enhanced various growth parameters of maize, yield parameters and percentage yield of maize as shown by Ayeni (2008) that combined application of manures, when properly managed, gave superior effects in terms of improved soil fertility, balanced plant nutrients and crop yield. However, combination of *T. koningii* and *T. harzianum* had the best performance on percentage yield at 10^{-7} spores/ml concentration, although other treatments at the various concentrations enhanced yield than the controls. This was because of low level nutrients in the untreated soil while the treated soil had faster release of essential nutrients which increased the status of organic matter in the treated soil. A positive residual impact of soil properties on maize plant was achieved which reflected on the growth and yield of maize.

Conclusion

Trichoderma species positively promoted all the growth parameters at the various concentration levels all through the vegetative stage of maize except at 7 WAP where there was a decline in growth due to the reproductive stage that enhanced teaseling while combination of *T. koningii* and *T. harzianum* had the best performance on percentage yield when compared to the control.

References

Adediran G. (1999). Nutrient composition and Weight Evaluation of Small Newly Developed Maize Varieties in Nigeria. *Journal of Food Technology*. 7: 25-35.

Anil K and Lakshmi T. (2010).Phosphate Solubilization Potential and Phosphatase Activity of Rhizospheric*Trichoderma* Spp. *Journal of Microbiology*, 51, 312-317.

Behzad H. (2010). Effects of some Iranian *Trichoderma* isolates on maize seed germination and seedling vigor. African Journal of Biotechnology, 9(28), 4342-4347.

Benitez, T., Rincon, A. M., Limon, M. C., and Codon, A. C. (2004). Biocontrol Mechanisms of *Trichoderma* strains. *International Microbiology*. 7(4):249−260.

Bharath, B. G., Lokesh, S., Prakash, H. S. and Shetty H. S. (2006). Evaluation of different plant protectants against seed mycoflora of watermelon (*Citrullus lanatus*). *Research Journal of Botany*. 16: 1-5.

Celar, F. and Valic, N. (2005). Effects of *Trichoderma* spp. and *Gliocladium roseum* culture filtrates on seed germination of vegetables and maize. *Journal of Plant Disease*. 112: 343-350.

Chuku, E. C. (2020). Sustainable Agriculture: A nevus for environmental resource management. A key note address at the 3rd National Conference of the Society for Agriculture, Environmental Resource Management, ….. 4-10.

Contreras-Cornejo, H. A., Macías-Rodriguez, L., Cortés-Penagos, C. and López-Bucio, J. (2009). *Trichoderma virens*, a Plant Benefcial Fungus, Enhances Biomass Production and Promotes Lateral Root Growth through an Auxin-Dependent. *Plant Physiology*. 149(3):1579–1592.

Cooke B. M, (2006). Disease assessment and yield loss. In: The Epidemiology of Plant Diseases, pp.43-75, (Cooke, B.M., Jones, D.G. and Kaye, B., eds). Springer, the Netherlands. culture médium. Pesqui. Agropecu. Bras. 43(4), 529-535 (in Portuguese).

Dubey, S. C., Suresha, M. and Singha, B, (2007). Evaluation of *Trichoderma* species against *Fusarium oxysporum f. sp. ciceris* for integrated management of chickpea wilt. *Biological Control*, 40: 118-127.

Engel, R. E., Bruebaker, P. L., and Ornberg T. J. (2001). A chloride deficient leaf spot of WB881 Durum. *American Journal of Soil Science Society*. 65:1448-1454.

Hanson, L. D. (2000). Reduction of *Verticillium* wilt symptoms in cotton following seed treatment with *Trichoderma virens. Journal of Cotton Science*, 4: 224-231.

Harman, G. E (2006). Overview of mechanisms and uses of *Trichoderma* spp. *Phytopathology,* 96: 190-194.

Illmer, P.; Barbato, A. and Schinner, F. (1995). Solubilization of hardly soluble AlPO4 with P-solubilizing microorganisms. *Soil Biol. Biochemistry*. 27(3), 265-270.

Inbar J, Abramsky M, Cohen D, Chet I (1994). Plant growth enhancement and disease control by *Trichoderma harzianum* in vegetable seedlings growth under commercial conditions. *Europian Journal of Plant Pathology*, 100: 337- 346.

Isitekhale, H. H. E., Aboh, S. I., and Ekhomen, F. E. (2014). Soil suitability evaluation for rice and sugarcane in lowland soils of Anegbette, Edo State, Nigeria. *International Journal of Engineering Science* 3(5)54-62.

Lo, C. T., Liao, F. T. and Deng, T. C. (2000). Induction of systemic resistance of cucumber to cucumber green mosaic virus by the root colonizing *Trichoderma* spp. (Abstract.) *Phytopathology*, 90: 47.

Lynch JM, Wilson KL, Ousley MA, Wipps JM (1991). Response of lettuce to Trichoderma treatment. *Letter Applied Microbiology,* 12: 59-61.

Machado, R. G., Sá, E. L. S., Damasceno, R. G., Hahn, L., Almeida, D., Moraes, T., Camargo, F. A. O., and Reartes, D. S. (2011). Promotion of growth in plants *Lotus corniculatus* L. (birdsfoot trefoil) and *Avena strigosa* Schreb (black oat), by inoculation with rhizobia and *Trichoderma harzianum*. *Science Nature*. 33 (2), 111-126 (in Portuguese).

Manju, S. and Mall, T. P. (2008). Efficacy of *Trichoderma* species on *Phytophthora dresceleri* f. sp. *cajani* of Pigeon pea. *Annual Plant Protection Science.* 16: 162-164.

Mishra, D. S, and Sinha, A. P. (2000). Plant growth-promoting activity of some fungal and bacterial agents on rice seed germination and seedling growth. *Tropical Agriculture.*, 77:188-191.

Mousanejad, S., Alizadeh A, Safaie N, (2010). Assessment of yield loss due to rice blast disease in Iran. *Journal of Agricultural Science and Technology*. 12: 357-364.

Mukhtar I., Hannan A., Atiq A., and Nawz A. (2012). Impact of Trichoderma species on seed germination in Soybeen. *Pskistan Journal of Phytopathology.* 24(2): 159-162.

Mukhtar I. (2008). Influence of Trichoderma Species on seed germination in Okra. *Journal of Mycopathology*. 6 (1 & 2): 47-50.

Oyarbide, F., Osterrieth, M. L, and Cabello, M. (2001). *Trichoderma koningii* as a biomineralizing fungous agent of calcium oxalate crystals in typical Argiudolls of the Los Padres Lake natural reserve (Buenos Aires, Argentina). *Microbiological Research.* 156: 113-119.

Prasad, D., and Anes, K. M. (2008). Effect of metabolites of *Trichoderma harzianum* and *T. viride* on plant growth and meloidogyne incognita on okra. *Annual Plant Proection Science*. 16: 461-465.

Rabeendran, N., Moot, D. J., Jones, E. E. and Stewart, A. (2000). Inconsistent growth promotion of cabbage and lettuce from *Trichoderma* isolates. *New Zealand Plant Protection.* 53: 143-146.

Rojoa, F. G., Reynosoa, M. M., Fereza, M., Chulze, S. N., and Torres, A. M. (2007). Biological control by *Trichoderma* species of *Fusarium solani* causing peanut brown root rot under field conditions. *Crop Protection.,* 26: 549-555.

Santos, H. A., Mello, S. C. M., and Peixoto, J. R. (2010). Association of isolates of *Trichoderma* spp. And indole-3-butyric acid (iba) in promoting root and growth of passion. *Bioscience Journal,* 26(6), 966-972 (in Portuguese).

Shanmugaiah V, Balasubramanian N, Gomathinayagam S, Monoharan PT, Rajendran A (2009). Effect of single application of *Trichoderma viride* and *Pseudomonas fluorences* on growth promotion in cotton plants. *African Journal of Agricultural Research,* 4(11): 1220-1225.

Tubonimi, J. K. I. and Udonna, I. (2015). Hydrogeochemical Characteristics and Quality Assessment of Groundwater in University of Science and Technology Port Harcourt *International Journal of Environmental Monitoring and Analysis* 3(4):221-232.

Vargas, W. A., Mandawe, J. C., and Kenerley, C. M. (2009). Plant-Derived Sucrose Is a Key Element in the Symbiotic Association between *Trichoderma virens* and Maize Plants. Plant Physiology, 151, 792–808.

Vassilev, N., Vasileva, M. A. and Nikolaeva, L. (2006). Simultaneous Psolubilizing and biocontrol activity of microorganisms: potentials and future trends. *Applied Microbiology and Biotechnology.* 71(2), 137-144.

Vinale, F., Sivasithamparam, K., Ghisalberti, E.L., Marra, R., Woo, S.L., and Lorito M. (2008). *Trichoderma* – plant –pathogen interactions. *Soil Biology and Biochemistry*. 40 (1):1−10.

Yedidia, I., Srivastva, A. K., Kapulnik, Y, and Chet, I, (2001). Effect of *Trichoderma harzianum* on microelement concentrations and increased growth of cucumber plants. *Plant Soil*, 235: 235-242.

Zheng, Z., and Shetty K, (2000). Enhancement of pea (*Pisum sativum*) seedling vigour and associated phenolic content by extracts of apple pomace fermented with *Trichoderma* spp. *Process Biochemistry.,* 36: 79-84