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The Effect of *Trichoderma* Species on the Vegetative Growth Phase f Rice *(Oryza sativa* L.) in Gombe State

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ABSTRACT

The novel technologies in all areas of agriculture have improved agricultural production, but some modern practices affect the environment. The recent challenge faced by advanced farming is to achieve higher yields in environment-friendly manner. Thus, there is an immediate need to find eco-friendly solutions such as wider application of biocontrol agents. Among various types of species being used as biocontrol agents, including fungi and bacteria, fungal genus Trichoderma produces different kinds of enzymes which play a major role in biocontrol activity like degradation of cell wall, tolerance to biotic or abiotic stresses, hyphal growth etc. This experiment was conducted to find out the effects of *Trichoderma viride* on growth and yield of rice in Gombe State during May 2019 – September 2019. The experiment consisted of four treatments; (T1: NPK; T2: NPK CONTROL; T3: Trichoderma; T4: Trichoderma Control) laid out in completely randomized design (CRD) with three replications. The results showed that *Trichoderma viride* increased the plant height by 4.6 %, root weight (1.5 %), number of grains (3.8 %), grain yield (36.5 %) and biomass yield (2.7 %) over control; while root length (17.4 %), tiller number (10.8%) highlighted the negative impact of *T. viride* on rice plant. *T. viride* displayed antagonism with inorganic fertilizer. When *T. viride* and NPK were accompanied with manure, most of the growth and yield parameter showed the highest value. Though *Trichoderma viride* decreases several growth parameters, it still can be used as biofertilizer which increases the grain yield. Using *T. viride* with a full dose of NPK during sowing stage may not be efficient and economical in terms of productivity. Introducing farmyard manure to *T. viride* gives better yield than *T. viride*.

Keywords: *Trichoderma viride;* Biocontrol; Fungi: Biofertilizer; NPK

INTRODUCTION

Trichoderma is a genus of filamentous ascomycete fungi (Division - Ascomycota, Subdivision - Pezizomycotina, Class - Sordariomycetes, Order - Hypocreales, Family - Hypocreaceae) that are among the most frequently isolated soil microorganisms; tropical soils contain 101–103 culturable propagules per gram (Fejes *et al.,* 2021) Nonetheless, reports have shown isolation of some species from Mediterranean *Psammocinia* sp. sponges and other substrates mainly rich in organic matter (Gal-Hemed *et al.,* 2011). These fungi have been widely used as biocontrol agents, and they can also stimulate plant growth and suppress plant diseases by one or more different direct and/or indirect mechanisms. The success of *Trichoderma* in the rhizosphere is due to their high reproductive capacity, ability to survive under very unfavorable conditions, efficiency in the utilization of nutrients, capacity to modify the rhizosphere and strong aggressiveness against plant pathogenic fungi (Ben´ıtez *et al.,* 2004; Harman 2006; Kaishun *et al*., 2019). Responses of *Trichoderma* to fluctuations in environmental conditions and how plants respond to fungal metabolites are the subject of research in a number of ongoing studies. *Trichoderma spp.* are common soil and root

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inhabitants that have been widely studied due to their capacity to produce antibiotics, parasitize other fungi and compete with deleterious plant microorganisms (Druzhinina *et al.,* 2011). These fungi produce a number of secondary metabolites such as non-ribosomal peptides, terpenoids, pyrones and indolic-derived compounds (Harman 2006). *Trichoderma* send signalling molecules into the rhizosphere, which may directly or indirectly modify the physiological and biochemical pathways during the exchange and recognition. Furthermore, *Trichoderma*, in association with plant roots, can trigger systemic resistance and improve plant nutrient uptake (Gal-Hemed *et al.,* 2011).

The cultivation of rice (*Oryza sativa*) is one of the most important cereal crops cultivated in sub-Saharan Africa (SSA). It is ranked as the fourth most important crop in terms of production after sorghum (*Sorghum bicolor*), maize (*Zea mays*) and millet (*Eleusine coracana*) (FAOSAT, 2006). In Nigeria for example, the Federal Government provided subsidy on basic farm inputs (improved rice varieties and fertilizer) for rice farmers under the presidential initiative and banned rice importation in 2006 so as to promote local rice production (Moni *et al*., 2020).

Rice is an increasingly important crop in Nigeria. Rice is grown for different purposes, from home consumption and sale. For ages now, it has been a tradition to grow rice though many considered it a food for luxury occasions. Rice has become an integral diet of an average home in Nigeria. With the advent of growing rice in almost everywhere in the Country, many varieties both local and improved have been introduced in to the fields. Depending on the variety, rice can be grown in paddy fields, upland or lowland fields, though less mangrove cultivation was done.

New varieties are produced and disseminated by research institutes, or are imported from Asia. The success of the spread of these strains was determined by farmers simply multiplying the seeds in their plots when they saw varieties thriving well in someone else's field, or if a variety is fetching a good price in the market. In the Country, strong political issues affect the dispersion of varieties; a striking example is that of a variety "China", which was imported to Nigeria around twenty years ago by a political figure and now grown everywhere despite the fact that seed trials carried out by NCRI declared it unsatisfactory.

Gombe State (Fig.1) is noted for rice production due to the presence of dams (Dadin Kowa and Balanga) that ensure all year-round rice production. The climate of the study area has two distinct seasons, rainy seasons and dry seasons or summer and winter seasons. The rains start around April/May and end around October/November and it has an average of rainfall of 42.4mm. Farming is the primary activities of the inhabitancies of the study area. Having coordinate of $10^{0}15$” N $11^{0}10$” E with total rank of 18,768km^2.

Rice production has been a traditional practice in Nigeria, right from the word go, but was limited until of recent when internal demands become increased. Rice is known to be a major commodity of World trade and the Country went under pressure to open up to markets for importation. Production was done to keep up with larger mechanised productions worldwide, thereby incurring challenge to farmers and the country at large. The major problems associated with the production of cereals particularly rice include drought, flooding, extreme temperatures and changes in rainfall patterns (Ajetumobi *et al*., 2010). Climatic resource which is the back born of every agricultural process and rainfall is the primary source of moisture for crop production in Nigeria. Climatic fluctuation is putting Nigeria’s agriculture system under serious threat and stress (Ayinde, *et al*., 2011). The rainfall of

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400 mm-1200 mm is the requirement for the production of cereals (Rice, Maize, Sorghum and Millets), any variation in the rainfall or temperature may result to crop failure. Death of many microorganisms growing close to *Trichoderma* strains is as a result of competition for limiting nutrient resources. The major focus of *Trichoderma sp* research was to understand the direct effects and to determine the plant growth and yield due to the interference and action of *Trichoderma* (fungi family) in stimulating plant growth and development vividly in rice farming.

Trichoderma viride decreases several growth parameters, it still can be used as biofertilizer which increases the grain yield. *Trichoderma viride* enhanced rice root and shoot length, seed germination, fresh weight, dry weight, and vigor index (Mahato *et al.,*2018).

Trichoderma viride are involved in triggering expressions of defence protein within the plant to induce plant immunity against pathogens and, in turn, improve plant growth (Shrestha, 2018). *Trichoderma* species are, in most cases, common soil inhabitants that associate with plant roots. Thus, light entry into the conidiation programme may resultantly indicate modification in the behaviour of *Trichoderma* when it enters the soil surface. Gutter, (1957) reported that *Trichoderma viride grows* on nutrient-rich medium in the dark, grows indefinitely as mycelium, but a slight flash of light on the growing zone of the mycelium resulted in the formation of dark-green mature conidia, forming a ring at the periphery of the colony (Gutter, 1957). The fungus appears to be responsive to light (competent) only after 10–16 h of growth.

MATERIALS AND METHODS

Experimental Site

The experimental study was carried out at the premises of Gombe State University Botanical Garden behind Science complex occupied by sandy-loamy soils with pH of 7. The site is located at 10”18”15N latitude and 11”10”35E longitude of the school area having four plots (Figure 1), each plot is split into four sub-plot which has the two treatments alongside their respective controls.

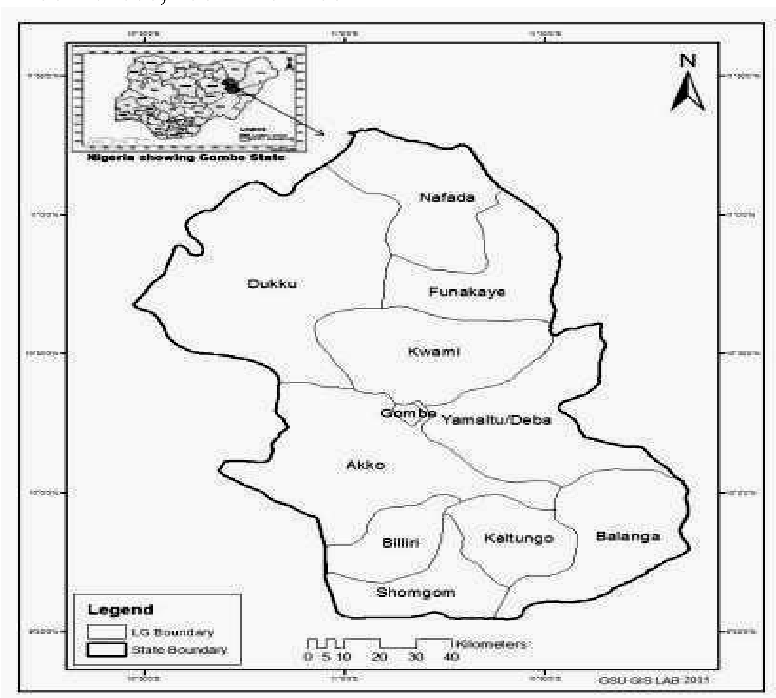

Figure 1: Map of Gombe State

Seed Collection

Improved and local varieties were utilised for the experiment. The improved rice variety used is the Nerica which was sourced from Department of Applied Ecology ATBU Bauchi, it has a medium length and a relatively short cycle of 120 days. Nerica variety was originally introduced by New Improved Rice for Africa. The second variety is a popular local variety known as Jamila rice seed, the seed is sourced from School of Agriculture Tumu Akko LGA, Gombe State. It has a crop cycle of 120-135 days.

Seed Treatment

The complete randomized design method with slight modification as described by Wanner et al., 2019 was used for the study. The rice seeds varieties were surface sterilized with 70 % ethanol, followed by 5% sodium hypochlorite and washed with sterilized distilled water. A total number of 50 local rice seed grains and 50 improved rice seed grains were selected for each treatment then soaked in the respective *Trichoderma specie* in a flask containing 10 spores' ml suspension for 30 minutes. Rice seed soaked in sterilized distilled water served as control. The experiment was replicated three times. The treated seeds were incubated for 5days in sterilized petri dishes fitted with filter paper and each petri dish was irrigated with 10 ml of sterilized water. The seeds were then planted in a polyethene bags.

Application of *Trichoderma*

Although purchasing the Fungi from a retailer is recommended for safety's sake, *Trichoderma* is available in dry powder form in a package, which can be used for seed inoculation, direct broadcasting on seeds or mixed with water as a root dip when transplanting. The *Trichoderma* powder formulation was stirred in water until it is completely suspended at the rate of 1kg per ton of compost, covered the compost heap with a plastic sheet or similar and keep it in a shaded place. It was, placed on the compost on a support that allows access of air underneath the heap. Within 4-5days of inoculation the compost with *Trichoderma*, successful development was indicated by a whitish layer on the compost, which is the growing fungal mycelium.

Cultural Practice

In all treatments,14-day old seedling was transplanted at 2-3 seedling per hill, missing hills were replanted within 7days after transplanting date. For the inoculation treatment, the seedling was dip in *Trichoderma* spore suspension for 16-20 minutes before transplanting. In the non-inoculated treatment seedlings were transplanted without any treatment application. For weed control, weeding with hoe 2 times at 20 and 40 days after transplant to give aeration to the rhizosphere and the plots were continuously flood during the experimental period until 15-20 days before harvesting irrigation was up held.

Data Analysis

One-Way ANOVAs and the statistical program SPSS 21.0 (Statistical Package for the Social Sciences) was used for the assay. The results were presented as the means ± standard deviation. Significance level for the differences was set at $p<0.05$.

RESULTS

Table 1 is showing the effects of *T. viride* and NPK on the parameters measured during the period of the experimental study. Significant differences were observed for plant height in week 6 and 7 ($P<=0.009$; 0.006) respectively. Whereas no treatment effect was picked up for number of tillers, plant biomass and weight of seeds.

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Table 1: Table showing the plant height and seed weight for all the treatments from week 6 to 8.

Parameters	Treatments				P values
	Fertilizer	control	Trichoderma	control	
Plant height(cm) week 6	72.70[b]	86.50[ab]	85.35[ab]	91.80[a]	0.009
Plant height(cm) week 7	99.10[b]	103.30[b]	113.00[ab]	119.80[a]	0.006
Plant height(cm) week 8	119.40[a]	122.50[a]	131.30[a]	128.70[a]	0.179
Number of tillers week 6	17.00[a]	28.50[a]	25.60[a]	26.40[a]	0.167
Number of tillers week 7	20.60[a]	34.00[a]	30.60[a]	30.60[a]	0.115
Number of tillers week 8	23.30[a]	36.20[a]	33.70[a]	32.80[a]	0.134
Weight of 100 seeds(g)	2.58[a] ± 0.007	2.47[a] ±0.481	2.94[a] ±0.594	2.55[a] ±0.290	0.687
Biomass(g)	15.44[a] ±5.02	11.54[a] ±9.14	26.11[a] ±0.61	10.91[a] ±4.52	0.154

*Values with the same alphabet(s) indicate there is no significant difference at(P=>0.05)

Table 2 is having the information on the varietal variations based on the treatments they were exposed to. Plant height for week 7 and 8 was observed to be taller in Jamila than Nerica. While the varieties were not different in number tillers, plant biomass and grain weight.

Table 2. Table showing the plant height and seed weight for all the rice varieties from week 6 to 8

Parameters	Varieties		P values
	Nerica	Jamila	
Plant height(cm) week 6	83.56[a]	84.60[a]	0.788
Plant height(cm) week 7	103.15[b]	114.45[a]	0.012
Plant height(cm) week 8	118.40[b]	132.55[a]	0.002
Number of tillers week 6	25.70[a]	23.05[a]	0.488
Number of tillers week 7	30.75[a]	27.15[a]	0.371
Number of tillers week 8	33.00[a]	30.00[a]	0.458
Weight of 100 seeds(g)	2.873[a] ±0.203	2.873[a] ±0.341	0.052
Biomass(g)	14.37[a] ± 9.66	17.63[a] ± 6.45	0.594

*Values with the same alphabet(s) indicate there is no significant difference at(P=>0.05).

The Figures below represent a graphical presentation of the trend in growth and some harvest parameters measured. The rice plants started to show a steep growth form week 6 till week 8 of harvest when exposed to both treatment of *T.viride* (Figure 2) and NPK fertilizer (Figure 3).

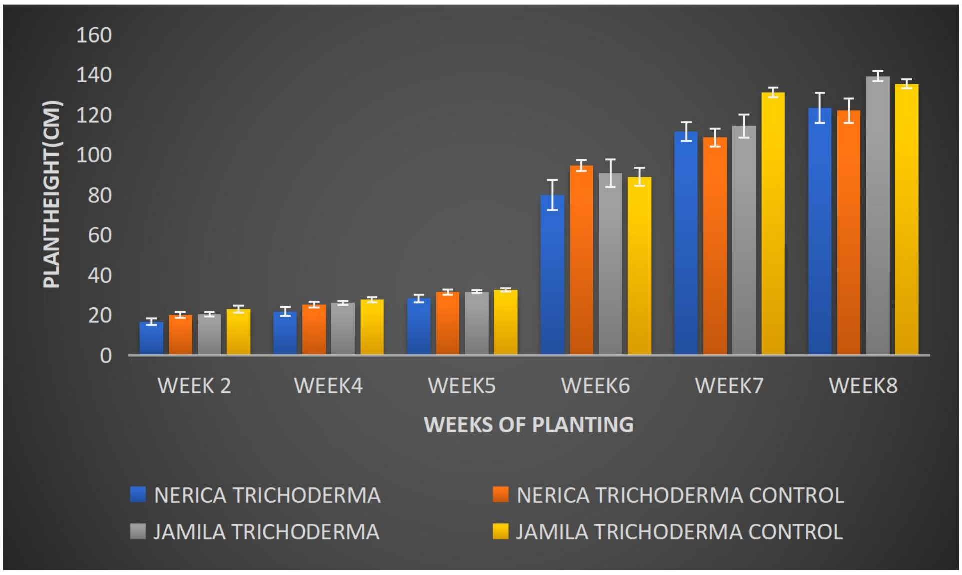

Figure 2: Effect of *Trichoderma* on plant height.

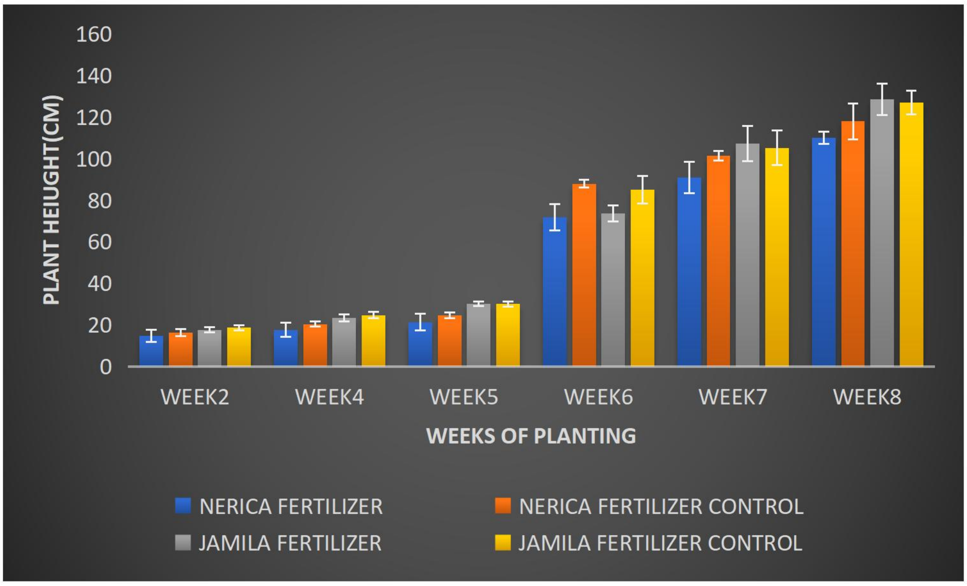

Figure 3: Effect of fertilizer on plant height.

The Figures below represent a graphical presentation of the trend on the yield parameters measured. The rice variety (Jamila) treated with *T.viride* has shown a steep growth at week 8 of harvest for both weight of 100 seeds of *T.viride* (Figure 4) and plant biomass of *T.viride* (not shown).

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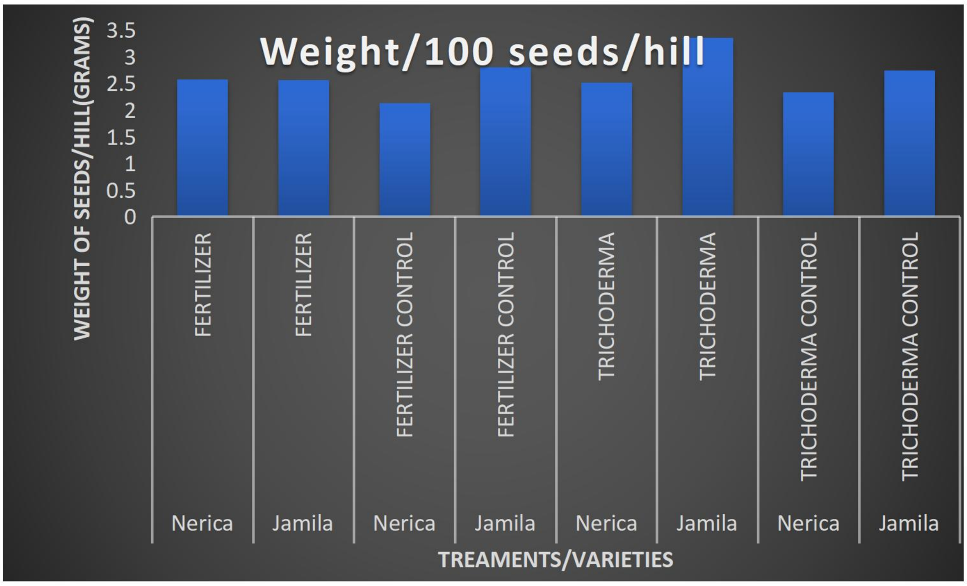

Figure 4: Effect of the treatments on the seeds.

DISCUSSION

The results of the experiments showed that the treatment of rice plants with *Trichoderma* spp. has a significant effect on rice plant growth performance (Table 1). In this research, the results showed that rice plant significantly increased rice growth components. Plant height of *Trichoderma* spp. inoculated rice plants was higher compared to NPK treatment and control. The ability of Trichoderma spp. to produce phytohormones is the key factor in the increase in rice plant height and better nutrient uptake as reported by (Chowdappa *et al*., 2013). Better nutrient uptake will enhance the physiological processes within the rice plants treated with *Trichoderma* spp. leading to good growth performance. Leaf colour and tiller number were significantly higher in *Trichoderma* spp. treated rice plants compared to NPK treatment and control. The enhancement of leaf and tiller number by *Trichoderma* spp. were made possible because of the ability of the *Trichoderma* spp. to act through several mechanisms such as environmental buffering (against pH, drought, waterlogging, cold and heat), solubilization and siderophore production as suggested by Saba *et al*. 2012.

Trichoderma spp. applied to rice plants reported in this research significantly increased rice root length compared to NPK treatment and control (Figure 5). *Trichoderma* sp. treated rice plants showed an impressive increase in root length compared to the plants treated with the other strains. Elicitors released by *Trichoderma* spp. are also involved in triggering expressions of defense protein within the plant (Thakur and Sohal, 2013). In this way, plant immunity against pathogens is induced and *Trichoderma* spp. was significantly greater than the NPK treated plants and control. However, the weight of dry rice root plants was not significant among treatments. Rice plants inoculated with *Trichoderma* sp. have the highest increase in root fresh weight. The capacity of Trichoderma spp. to produce growth hormones such as auxins and gibberelins were reported as the main factor that contributes to the ability of *Trichoderma* spp. to support root growth and increase water absorption from soil (Martínez-Medina *et al*., 2011). Previous research by Yap *et al*. (2009) also suggested that the use of NPK fertilizers in rice cultivation significantly increase heavy metal content in rice plants. Further, Yadav (2010) stated that heavy metals may cause oxidative stress inside the plants leading to cellular damage. This research is in agreement with previous researches which revealed that *Trichoderma* is a great biofertilizer than NPK fertilizer.

CONCLUSION

Trichoderma spp. possess many qualities and they have great potential use in agriculture such as amend abiotic stresses, improving physiological response to stresses, alleviating uptake of nutrients in plants, enhancing nitrogen-use efficiency in different crops, and assisting to improve photosynthetic efficiency.

Trichoderma shows a slight increase in the plant height, number of grains, grain yield, and biomass yield over control; while root length, tiller number, colour of leaves highlight the negative impact of *Trichoderma* on the rice plant. *Trichoderma* shows antagonism with inorganic fertilizer. In most of the parameters, more is the inorganic fertilizer with *Trichoderma*, higher is the antagonism. When *Trichoderma* and NPK are accompanied with farmyard manure, most of the growth and yield parameter shows the highest value, but the yield was slightly higher than NPK alone treatment. This finding indicates that while sowing seed, the use of *Trichoderma* with manure and NPK may not improve the yield over NPK to a greater extent. Hence it is indicated that *Trichoderma viride* can be a growth promoter and be used as a biofertilizer.

The sufficient population of fungus in the soil promoted growth and increased rice effectiveness and also improving soil moisture availability and thus increased plant establishment. The present study concludes that *Trichoderma* spp. Have the potential to enhance rice vegetative growth. In this respect, the present experiment proved that *Trichoderma viride* was the best strain compared to others strains.

Recommendation

Trichoderma is useful to rice agroecosystem and provide optimal ecosystem services like unsaturated soil condition, relies of slightly aerobic and the absence of toxic chemicals which provide ideal condition for *Trichoderma* to thrive unabated. Hence, it is highly recommended in Agricultural sector.

It is also recommended for the Nigerian Government to allow the import of *Trichoderma* spp. For the benefit of our local farmers to help boost their economic produce for more income.

REFERENCES

Benítez, T., Rincón, A. M., Limón, M. C. & Codón, A. C. (2004). Biocontrol mechanisms of Trichoderma strains. *Microbiology*. 7, 249–260

Casas-Flores, S. E. & Herrera-Estrella, A. (2007) in The Mycota, Environmental and Microbial Relationships 2nd edn Vol. 4, 159–187 (Springer Berlin-Heidelberg, New York.

Irina, S. D., Verena, S., Alfredo, H., Benjamin, A. Horwitz C. M., Kenerley, E. M., Prasun, K. M., Susanne, Z., Igor, V. G. & Christian, P. K. (2011). *Trichoderma*: the genomics of opportunistic success. *Nature Reviews Microbiology* 9, 749–759.

Fejes, S., Blazovics, A., Lugas, A., Lemberkovics, E., Petri, G., and Kery, A., (2021). Establishment of chloroplast genetic system in rice during early leaf developement. *Journal of Ethnopharmacolology* 69: 259-265

Food and Agricultural Organization-FAO (2016). Rice Market Monitor, Volume XIX Issue N0.1 glutathione and phytochelatins in heavy metal stress tolerance of plants.

Inbal G., Lea, A., Monika K., Irina, S. D., Ada, V. & Oded, Y. (2011). Marine

DOI: 10.56892/bima.v8i1.639

Isolates of Trichoderma spp. as Potential Halotolerant Agents of Biological Control for Arid-Zone. *Applied and Environmental Microbiology* 77 (15) 5100-5109; DOI: 10.1128/AEM.00541-11

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

Kaishun, B., Damle, S. and Sharon, K. (2019). Rice crop establishment from karwar district. *International Journal of Biology, Pharmacy and Allied Sciences,* 6(7): 1403-1415

Moni, R. S., Ashraful, A. M., Raushanara, A., & Rumana, J., (2020). Rice blast management in Cambodian rice fields using *Trichderma harzianum* and a resistant variety. Bangladesh *Journal of Pharmacology*. 3: 90-96.

Morán-Diez., M.E., Trushina, N., Lamdan, N.L. Lea Rosenfelder, Prasun K Mukherjee, Charles M Kenerley & Benjamin A Horwitz. (2015). Host-specific transcriptomic pattern of Trichoderma virens during interaction with maize or tomato roots. BMC Genomics 16, 8 https://doi.org/10.1186/s12864-014-1208-3

Thakur, M., & Sohal, B.S. (2013). Role of elicitors in inducing resistance in plant against pathogen infection: a review. ISRN Biochemistry, *Food Chemistry,*91(2): 287-292

Wanner, B. L. & Metcalf, W.W. (2019). Molecular Genetic Studies of a 10.9-kb Operon in E. coli for Phosphate update and biodegradation. *FEMS Microbiology Letters*. 100, 133-140.

Yadav, S.K. (2010) Heavy metals toxicity in plants: an overview on the role of glutathione and phytochelatins in heavy metal stress tolerance of plants. *South African Journal of Botany* 76:167–179. doi:10.1016/j.sajb.2009.10.

Yap, D.W., Adezrian, J., Khairiah, J., Ismail, B.S. & Ahmad-Mahir, R. (2009) The uptake of heavy metals by paddy plants (Oryza sativa) in Kota Marudu, Sabah, Malaysia. *Eurasian Journal of Agricultural Environmental Sciences* 6(1):16–19