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Trichoderma viride affects soil organic carbon and phosphorous availability in Sokoto Sudan Savanna, Nigeria

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Abstract. *This study was conducted to determine the influence of mycorrhizal fungus (Trichoderma viride) as biostimulator powder and NPK fertilizer on some soil chemical properties in Sokoto Sudan Savanna, Nigeria. The experiment was conducted at Usmanu Danfodiyo Fadama Teaching and Research Farm in Wamakko Local Govemment Area of Sokoto State. Soil samples were collected at a depth of 0 – 30 cm from four (4) plots of 3 m x 3 m size, two (2) weeks after treatment application. Treatments were applied in a Randomized Complete Block Design (RCBD) replicated three times. The treatments include: Control, Trichoderma viride, NPK fertilizer and Trichoderma viride + NPK fertilizer. A total number of ten (10) sub-samples were collected from each plot to make a composite sample. 0.25Kghha^{-1} of biostimulator (Trichoderma viride) and 120K gha^{-1} of NPK chemical fertilizer were applied (inoculated) after mixing with 200 litres of water. The results of the study showed that Trichoderma viride significantly influenced the soil pH, organic carbon and organic matter in soils. Application of plant Biostimulator greatly influenced the soil chemical properties. Soil pH was within the range 6.83 – 7.02 most favorable for plant growth because most nutrients are easily available at this range. The results obtained showed a significant ($p<0.05$) difference between the treatments. Organic carbon was significantly ($p<0.05$) higher than the control treatments. The combination of Trichoderma viride + NPK fertilizer was significantly higher ($p<0.05$) 1.5 g/kg than the treatment with sole application of NPK fertilizer. Available phosphorus ranged from 0.89 – 0.96 mg/kg with a mean value of 0.91 mg/kg for control treatment, while treatment with the application of Trichoderma viride ranged from 0.87 – 0.91 mg/kg with a mean value of 0.89 mg/kg, while NPK fertilizer treatment had a value ranging from 0.86 – 0.95 mg/kg with a mean value of 0.90 mg/kg, whereas the combined treatment with Trichoderma viride + NPK fertilizer had available phosphorus value ranging from 0.89 – 0.95 mg/kg with a mean value of 0.92 mg/kg which was slightly higher than all the treatments. This further revealed that Trichoderma viride can greatly influence the availability of soil nutrients which promote their uptake in plants for growth and development in Sokoto Sudan Savanna agroecological zone, Nigeria.*

Keywords: available phosphorous, biostimulator, mycorrhizal fungi, organic carbon, *Trichoderma viride*

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Introduction

Soil is the most vital and precious natural resource that sustains life on the earth. It takes almost 1000 years to produce an inch of topsoil (Chandra and Singh, 2009). *Trichoderma viride* is a powerful fungal isolate that promotes plant growth, improves nutrient utilization efficiency, enhances plant resistance, and improves agrochemical pollution in the environment (Adetunji and Varma, 2020). *Trichoderma viride* is also used to control soil-borne diseases of various plants (Mukesh et al., 2015). *Trichoderma viride* is a mycorrhizal fungi that is involved in phosphorus acquisition, most plants form symbiotic associations with the arbuscular mycorrhizal fungi (AMF) acting as bio-ameliorators, that has the potential to enhance the rhizospheric soil characteristics considerably thereby improves soil structure to promote plant growth under normal as well as stressed conditions (Rabie and Almadini, 2005; Yadav et al., 2015). One of the major concerns in today's world is the pollution and contamination of soil. The degradation of soil has started occurring both due to natural and human-induced factors which in turn affects soil productivity (Karlen and Rice, 2015). As human population continues to increase, human disturbance of the earth's ecosystem to produce food and fiber will place greater demand on soils to supply essential nutrients. The soil's native ability to supply sufficient nutrients has decreased with higher plant productivity levels associated with increased human demand for food (Havlin et al., 2010).

Trichoderma is a genus of fungi that plays a significant role in soil ecosystems. Its spores and mycelia can influence the soil in several ways: Trichoderma spores can colonize soil, increasing the fungal population and diversity, can promote seed germination and plant growth by producing plant growth-promoting substances (PGPS) (Harman et al., 2004; Shoresh et al., 2010). Trichoderma spores increase soil enzyme activity, such as phosphatase and urease, which can improve soil fertility (Kumar et al., 2014). Trichoderma mycelia can improve soil structure by forming hyphal networks that bind soil particles together (Rillig et al., 2010), and can contribute to nutrient cycling by decomposing organic matter and releasing nutrients (Kubátová et al., 2015). Trichoderma mycelia can as well suppress plant diseases by producing antibiotics, competing with plant pathogens for resources and can contribute to soil carbon sequestration by forming stable soil aggregates and promoting soil organic matter accumulation (Howell, 2003; Six et al., 2006).

Modern agriculture is largely dependent upon synthetic chemical fertilizers. These are threats to the environment and food safety (Heena et al., 2021). Continuous utilization of chemical fertilizers is responsible for the decline of soil organic matter (SOM) content coupled with a decrease in the quality of agricultural soil (Kaur et al., 2008). Constant use of chemical fertilizer can alter the pH of soil, increase pests, acidification, and soil crust, which results in decreasing organic matter load, humus load, useful organisms, stunting plant growth, and even becoming responsible for the emission of greenhouse gases. Bio-fertilizers are Biostimulators that increase plant growth by stimulating nutrients and water uptake especially nitrogen and phosphorus which play significant roles in the assimilation of numerous amino acids that are subsequently incorporated in proteins and nucleic acid, which provides a framework for chloroplast for plant photosynthesis and other structures in which most of the biochemical reactions occur (Hazarika and Aheibam, 2019).

For sustainable crop production, integrated use of bio-fertilizers has been proven highly beneficial by increasing crop performance, there is always a need to establish relationships between soil chemical properties and soil capacity to produce food crops. Biofertilizers keep the soil environment rich in all kinds of micro- and macro-nutrients via nitrogen fixation, phosphate and potassium solubilization or mineralization, release of plant growth regulating substances, production of antibiotics and biodegradation of organic matter in the soil (Singh et al., 2014; Kumar et al., 2014). The need for this research is important in modern agriculture; because bio-fertilizers can have the ingredients needed by plants and can improve soil's physical, biological, and chemical properties.

The purpose of this study was to determine the influence of *Trichoderma viride* biostimulator powder and NPK fertilizers on soil organic carbon and available phosphorous.

Material and methods

A field trial was conducted at Usmanu Danfodiyo Fadama Teaching and Research Farm in Wamakko Local Government Area of Sokoto State. The State falls between the Sudan savanna agro-ecological zone of northwestern Nigeria, located on longitude 11°3 to 13°501 E and latitude 4° to 6°40' N. It covers a land area of 2,648.48 km^2 (Singh and Yakouba, 2000). There are two temperature extremes; the hot period (March to May) which is as high as 39°C and the cold harmattan months of December to January; when cold, dust-laden winds blow from across the Sahara bringing down the temperature to as low as 15°C (SERC, 2021). The experimental soil type is sandy loams to loamy sands in texture with a soil pH between 6.0 - 7.0 slightly acidic to neutral, and low levels of organic matter which affect their fertility and water-holding capacity and limited nutrient availability, particularly nitrogen, phosphorus, and potassium (Ojanuga, 1986; Adeoye et al., 2015).

The experiment consists of four (4) treatments. Soil samples were collected randomly using soil auger from the four plots at a depth of 0-30 cm which consisit of NPK fertilizer (120 kg/ha), *Trichoderma viride* (Biostimulator) (0.25 kg/ha) which was sourced from Nando Biological Products, Lithuania, combination of NPK Fertilizer + *Trichoderma viride* and Control (where no treatment was added) on a 3 m x 3 m plot size, two (2) weeks after treatment application. Treatments were applied in a randomized complete block design (RCBD) replicated three times. A total number of 10 subsamples were collected from each plot to make a composite sample.

Treatments were applied (inoculated) after mixing with 200 litres of water based on the recommended rate from the manufacturer (Nando Biological Products, Lithuania). Soil samples collected from treatments were then placed in sterile sample bags and labeled for laboratory analysis. Available phosphorus was determined by Bray II method according to the procedure of (Bray and Kurtz, 1945). Organic carbon was determined using the Walkley-Black wet combustion method (Walkley and Black, 1934). Total nitrogen was determined by the micro-Kjeldahl digestion technique (Bremner, 1996).

Statistical analyses

The collected data were subjected to descriptive statistics and ANOVA, mean separation was done using Least Significant Difference (LSD) at $P<0.05$ instead of Duncan because variances of the groups being compared are not equal. Duncan's test assumes that the variances of the groups being compared are equal. If this assumption is violated, the test may not be reliable and it may produce more Type I errors (false positives) than expected. This was computed using Statistical Package for Social Sciences (SPSS 22.0).

Results and discussion

The result of the influence of Biostimulator (*Trichoderma viride*), NPK fertilizer and combination of *Trichoderma viride* + NPK fertilizer on soil pH is presented in Table 1. Control has a pH value ranging from 6.98 – 7.52 with a mean value of 7.23. The treatment with the application of *Trichoderma viride* had pH value ranging from 6.83 – 7.02 with a mean value of 6.92. The treatment with the application of NPK fertilizer had pH value ranging from 6.34 – 6.55 with a mean value of 6.47 whereas the treatment applied with *Trichoderma viride* + NPK fertilizer had pH value ranging from 6.88 – 7.12 with a mean value of 7.04. There was significant ($p<0.05$) difference between the treatments because pH values were obtained in the control where no amendment was applied, *Trichoderma viride* and the treatment with *Trichoderma viride*+ NPK fertilizer was significantly higher ($p<0.05$) than the treatment with the application of NPK fertilizer. The result of pH values obtained ranged from 6.47 – 7.23. According to Chude et al. (2011), pH values from 6.1 – 6.5 are slightly acidic while values from 6.6 – 7.25 are neutral. Therefore, the results obtained indicate that pH was slightly acidic to neutral. According to USDA (1999), a pH range of 6.5 - 7.0 is generally most favorable for plant growth because most nutrients are easily available at this range. Although some plants have pH requirement above or below this average range, the pH value was considered ideal for most crops (Brady and Weil, 2002).

The result of the influence of *Trichoderma viride*, NPK fertilizer and combination of *Trichoderma viride* + NPK fertilizer on organic carbon is presented in Table 1. Control has an organic carbon value ranging from 0.53 – 0.70 g/kg with a mean value of 0.59 g/kg. *Trichoderma viride* had an organic carbon value ranging from 1.10 – 1.64 g/kg with a mean value of 1.29 g/kg. NPK fertilizer had an organic carbon value ranging from 0.98 – 1.14 g/kg with a mean value of 1.08 g/kg, whereas the combination of *Trichoderma viride* + NPK fertilizer had an organic carbon value ranging from 0.39 – 1.79 g/kg with a mean value of 1.50 g/kg. The combination of *Trichoderma viride* and NPK fertilizer was significantly ($p<0.05$) higher compared to other treatments. According to Esu (1991), organic carbon content is categorized as follows, <10 g/kg are low, 10 – 15 g/kg are medium whereas values >15 g/kg are high. Therefore, the results obtained indicate that organic carbon content was categorized as low. A similar result was reported by Mustapha and Nnalee (2007) who stated an average organic carbon contents in West African countries to be low (1.2 g/kg), while Singh (2002) reported a mean value of organic carbon content for soils of Sokoto (2 g/kg).

Table 1. Influence of *Trichoderma viride* and NPK fertilizer on Soil pH and Soil organic carbon under Sokoto Sudan Savanna

Treatment	pH (H2O) 1:1	Organic Carbon gkg^{-1}
Control	7.23a	0.59c
Trichoderma viride	6.92a	1.29ab
NPK fertilizer	6.47b	1.08b
Trichoderma viride + NPK fertilizer	7.04a	1.50a
SE	0.14	0.16
Sig.	*	*

Means within a column with different letter(s) are significantly different at p<0.05, SE= standard error.

The result of the influence of Bio NPK, NPK fertilizer and combination *Trichoderma viride* + NPK fertilizer on organic matter is presented in Figure 1. Control has an organic matter value ranging from 0.91 – 1.21 g/kg with a mean value of 1.02 g/kg. The treatment with the application of *Trichoderma viride* had an organic matter value ranging from 1.97 – 2.83 g/kg with a mean value of 2.22 g/kg. The treatment with the application of NPK fertilizer had an organic matter value ranging from 1.69 – 1.97 g/kg with a mean value of 1.86 g/kg, whereas the treatment applied with *Trichoderma viride* + NPK fertilizer had an organic matter value ranging from 0.67 – 1.36 g/kg with a mean value of 2.57 g/kg. Application of *Trichoderma viride* and NPK fertilizer is significantly ($p<0.05$) higher than the control. The high level of organic matter was attributed to the mycorrhizal fungi (*Trichoderma viride*) added as biostimulator in the soil amendments.

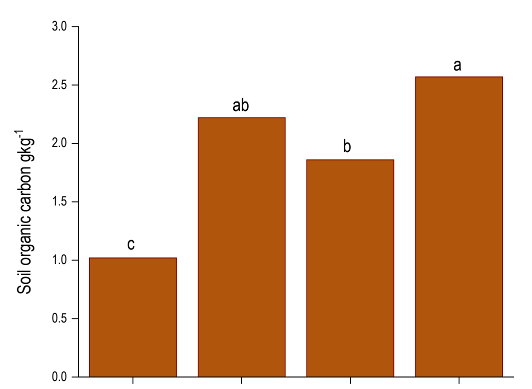

Figure 1. Effect of *Trichoderma viride* and NPK fertilizer on soil organic matter content

The result of the influence of Biostimulator (*Trichoderma viride*), NPK fertilizer and combination of *Trichoderma viride* + NPK fertilizer on total nitrogen is presented in Table 2. Controls have a total nitrogen value ranging from 0.003 – 0.005 g/kg with a mean value of 0.004 g/kg. The treatment with the application of *Trichoderma viride* had a total nitrogen value ranging from 0.001 – 0.003 g/kg with a mean value of 0.002 g/kg. The treatment with the application of NPK fertilizer had a total nitrogen value ranging from 0.003 – 0.005 g/kg with a mean value of 0.003 g/kg, whereas the treatment applied with *Trichoderma viride* + NPK fertilizer had a total nitrogen value ranging from 0.002 – 0.005 g/kg with a mean value of 0.004 g/kg. There was no significant (p>0.05) difference with the treatments in their total nitrogen value. According to Esu (1991), total nitrogen contents are categorized as follows, <0.1 g/kg are low, 0.1 – 0.2 g/kg are medium, whereas values >0.2 g/kg are high. Therefore, the results obtained indicate that total nitrogen contents (0.002 – 0.004 g/kg) are categorized as low. The result obtained is following Mustapha and Nnalee (2007) who reported that tropical soils are generally low (<0.1 g/kg) in their total nitrogen content.

The influence of *Trichoderma viride*, NPK fertilizer and *Trichoderma viride* + NPK fertilizer on available phosphorus is presented in Table 2. Available phosphorus value for control ranged from 0.89 – 0.96 mg/kg with a mean value of 0.91 mg/kg. The treatment with the application of *Trichoderma viride* had available phosphorus value ranging from 0.87 – 0.91 mg/kg with a mean value of 0.89 mg/kg. The treatment with the application of NPK fertilizer had an available phosphorus value ranging from 0.86 – 0.95 mg/kg with a mean value of 0.90 mg/kg, whereas the treatment applied with *Trichoderma viride* + NPK fertilizer had available phosphorus value ranging from 0.89 – 0.95 mg/kg with a mean value of 0.92 mg/kg. There was no significant (p<0.05) difference between the treatments. According to Esu (1991), available phosphorus is categorized as follows, <10 mg/kg are (low), 10 – 20 mg/kg are (medium) and >20 mg/kg are (high).

Table 2. Influence of *Trichoderma viride* and NPK fertilizer on Soil total Nitrogen and Available phosphorus under Sokoto Sudan Savanna

Treatment	Total Nitrogen	Available phosphorous
	gkg^{-1}	
Control	0.004	0.91
Trichoderma viride	0.002	0.89
NPK fertilizer	0.003	0.90
Trichoderma viride + NPK fertilizer	0.004	0.92
SE	0.001	0.03
Sig.	NS	NS

NS = not significant at p>0.05, SE= standard error.

The overall results obtained for available phosphorus in Table 2 ranged from 0.89 – 0.92 mg/kg with a mean of 0.90 mg/kg being categorized as low (Esu, 1991). The report is in agreement with the findings of Akirinde et al. (2005) who reported that extensive shortage of available phosphorus is observed in most Nigerian soils like what is found in other tropical regions of Africa. The low level of available phosphorus may be connected with the low organic carbon and organic matter content which is known to influence its availability. Low available phosphorus of 2.76 mg/kg was also reported by Mustapha and Nnalee (2007).

Conclusion

The results obtained from the study showed that mycorrhizal fungi (*Trichoderma viride*) was a beneficial microorganism that can influence soil pH, organic carbon and available phosphorus under Sokoto Sudan Savanna agroecological zone, Nigeria. Application of *Trichoderma viride* can greatly influence these soil chemical properties, making nutrients accessible which promotes their uptake in plants for growth and development. Therefore, sufficient quantity should be applied to the soils to maintain and improve nutrient availability.

References

Adeoye GO, Akinbola GE and Idowu OJ, 2015. Soil fertility status and nutrient requirements of maize in Dundaye Fadama soils of Nigeria. Journal of Soil Science and Environmental Management, 6, 1-9.

Adetunji CO and Varma A, 2020. Biotechnological application of trichoderma: A powerful fungal isolate with diverse potentials for the attainment of food safety, management of pest and diseases, healthy planet, and sustainable agriculture. Trichoderma: Agricultural Applications and Beyond, 257-285.

Akirinde EA, Bello OS, Ayebgoyin KO and Iron L, 2005. Added Benefits of Combined Organic and Mineral Phosphate Fertilizers Applied to Maize and Melon. Journal of Food, Agriculture and Environment, 13, 75-80.

Brady C and Weil R, 2002. The nature and properties of soils, 13th Pearson education (Singapore) Pte. Ltd. Indian Branch, 482, 621-624.

Bray RH and Kurtz LT, 1945. Determination of total, organic and available forms of phosphorus in soils. Soil Science, 59, 39-45.

Bremner JM, 1996. Nitrogen Total. In: Sparks, D.L., Ed., Methods of Soil Analysis Part 3: Chemical Methods, SSSA Book Series 5, Soil Science Society of America, Madison, Wisconsin, 1085-1122.

Chandra R and Singh SK, 2009. Fundamentals and management of soil quality, Westville Publishing House, New Delhi, November

Esu IE, 1991. Detailed Soil Survey of NIHORT FARM at Bunkure. Kano state, Nigeria, 72 pp.

Harman GE, Howell CR, Viterbo A, Chet I and Lorito M, 2004. Trichoderma species - opportunistic, avirulent plant symbionts. Nature Reviews Microbiology, 2, 43-56.

Havlin JL, Beaton JD, Tisdale SL and Nelson WL, 2010. Soil fertility and fertilizers, 7th edition, PHI Learning PVT Ltd, New Delhi.

Hazarika TK, and Aheibam B, 2019. Soil nutrients status, yield and quality of lemon (Citrus limon Burm) cv. 'Assam lemon' as influenced by bio-fertlizers, organics and inorganic fertilizers.

Heena NP, Lone R and Sumaira R, 2021. Chemical Fertilizers and Their Impact on Soil Health Microbiota and Biofertilizers, 2, 2021ISBN: 978-3-030-61009-8

Howell CR, 2003. Mechanisms employed by Trichoderma species in the biological control of plant diseases. Journal of Plant Diseases and Protection, 110, 353-364.

Karlen DL and Rice CW, 2015. Soil degradation: Will humankind ever learn? Sustainability, 7, 12490-12501.

Kaur T, Brar BS and Dhillon NS, 2008. Soil organic matter dynamics as affected by long-term use of organic and inorganic fertilizers under maize–wheat cropping system. Nutrient Cycling in Agroecosystems, 81, 59-69.

Kubátová A, Novák M, and Prášil K, 2015. Trichoderma spp. as decomposers of organic matter. In Trichoderma: Biology and Applications, pp. 157-174, Springer International Publishing.

Kumar S, Kumar V, and Sharma S, 2014. Trichoderma: A potent biofertilizer and biopesticide. Journal of Environmental Science and Health, Part B, 49, 537-546.

Mukesh S, Mohammad S, Sonika P, Vipul K, Anuradha S, Shubha T and Srivastava YK, 2015. Trichoderma: A scientific approach against soil borne pathogens. African Journal of Microbiology Research, 9, 2377-2384.

Mustapha S and Nnalee CC, 2007. Fertility and Salinity/Sodicity Status of Fadama soil in Jos Plateau State, Nigeria. Journal of Sustainable Development in Agriculture and Environmental, 3, 96-103.

Ojanuga AG, 1986. Soil survey and land evaluation of the Dundaye Fadama area, Nigeria. Soil Survey and Land Evaluation, 6, 1-15.

Rabie GH and Almadini AM, 2005. "Role of bioinoculants in development of salt-tolerance of Vicia faba plants under salinity stress". African Journal of Biotechnology, 4, 210-222.

Rillig MC, Mardatin NF, Leifheit EF and Antunes PM, 2010. Mycelium of arbuscular mycorrhizal fungi increases soil water repellency and is negatively related to mycorrhizal responsiveness. Soil Biology and Biochemistry, 42, 1250-1256.

SERC, 2021. Sokoto Energy Research Center (SERC) Rainfall, Temperature and Humidity Data Record Sheets.

Shoresh M, Harman GE, and Mastouri F, 2010. Induced systemic resistance and plant responses to fungal biocontrol agents. Annual Review of Phytopathology, 48, 21-43.

Singh BR and Yakouba M, 2000. Physico-chemical and hydraulic properties of the fadama soils in Sokoto-Rima River Basin. Department of Soil Science and Agricultural Engineering, Usman Danfodio University, Sokoto (unpublished data).

Singh BR, 2002. Constraints to Sustainable Crop Production in the Semi-Arid North West of Nigeria. Nigerian Journal of Agricultural and Rural Management, 7, 40-62.

Singh H, Verma A, Ansari MW and Shukla A, 2014. Physiological response of rice (Oryza sativa L.) genotypes to elevated nitrogen applied under field conditions. Plant Signal. Behav. 9, e29015.

Six J, Frey SD, Thiet RK, and Batten KM, 2006. Bacterial and fungal contributions to carbon sequestration in agroecosystems. Soil Science Society of America Journal, 70, 555-569.

USDA-NRCS, 1999. Liming to Improve Soil Quality in Acid Soils. Soil Quality- Agronomy Organic Matter and Modification of Chromic and Titration Methods. Soil Science Journal, 37, 29-38.

Walkley A and Black IA, 1934. An examination of the Degtjarett method for determining Soil organic matter and proposed modification of the chromic acid titration method. Soil Science, 37, 29-38.

Yadav A, Yadav K and Aggarwal A, 2015. Impact of arbuscular mycorrhizal fungi with *Trichoderma viride* and Pseudomonas fluorescens on growth, yield and oil content in *Helianthus annuus* L. Journal of Essential Oil Bearing Plants, 18, 444-454.