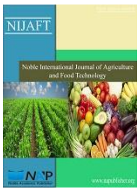
Noble International Journal of Agriculture and Food Technology
Vol. 01, No. 02, pp: 50-61, 2019

Published by Noble Academic Publisher
URL: www.napublisher.org



Original Article **Open Access**

COMBINE EFFECTS OF INDEGENEOUS MYCORRHIZA INOCULUMS AND SOIL NUTRIENT LEVELS FROM UNDER LOCUST BEAN (*PARKIA BIGLOBOSA*) AND TAMARIND (*TAMARINDUS INDICA*) ON CHLOROPHYLL CONTENTS OF SOME CEREAL AND LEGUME CROPS

Shuaibu Yunusa Muhammad[1*], **Toma Buba**[2]

[1*]Department of Crop Production, Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University, Bauchi, Nigeria
[2]Department of ecology, Faculty of Science, Abubakar Tafawa Balewa University, Bauchi, Nigeria

ABSTRACT: The study was carried out to find the effects of mycorrhizal soil inoculums from under trees Parkia biglobosa and Tamarindus indica on leaf chlorophyll contents of some cereal and legume crops. The result of the study revealed that, mycorrhizal soil from T. indica positively improves chlorophyll contents of maize in the high nutrient soil ($P = 0.014$), millet in the low nutrient soil ($P = 0.004$) and soybean in the medium ($P = 0.000$) and low ($P = 0.000$) nutrient soil. Soils of both T. indica and P. biglobosa showed no effects on chlorophyll content of maize in both medium ($P = 0.137$) and the low ($P = 0.067$) nutrient soils. Additionally, they show no effects on the leaf chlorophyll contents of sorghum in both high and medium nutrient soils ($P = 0.439$ and $P = 0.075$, respectively) and the same with millet ($P = 0.608$ and $P = 0.252$, respectively). Mycorrhizal soils of both the P. biglobosa and T. indica did not affects the chlorophyll contents of cowpea in the high, medium and low nutrient soils ($P = 0.052$, $P = 0.084$ and $P = 0.085$, respectively) and the same with groundnut ($P = 0.245$, $P = 0.306$, and $P = 0.180$, respectively). Both T. indica and P. biglobosa soils negatively affect chlorophyll contents of sorghum in the low nutrient soil ($P = 0.030$). To exploits the maximum benefits of these mycorrhizas in crop production in the savanna, more complex and extensive research is required.

Keywords: Maize, Chlorophyll, Leaf, Mycorrhizal, Savannah.

1. INTRODUCTION

Agriculture is the dominant occupation in the developing countries, which involves major socioeconomic and cultural activities. The vast majority of people particularly in sub-Saharan Africa depend on rain-fed agriculture for their livelihoods [1]. Paradoxically, food insecurity and malnutrition is a norm in this region, with millions of poor people often being afflicted [1-3]. Unfortunately, many environmental issues pose a lot of constrains to agricultural production which perpetuate food crisis among the populace. Such environmental issues are mainly climatic change-induced drought and soil nutrient deficiency as a result of soil nutrient mining by continuous cultivation with low supply of fertilizer [4-6].

The mycorrhizas are mutualistic associations between higher roots and specific soil macro-fungi that significantly improve the absorption of water and nutrients by the plant and also provide protection from root pathogens [7]. They colonize the plants' roots biotrophically and develop an extramatrical mycelium that helps the plants to acquire mineral nutrients and soil water more efficiently. The fungus in the other hand gets photosynthates from the plant. These greatly influence the survival, growth and establishment of crops, especially during drought and in nutrient deficient soils [8, 9] thereby increases crop productivity in degraded agricultural systems [4, 10, 11]. However, the effectiveness of this relationship depends on local environmental factors and time [12-14]. Some plant species may perceive a particular mycorrhizal fungus as antagonists. The effect of mycorrhizal fungi on plant growth also depends on other environmental factors. When soil water and fertility are not limited, usually there is no benefit, and plant growth can even be slightly reduced in the presence of mycorrhizal fungi due to demand of photosynthetic assimilates. It is also reported that a mycorrhizal fungus may be mutualistic with one host plant species but parasitic on another [7, 10, 15].

The most suitable mycorrhizal inoculants to be used are controlled ectomycorrhization. This is the used of pure culture of fungal mycelia or spores of specific compatible mycorrhiza. However, controlled mycorrhization method is relatively complex and is associated with so many challenges, especially that of ectomycorrhizas fungi. These include slowness of growth; contamination by plant pathogens and any free-living microorganisms; accumulation of toxic metabolites; loss of viability and infectivity; insufficient knowledge biochemistry, physiology of many ectomycorrhizal fungi; difficulty in application; and financial implication of production cost. These restrict large-scale production which is usually essential for practical applications by the general populace [7, 9]. Moreover, laboratory production of pure culture and experimental results may be far from reality in the because of interaction with other soil organisms and physical environmental cues [13, 16]. For these reasons, the use of mycorrhizas in agriculture and forestry is rarely applied especially in the developing countries. Fortunately, mycorrhizal soil inoculants (a method by which thin layer of soil obtained from under trees and mixed with the planting soil or growth substrate) is easy and by far cheaper way of obtaining the desired mycorrhizal benefits. It also has the advantage of inoculating the seedlings with fungal strains that are adapted to the specific environment that it will experience. However, there are also problems associated with this type of mycorrhizal inoculants. It requires large amounts of soil and the risk of introducing plant pathogens and weeds. In addition, the fungal species that are being introduced and their infection potential are not known for academic records. However, mycorrhizal soil inoculants are still recommended where other method are not possible, notably developing countries [7]. The aim of this study is to find the effects of mycorrhizal soil inoculum from under trees *Parkia biglobosa* and *Tamarindus indica* on chlorophyll contents of some legume and cereal crops under different levels of soil nutrient status.

2. METHODOLOGY

The experiment was conducted during the dry season of 2018 at the screen house of Biological science department of the Abubakar Tafawa Balewa Univeraity, Bauchi. (10.263954° N, 9.811298° E) in the savannah region of Nigeria. The experimental soil was collected from intensively cultivated land with poor nutrient status and a soil from domestic waste dump (municipal waste) and sterilized for one hour to sterilize. Soils as source of mycorrhizae inoculums were collected under trees *Parkia biglobosa* and *Tamarindus indica* of the bigger size as suggested by [7]. The soil was collected at four different points under four individual of each of the tree species at a distance of 2 meters from the trunk but within the canopy zone at a depth of 0-10 cm. The seeds of maize (EVDT), sorghum (CRS-01), cowpea (KANANNADO), soybean (TGX1448-2E) and groundnut (SAMNUT 24) were obtained from seed multiplication unit of Bauchi state Agricultural Development Programme (BSADP). The seeds were surface sterilized in a 30% hydrogen peroxide (H_20_2) solution for 15 minutes and then thoroughly rinse with three changes of sterile water as suggested by [17]. The experimental soils were prepared into three different types, such that they have different levels of soil nutrients status. One contained a mixture of top soil and waste dump soil in the ratio of 3:1 (nutrient rich soil); the second contained the mixture of the top soil and waste dump soil in the ratio of 6:1 (medium nutrient soil); and the third one was purely the top soil without any amendment with the waste dump soil (low nutrient soil). One kilogram of each of the soil was placed in a plastic pot [17]. On top of the soil inside the pot, four table spoonful of the treatment soils (soils from under trees, either *Parkia biglobosa* or *Tamarindus indica*) was placed. For the control pots, a sterile soil was used to avoid any mycorrhiazal propagules that may be present. Four to five seeds of each of the crops were planted on the treatment soils inside the pots and then covered with about 2 cm of the same corresponding experimental soil. These were laid out in a completely randomized design (CRD) repeated eight times. After emergence, the plants were thinned to two stands per hill and were irrigated twice a week throughout the study period. Data on chlorophyll content was collected at six weeks of emergence using TYS-A Plant Chlorophyll Meter. All data collected were subjected to analysis of variance (ANOVA) followed by Tukey Multiple Comparisons of means using a *Minitab*® *18*.1 statistical software.

3. RESULT

3.1. Effects of Mycorrhizal Soil Inoculation From Under Parkia Biglobosa and Tamarindus Indica on Leaf Chlorophyll Contents of Maize

In the high nutrient soil (3:1, waste dump/top soil ratio), plants that were inoculated with mycorrhizae soil from under *Tamarindus indica* have significantly ($P = 0.014$) more chlorophyll contents than plants inoculated with mycorrhizae soil from under *Parkia biglobosa* and the control (Table 1). In the medium nutrient soil (6:1, waste dump/top soil ratio), there was no significant difference ($P = 0.137$) between the treatments and the control, although the mean chlorophyll contents of the treatments were slightly higher than the control. While in the low nutrient soil (top soil) the mean chlorophyll contents of plants inoculated with *T. indica* soil and the control were more than twice greater than plants inoculated with *P. biglobosa* soil. However, this difference is not statically significant (*P* = 0.067) (Figure 2).

Table 1. Analysis of Variance for chlorophyll contents of maize grown on soils with different nutrient status inoculated with ectomycorrhizae spores from soils under trees, *Parkia biglobosa* and *Tamarindus indica.* Significance level: α = 0.05.

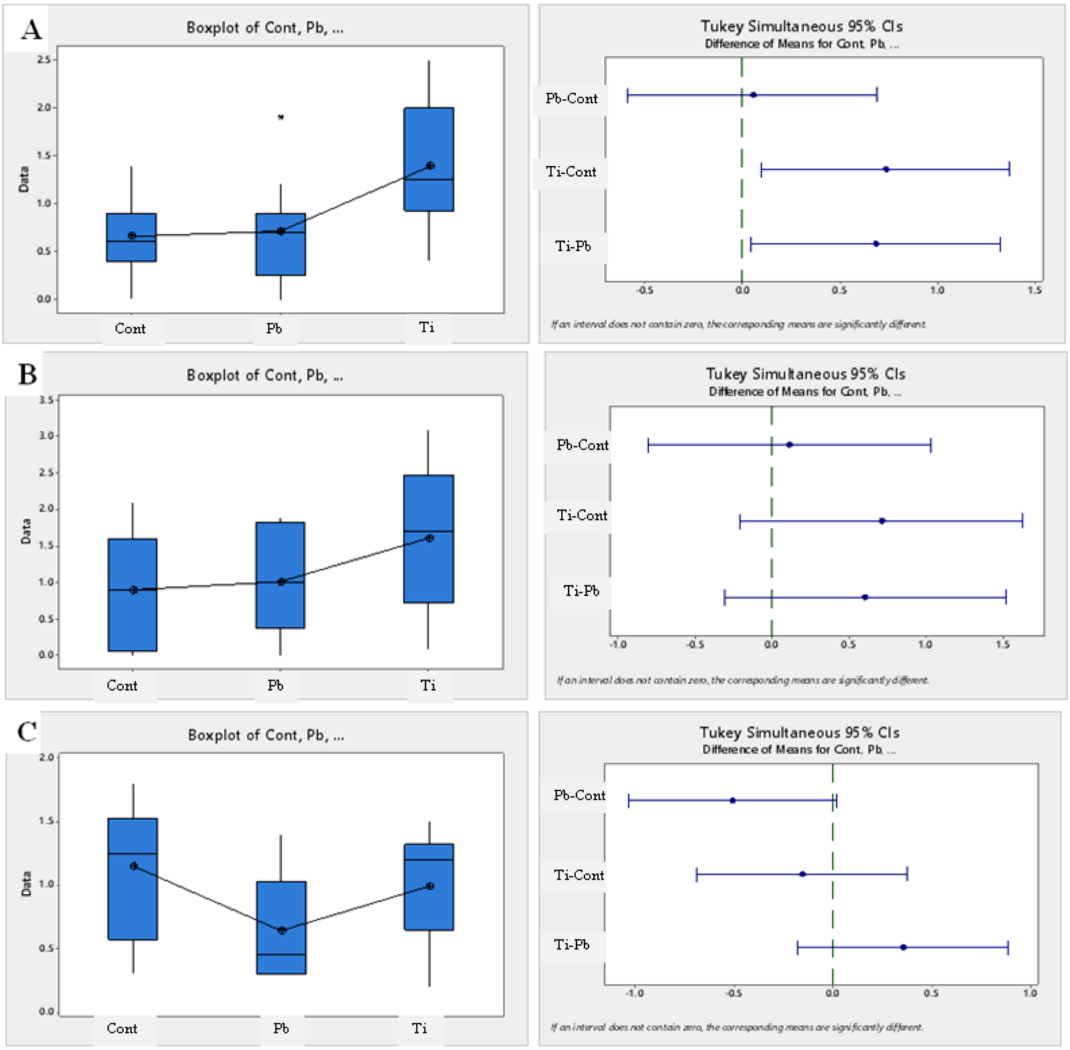
Soil Type*	Variable	N	Mean	SE Mean	StDev	Variance	Min	Max	*F*-Value	*P*-Value	TPC**
Soil 3:1	Control	10	0.760	0.165	0.523	0.274	0.000	1.700	5.07	0.014	B
	P. biglobosa	10	0.710	0.175	0.553	0.305	0.000	1.900			B
	T. indica	10	1.390	0.227	0.717	0.514	0.400	2.500			A
Soil 6:1	Control	10	0.900	0.237	0.748	0.560	0.000	2.100	2.14	0.137	C
	P. biglobosa	10	1.010	0.224	0.709	0.503	0.000	1.900			C
	T. indica	10	1.610	0.314	0.992	0.983	0.100	3.100			C
Top Soil	Control	10	1.130	0.158	0.499	0.249	0.300	1.800	2.99	0.067	D
	P. biglobosa	10	0.560	0.128	0.406	0.165	0.000	1.400			D
	T. indica	10	1.260	0.154	0.486	0.236	0.200	1.900			D

Source: Field experiment, 2018

*Ratio between top soil and waste dump soil: Soil 3:1 = high nutrient soil; Soil 6:1 = medium nutrient soil and Top soil = low nutrient soil.

** Tukey Pairwise Comparisons test. Means that do not share a letter are significantly different.

Figure 1. Box Plots and their corresponding Interval Plots of Analysis of Variance for chlorophyll contents of maize grown in different soils with different source of ectomycorrhizae spores. Soil type (top soil/waste dump soil ratio): A = 3:1 (high nutrient); B = 6:1 (medium nutrient); C = top soil (low nutrient). If an interval does not contain zero, the corresponding means are significantly different.



Source: Field experiment, 2018

3.2. Effects of Mycorrhizal Soil inoculation From Under *Parkia Biglobosa* and *Tamarindus Indica* on Leaf Chlorophyll Contents of Guinea Corn

There was no significant difference between the mean chlorophyll contents of plants inoculated with *T. indica* and *P. biglobosa* soils and the control in both the high and medium nutrient soils (P = 0.439 and P = 0.075, respectively), but mean chlorophyll contents of the treatments were slightly higher in the high nutrient soils (Table 2). In the medium nutrient soil, plants inoculated with *T. indica* soil show slightly higher chlorophyll contents than both plants of the *P. biglobosa* soils and the control, while the control performed little better than *P. biglobosa* soils. In the low nutrient soil, the mean chlorophyll contents of plants in the control was significantly (P = 0.030) more than both plants inoculated with the *T. indica* and *P. biglobosa* soils. While the mean chlorophyll contents of plants of *T. indica* soil was significantly (P = 0.030) more than that of *P. biglobosa* (Figure 2).

Table 2. Analysis of Variance for chlorophyll contents of sorghum grown in soils with different nutrient status inoculated with ectomycorrhizae spores from soils under trees, *Parkia biglobosa* and *Tamarindus indica*. Significance level: α = 0.05.

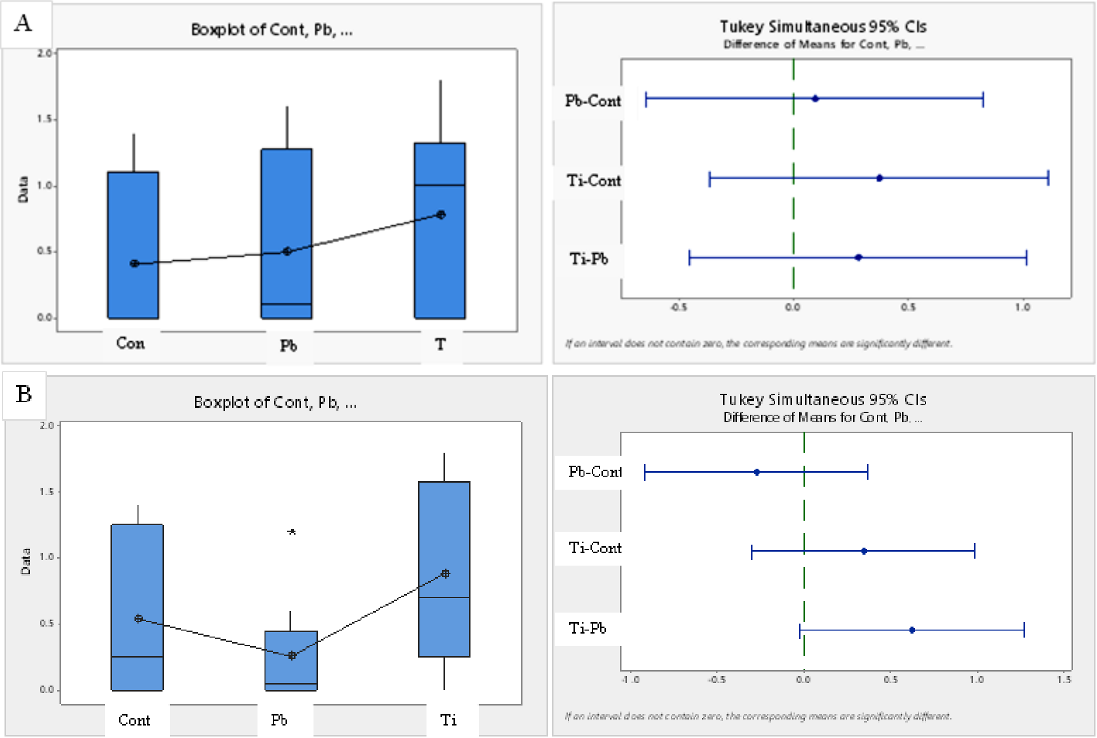
Soil Type*	Variable	N	Mean	SE Mean	StDev	Variance	Min	Max	F-Value	P-Value	TPC**
Soil 3:1	Control	10	0.410	0.192	0.608	0.370	0.000	1.400	0.85	0.439	A
	P. biglobosa	10	0.500	0.211	0.668	0.447	0.000	1.600			A
	T. indica	10	0.780	0.224	0.707	0.500	0.000	1.800			A
Soil 6:1	Control	10	0.540	0.189	0.599	0.358	0.000	1.400	2.86	0.075	B
	P. biglobosa	10	0.260	0.124	0.392	0.154	0.000	1.200			B
	T. indica	10	0.880	0.224	0.707	0.500	0.000	1.800			B
Top Soil	Control	10	0.630	0.163	0.514	0.265	0.000	1.300	4.01	0.030	D
	P. biglobosa	10	0.110	0.072	0.228	0.052	0.0000	0.700			DE
	T. indica	10	0.490	0.150	0.475	0.225	0.000	1.300			E

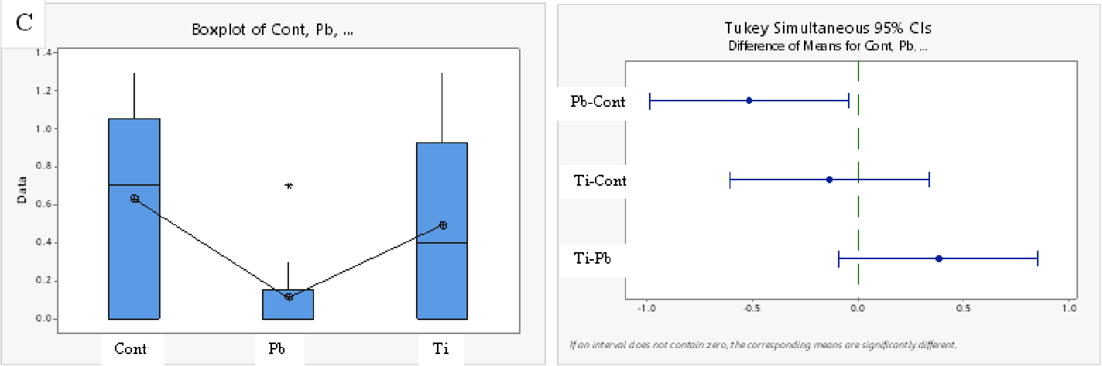
Source: Field experiment, 2018

*Ratio between top soil and waste dump soil: Soil 3:1 = high nutrient soil; Soil 6:1 = medium nutrient soil and Top soil = low nutrient soil.

** Tukey Pairwise Comparisons test. Means that do not share a letter are significantly different.

Figure 2. Box Plots and their corresponding Interval Plots of Analysis of Variance for chlorophyll contents of sorghum grown in different soils with different source of ectomycorrhizae spores. Soil type (top soil/waste dump soil ratio): A = 3:1 (high nutrient); B = 6:1 (medium nutrient); C = top soil (low nutrient). If an interval does not contain zero, the corresponding means are significantly different.





Source: Field experiment, 2018

3.3. Effects of Mycorrhizal Soil Inoculation From Under *Parkia Biglobosa* and *Pamarindus Indica* on Leaf Chlorophyll Contents of Millet

In millet, there was no significant difference between the mean chlorophyll contents of plants inoculated with *T. indica* and *P. biglobosa* soils and the control in both the high and medium nutrient soils (*P* = 0.608 and *P* = 0.252, respectively). However, but in both cases (high and medium nutrient soils) mean chlorophyll contents of the plant treated with *T. indica* soil and the control were higher than that of plants treated with *P. biglobosa* soils (Table 3). In the low nutrient soil, the mean chlorophyll contents of plants treated with *T. indica* soil was significantly (*P* = 0.004) higher than both plants inoculated with the *P. biglobosa* soils and the control. Also, the control performed better than plants of the *P. biglobosa* soils, although statistically not significant (Figure 3).

Table 3. Analysis of Variance for chlorophyll contents of millet grown in soils with different nutrient status inoculated with ectomycorrhizae spores from soils under trees, *Parkia biglobosa* and *Tamarindus indica*. Significance level: α = 0.05.

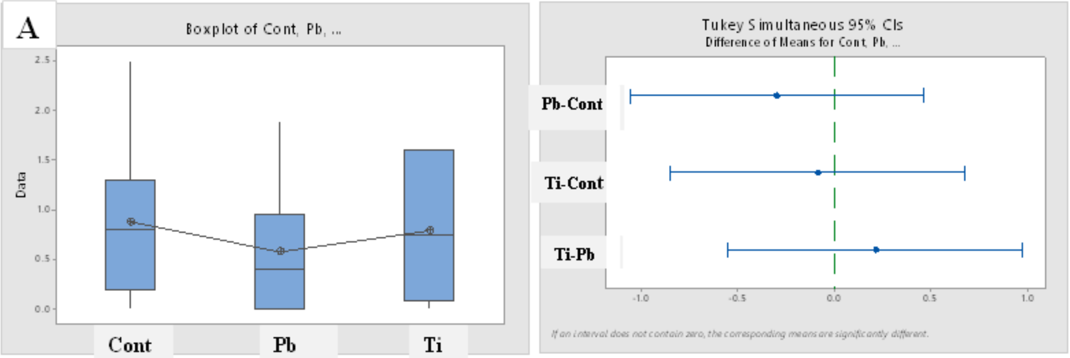
Soil Type*	Variable	N	Mean	SE Mean	StDev	Variance	Min	Max	F-Value	P-Value	TPC **
SOIL 3:1	Control	10	0.880	0.239	0.755	0.571	0.000	2.500	0.51	0.608	A
	P. biglobosa	10	0.580	0.192	0.607	0.368	0.000	1.900			A
	T. indica	10	0.790	0.216	0.682	0.465	0.000	1.600			A
Soil 6:1	Control	10	0.700	0.156	0.494	0.244	0.000	1.500	1.45	0.252	B
	P. biglobosa	10	0.400	0.140	0.442	0.196	0.000	1.100			B
	T. indica	10	0.780	0.197	0.623	0.388	0.000	1.800			B
Top Soil	Control	10	0.350	0.116	0.366	0.134	0.000	1.200	6.83	0.004	C
	P. biglobosa	10	0.160	0.108	0.341	0.116	0.000	0.900			C
	T. indica	10	0.990	0.241	0.762	0.581	0.000	2.200			D

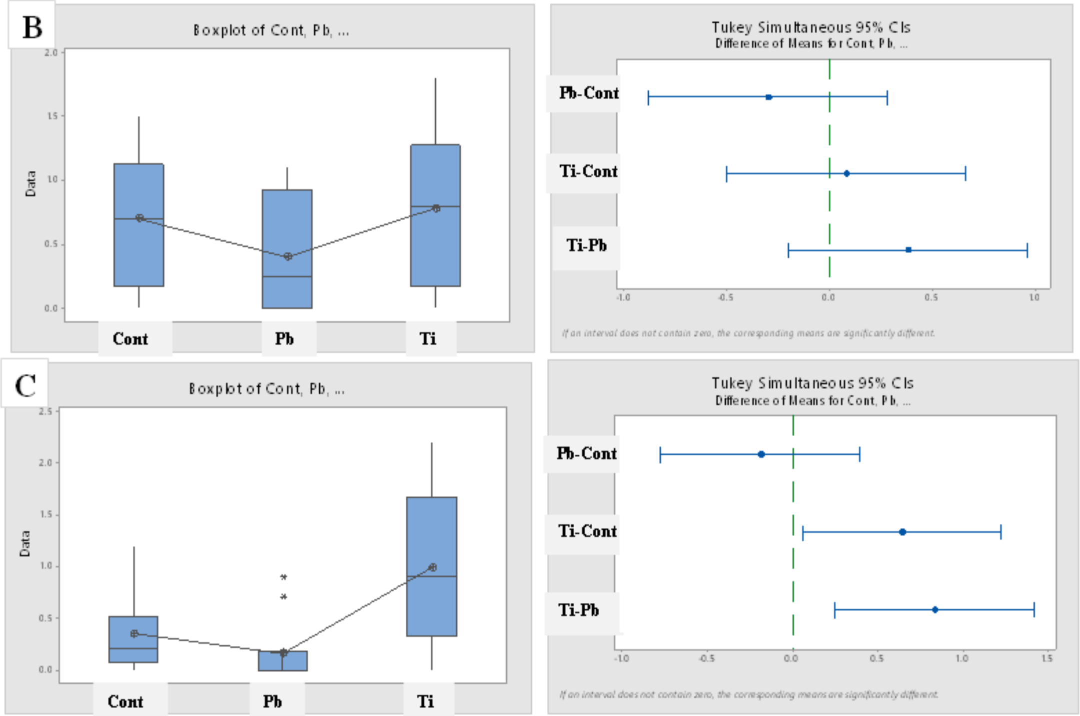
Source: Field experiment, 2018

*Ratio between top soil and waste dump soil: Soil 3:1 = high nutrient soil; Soil 6:1 = medium nutrient soil and Top soil = low nutrient soil.

** Tukey Pairwise Comparisons test. Means that do not share a letter are significantly different.

Figure 3. Box Plots and their corresponding Interval Plots of Analysis of Variance for chlorophyll contents of millet grown in different soils with different source of ectomycorrhizae spores. Soil type (top soil/waste dump soil ratio): A = 3:1 (high nutrient); B = 6:1 (medium nutrient); C = top soil (low nutrient). If an interval does not contain zero, the corresponding means are significantly different.





Source: Field experiment, 2018

3.4. Effects of Mycorrhizal Soil Inoculation From Under *Parkia Biglobosa* and *Pamarindus Indica* on Leaf Chlorophyll Contents of Cowpea

There was no significant difference between the mean chlorophyll contents of plants treated with *T. indica* and *P. biglobosa* soils and the control in both the high, medium and low nutrient soils (*P* = 0.245, *P* = 0.306, and *P* = 0.180, respectively) (Table 4). However, mean chlorophyll contents of plants inoculated with *P. biglobosa* soils were slightly lower than plants inoculated *T. indica* soil and the control in the low and medium nutrient soil, but slightly higher in the high nutrient soils (Figure 4).

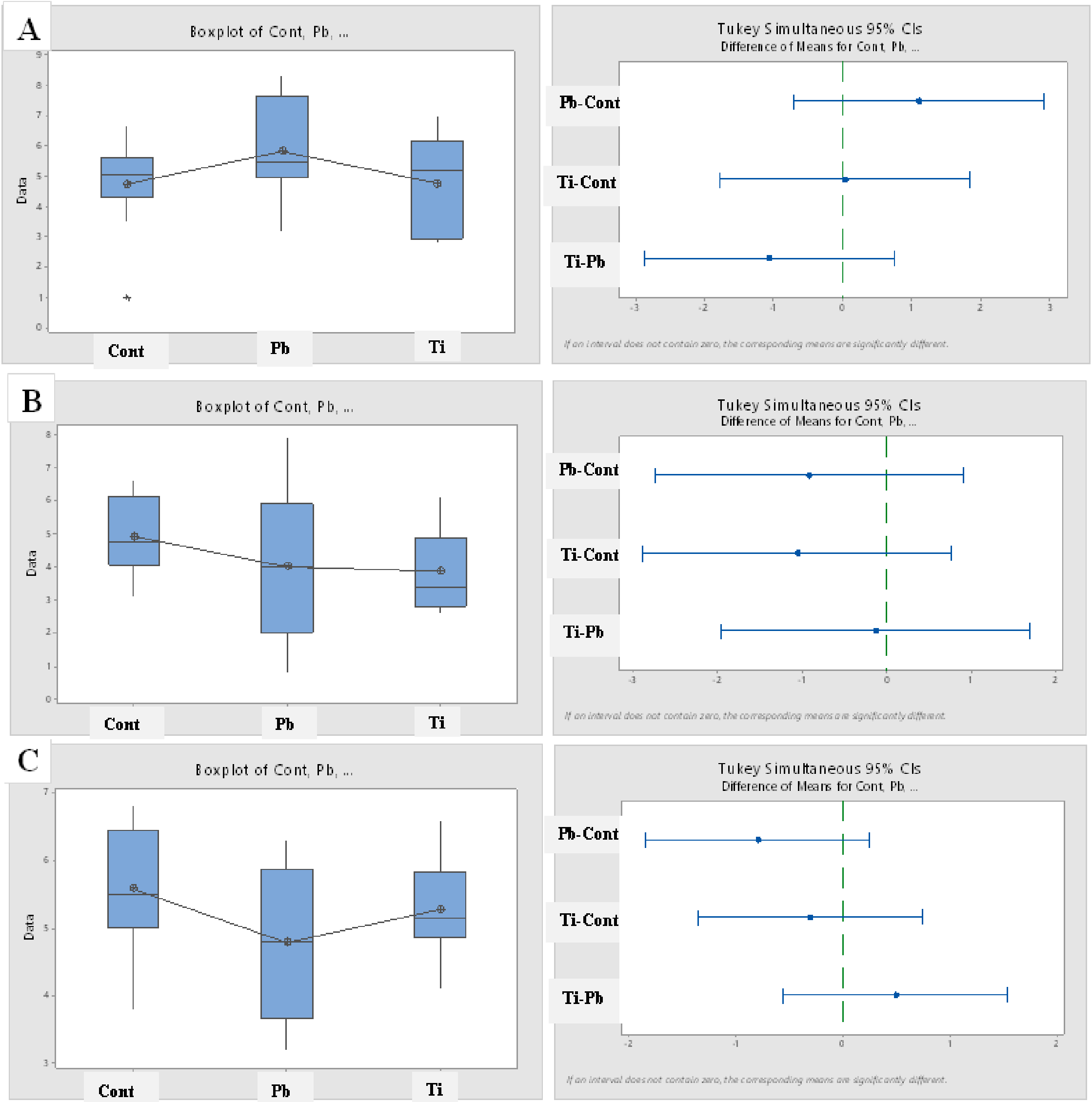
Table 4. Analysis of Variance for chlorophyll contents of cowpea grown in soils with different nutrient status inoculated with ectomycorrhizae spores from soils under trees, *Parkia biglobosa* and *Tamarindus indica*. Significance level: α = 0.05.

Soil Type*	Variable	N	Mean	SE Mean	StDev	Variance	Min	Max	F-Value	P-Value	TPC**
SOIL 3:1	Control	10	4.740	0.501	1.584	2.509	1.000	6.700	1.48	0.245	A
	P. biglobosa	9	5.833	0.562	1.687	2.845	3.200	8.300			A
	T. indica	10	4.770	0.542	1.715	2.940	2.800	7.000			A
Soil 6:1	Control	10	4.010	0.725	2.291	5.250	0.800	7.900	1.24	0.306	B
	P. biglobosa	10	3.870	0.393	1.243	1.545	2.600	6.100			B
	T. indica	10	4.930	0.354	1.120	1.253	3.100	6.600			B
Top Soil	Control	10	5.590	0.312	0.986	0.972	3.800	6.800	1.83	0.180	C
	P. biglobosa	10	4.790	0.339	1.071	1.148	3.200	6.300			C
	T. indica	10	5.280	0.234	0.741	0.548	4.100	6.600			C

Source: Field experiment, 2018

*Ratio between top soil and waste dump soil: Soil 3:1 = high nutrient soil; Soil 6:1 = medium nutrient soil and Top soil = low nutrient soil.
** Tukey Pairwise Comparisons test. Means that do not share a letter are significantly different.

Figure 4. Box Plots and their corresponding Interval Plots of Analysis of Variance for chlorophyll contents of cowpea grown in different soils with different source of ectomycorrhizae spores. Soil type (top soil/waste dump soil ratio): A = 3:1 (high nutrient); B = 6:1 (medium nutrient); C = top soil (low nutrient). If an interval does not contain zero, the corresponding means are significantly different.



Source: Field experiment, 2018

3.5. Effects of Mycorrhizal Soil Inoculation From Under *Parkia Biglobosa* and *Pamarindus Indica* on Leaf Chlorophyll Contents of Soybean

The mean chlorophyll contents of plants inoculated with *T. indica* and *P. biglobosa* soils and the control show no significant difference between in the high nutrient soils (*P* = 0.041), the difference was significant in the and medium and low nutrient soils with *P* = 0.000 in both (Table 5). The plant treated with *T. indica* soil performed better than plants treated with *P. biglobosa* soils and the control. While in the low nutrient soil, the control performed better than both plants treated with *P. biglobosa* and *T. indica* soils. In all the three soil types, mean chlorophyll contents of plants inoculated with the *P. biglobosa* soils were lower than both than plants of treated with *T. indica* soils and the control (Figure 5).

Table 5. Analysis of Variance for chlorophyll contents of soybean grown in soils with different nutrient status inoculated with ectomycorrhizae spores from soils under trees, *Parkia biglobosa* and *Tamarindus indica.* Significance level: α = 0.05.

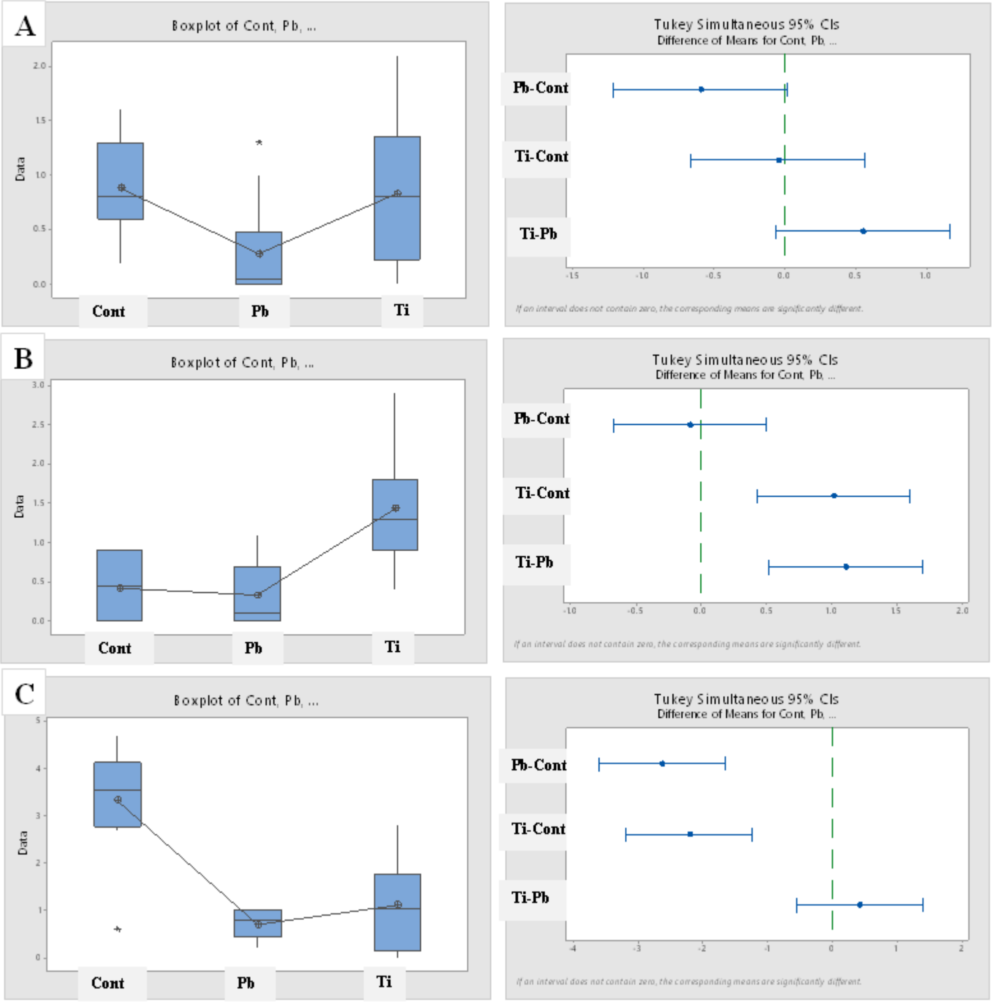
Soil Type*	Variable	N	Mean	SE Mean	StDev	Variance	Min	Max	F-Value	P-Value	TPC**
SOIL 3:1	Control	10	0.890	0.155	0.491	0.241	0.200	1.700	3.60	0.041	A
	P. biglobosa	10	0.280	0.150	0.473	0.224	0.000	1.300			A
	T. indica	10	0.830	0.218	0.690	0.476	0.000	2.100			A

Soil 6:1	Control	10	0.420	0.126	0.399	0.160	0.000	0.900	13.40	0.000	B
	P. biglobosa	10	0.330	0.136	0.430	0.185	0.000	1.100			B
	T. indica	10	1.430	0.222	0.701	0.491	0.400	2.900			C
Top Soil	Control	10	3.330	0.368	1.164	1.356	0.600	4.700	25.84	0.000	D
	P. biglobosa	10	0.7000	0.0919	0.2906	0.0844	0.2000	1.0000			E
	T. indica	10	1.120	0.296	0.937	0.877	0.000	2.800			E

Source: Field experiment, 2018

*Ratio between top soil and waste dump soil: Soil 3:1 = high nutrient soil; Soil 6:1 = medium nutrient soil and Top soil = low nutrient soil.
** Tukey Pairwise Comparisons test. Means that do not share a letter are significantly different.

Figure 5. Box Plots and their corresponding Interval Plots of Analysis of Variance for chlorophyll contents of soybean grown in different soils with different source of ectomycorrhizae spores. Soil type (top soil/waste dump soil ratio): A = 3:1 (high nutrient); B = 6:1 (medium nutrient); C = top soil (low nutrient). If an interval does not contain zero, the corresponding means are significantly different.



Source: Field experiment, 2018

3.6. Effects of Mycorrhizal Soil Inoculation From Under *Parkia Biglobosa* and *Pamarindus Indica* on Leaf Chlorophyll Contents of Groundnut

There was no significant difference between the mean chlorophyll contents of plants inoculated with *T. indica* and *P. biglobosa* soils and the control in both the high, medium and low nutrient soils (*P* = 0.052, *P* = 0.084 and *P* = 0.085, respectively). However, in both the high, medium and low nutrient soils mean chlorophyll contents of the plants with *P. biglobosa* soils treatment were lower (Table 6). While in the medium nutrient and low nutrient soils, plants inoculated with *T. indica* soil show slightly higher chlorophyll contents than both the control and plants inoculated with the *P. biglobosa* soils (Figure 6).

Table 6. Analysis of Variance for chlorophyll contents of groundnut grown in soils with different nutrient status inoculated with ectomycorrhizae spores from soils under trees, *Parkia biglobosa* and *Tamarindus indica.* Significance level: α = 0.05.

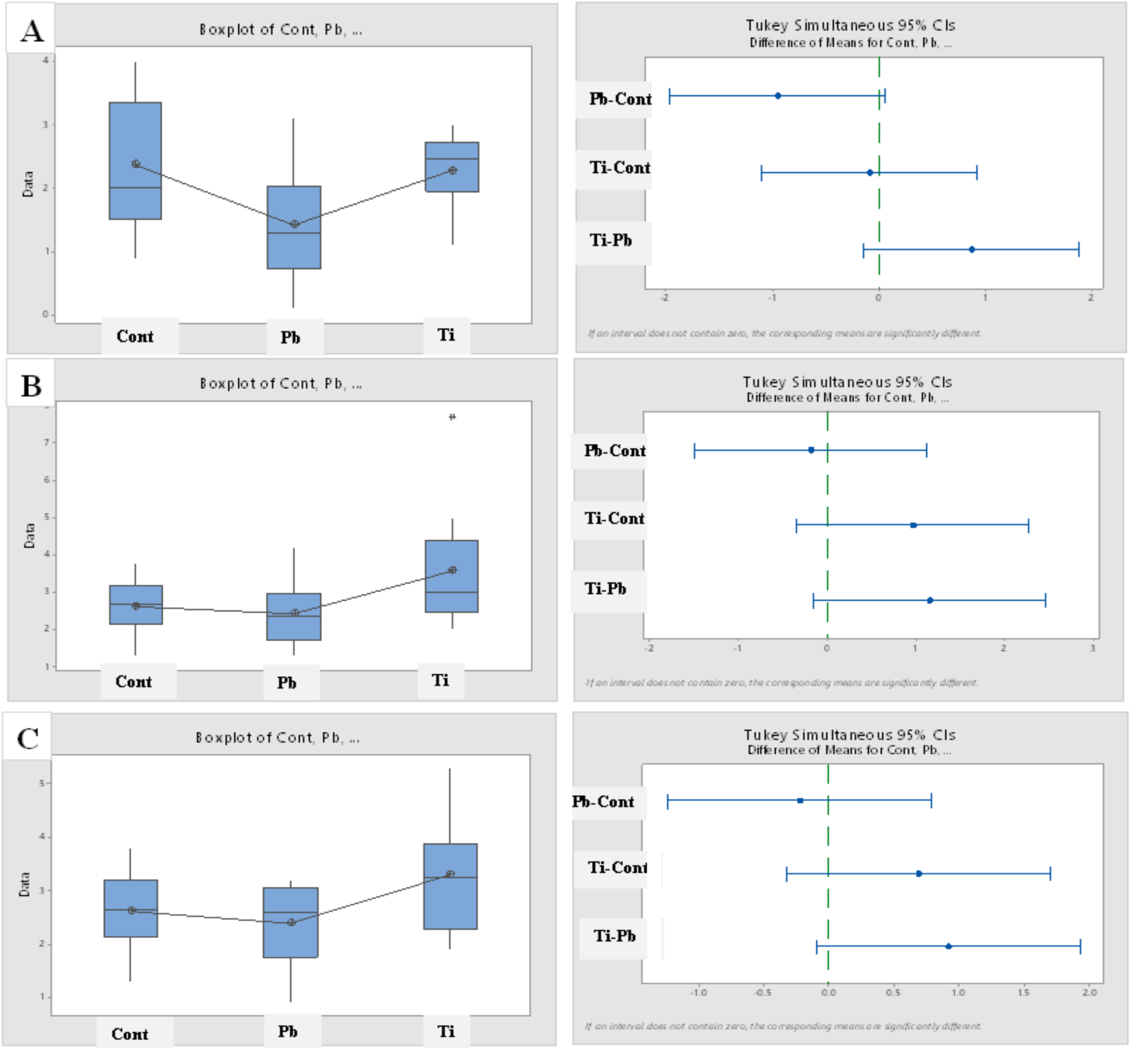
Soil Type*	Variable	N	Mean	SE Mean	StDev	Variance	Min	Max	F-Value	P-Value	TP C**
SOIL 3:1	Control	10	2.370	0.334	1.057	1.118	0.900	4.000	3.32	0.052	A
	P. biglobosa	10	1.420	0.319	1.008	1.015	0.100	3.100			A
	T. indica	10	2.280	0.188	0.596	0.355	1.100	3.000			A
Soil 6:1	Control	10	2.620	0.234	0.739	0.546	1.300	3.800	2.73	0.084	B
	P. biglobosa	10	2.430	0.270	0.854	0.729	1.300	4.200			B
	T. indica	10	3.580	0.539	1.705	2.908	2.000	7.700			B
Top Soil	Control	10	2.620	0.234	0.739	0.546	1.300	3.800	2.70	0.085	C
	P. biglobosa	10	2.390	0.251	0.794	0.630	0.900	3.200			C
	T. indica	10	3.300	0.362	1.145	1.311	1.900	5.300			C

Source: Field experiment, 2018

*Ratio between top soil and waste dump soil: Soil 3:1 = high nutrient soil; Soil 6:1 = medium nutrient soil and Top soil = low nutrient soil.

** Tukey Pairwise Comparisons test. Means that do not share a letter are significantly different.

Figure 6. Box Plots and their corresponding Interval Plots of Analysis of Variance for chlorophyll contents of groundnut grown in different soils with different source of ectomycorrhizae spores. Soil type (top soil/waste dump soil ratio): A = 3:1 (high nutrient); B = 6:1 (medium nutrient); C = top soil (low nutrient). If an interval does not contain zero, the corresponding means are significantly different.



Source: Field experiment, 2018

4. DISCUSSION

The results of this study found that, plant's responses in terms of leaf chlorophyll contents to mycorrhizal soil inoculums from under *Parkia biglobosa* and *Tamarindus indica* differs with different soil nutrient status. Depending on the plant-soil type combination, the effect of mycorrhizal soil inoculums on the leaf chlorophyll contents can be positive, negative or neutral. This is in line with many other reports that mycorrhizal fungi differ in their ability to colonize roots of different plants species and their benefits are also variable [7]. Different plant species were found to respond in different ways to different mycorrhizas as they differ in their compatible [16]. Mycorrhizal soil inoculums from under *Tamarindus indica* indicate positive results on the leaf chlorophyll contents of maize, millet and soybean. Mycorrhizal soil from under *Tamarindus indica* positively improves chlorophyll contents of maize in the high nutrient soil but had no effects on the maize plants grown in the medium and low nutrient soils. This is contrary to most studies, which revealed that the effects of mycorrhizas on plant performance are more pronounce in nutrient deficient soils [8, 9]. According to [18], mycorrhizas can have even a negative effects on plants growing in high nutrient soils. However, *T. indica* soil significantly improved the leaf chlorophyll contents of the millet in the low nutrient soil; and soybean in the medium nutrient soil. This supports other findings that the effectiveness of plant-mycorrhizal mutualistic relationship depends on environmental factors. When soil water and fertility are optimal for the growth of plant in question, usually there is no benefits of mycorrhizal relationship; and in some plants, it may slightly reduce growth due to demand of photosynthetic assimilates by the mycorrhizal fungi [12, 14]. Also, [18] noted that while some mycorrhizas mutualistic, others are clearly competitive.

This study also revealed that, mycorrhizal soils of both *T. indica* and *P. biglobosa* showed no effects on the leaf chlorophyll contents of maize in both the medium nutrient and the low nutrient soils. Additionally, there was no effects on the leaf chlorophyll contents of sorghum and millet in both the high and medium nutrient soils. Moreover, mycorrhizal soils of both the *P. biglobosa* and *T. indica* did not affects the leaf chlorophyll contents of cowpea and ground in all the soil types - high, medium and low nutrient soils. [19] and [20] noted that mycorrhizal fungi differ in their host specificity and abilities to promote the growth via efficient nutrients acquisition. In soybean and sorghum, both the *P. biglobosa* and *T. indica* mycorrhizal soils negatively affected the leaf chlorophyll contents of the plants, with the *P. biglobosa* soils being the worst. Many other studies reported that mycorrhizal fungi may suppress performance of some plants and in some cases they may even reduce growth in one plant species but promote the growth of others [16]. According to [21], there is a continuum from the mutualistic to the parasitic relationships between plants and mycorrhizas. Also, fluctuations of soil conditions may affect a given plant-mycorrhiza association to oscillate from mutualism-neutrality-parasitism gradient. This means that the benefits in the relationship may be quantitatively unequal and qualitatively unbalanced, i.e., one partner in the plant-mycorrhiza relationship is gaining more than the other.

However, interpretation of the results of this study in the context of other studies has some limitations. Firstly, there is no standardized universal definition of low or high nutrient soils content. Therefore, the low or high nutrient soils used in this study may be different from what others used elsewhere. Secondly, since natural soils are used as inoculums, the particular mycorrhizas that were involved are not identified. They might be endomycorrhizas or ectomycorrhizas. Hence different mycorrhizas might have colonized the roots of different crop plants. Finally, there might be possible complex interactions among the mycorrhizas that were present and other soil microbes and the crops, which might have include parasitism, competition in addition to the mutualism. Nevertheless, this study revealed that the mycorrhizas harbored by the tree *T. indica* in the savanna parkland have some positive impact on the performance of some crops that are cultivated in their proximity. To exploits the maximum benefits of these mycorrhizas in crop production in the savanna, more complex and extensive research is required.

5. CONCLUSION

The results of this study revealed that crop's responses in terms of leaf chlorophyll contents to mycorrhizal soil inoculums from under *Parkia biglobosa* and *Tamarindus indica* differs with different soil nutrient status. The effect of mycorrhizal soil inoculums on the leaf chlorophyll contents can be positive, negative or neutral, depending on the plant-soil type combination. Mycorrhizal soil inoculums from under *T. indica* indicate positive results on the leaf chlorophyll contents of maize, millet and soybean. The mycorrhizal soils of both the *P. biglobosa* and *T. indica* negatively affected the leaf chlorophyll contents of soybean and sorghum, with the *P. biglobosa* soils being the worst.

ACKNOLEDGEMENT

My sincere appreciation goes to Tertiary Education Fund (Tet-Fund) for sponsoring this research. I sincerely appreciate the effort of Department of Biological sciences, Abubakar Tafawa Balewa University, Bauchi, for providing the enable environment to carry this research.

COMPLICT OF INTEREST

The authors of this manuscript declared that there is no complicit of interest.

REFERENCE

[1] S. Bekele, K. Tesfaye, M. Kassie, T. Abate, B. M. Prasanna, and M. Abebe, "Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options," *Weather and Climate Extremes,* vol. 3, pp. 67-79, 2014.

[2] J. Schmidhuber and F. N. Tubiello, "Global food security under climate change," *PNAS,* vol. 104, pp. 19703-19708, 2007.

[3] I. J. Otaha, "Food insecurity in Nigeria: Way forward," *African Research Review,* vol. 7, pp. 26-35, 2013.

[4] S. Zaidi, S. Usmani, B. R. Singh, and J. Musarrat, "Significance of Bacillus subtilis strain SJ-101 as a bioinoculant for concurrent plant growth promotion and nickel accumulation in Brassica juncea," *Chemosphere,* vol. 64, pp. 991-997, 2006.

[5] A. Sasson, "Food security for Africa: an urgent global challenge," *Agriculture and Food Security,* vol. 1, pp. 2-16, 2012.

[6] S. Zakari, L. Ying, and B. Song, "Factors influencing household food security in West Africa: The case of southern Niger," *Sustainability,* vol. 6, pp. 1191-1202, 2014.

[7] M. J. Rossi, A. Furigo, and V. L. Oliveira, "Inoculant production of ectomycorrhizal fungi by solid and submerged fermentations," *Food Technology and Biotechnology,* vol. 45, pp. 277-286, 2007.

[8] E. Khurana and J. S. Singh, "Ecology of seed and seedling growth for conservation and restoration of tropical dry forest: A review," *Environmental Conservation,* vol. 28, pp. 39-52, 2001.

[9] A. Sanon, F. Ndoye, E. Baudoin, Y. Prin, A. Galiana, and R. Duponnois, *Management of the Mycorrhizal Soil Infectivity to Improve Reforestation Program Achievements in Sahelian Ecosystems In : by A. Mendez-Vilas (ed). Current research, technology and education topics in applied microbiology and microbial biotechnology. vol. 1. Badajoz : Formatex Research Center*, 2010.

[10] A. Auc-Ina, M. Rudawska, T. Leski, A. Skridaila, E. Rieps-As, and M. Iwanski, "Growth and mycorrhizal community structure of pinus sylvestris seedlings following the addition of forest litter," *Applied And Environmental Microbiology,* vol. 73, pp. 4867-4873, 2007.

[11] J. A. Millar and D. J. Ballhorn, "Effect of mycorrhizal colonization and light limitation on growth and reproduction of lima bean (Phaseolus lunatus L.)," *Journal of Applied Botany and Food Quality,* vol. 86, pp. 172-179, 2013.

[12] S. K. Jha and N. Kumar, "Potential of mycorrhizal fungi in ecosystem: A review," *International Journal of Research in Botany,* vol. 1, pp. 1-7, 2011.

[13] D. Klavina, *Ectomycorrhizas of Norway Spruce (Picea Abies (L.) Karst.) in Managed Forest Stands of Latvia. Doctoral Thesis Submitted for the Degree of Doctor of Biology, Subfield: Ecology. University of Latvia, Faculty of Biology Latvian State Forest Research Institute "Silava"*, 2015.

[14] M. Torres-Aquino, A. Becquer, C. Le-Guerneve, J. Louche, L. K. Amenc, S. Staunton, *et al.*, "The host plant Pinus pinaster exerts specific effects on phosphate efflux and polyphosphate metabolism of the ectomycorrhizal fungus Hebeloma cylindrosporum: a radiotracer, cytological staining and 31P NMR spectroscopy study. Plant, Cell and Environment," vol. 40, pp. 190-202, 2017.

[15] Van-der, M. G. A. Heijden, and T. R. Horton, "Socialism in soil? The importance of mycorrhizal fungal networks for facilitation in natural ecosystems," *Journal of Ecology,* vol. 97, pp. 1139-1150, 2009.

[16] V. Rinaudo, P. Bàrberi, M. Giovannetti, Van-der., and M. G. A. Heijden, "Mycorrhizal fungi suppress aggressive agricultural weeds," *Plant Soil*, vol. 333, pp. 7-20, 2010.

[17] M. Brundrett, N. Bougher, B. Dell, T. Grove, and N. Malajczuk, "Working with mycorrhizas in forestry and agriculture," *AClAR Monograph*, vol. 32, p. 374, 1996.

[18] R. Sharma, R. C. Rajak, and A. K. Pandey, "Evidence of antagonistic interactions between rhizosphere and mycorrhizal fungi associated with Dendrocalamus strictus (Bamboo)," *Journal of Yeast and Fungal Research*, vol. 1, pp. 112-117, 2010.

[19] J. D. Hoeksema, "Plant–plant interactions vary with different mycorrhizal fungus species," *Biol Letter*, vol. 1, pp. 439-442, 2005.

[20] D. Zimmer, C. Baum, P. Leinweber, K. Hrynkiewicz, and R. Meissner, "Associated bacteria increase the phytoextraction of cadmium and zinc from a metal-contaminated soil by mycorrhizal willows," *International Journal of Phytorem*, vol. 11, pp. 200-213, 2009.

[21] S. E. Bellgard and S. E. Williams, "Response of mycorrhizal diversity to current climatic changes," *Diversity*, vol. 3, pp. 8-90, 2011.