Original Article

Fungi in the Rhizosphere and Rhizoplane of Cassava cultivar TME 419

*Sule, I. O. and Oyeyiola, G. P.

Department of Microbiology, University of Ilorin, Ilorin, Nigeria.

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ABSTRACT

The physicochemical properties of the rhizosphere soils of cassava cultivar TME 419 as the plants aged had range of 4.19 – 6.68 for pH; 0.25 – 0.34 ml/g for water holding capacity; 0.12 – 8.76% for moisture content and 0.36 – 11.8% for organic matter content respectively. The percentage composition of sand, clay and silt varied from time to time but the soil texture remain constant (sand) throughout the duration of the experiment. The number of fungi in the non-rhizosphere, rhizosphere and rhizoplane of cassava cultivar TME 419 ranged from 9.0×10^2 – 9.5×10^3 cfu/g, 4×10^2 - 6.3×10^3 cfu/g, and 3×10^2 - 2.0×10^4 cfu/g respectively. The degree of stimulation of fungi on the rhizosphere and rhizoplane of cassava cultivar TME 419 ranged from 0.14 – 2.18 and 0.03 – 8.46 respectively. More rhizosphere effect was observed on the rhizoplane than in the rhizosphere for the 1^{st}- 7^{th} month of cultivation. It was however, overtaken by the rhizosphere from 8^{th} to 14^{th} month. The genera of fungi isolated in the rhizosphere soils and rhizoplane of cassava cultivar TME 419 included: *Alternaria, Aspergillus, Acremonium, Brettanomyces, Botrytis, Byssochamys, Cladosporium, Doratomyces, Geotrichum, Humicola, Moniliella, Monascus, Neurospora, Oidiodendron, Penicillium, Piricularia, Papulospora, Rhodotorula, Rhizopus, Saccharomyces, Sporothrix, Trichothecium,* and *Trichoderma*. The dominant fungi on the rhizosphere soils of cassava cultivar TME 419 was *Byssochamys fulva* (23.1%), followed by *Geotrichum candidum* (10.9%) and then *Papulospora coprophila* (10.2%). However, on the rhizoplane the first-three prevalent fungi were *Brettanomyces bruxellensis* (18.3%), *Papulospora coprophila* (16.1%) and *Geotrichum candidum* (14.3%). It can be concluded from this study that the physicochemical characteristics of the soil such as pH, water retentive capacity and soil structure had improved as a result of cassava cultivation and that more fungi were stimulated on the rhizoplane than in the rhizosphere. Also, the root exudates had prevented some organisms present in the non- rhizosphere soils from gaining access to the root region.

Key words: Rhizosphere, Rhizoplane, Fungi, Soils, Cassava cultivar TME 419

***Corresponding Author**: suleism@gmail.com

INTRODUCTION

Cassava account for approximately a third of the total staples produced in sub- Saharan Africa (Akoroda and Arene, 1989). Cassava's virtue as a human food item is that it is cheap and abundant source of energy. A hardy plant, Cassava has the ability to recover from severe climatic stress particularly drought (IITA, 1990). Cassava is mainly regarded as a subsistence crop of low-income families or as a famine- reserve crop. In 1991, the output though the highest in the world was just 27 million tonnes. Between 1996 and 1997, it was estimated at 33 million tones. By the end of 2005, the Federal Ministry of Agriculture announced an annual output of about 40 million tonnes. The bulk of cassava produced in the forest and savannah ecologies of Nigeria are the bitter high cyanide containing varieties (Bokanga *et al*., 1994).

In Nigeria, the earlier recommended and released varieties include TMS 30572, TMS 30555, TMS 90257, TMS 84537, NR 41044, TMS 82/0061, TMS 50395, TMS 30001, TMS 81/ 00110, TMS 91934, TMS 4(2)1425, NR 8082, TMS 92/0326, NR 8208 and NR 8083 (IITA, 1984). Some of the earlier released varieties are reported to be losing some of the desirable characteristics. To help sustain and increase the root yield of cassava in Nigeria, the National Root Crops Research Institute (NRCRI), in collaboration with the International Institute of Tropical Agriculture (IITA) Ibadan, released five new varieties, which not only have high root yield (above 30 tonnes/ ha) and resistant to the destructive cassava mosaic disease (CMD) but also the roots have high dry matter content. These newly released improved varieties were: TMS 97/ 2205, TMS 98/ 0505, TMS 98 /0510, TMS 98 /0581 and TME 419 (NRCRI, 2006).These five new varieties generally yield more than those released before the 21st century. They even out yielded the old favourites, TMS 30572, TMS 4(2)1425 and NR 8082, which were used as the national checks at Umudike (NRCRI, 2005). These new improved cassava varieties are also resistant to other major pests and diseases of cassava such as cassava bacterial blight (CBB), cassava mealy bug (CMB) and cassava green mite (CGM). Cassava cultivar TME 419 was released by IITA in 2005. It is one of the bitter varieties. It has erect tall stem which is dark in colour with up to 5 palmate leaves per petiole. Its petiole is whitish toward the leaf base but purple near the leaf.

Rhizosphere is that portion of the soil under the direct influence of the roots of higher plants, whereas the rhizoplane encompasses the root surface and its adhering soil. During the growing season, the rhizosphere and rhizoplane are expanding focus of biological energy. Benefits accrued from the stimulation of soil microbial populations whose functions encourage plant development through nitrogen mineralization and reduction of plant pathogenic interactions. Rhizosphere microflora directly or indirectly inhibits the invasion of the plant tissue by the pathogen, and synthesis of growth–controlling plant hormones such as indole acetic acid and giberellic acid (Nietko and Frankenberg, 1989). A more indirect, result of stimulation of soil community by root invasion is the contribution of rhizosphere microbial communities to development of a stable soil structure conducive to plant community

development (Henry and Boyd, 1988). The rhizosphere community produces polysaccharide material such as capsules and slimes that cements soil mineral particulates into microaggregates. Furthermore, soil structural improvements are gained from fungal mycelial production as well as by association of soil particles with root tissue. This improvement in soil structure through increased soil aggregation results in improvement in soil aeration, water infiltration, and root penetration. This research is justify bearing in mind the impact of cassava tuber to the economy of most countries in Africa. Hence, it is necessary to determine the fungal populations in the root region which could have positive or sometime negative impact on the growth and development of the root tuber. This study would provide comprehensive information on the fungi associated with the rhizosphere and rhizoplane of cassava cultivar TME 419 from period of planting to maturity.

MATERIALS AND METHODS

Collection and planting of cassava stem: The stem of cassava cultivar TME 419 was collected from root tuber expansion programme, Federal Department of Agriculture, Ajase-ipo, Kwara, Nigeria, which is a project assisted by International Fund for Agriculture Development (IFAD). The stems were planted as recommended by (NRCRI, 1983; NRCRI, 1997).

Collection of rhizosphere soil sample: This was collected by carefully digging round the stem and its tubers if they have developed. Then, the plant was carefully uprooted, its soils shakened and collected into a sterile polythene bag (Oyeyiola, 2009; Ajokpaniovo and Oyeyiola, 2011). Soil samples were taken from two plants of the same cultivar into the same polythene bag to form representative sample.

Collection of rhizoplane sample
The roots of the cassava plant were aseptically cut into small bits of about 1-2mm each and each of the bit with a few adhering soil was collected aseptically into a sterile small polythene bag (Dongmo and Oyeyiola, 2009).

Determination of physicochemical characteristics of soils:
The soil pH, moisture content, soil particle composition and textural classification were determined according to Oyeyiola (2009) while the water holding capacity was determined using the method of Dongmo and Oyeyiola (2006). These parameters were determined for the rhizosphere soils only.

Isolation and enumeration of fungi from the soil samples
Fungi were isolated from the rhizosphere soil and rhizoplane by weighing 1g of soil or root. Then, tenfold serial dilution was made. Sterile Potato dextrose agar (PDA) cooled to about 45^{o}C and supplemented with 30 mg/l of streptomycin and was aseptically poured into sterile plate to solidify. This set plate of PDA was then inoculated with 0.1ml of aliquot from 10^{-2} dilution and the inoculum spread with sterile spreader. This technique is called spread plate method (Pelczar *et al*., 2005; John *et al*., 2010). The plates were incubated at room 25^{o}C for 72 hours. The number of colonies that developed at the end of incubation was counted and expressed in cfu/g of the fresh soil (Dubey and Meheshwari, 2005).

Purification of fungal isolates
The non–filamentous fungi obtained were subcultured using inoculating loop to streak sterile set plate of PDA. However, for the

mycelial fungi little portion of their hyphae was picked with the aid of sterile inoculating needle onto the surface of set plate of PDA and incubated at 25^{o}C for 72 hours. The process of subculturing was repeated until pure culture was obtained. The pure isolates obtained were transferred into sterile set plate of PDA and incubated. These agar slants obtained were kept in the refrigerator at 4 – 8^{o}C until required for use (Fawole and Oso, 1988).

Identification of fungal isolates

The fungal isolates were characterized based on their macroscopic and microscopic characteristics (Fawole and Oso, 1988). They were then identified using standard mycological texts (Alexopoulos and Mins, 1979; Onions *et al*., 1981; Samson and Van Reenen-Hoekstra, 1988).

Estimation of R:S ratio and assessment of rhizosphere effect

This was determined by dividing the population of fungi in cfu/g in the rhizosphere soil by that obtained in the non – rhizosphere soil (Dubey and Maheshwari, 2005). Estimation of R:S ratio on the rhizoplane (inner rhizosphere effect) was also determined by dividing the population of fungi in cfu/g in the rhizoplane by that on the non- rhizosphere (Robert, 1995).

Determination of percentage (%) of occurrence of fungal isolates

Measurement of occurrence of each fungal isolate was determined based on the method of Dubey and Maheshwari (2005).

$$\text{Occurrence (\%)} = \frac{\text{Number of a species}}{\text{Number of colonies of fungal species isolated}} \times 100$$

Statistical analysis

The statistical analysis employed in this research includes range, means, and analysis of variance (ANOVA). These were done using SPSS 15.0 statistical analysis package (2010).

RESULTS AND DISCUSSION

The physicochemical parameters of the rhizosphere soils of cassava cultivar TME 419 as the plant aged had range of 4.91 – 6.68 for pH; 0.25 – 0.34 ml/g for water holding capacity; 0.12 – 8.76% for moisture content; 0.36 – 11.8% for organic matter content. The pH of the soil improved toward neutrality due to cultivation of cassava. Similarly, the water holding capacity also improved from initial value of 0.27ml/g to the maximum value of 0.34ml/g. Moisture content fluctuates and the amount of soil moisture depends on the season of the year.

The percentage composition of sand, clay and silt varied from time to time but the soil texture remains constant throughout the duration of the experiment (Table 1).The texture of the soils remain sand. This was in consistence with the works of Olaitan and Lombin (1984); Robert (1995) that the texture of a soil in the field is not readily subject to change, so it is considered a basic property of a soil.

The pH of a particular soil reflects the chemical and mineralogical environment in that soil, and thus the pH is of great importance to plant roots and microbial activity (Henry and Boyd, 1988). The pH of the experimental soils could be classified as being moderately to slightly acidic. Cassava grows best on sandy or sandy loam soils and it is highly acid tolerant, exhibiting little or no yield reduction at soil pH values as low as 4.3 (Akoroda and Arene, 1989). It prefers soil that is not saline and well drained. When grown on heavy clay soils, the plant produces stem and leaf growth at the expense of the roots and many cultivars give poor yields (Kowal and Hassam, 1978). The

soil organic matter content had the maximum value at the first month of cultivation (Table 1). This could come from stumps from previous vegetation.

The number of fungi in the non-rhizosphere soils, rhizosphere soils and rhizoplane of cassava cultivar TME 419 ranged from 9.0 x 10^2 – 9.5 x 10^3 cfu/g, 4 x 10^2 - 6.3 x 10^3 cfu/g, and 3 x 10^2 - 2.0 x 10^4 cfu/g respectively (Figure 1). The range of fungal counts on the rhizosphere soils were lesser those on the non- rhizosphere soils. This showed that the root exudate has successfully prevented some organisms from the non-rhizosphere to gain access to the rhizosphere. This is probably due to the fact that the root exudates from cassava contain Hydrocyanic acid (HCN).

Thirty different fungal species were isolated on the rhizosphere soils while in the rhizoplane it was eighteen species. The genera of fungi isolated in both the rhizosphere soils and rhizoplane included: *Alternaria alternata, Aspergillus clavatus, Aspergillus flavus, Aspergillus niger, Aspergillus wentii, Aspergillus terreus, Acremonium strictum, Brettanomyces bruxellensis, Botrytis cinerea, Byssochamys fulva, Cladosporium herbarium, Doratomyces stemonitis, Geotrichum candidum, Humicola fuscoatra, Moniliella acetoabutans, Mucor racemosus, Neurospora sitophila, Monascus ruber, Oidiodendron griseum, Papulospora coprophila, Penicillium chrysogenum, Penicillium digitatum, Penicillium thomii, Penicillium* sp., *Piricularia oryzae, Rhodotorula glutinis, Rhizopus oryzae, Rhizopus stolonifer, Saccharomyces cerevisiae, Sporothrix schenckii, Trichothecium roseum,* and *Trichoderma* sp. A number of fungi present in the rhizosphere soils were conspicuously absent from the rhizoplane. These included: *Aternaria alternata, Aspergillus clavatus, Aspergillus flavus, Aspergillus niger, Aspergillus terreus, Acremonium strictum, Cladosporium herbarium, Doratomyces stemonitis, Humicola fuscoatra, Monascus ruber, Oidiodendron griseum, Penicillium digitatum, Penicillium* sp. *a*nd *sporothrix schenckii.* Despite this inhibition of some fungi there was selective stimulation of certain species which resulted in the rhizoplane having the highest fungal counts.

The dominant fungi on the rhizosphere soils of cassava cultivar TME 419 was *Byssochamys fulva* (23.1%), followed by *Geotrichum candidum* (10.9%) and then *Papulospora coprophila* (10.2%). However, on the rhizoplane the first-three prevalent fungi were *Brettanomyces bruxellensis* (18.3%), *Papulospora coprophila* (16.1%) and *Geotrichum candidum* (14.3%) (Tables 2 - 3). Booth and Coursey (1974) isolated various species of *Pythium, Mucor, Rhizopus, Penicillium, Aspergillus, Fusarium, Cladosporium, Gloeosporium, Rhizoctonia* from the surface of cassava roots. Ferreira *et al*. (2009) isolated *Debaromyces hansenii, Kodamaea ohmeri, Candida glabrata, Candida haemulonii* and *Pichia gullhermondii* (yeast microflora) from Brazilian Cassava roots. Ikediugwu and Ejale (1980) worked on the root surface mycoflora of cassava (*Manihot esculenta*) and post harvest rot of the tubers. A small group of fungi which included *Aspergillus niger, Botryodiplodia theobromae, Fusarium solani, Penicillium javanicum, Penicillium* sp. and *Trichoderma* sp. were found to be consistently associated with the root surface. Furthermore, Arotupin and Akinyosoye (2006) isolated *Aspergillus flavus, Aspergillus fumigatus, Aspergillus niger, Aspergillus repens, Botrytis cinerea, Neurospora sitophila,* and *Varicosporium elodea* from cassava cultivated soils.

The degree of stimulation of fungi on the rhizosphere soils and rhizoplane of cassava

cultivar TME 419 ranged from 0.14 – 2.18 and 0.03 – 8.46 respectively (Figure 2). More rhizosphere effect was observed on the rhizoplane than in the rhizosphere for the 1st- 7th months of cultivation. It was however, overtaken by the rhizosphere soils from 8th to 14th months. Brady and Weil (1999) said that the highest rhizosphere effect occur at the stage of the highest vegetative growth of the plant.

Table 1: Physical and Chemical Characteristics of soils in the rhizosphere of Cassava cultivar TME 419

Sample/ Characteristics	Sampling periods (Months)													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Rhizosphere soils:														
pH	5.71	6.24	6.03	5.75	4.91	6.52	5.46	6.49	6.50	5.47	5.91	6.68	6.50	6.34
Water holding Capacity (ml/g)	0.27	0.30	0.34	0.32	0.34	0.33	0.30	0.26	0.28	0.25	0.25	0.29	0.33	0.26
Moisture content (%)	8.76	7.30	5.32	8.46	5.04	7.66	1.12	0.12	0.78	0.28	0.97	3.13	4.90	1.48
Organic matter content (%)	11.8	4.48	4.38	0.36	1.42	1.04	0.98	2.38	0.50	0.62	1.14	1.21	1.07	1.41
Sand (%)	90	89	88	89	89	90	88	88	89	91	89	92	90	88
Clay (%)	4	5	4	3	4	2	2	4	2	2	2	2	1	2
Silt (%)	6	6	8	8	7	8	10	8	9	7	9	6	9	10
Soil texture	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand	Sand

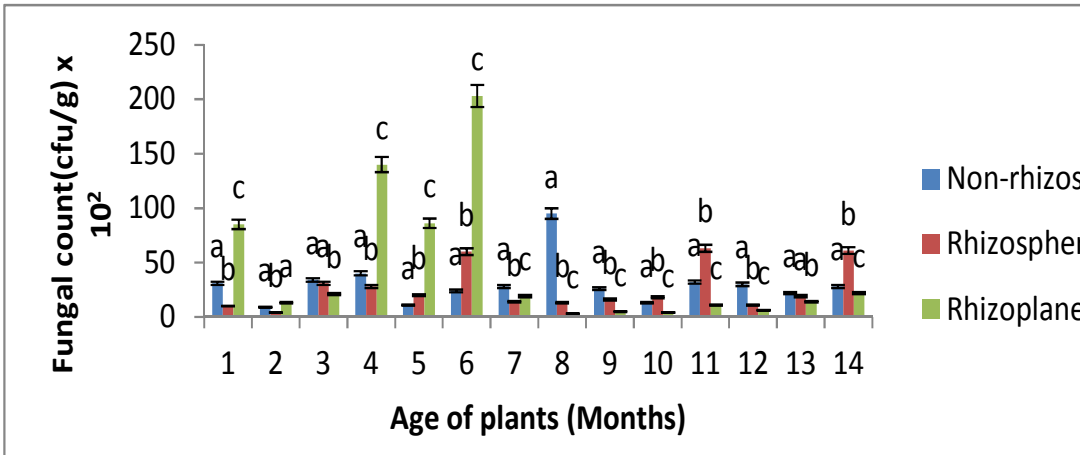

Figure 1: Count of fungi in the root region of cassava cultivar TME 419
Bars followed by the same letters in the same month (period) are not significantly different at α= 0.05% based on Duncan's Multiple Range Test (DMRT).

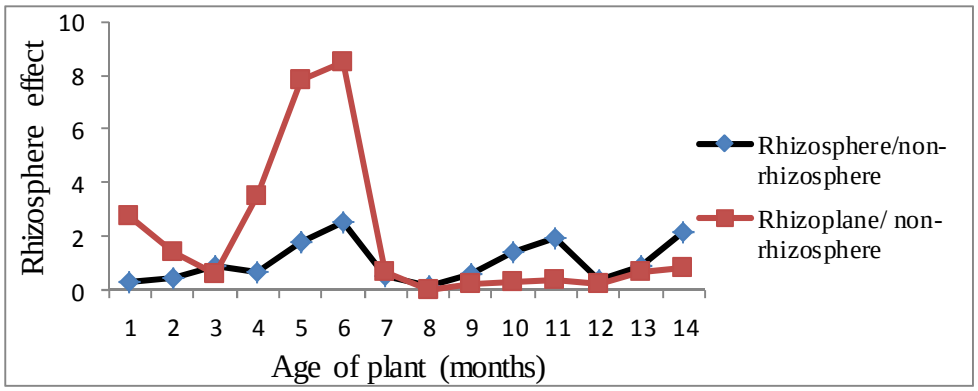

Figure 2: Rhizosphere effect of fungi in the root region of Cassava cultivar TME 419

Table 2: Frequency of occurrence (%) of fungal isolates in the rhizosphere soils of Cassava cultivar TME 419

S/N	Fungal isolates	Age of plant (months)														Mean
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	*Alternaria alternata*	-	-	-	-	-	-	14	-	-	-	-	-	-	-	1.0[b]
2	*Aspergillus clavatus*	10	-	-	-	-	3	-	8	-	-	-	-	-	-	1.5[c]
3	*Aspergillus flavus*	10	-	-	-	-	-	-	-	-	-	-	-	-	-	0.7[ab]
4	*Aspergillus niger*	-	-	-	7	-	-	-	-	-	-	2	-	16	20	3.2[e]
5	*Aspergillus terreus*	-	-	-	-	-	-	-	-	-	-	-	-	-	10	0.7[ab]
6	*Aspergillus wentii*	10	-	-	-	-	-	-	-	19	-	63	-	-	-	6.6[i]
7	*Acremonium strictum*	-	-	-	-	-	-	-	-	-	-	-	-	-	20	1.4[c]
8	*Brettanomyces bruxellensis*	10	-	7	25	-	-	-	-	-	28	-	-	-	-	5.0[g]
9	*Botrytis cinerea*	-	-	7	-	-	-	-	-	-	-	-	-	-	-	0.5[a]
10	*Byssochamys fulva*	-	100	58	39	45	-	22	60	-	-	-	-	-	-	23.1[l]
11	*Cladosporium herbarum*	-	-	-	-	-	-	-	-	-	-	-	-	-	10	0.7[ab]
12	*Doratomyces stemonitis*	-	-	7	-	-	-	-	-	-	-	-	-	-	-	0.5[a]
13	*Geotrichum candidum*	50	-	7	11	10		14	8	19	33	-	-	-	-	10.9[k]
14	*Humicola fuscoatra*	-	-	-	-	-	-	-	-	-	21	-	-	-	-	1.5[c]
15	*Moniliella acetoabutans*	-	-	-	-	-	-	36	-	43	-	-	-	-	-	5.6[h]

16	*Mucor racemosus*	-	-	-	-	-	17	-	-	-	-	-	-	5	-	1.6[c]
17	*Monascus ruber*	-	-	-	-	-	-	-	-	-	6	-	-	-	-	0.4[a]
18	*Neurospora sitophila*	-	-	-	-	-	-	-	8	-	-	-	-	-	-	0.6[a]
19	*Oidiodendron griseum*	-	-	-	-	-	-	-	-	-	-	35	-	-	-	2.5[d]
20	*Penicillium chrysogenum*	-	-	-	-	10	3	-	8	-	-	-	-	-	-	1.5[c]
21	*Papulospora coprophila*	-	-	-	-	-	-	-	-	-	-	-	64	79	-	10.2[j]
22	*Penicillium digitatum*	-	-	-	-	-	-	-	8	-	-	-	-	-	-	0.6[a]
23	*Piricularia oryzae*	-	-	-	-	-	-	-	-	-	6	-	-	-	-	0.4[a]
24	*Penicillium thomii*	-	-	7	18	-	-	-	-	-	6	-	-	-	-	2.2[d]
25	*Penicillium* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	20	1.4[c]
26	*Rhodotorula glutinis*	-	-	-	-	35	-	-	-	-	-	-	-	-	-	2.5[d]
27	*Rhizopus oryzae*	-	-	-	-	-	-	14	-	-	-	-	18	-	-	2.3[d]
28	*Rhizopus stolonifer*	10	-	7	-	-	-	-	-	19	-	-	18	-	-	3.9[f]
29	*Saccharomyces cerevisiae*	-	-	-	-	-	77	-	-	-	-	-	-	-	-	5.5[h]
30	*Sporothrix schenckii*	-	-	-	-	-	-	-	-	-	-	-	-	-	20	1.4[c]

Means followed by the same letter(s) in the same column are not significantly different at 5% level of (p=0.05) based on Duncan's Multiple Range Test.

- = not isolated

Table 3: Frequency of occurrence (%) of fungal isolates in the rhizoplane of Cassava cultivar TME 419

S/N	Fungal Isolates	Age of plant (months)														Mean
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	
1	*Aspergillus wentii*	4	-	9	-	-	-	-	-	-	-	55	-	-	-	4.9[f]
2	*Brettanomyces bruxellensis*	96	50	-	2	7	1	-	-	-	100	-	-	-	-	18.3[l]
3	*Botrytis cinerea*	-	-	-	-	-	-	-	-	-	-	-	-	7	-	0.5[ab]
4	*Byssochamys fulva*	-	-	24	-	41	5	16	-	-	-	-	-	-	-	6.1[g]
5	*Geotrichum candidum*	-	-	14	95	-	-	73	-	-	-	18	-	-	-	14.3[j]
6	*Moniliella acetoabutans*	-	-	-	-	-	2	-	-	40	-	-	-	-	-	3.0[e]
7	*Mucor racemosus*	-	-	-	-	-	-	11	-	60	-	27	-	-	-	7.0[h]
8	*Neurospora sitophila*	-	-	14	-	-	-	-	34	-	-	-	-	-	-	3.4[e]
9	*Penicillium chrysogenum*	-	-	-	1	-	-	-	33	-	-	-	-	-	-	2.4[d]
10	*Papulospora coprophila*	-	50	-	-	-	-	-	-	-	-	-	83	93		16.1[k]
11	*Piricularia*	-	-	29	-	-	-	-	-	-	-	-	-	-	-	2.1[cd]

	oryzae															
12	*Penicillium thomii*	-	-	-	-	-	-	-	33	-	-	-	-	-	-	2.4[d]
13	*Rhodotorula glutinis*	-	-	-	1	7	1	-	-	-	-	-	-	-	-	0.6[b]
14	*Rhizopus oryzae*	-	-	10	-	-	-	-	-	-	-	-	17	-	-	1.9[c]
15	*Rhizopus stolonifer*	-	-	-	-	-	-	-	-	-	-	-	-	-	91	6.5[g]
16	*Saccharomyces cerevisiae*	-	-	-	-	45	91	-	-	-	-	-	-	-	-	9.7[i]
17	*Trichothecium roseum*	-	-	-	1	-	-	-	-	-	-	-	-	-	-	0.1[a]
18	*Trichoderma* sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	9	0.6[b]

- = not isolated: Means followed by the same letter(s) in the same column are not significantly different at 5% level of (p=0.05) based on Duncan's Multiple Range Test

CONCLUSION

It can be concluded from this study that the physicochemical characteristics of the soil such as pH, water retentive capacity and soil structure had improved as a result of cassava cultivation and that more fungi were stimulated on the rhizoplane than in the rhizosphere. Also, the root exudates had prevented some organisms present in the non-rhizosphere soils from gaining access to the root region.

REFERENCES

Ajokpaniovo, H. and Oyeyiola, G. P. (2011). Rhizosphere fungi of red pepper (*Capsicum frutescens*). *Journal of Agriculture and Food Sciences,* 9(1): 1-11. *www. Ajol.info*.

Akoroda M. O. and Arene O. B. (1989). Tropical Root Crops. Promotion of Root Crop

Based Industries: An incentive for Research and Development. *Proceeding of the Fourth Triennial Symposium of the International Society for Tropical Root Crops*–Africa Branch held in Kinshasa, zaire, 5–8 December 1989. Intec Printers Limited, Ibadan. 433pp.

Alexopoulos, C. J. and Mins, C. W. (1979). *Introductory Mycology*. 3rd Edition. John Wiley and sons, Newyork. 269pp.

Arotupin, D. J. and Akinyosoye, F. A. (2006). Microbiological and Physicochemical Characteristics of Cassava Cultivated Soils. *Nigerian Journal of Microbiology*, 20(3): 1361-1369.

Bokanga, M., A., Essers, J. A., Poulter, N. Rosling, H. Tewe, O. (1994). *International workshop on Cassava Safety*. Acta Horticulture, published by ISHI, Ibadan, Nigeria. 416pp.

Booth, R. H., Coursey, D. G. (1974). Storage of Cassava and related post harvest problems In: Cassava processing and storage, *Int. Dev. Res. Centre*, IDRC -031C, Ottawa, Canada. Pp .43 - 49.

Brady N. C. and Weil, R. R. (1999). *The Nature and Properties of Soils*. 12th Edition. Prentice Hall, Upper Saddle River, New Jersey. 758pp.

Dongo J. C. and G. P. Oyeyiola (2006). Fusaria in the rhizosphere and rhizoplane of groundnut (*Arachis hypogaea*). *J. Agric. Res. and Develop*., 5: 153 – 164.

Dongo J. C. and Oyeyiola, G. P. (2009). Fusaria in the Root Zone of Tomato (*Lycopersicon esculentum*). *Nigerian Journal of Microbiology*, 23(1): 1918 – 1928.

Dubey, R. C. and Maheshwari, D. K. (2005). *Practical Microbiology*. S. Chand and Company Ltd., New Delhi. 352pp.

Fawole M. O. and Oso, B. A. (1988). *Laboratory Manual of Microbiology*. Spectrum Books Limited. 127pp.

Ferreira, N., Belloch, C. Querol, A., Manzanares, P., Vallez, S. and Santos, A. (2009). Yeast Microflora Isolated from Brazilian Cassava roots: Taxonomical Classification Based on Molecular Identification. *Current Microbiology*, 60(4): 287 -293.

Henry, D. F. and Boyd, G. E. (1988). *Soil Fertility*. John Wiley and Sons, Newyork. 212pp. Ikediugwu F.E.O.,and A. U. Ejale (1980). *Mycopathologia*, 71: 67 - 71.

IITA. (1984). International Institute of Tropical Agriculture, Ibadan Nigeria. *Annual report.*

IITA. (1990). International Institute of Tropical Agriculture: *Cassava in Tropical Africa: A reference manual*.

John, R. C., Akpan, M. M., Essien, J. P. and Ikpe, D. I. (2010). Variation in rhizosphere microbiological properties of Tropical Legumes grown on oil contaminated wetland ultisol. *Nigerian Journal of Microbiology*, 24(1): 2081 - 2087.

Kowal, J. M. and Hassam, A. H. (1978). *Agricultural ecology of Savanna: A study of West Africa* Clarendon press. Oxford. 403pp.

NRCRI. (1983). National Root Crops Research Institute. Guide to Cassava cultivation in Nigeria. *Advisory Bulletin* No. 10, Umudike, Nigeria.

NRCRI. (1997).National Root Crops Research Institute, 1982 – 1997. *Annual Reports*, Umudike.

NRCRI. (2005). *Annual Report 2004.* National Root Crops Research Institute, Umudike, Nigeria.

NRCRI. (2006). *Annual Report 2005*.National Root Crops Research Institute, Umudike, Nigeria.

Nietko, K. F. and Frankenberg, W. T. Jr. (1989). Biosynthesis of cytokinins in soil. *Soil Sci. Soc. Am. J.*, 53: 735 – 740

Olaitan, S. O. and Lombin, G. (1984). *Introduction to Tropical Soil Science.* Macmillan Publishers Ltd. Hong Kong. 126pp.

Onions, A. H. S., Allsopp, D., Eggins, H. O. W. (1981). *Smith's Introduction to Industrial Mycology.* 7th Edition. Edward Arnold (Publisher) Ltd., 41 Bedford Square, London. 398pp.

Oyeyiola, G. P. (2009). Rhizosphere Mycoflora of Okro (*Hibiscus esculentus*). *Research Journal of Soil Biology*, 1(1): 31-36

Pelczar, M. J., Chan E .C .S. and Krieg, N. R. (2005). *Microbiology*. 5th Edition, Tata Mc Graw Hill Publishing Company Ltd., New Delhi. pp. 333- 364 Robert, L. T. (1995). *Soil Microbiology*, John Wiley and Sons, inc., New Jersey. 398pp.

Samson, R. A. and Van-Reenen-Hoekstra, E. S. (1988). *Introduction to Food-borne Fungi*. 3rd Edition. Centraalbureau voor Schimmelcultures, Baarn. 299pp.

SPSS. (2010). Statistical Package for Social Scientists (SPSS) 15.0 for window evaluation versions. *www.spss.com*