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Mycorrhiza Fungi Distribution in Six Different Soil Types of Southwestern Nigeria

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Abstract: Detailed soil survey of Mycorrhiza fungi distribution of 6 soil types of southwestern Nigeria was carried out at the valley bottom of Faculty of Agriculture and Forestry, University of Ibadan to investigate the relationship between different soil types and how it affect Mycorrhizal distribution. Sampling points were determined using a rigid grid survey method. Transect were cut at every 20 m interval across the field, while samples were collected at every 10 m at both topsoil (0-15 cm) and subsoil (15-30 cm). The whole landscape was classified into 6 series namely: Apomu (series I), Jago (series II), Matako (series III), Ikire (series IV), Oshun (series V) and Adio (series VI). A total of 186 samples were collected for chemical, physical and Mycorrhiza extraction, identification and count at the laboratory. Mycorrhiza distribution was found to be highest at topsoil in all the soil series than at the subsoil, except on soil series I where the subsoil population was higher. Soil series VI has the greatest population of Mycorrhiza in both the topsoil and subsoil. Thus, soil types do not significantly affect the population of Mycorrhiza fungi.

Key words: Mycorrhiza fungi, soil types, samples, Sourthwestern Nigeria

INTRODUCTION

Soil is the product of the interaction of climate and vegetation on parent materials as conditioned by relief overtime. Thus, each soil has its own inherent variability imposed by each of these soil-forming factors. One of the basic problems constantly facing man is that of adequately feeding himself. Apart from air and water, food is the next paramount need of man. Thus, man, animals and plants are dependent on soil for their survival. Therefore, there is a great need for man to thoroughly understand the soil. Thus, a detailed survey of a piece of land is necessary to understand the benefits, limitation and restriction imposed on the use of such land.

Soil survey had been more of soil characteristics such as particle size distribution, organic matter content, micro and macro nutrients with little or no consideration for the influence of soil microorganism that could also affect the productivity of the soil and in particular crop yield. But of recent, the study of soil microorganism has brought into light the positive impact of some soil organism such as Rhizobium (N-fixing bacteria), Cyanobactaria and soil Mycorrhiza. While some research had been done on other aspect of soil survey, more is yet to be known on the distribution of micorrhiza in the soil. The term mycorrhizae defines a structural as well as functional association: A mycorrhizae is a mutualistic symbiosis between plant and fungus localized in a root in which energy (carbon compounds) move primarily from plant to fungus and inorganic resources (principally phosphate) move from fungus to plant. Basically, the association is divided into 2 groups. The Ectomycorrhizal and Endomycorrhiza. In endomycorrhizae, following hyphae penetrates into the root; the hyphae penetrate the cell walls of the cuticle cells. These types are generally called Vesicular-Arbuscular Mycorrhizae (VAM). The intracellular hyphae produce structures that frequently branch many times within the host cells. These structures are known as arbuscules. Arbuscules are the organs where nutrients and carbon are exchanged between host and fungus. Typically, also formed are vesicles, which are fungal storage units. The host subsequently reabsorbs the hyphae within the cells of older roots (Hunt, 1991).

Thus, the most common association of Mycorrhiza is Vesicular-Arbuscular Mycorrhizae (VAM). Powell and Bagyuraj (1984). The endomycorrhizal fungi generally associated with the roots of agricultural crops are in the Class Zygomycetes to which the common black bread

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mold belongs. However, these fungi are obligate symbionts and cannot be cultivated outside the living roots of plants. Their colonization is internal to the root and cannot be seen without staining and microscopy.

Vesicular-arbuscular Mycorrhiza enhances the growth of plant through the spread of hyphae, which extends considerably beyond root hairs into the soil, thus effectively extending the zone of nutrient like P, Cu and Zn (Abbot and Robson, 1978). Colonized roots are tolerant to high soil temperature, drought, stress, soil toxins and extreme soil pH, besides all these, they produce antibiotics, which prevent pathogens (Nelsen and Safir, 1985; Mengel and Kirkby, 1982). Mycorrhizal root systems are of benefit to their respective hosts by increasing the capacity of the roots to absorb nutrients from the soil (Mack and Kozlowski, 1973). This is apparently accomplished in several ways.

The root-absorbing surface is markedly increased (measurements have indicated that in some instances total root surface was increased 30 times more than an uninfected root) (Abbot and Robson, 1982). Hyphae radiating from the mycorrhizal root is able to penetrate farther into the soil up to 90 mm has reported by Camel (1991). Phosphate uptake per unit area of mycorrhizal roots is more than that of non-mycorrhizal roots. High concentration of Nitrogen is found in mycorrhizae plants than in non-mycorrhizae plant. Mycorrhiza infection increases the rate of nodulation and nitrogen fixation by Rhizobium in leguminous plants (Fagbola, 1996). Physiologically, the concentration of P and K is increased in the plant tissue, the plant takes up elemental nutrients more evenly and susceptibility of plants to diseases is reduced (Graham, 1983). There is an indirect effect of VAM on nitrogen fixation as a result from improved phosphorus nutrition and growth at low phosphorus level.

The distribution of VAM (Vesicular-arbuscular Mycorrhiza) fungi in soils is not homogenous and there are vegetational soil areas and crop production systems where the indigenous concentrations are too low for optimum plant production. However, as a result of high cost of chemical fertilizer, it has been suggested that biological solution to phosphorus deficiency or in availability should be sought.

Thus, this study was carried out to investigate the relationship between different kinds of soil types and Mycorrhizal population distribution.

MATERIALS AND METHODS

Description of the study site: The study was done on a valley swamp of about 2.98 ha, situated in the Northwestern part of the University of Ibadan between year 2004 and 2005. The University campus is located within the Northern fringe of the tropical rainforest of the Southwestern Nigeria. It covers a quarter degree sheet (Sheet 261 NE) between latitudes 7° 15 to 7° 30'N and longitudes 3° 45' to 4° 00'E and it is about 140 km from the Atlantic Ocean. The valley bottom has been surveyed and classified into six series namely;

Series I (Apomu), Series II (Jago), Series III (Matako), Series IV (Ikire), Series V (Oshun), Series VI (Adio) according to Smith and Montgomery soil classification 1962 (Akinbola, 2001b). The textural class ranges from loamy sand, sandy loam to loam and at the same point sandy clay loam.

The slopes are generally gentle and concave in shape. The land is about 80-100 m above sea level and was formed by the process of alluviation over many years (Akinbola, 2001a). The land has being in use continuously for over 16 years as a practical year training programme plot using different kinds of fertilizers ranging from organic to inorganic and even organo-mineral fertilizer. At the start of rains, the entire land is planted to maize and relayed with cowpea on the western part as maize is being harvested while the eastern part is allowed to fallow. As dry season sets in, the eastern end of the valley is planted to dry season vegetables (amaranthus, celosia, corchorus and okra) as the western part goes into fallow.

Field and soil mapping: Transects of 20 m apart were constructed at intervals across the valley floor and examination points were located at regular intervals of 10 m along each transect. A Dutch auger was used to collect soil samples at depth of 0-15 and 15-30 cm. The collected soil samples were taking to the laboratory for physical and chemical analysis. A total of 186 samplings were taken.

Laboratory analysis: Particle size analysis was done using Bouyoucos hydrometer method (Bouyoucos, 1926), to determine percentage clay, silt and sand. Arbuscular Mycorrhiza Fungi Extraction was done through Sucrose flotation. This is achieved by thoroughly wet 100 g of air-dried soil. The suspension was then passed through a 710 μm Endicolt sieve, to remove stones and roots. The soil suspension was again passed through a fine sieve (32 μm) and the solid matter collected was transferred to four, 50 mL centrifuge tubes. Water was added to balance the tubes and to re-suspend the soil sample. This was centrifuge at 1800 rpm for 5 min. The supernatant solution which contains floating organic material including dead spores, was discarded. Then, re-suspended in sucrose solution and centrifuge up to 1800 rpm then stopped immediately. This was rapidly sieved (32 μm) and washed thoroughly to remove the sucrose and alleviate osmotic stress on the spores. The residue was discarded and all the solid materials from the sieve were carefully washed into a petridish for counting under microscope.

Statistical test of variability: The mean ($\bar{x}$), Standard Deviation (S.D.) and Coefficient of variation (CV%) for each soil property were calculated for each series in order to compare them.

RESULTS AND DISCUSSION

Variation in physical and chemical properties within the soil series: Table 1 a and b shows the Range, mean, std. and coefficient of variation for measured parameters on each soil series.

Mycorrhiza distribution: Mycorrhiza count on series I has a minimum value of 308 and a maximum value of 423; the mean was 356.25 at the topsoil while the coefficient of variation was 11.06% at the topsoil. At the subsoil the minimum value was 258 and maximum 531 with the mean of 372.75 and c.v of 19.47%. On soil series II, Mycorrhiza distribution has a minimum count of 281 and a maximum of 482 with a mean of 36178. The c.v was 13.58% on the topsoil, while on the subsoil the minimum count was 184 and maximum count of 473 with a mean of 338.06 and c.v of 23%. Mycorrhiza count was 216 at minimum level, 471 maximum and mean of 361.88 with c.v of 24.44% at the topsoil. While, at the subsoil it was 230 at minimum, 531 maximum and the mean of 350.75, with a c.v of 26.60% on soil series III. Mycorrhiza distribution has a minimum count of 234, maximum of 897 and mean of 449.3. The c.v was 41.81% on the topsoil, while at the subsoil it was 278 minimum, 879 maximum and 442.1 mean. The c.v was 42.90% in soil series IV. Mycorrhiza count at the topsoil has a minimum value of 159, maximum value of 1003 and mean of 402.62 with c.v of 44.79% and at the subsoil, a minimum value of 202, maximum value of 100 on series V. In series VI, Mycorrhiza count has a minimum value of 230 and maximum value of 618 and mean of 357.67 with c.v of 29.23% at the topsoil. At the subsoil, the minimum value was 229; maximum was 618 and mean of 326.92 with c.v of 34.18% was recorded.

Mycorrhiza distribution was found to be highest at the topsoil in all the soil series than at the subsoil, except on soil series I where the subsoil population is higher than that of the subsoil (Fig. 1). Mycorrhiza distribution was least variable in soil series I, II at the topsoil. Moderately variable at the topsoil of series III, VI and subsoil of soil series I, II, III and VI. It was extremely variable at both topsoil and subsoil of soil series IV and V, this could be due to fluctuation of water table, which also affect the infection of mycorrhiza (West, 1991).

The study shows that there is the presence of indigenous-Vesicular mycorrhizal symbiont in all the 6 soil series within the landscape. However, high degree of

Table 1a: Measured parameters on soil series I-III

	Range		Mean	S.D.	c.v (%)	Range		Mean	Std.	c.v. (%)
Summary of measured parameters on series I (Apomu) (0-15) and (15-30 cm)										
Sand (%)	33.00	86.00	70.25	16.44	23.40	28.00	89.00	70.75	14.13	19.97
Silt (%)	8.00	24.00	13.81	4.25	30.74	6.00	58.00	17.94	11.73	65.41
Clay (%)	5.00	48.00	16.00	14.14	88.39	5.00	24.00	12.54	5.27	42.01
T. Mycorrhiza	308.00	423.00	356.25	41.34	11.60	258.00	531.00	372.75	72.58	19.47
Summary of measured parameters on series II (Jago) (0-15) and (15-30 cm)										
Sand (%)	46.00	89.00	74.11	11.48	15.49	60.00	90.00	77.83	8.18	10.51
Silt (%)	6.00	38.00	13.89	7.18	51.68	6.00	28.00	13.28	5.53	41.64
Clay (%)	4.00	27.00	12.00	6.67	55.57	4.00	21.00	9.00	4.93	54.83
T. Mycorrhiza	281.00	482.00	361.28	49.07	13.58	184.00	473.00	338.06	77.74	23.00
Summary of measured parameters on series III (Matako) (0-15) and (15-30 cm)										
Sand (%)	65.00	80.00	74.63	5.01	6.72	64.00	87.00	76.38	7.54	9.87
Silt (%)	12.00	18.00	15.50	2.07	13.36	8.00	26.00	16.38	6.59	40.24
Clay (%)	6.00	17.00	9.88	3.83	38.82	4.00	15.00	8.50	3.55	41.71
T. Mycorrhiza	216.00	471.00	361.88	88.43	24.44	230.00	531.00	350.75	93.31	26.60

Table 1b: Measured parameters on soil series IV-VI

	Range		Mean	S.D.	c.v (%)	Range		Mean	Std.	c.v. (%)
Summary of measured parameters on series IV (Ikire) (0-15) and (15-30 cm)										
Sand (%)	52.00	79.00	70.70	8.55	12.10	56.00	86.00	73.80	10.52	14.25
Silt (%)	13.00	34.00	19.10	6.57	34.42	10.00	28.00	16.30	6.63	40.70
Clay (%)	4.00	15.00	9.80	3.52	35.93	2.00	17.00	9.90	5.22	52.69
T. Mycorrhiza	234.00	897.00	449.30	187.87	41.81	278.00	897.00	442.10	189.67	42.90
Summary of measured parameters on series V (0-15) and (15-30cm)										
Sand (%)	51.00	92.00	70.78	9.47	13.38	59.00	86.00	73.38	7.36	10.03
Silt (%)	6.00	28.00	17.10	5.15	30.11	6.00	24.00	15.38	4.84	31.44
Clay (%)	2.00	25.00	12.33	5.72	46.37	4.00	19.00	11.01	4.26	38.69
T. Mycorrhiza	159.00	1003.00	402.62	180.35	44.79	202.00	1003.00	396.72	175.17	44.15
Summary of measured parameters on series VI (Osun) (0-15) and (15-30 cm)										
Sand (%)	49.00	82.00	68.83	10.29	14.96	52.00	89.00	71.33	10.81	15.15
Silt (%)	14.00	26.00	17.67	3.42	19.36	6.00	24.00	16.83	5.20	30.90
Clay (%)	2.00	33.00	13.50	9.20	68.15	4.00	29.00	11.83	7.83	66.13
T. Mycorrhiza	230.00	618.00	357.67	104.55	29.23	229.00	618.00	326.92	111.74	34.18

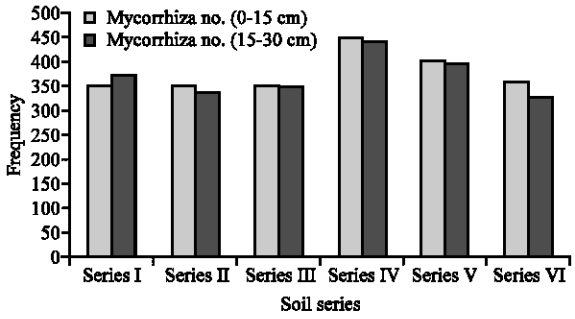

Fig. 1: Variation in the means of Mycorrhiza distribution at both topsoil and subsoil in all the series

infectivity was observed in soil series IV at both topsoil and subsoil. This could be due to the high density of sweet potato root that were growing at the time the experiment was been carried out. Although, the distribution in all the series is optimum for sustainable crop productivity, it is also advised that more study should be carried out to improve the infectivity and sustained plant growth.

CONCLUSION

From the study, the soil type do not significantly affect the distribution of mycorrhiza and it has been found out that mycorrhiza even do better in an infertile soils than fertile soils. However, if the long term benefits such as slow release of plant nutrients, biochemical conditioning of the soil, reduced water and soil pollution stress, biological control of soil pathogen are to be taken into consideration. It is advisable that scientist and extension agent should encourage farmers to plant/grow crops that are mycorrhizal dependent and could utilize the benefit conferred to plant by the presence of indigenous arbuscular mycorrhiza fungi.

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