

IMPACT OF PESTICIDES ON AMF SPORE POPULATION AND DIVERSITY IN BANANA (*MUSA SPP.*) PLANTATION SOILS

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ABSTRACT

Impact of pesticides on arbuscular mycorrhizae fungi (AMF) was carried out in banana plantation soils at Lalapet, Karur District. Maximum number of twenty two species of AMF population were isolated and identified from the soil of natural site without pesticides sprayed soils with moderate pH, high soil organic carbon, nitrogen and potassium, least available phosphorus content as compared to artificial site contaminated with pesticide and only seven species of AMF population were isolated from this soil. The present study would help to determine to what extent and which soil environment variables affects the density and abundance of AMF associations in banana plantation soils.

Key words: AMF population, Banana plantation soil, Symbiotic association.

INTRODUCTION

Mycorrhiza fungi form a symbiotic association in natural environment essential for one or both partners between a fungus (specialized for life in soils and plants) and a root (or other substrate - contacting organ) of a plant, that is primarily responsible for nutrient transfer^[1]. Arbuscular mycorrhiza (AM), are a type of mycorrhiza which is characterized by inter and intra fungal growth in the root cortex, forming specific fungal structures referred to as arbuscles and vesicles.

AM fungi are commonly found as communities that vary in composition and diversity^[2]. Approximately 37 different AM fungal taxa have been found at one site^[3]. These AMF species have a specific multidimensional niche that is regulated by the plant species present at a site and also by edaphic factors such as pH, moisture

content, phosphorus (P) and nitrogen (N) availability, as a result there is large variation between and within site in the composition of AM fungal taxa^[4]. AMF Spore populations are dynamic, being influenced by soil type, soil moisture, light intensity, nutrient availability, seasons and land usage.

AM Fungi forming associations include about 150 species belonging to the class Zygomycetes order Glomales, families Glomaceae (*Glomus* and *Sclerocystis*), Acaulosporaceae (*Acaulospora* and *Entrophosphora*), Gigasporaceae (*Gigaspora* and *Scutellispora*)^[5].

Bananas are grown in tropical environments because it takes hot humid weather to sustain the banana throughout its growth cycle. Banana plantations are often sprayed with pesticides, weedicides and these chemicals deposit in soil and bring about several toxicity to soil microbes

and AM fungal spores. Therefore the present work was taken up with the objective to test the impact on AMF spore population and diversity in banana plantation soils of natural site (without pesticide sprayed soil site) and artificial site (pesticide sprayed soil site).

MATERIAL AND METHODS

The work on status of AM fungi in banana plantation was performed during the year 2012-13 at Lalapet, Karur District, Tamil Nadu, India.

Ecological conditions of the region:

The soil type of this area is deep loamy, alluvium, shallow to sandy and loamy grey brown. The summer temperature going up to 38 °C or even more, while the winters are usually 22-24 °C. During the study period the region experienced rainfall in monsoon (October to December) period.

Study sites and sample collection:

Two different sites were chosen at two different localities, *i.e.*, natural site selected as site-A without pesticide application and artificial site, *i.e.*, pesticide sprayed site assigned as site-B. Soil samples from 15 cm depth (approx. 500 g) were collected from both sites beneath healthy plants of banana plantation regularly at an interval of three months, during three different seasons, *i.e.*, winter, summer and monsoon, respectively, the samples were air dried and were then subjected to experimental analysis.

Isolation, identification and quantification of AMF spores from the soil samples:

In this study, wet sieving and decanting technique of Gerdemann and Nicolson^[6], was used for isolation of spores. AMF spore identification and their morphological characteristics were determined and analyzed qualitatively by using manual of Schenck and Perez^[7]. AMF spore density was estimated as the mean number of spores per 100 gm soil^[8]. Quantification was carried out in 9 cm petridishes with a gridline of 1 cm per slide under stereo microscope at 50x^[9]. Spore photographs were taken at 400X magnification.

Analysis of physicochemical characteristics of soil:

Soil pH:

The soil pH was determined by taking 10 gm of soil sample in 100 ml distilled water at 1:10 (w/v) soil water suspension it was then thoroughly shaken, later on pH of the supernatant was determined with the help of digital pH meter^[10].

Available nutrients nitrogen (N), phosphorus (P), and potassium (K)

Mineralizable Nitrogen by Kjeldahl method^[11].

Calculation

Available

$$N \left(\frac{\text{Kg}}{\text{Ha}} \right) = \frac{(\text{SR} - \text{BR}) \times 0.00028}{20} \times (10)^6 \times 2.24n$$

SR = Sample Reading, BR = Blank Reading

Available phosphorus in soil:

Olsen *et al.*^[12] method was used.

Calculation:

Available

$$P \left(\frac{\text{Kg}}{\text{Ha}} \right) = \frac{R \times \text{Volume make up} \times 25 (\text{last vol.}) \times 2.24 \times (10)^6}{\text{Volume of aliquot} \times \text{Wt. of soil} \times (10)^6}$$

where, R means reading of colorimeter.

Available potassium content:

Potassium content was determined by Hanway and Heidel method^[13].

Calculation:

$$\text{Available K (kg/ha)} = \text{Reading} \times 25/5 \times 2.24$$

Data Analysis:

Pearson's correction co-efficient was used to assess the relationship between spore density, and edaphic factors.

RESULTS AND DISCUSSION

The experimental findings obtained from the present study have been discussed in the following heads:

Table-1. Physicochemical characteristics of soil of Banana field at site-A during three different seasons in Lalapet, Karur District in Site-A.

Season	pH	Physicochemical Characteristics of Soil (kg/ha)		
		Nitrogen	Phosphorus	Potassium
Winter	7.50 ± 0.01	382.02 ± 0.08	15.20 ± 0.12	390.10 ± 0.62
Summer	8.09 ± 0.01	342.60 ± 0.14	16.10 ± 0.05	330.60 ± 1.20
Monsoon	8.30 ± 0.02	314.20 ± 0.18	16.30 ± 0.30	320.70 ± 2.05

Soil analysis: pH

The study revealed slightly alkaline to alkaline soils: pH range 7.50–8.30 at site-A and 7.80–8.40 at site-B.

Available nutrients (nitrogen, phosphorus and potassium):

Nitrogen and Potassium content was found in abundance at both the sites in winter and summer seasons. Highest nitrogen content 382.02 kg/ha was found at site-A during winter season, and comparatively minimum nitrogen content 303.20 kg/ha, was found at site-B in summer (Table 1 and 2).

Relatively lower phosphorus content was recorded in both the sites, the maximum phosphorus was recorded at site-A during monsoons (16.30 kg/ha), and minimum Phosphorus content observed was (13.10) kg/ha at site-B during winter (Table 1 and 2).

Highest value of potassium content in the soil was observed from site-A (390.10 kg/ha) during winter followed by lowest (290.20 kg/ha) at site-B during monsoon season (Table 1 and 2).

AM spore density:

Site-wise results of variation in spore density of AMF in the rhizosphere of banana plant undertaken for the study are listed in Table-3. The number of spores varied significantly between the sites with the variations in site-A and B. The natural soil (site-A) was rich in both spore number and species, maximum number of spores (240, 180 and 42 *Glomus mossae* spores/100 gm soil) were recorded at site-A and 160, 120 and 24 *G. mossae* spores/100 gm soil were recorded at site-B, during winter, summer and monsoon season respectively. Minimum of 20, 8 and 2 *Acaulospora elagvans* spores/100 gm soil were recorded at site-B during winter, summer and monsoon season (Table 3).

AMF diversity:

Over all 22 different AMF species were isolated from the rhizosphere soils of banana plant considered at site-A during three seasons, belonging to three genera *Acaulospora*, *Glomus* and *Sclerocystis* (Fig.1) *Glomus* was found to be the predominant genus in the rhizosphere of site-A with 19 species followed by *Acaulospora* 2 species and *Sclerocystis* with single species

Table-2. Physicochemical characteristics of soil of Banana field at site-B during three different seasons in Lalapet, Karur District in Site-B.

Season	pH	Physicochemical Characteristics of Soil (kg/ha)		
		Nitrogen	Phosphorus	Potassium
Winter	7.80 ± 0.14	351.40 ± 0.21	13.10 ± 0.18	382.70 ± 2.20
Summer	8.23 ± 0.03	303.20 ± 0.62	15.46 ± 0.23	316.18 ± 0.82
Monsoon	8.40 ± 0.02	343.42 ± 0.18	15.98 ± 0.51	290.20 ± 0.48

whereas at site-B pesticide sprayed soil only 7 species were found and all of them are *Glomus* spp. (Table 3).

Correlation analysis of soil parameters with respect to AMF spore count:

It has been widely speculated that N, P and K and other factors like undisturbed soil enhances

AMF development, a well defined relation was observed between these parameters and AMF spore number (Table 3).

The present investigation concludes the effect of various soil parameters like pH, soil phosphorus, nitrogen and potassium content on AMF population and diversity, the study reflected a

Table-3. AMF spore density associated with banana plantation at site-A and site-B during three different seasons at Lalapet, Karur District (Total Number of AMF spore per 100 gm soil).

AMF	Winter		Summer		Monsoon	
	Site-A	Site-B	Site-A	Site-B	Site-A	Site-B
<i>Glomus albidum</i>	82	40	62	32	20	10
<i>G. amphisporum</i>	180	120	124	42	36	20
<i>G. citricolon</i>	62	42	48	24	42	12
<i>G. claroideum</i>	26	–	12	–	8	–
<i>G. convolutum</i>	28	–	14	–	4	–
<i>G. deserticola</i>	56	–	26	–	12	–
<i>G. dimorphicum</i>	26	–	20	–	8	–
<i>G. etunicatum</i>	30	–	16	–	4	–
<i>G. fulvum</i>	42	–	14	–	12	–
<i>G. geosporum</i>	68	60	32	18	24	18
<i>G. macrocarpum</i>	46	–	24	–	18	–
<i>G. melanosporum</i>	120	80	105	65	38	20
<i>G. microcarpum</i>	44	30	32	24	26	16
<i>G. mossae</i>	240	160	180	120	42	24
<i>G. multisubstensum</i>	32	–	16	–	8	–
<i>G. occulatum</i>	40	–	14	–	6	–
<i>G. pulvinatum</i>	26	–	8	–	4	–
<i>G. radiatum</i>	32	–	20	–	4	–
<i>G. tortuosum</i>	28	–	24	–	4	–
<i>Acaulospora morrowiae</i>	26	–	20	–	8	–
<i>A. elegans</i>	20	–	8	–	2	–
<i>Sclerocystis rubiformis</i>	22	–	14	–	6	–

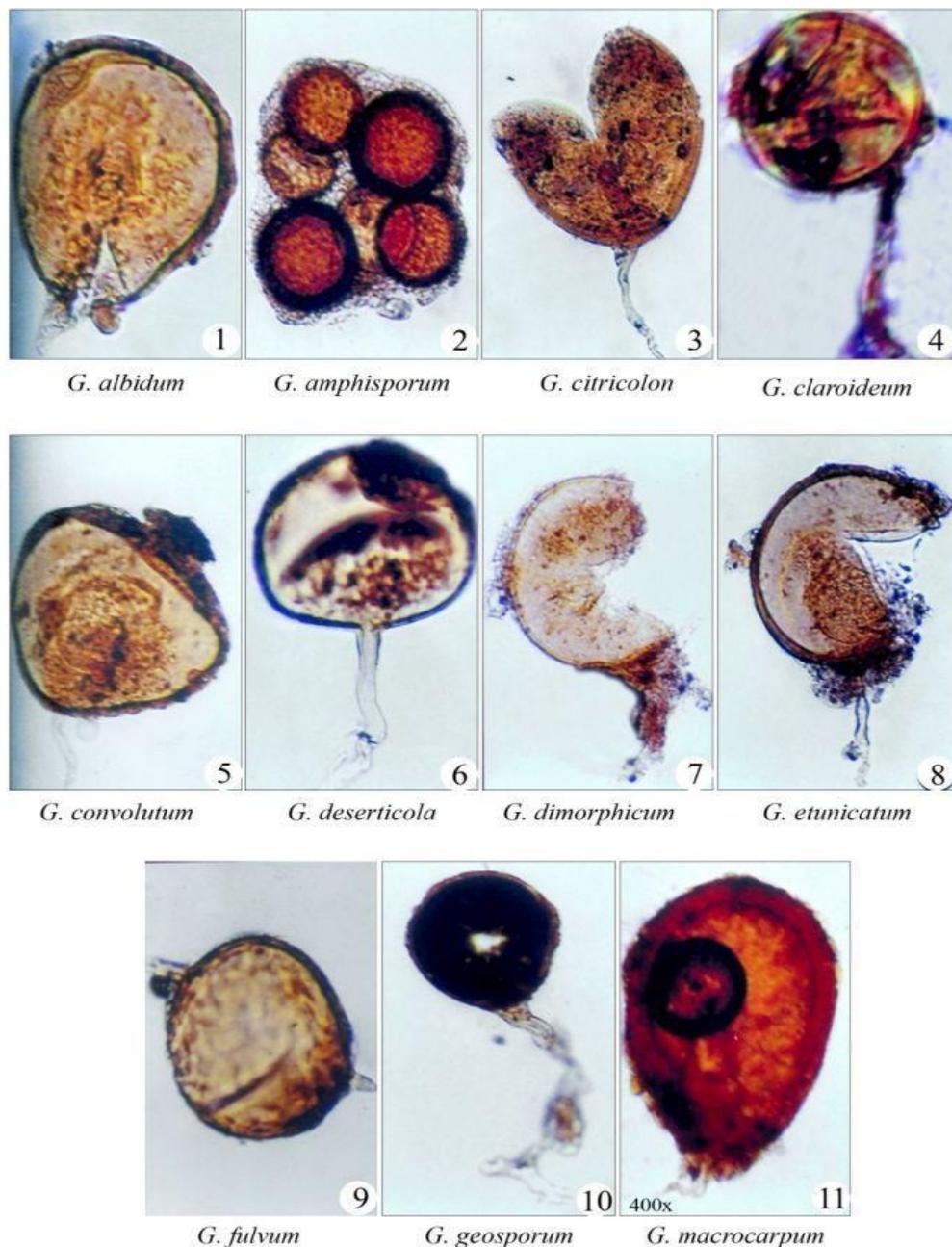
decreased trend in the abundance and diversity of AM fungi with the variation of edaphic factors as well as the pesticides sprayed soil.

Occurrence of many AMF are influenced by soil pH, many species like *Glomus mossae* and *Glomus intraradices* occur frequently in neutral to alkaline soil, whereas species of *Acaulospora* are usually found in acidic soil. pH alone may not be responsible for germination of AMF spores, as with the change in the soil pH, chemical properties of the soil also changes.

The relationship between soil pH and mycorrhization is complex and depends on the plant species and also the soil type, forms of phosphorus and fungal species involved. The optimum pH for different AMF endophytes can vary in different soils and specific endophytes have an optimum pH at which they execute best^[14].

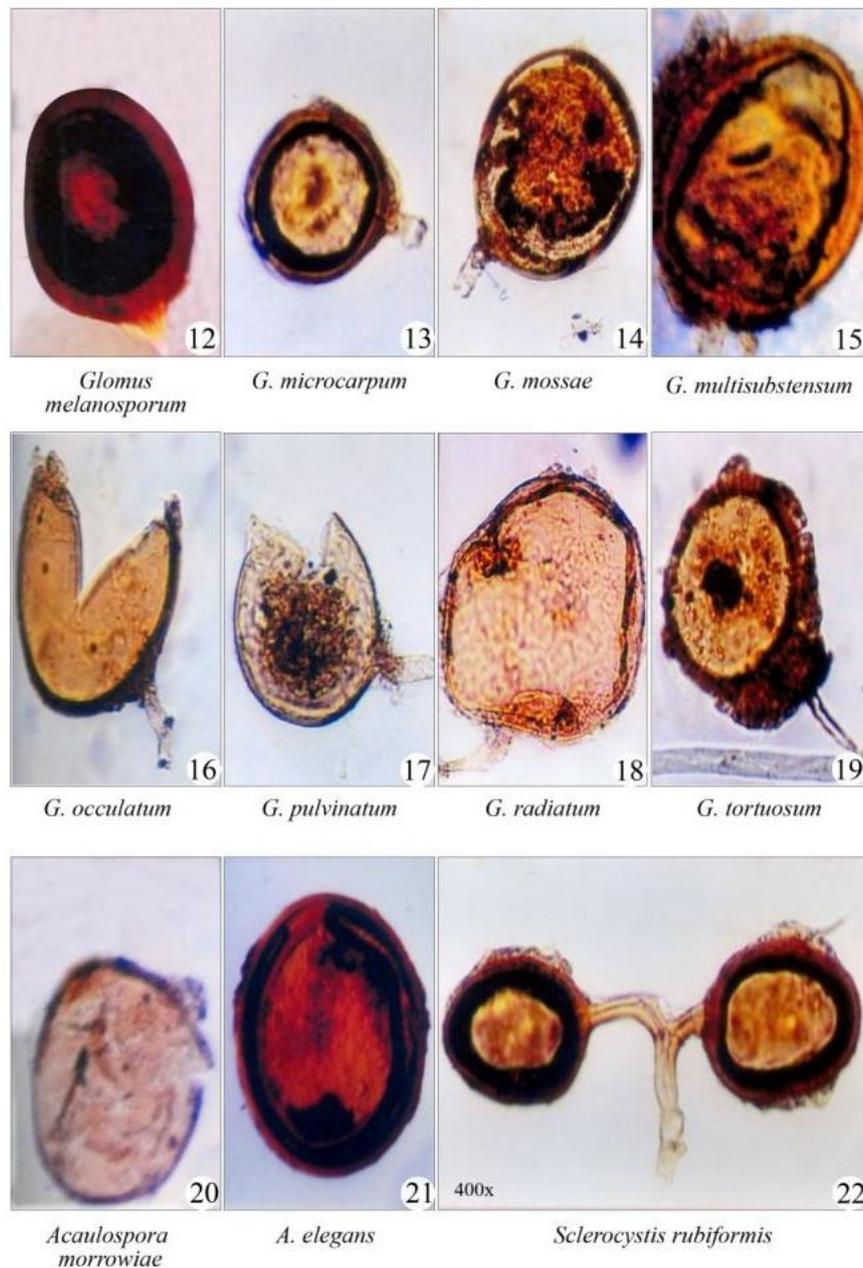
A significant positive correlation was found between spore count and available soil nitrogen content, maximum spores were isolated from the

Figure-1. Arbuscular Mycorrhizae Fungi of Banana (*Musa spp.*) Plantation soils.



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soils having higher nitrogen content, it is generally said that at moderate nitrogen content in the soil spore density is maximum, but at further increase in nitrogen content in soil results in decline of spore population. In contrast no direct correlation was found between the two^[15].

Phosphorus is one of the major plant nutrient and an essential component of the soil for plant growth and development of the AMF. In present investigation phosphorus content of the soil is in low levels in natural (site-A) and artificial soils

(site-B) (Table 1 and 2). In contrast with other seasons of the year, phosphorus levels are high and spore population is low, which depicts that higher levels of the phosphorus levels in the soils results in the decrease in the AMF spores multiplication. From the correlation analysis between phosphorus and spore population in relation to the seasons in and a significant negative correlation was observed in monsoon higher content (16.30 and 15.98 kg/ha) of phosphorus was observed from site-A and site-B resulting in decrease of spore count.

The present work shows specificity with findings of Gaur and Kaushik^[14], they also found that spore population and phosphorus content in the soil is negatively correlated^[16], they further elaborated that when phosphorus deficiency occurs in the soil, plants may release large amounts of amino acids and sugars into the rhizosphere which are utilized by AM fungi for their growth. Such a relationship was verified previously in phosphorus deficient sorghum by Grahm *et al.*^[17]. Elevated phosphorus levels in the plants may reduce the substrate leakage, thus suppressing fungal infection in the roots, this however, did not limit the uptake and concentration of phosphorus in the leaf tissue. The abundance of phosphorus in the soil was adequate to compensate for the reduced number of AMF spores and root phosphorus uptake was adequate^[18].

Based on the observations obtained potassium content of the soil is positively correlated with the spore number this can be clearly observed from the Table 1 and 2 that higher the levels of available potassium more is the spore density and diversity as well. The results are in agreement with the results of Gaur and Kaushik^[14], but were in contradiction with Khanam *et al.*^[19], they observed negative correlation between soil potassium and spore number.

The potential reason for maximum number of spore availability in undisturbed soils (site-A) is that the spores keep on multiplying in association with the plants^[16] and remain in the soil for isolation later on, whereas in disturbed site (site-B) top soil layer is disturbed at regular bases^[20] due to pesticide amendment and many AMF spores are sensitive to pesticide do not survive and those survived namely *G. albidum*, *G. amphispurum*, *G. citricolon*, *G. geosporum*, *G. melannosporum*, *G. microcarpum* and *G. mossae* are referred as pesticide tolerant spores.

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