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Impact of Chemical Inputs on Arbuscular Mycorrhizal Spores in Soil

Response of AM Spores to Fertilizer and Herbicides

OLUYEMISI B. FAWOLE[1*] AND ELIZABETH T. ALORI[2]

[1]Department of Agronomy, University of Ilorin, P.M.B. 1515, Ilorin, Kwara state, Nigeria

[2]Crop and Soil Science Department, Landmark University, P.M.B. 1001, Omu Aran, Kwara state, Nigeria

Abstract

Effects of chemical inputs on abundance of arbuscular mycorrhizal (AM) fungi spores were investigated under a maize monoculture in Southern Guinea Savanna ecological zone of Nigeria. The experimental plots received 0, 60, 120 and 180 kg N/ha of fertilizer (N.P.K. 15: 15: 15) and 0, 1, 2 and 3 kg active ingredient (a i) pre-emergence herbicide (atrazine) per hectare. AM fungal spores were isolated from the conventionally tilled, treated soils, cropped with maize by wet sieving and decanting method. Isolated AM spores were counted and spore abundance calculated. The spores were morphotyped and 13 AM fungi taxa were identified. These belong to six genera of AM fungi: *Glomus*, *Paraglomus, Acaulospora, Enthrophospora, Gigaspora* and *Scutellospora*. Increasing atrazine concentrations resulted in significant deduction in AMF spores while increasing N.P.K. content led to an initial significant increase in AMF spores but a later decline in spore population. Both fertilization and herbicide application resulted in a decrease in AMF spore numbers at maturity of maize crop. Application of 160kg N/ha and 3kg a.i. ha^{-1} of atrazine caused a significant reduction in spore density (117g^{-1} of soil as against 202 g^{-1} of soil at 0 kg N ha^{-1} and 0kg a.i. ha^{-1} atrazine).

Keywords: Arbuscular Mycorrhizal Spores, Herbicide, Fertilizer, Southern Guinea Savanna

1. Introduction

Arbuscular Mycorrhizal Fungi (AMF) are obligate biotrophs that form symbiotic interactions with a wide range of plants, wild and cultivated plants alike. They are ubiquitous in natural and agricultural soil [8]. AMF improve plant mineral nutrition thereby playing important role in nutrient cycling plant health and plant water relations [1, 5].

Atrazine is one of the most widely used agricultural herbicide worldwide. It may be applied before and after planting to control broad leaf and grassy weeds. Atrazine is applied on maize, sorghum and sugarcane.

A major problem facing crop production in Southern Guinea Savanna ecological zone of Nigeria is the low fertility status of the soil [4]. This therefore necessitates the use of large dressing of inorganic fertilizer for maximum plant growth and yield.

We hypothesized that agricultural inputs (Inorganic fertilizer and herbicide) would affect the population density of the AM fungal community. Loss of AMF species could lead to irreversible destruction of habitat and eventual loss of agroecosystem. There is little information on the effect of intensive agricultural systems on AMF in Southern Guinea Savanna ecological zone of Nigeria. This research is therefore aimed at evaluating the effects of fertilizer and herbicide application on the population of AMF spores in soils cropped with maize.

2. Materials and Methods

The field experiment was carried out at the Teaching and Research Farm of the University of Ilorin, Ilorin, Nigeria. The soil examined was an Alfisol with the following composition (at 0- 15 cm layer) % Organic Matter 0.48, %N 210, P (mg kg^{-1}) 1.88 and soil pH was 5.85. The agricultural inputs were herbicide (Atrazine 50% Sc.) treatment: 0, 1, 2 and 3kg active ingredient per hectare applied as pre-emergence; fertilization treatment (N. P. K. 15:15:15) : 0 Kg ha^{-1} N, 60 Kg ha^{-1} N,12 Kg ha^{-1} N 0 and 180 Kg ha^{-1} N at two weeks after planting. The test crop was maize. The treatments were arranged in randomized split plot design and replicated three times. To study AM fungal

*Corresponding author: Oluyemisi Fawole; E-mail: yemisifawole@yahoo.com
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spore population soil samples were collected at 4weeks after planting and at maturity. AMF community were studied by spore extraction from soil. Hence 100g soil (dry weight) of each soil sample was wet sieved and centrifuged, following the methodology proposed by [2]. Quantification was carried out in 9cm diameter petri dish with a grid line of 1cm per side under stereoscopic microscope at X40. Ten divisions were counted and related to total number of spores by using the method modified by Mckenney and Lindsey [6]. Data collected were subjected to analysis of variance. Means were separated using Least Significant Difference (LSD).

3. Results and Discussion

Thirteen (13) AMF taxa belonging to 6 genera of AMF: Glomus, Paraglomus, Acaulospora, Enthrophospora, Gigaspora and Scutellospora were identified from the study site. The percentage frequencies of the species recorded are shown in (fig.1). The effects of fertilizer (N. P. K 15: 15: 15) and herbicide (Atrazine) on the population of AMF spores are shown in Tables 1 and 2. A significant reduction in AMF spores associated with the increase in atrazine concentration agrees with the findings that fumigation to destroy weeds also kills AMF [7]. Increasing N. P. K. content led to significant increase in AMF spores at 4 weeks after planting (WAP) (Table 1), but an increase in the quantity of both herbicide and fertilizer used resulted in a significant decrease in the population of AMF spores at maturity of test plant. Application of 160kg N/ha and 3kg a.i/ha of atrazine caused a significant reduction in spore density (117/g of soil as against 202/g of soil at 0kg N/ha and 0kg ai/ha atrazine). This suggests that increase in fertilizer application probably supported an increase in AMF spore numbers until a critical level where a further increase in the availability of inorganic fertilizer in soil resulted in a decrease in number of AMF spores.

This is in line with the findings reported in [8] who stated that fertilizer and pesticide applications to soil may counteract super optimum AM fungal populations. Reduction in mycorrhizal population will have adverse effects on mycorrhizal infections and uptake of nutrients by mycorrhizal plants. It was also reported that application of atrazine resulted in a decrease in AMF colonization [3]. Elimination of AMF populations can lead to problems with plant establishment and survival. Nitrogen additions decrease investment in AMF by plants (assessed primarily as % Root Length Colonization (RLC)) by an average of 24% in field studies [10].

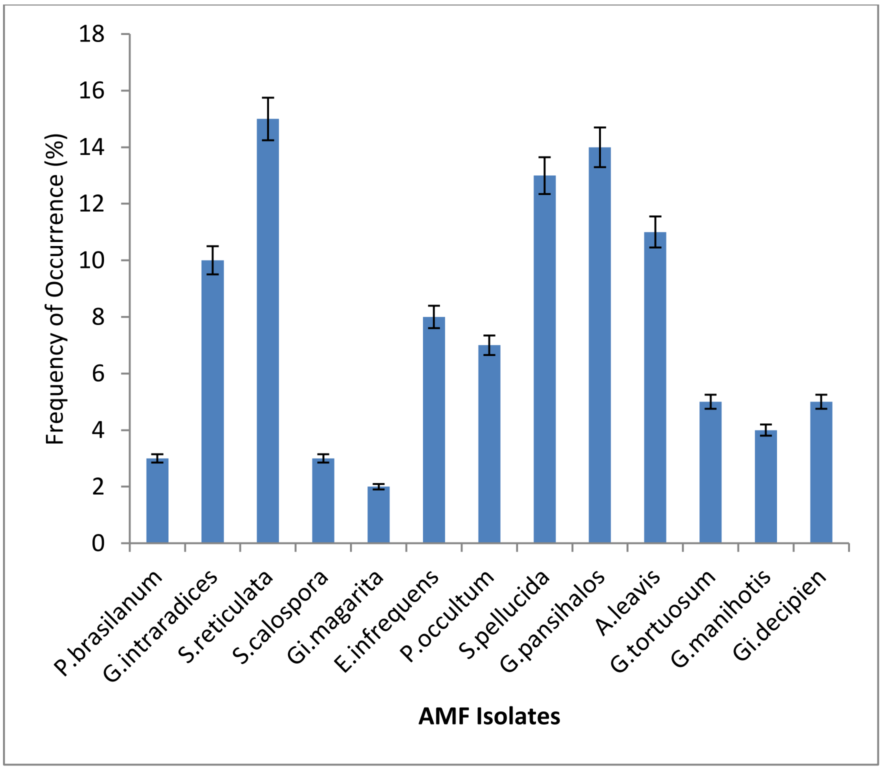

Figure 1. % Frequency of occurrence of AMF isolates. Bars are % error

Table 1. Interative effect of herbicide (Atrazine) and fertilizer (N.P.K) on AMF population at 4WAP

	HERBICIDE				
FERTILIZER	**H1**	**H2**	**H3**	**H4**	**MEAN**
F1	534e	505g	485h	421k	486
F2	545d	540de	508g	443j	509
F3	576b	556c	525f	478i	534
F4	613a	579b	542d	506g	560
MEAN	567	545	515	462	522
LSD		2.98			

[1]Means followed by the same letter (s) in column and row of any set of treatment are not significantly different at 5% level of probability using least significant difference (LSD) test

Table 2: Effect of herbicide (Atrazine) and fertilizer (N.P.K) on the AMF spore population

TREATMENT	**AMF SPORE POPULATION**	
HERBICIDE (H)	4WAP	MATURITY
H1	567a	437a
H2	545b	337b
H3	515c	228c
H4	462d	155d
MEAN	522.25	289.25
LSD	1.81	4.32
FERTILIZER (F)		
F1	486d	355a
F2	509c	304b
F3	534b	267c
F4	560a	231d
MEAN	522	289
LSD	1.49	3.35
INTERACTIVE (H & F)	2.98	6.70

[1]Means followed by the same letter (s) in column of any set of treatment are not significantly different at 5% level of probability using least significant difference (LSD) test

[2]***Key:*** F1=Fertilizer at 0kg, N/ha, F2=Fertilizer at 80Kg N/ha, F3=120Kg N/ha, F4=160Kg N/ha, H1=herbicide at 0 kg ai/ha, H2=herbicide at 1 kg a.i/ha, H3=herbicide at 2 kg a.i/ha, H4=herbicide at 3 kg a.i/ha.

4. Conclusions

The results of this study suggest that conventional agriculture that relies solely on inputs such as mineral fertilizers & herbicides for increasing productivity do reduce the population of AM spores in soil and would thus have a long term negative impact on mycorrhizal infections. There is therefore the need for use of more eco-friendly soil inputs for sustainable crop production.

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