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NOTA CIENTÍFICA

MYCORRHIZAL FUNGI IN SOILS CULTIVATED WITH COCOA IN ATLANTIC RAIN FOREST, BAHIA, BRAZIL

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The mycorrhizal fungi can be, and in many cases are, fundamental for the efficient nutrition process and appropriate development and production for most of the plants. Because the new scientific focuses based on agro environmental processes and, specially, for areas with deficient socioeconomic conditions and poor soils, biological alternatives of agricultural management based on mycorrhiza utilization for example, can be recommended. This preliminary study aimed at to identify the main mycorrhiza species associated with two main soils cultivated with cocoa, in the south of Bahia, Brazil. A larger diversity of genus / species in the Ultisol (Argissolo), and a prevalence of the genus Acaulospora in the Oxisol (Latossolo) was verified.

key words: Native mycorrhizal fungi, *Theobroma cacao*, Atlantic Rain Forest.

Fungos micorrízicos em solos cultivados com cacau na Mata Atlântica da Bahia, Brasil.
Os fungos micorrízicos podem ser, e em muitos casos são, fundamentais para o eficiente processo de nutrição e adequado desenvolvimento e produção, para a maioria das plantas. Diante dos novos enfoques científicos baseados em processos agroecológicos e, em particular, para regiões de condições sócio-econômicas deficientes e solos pobres, alternativas biológicas de manejo agrícola, a exemplo do uso de micorrizas, podem ser recomendadas. Este estudo preliminar objetivou identificar as principais espécies de micorrizas associadas aos dois principais solos cultivados com cacau, no sul da Bahia, Brasil. Verificou-se uma maior diversidade de gêneros / espécies no solo Bt (Argissolo), e um predomínio do gênero Acaulospora no solo Bw (Latossolo).

Palavras-chave: Micorrizas nativas, *Theobroma cacao*, Mata Atlântica

Introduction

Among the microorganisms that inhabit the interface between the roots of plants and the soil, some fungi have a special role because their capacity to penetrate into the alive cells of the host plant without causing damages and, at the same time, extendeding besides the area of depletion of the roots to establish intimate contact of their hyphae with the aggregates and the soil microorganisms. This symbiosis formed by the fungus with the roots of the host plant, known as mycorrhiza, is characterized by the mutual benefits of the association which form a dynamic system (Oliveira and Trindade, 2000).

Several mycorrhiza types exist, like Vesicular-arbuscular mycorrhiza (VAM) which are spread in the soil and in the world flora being the mycorrhiza type that prevails in the plants of economical interest. The main agronomic meaning of use of VAM is the ability to increase the efficiency of the uptake of P and Zn, which are diffused very slowly in the soil. Besides, the hyphae increase the superficial area of the roots for absorption of P of the solution of the soil.

Fungi facilitate the soil exploration, because their hyphae have better adaptability and present a larger volume, than the roots would be capable, supplying water and nutrients to the plants. Mycorrhizae are very fragile beings and they die if don't find roots to interact. VAM exercise effect in the

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relationship water-plant, and have a great importance for the host plant under low water supply. Increasing humidity levels means, in general, the increasing in availability of some nutrients in the surface of the roots P absorption, for example, is directly proportional to the level of soil humidity (Lima, 1996).

To some vegetable species, the dependence to the presence of those fungi is so accentuated, that in the total absence of the symbiosis the plants don't answer satisfactorily to P fertilization (Oliveira and Trindade, 2000). Mycorrhizal dependence is defined as "the degree that the plants need to be mycorrhizal active to produce a maximum growth under given level of soil fertility", and numbered expressed by the relationship among the growth of VAM-plants and no VAM-plants, multiplied by 100 (Silveira, 1992).

In countries with deficiency of socioeconomical and structural conditions, and low use of essential inputs, the adoption of biological technologies, as mycorrhizal associations, could mean a good alternative (Sieverding and Saif, 1984). Sanches and Salinas (1980) recommend the mycorrhiza use for the best P action, in the tropical oxisols and ultisols management.

For many communities of several nations, the philosophy and the practice of agriculture are changing from a conventional focus for a sustainable approach. The sustainable agricultural systems are characterized by reduced utilization of synthetic inputs and an increase on procedures related with conservationist practices. In the history of agriculture, the role of microorganisms in sustainable agriculture has been neglected in the conceptual discussions of the theme, in spite of those organisms play relevant part in the integrated management, plant diseases, cultural rotation, biological control, strategies of fertilization and soil conservation (Oliveira and Trindade, 2000).

The arbuscular mycorrhizal symbiosis is recognized for its multiple positive effects on plant growth and for its important contribution towards the maintenance of soil quality. In spite of these benefits to agriculture, at present, the realization of the full potential of this symbiosis has not yet been reached. The understanding of interactions existing among crops, fungal partners and environmental conditions must improve to allow for the efficient management of the mycorrhizal symbiosis through selected agronomic practices and inoculation of cultivated crops (Hamel, 1996).

Endomycorrizal of the vesicular-arbuscular type are widespread (Mosse, 1973) and have been reported in tropical crops such as sugar cane, coffee, oil palm, tea, rubber, cocoa (Johnson, 1949). The presence of vesicular-arbuscular mycorrhiza in cocoa and palm oil, was reported by Pyke (1935) and Laycock (1945). Since long time it has been observed that the cocoa plants are very dependent of the mycorrhizal fungi, specially the vesicular-arbusculars (Laycock, 1945).

The cocoa tree is a well-known plant and has great economical and industrial interest. It is grown in acid soils of the tropical areas in which the P availability is reduced. Considering that the generalized occurrence of mycorrhiza in cocoa tree is accepted the arbuscular mycorrhiza is very important for the cocoa nutrition. Besides the cocoa tree, several arboreal and herbaceous plants depend on the mycorrhiza to absorb nutrients with low availability in the soil, such as P and Zn (Lima, 1996). It has been presented experimental evidences that VAM influence the growth of cocoa tree, and the colonized plant had better growth and larger absorption of nutrients than the no colonized (Barbosa, 1992). Besides the cocoa tree, other plants like citrus, wheat and soy have showed relative dependence of the mycorrhiza for P absorption.

Phosphorus is related with the mycorrhiza dependence of the plants. There are differences among species and cultivars of the same species of plants, for the capacity of P extraction and for the demand of this element. Those species or cultivars of plants with smaller absorption capacity and with larger demand of P can get more benefit and have more dependence of the symbiosis. Besides P there is mycorrhizal dependence of the plants for absorption of Mn, Zn and Cu (Barbosa, 1992).

Cocoa seedlings cultivated in Brazilian tableland soils (haplorthox), presented a large growth (Santos, 1986), when associated with mycorrhiza (*Gigaspora margarita*). It was studied in Venezuela, that *Glomus etunicatum* is the VAM species that seems to be preferentially associated with cocoa plants (Cuenca *et al*., 1991). This species also tolerates a wide range of soil pH values. The authors observed in an old established plantation that the fertilization diminishes the percentage of VAM infection, both in cocoa plants and in their shade trees.

Mycorrhizal studies in soils of the Cocoa Researches Center, of the South of Bahia, Brazil (Santos, 1981) indicated that: there is a natural mycorrhizal infection in roots of cocoa trees; the most frequent genus was Glomus; in young cocoa trees and in the adults, the infection was increased with larger incidence of solar radiation; the high level of P (43 mg kg^{-1}) in the soil causes a quick decrease on the rate of root infection.

The basic evaluation carried out in this work, had as objective the initial identification of mycorrhiza in two of the predominant soils of Southern Bahia, Brazil, That have agricultural aptitude to and are cultivated by cocoa. The present information represents the preliminary scientific data for more detailed studies in that region.

Material and Methods

The soils studied in this evaluation belongs to the groups of Latossolo (Oxisol - Bw) and Argissolo (Ultisol - Bt), selected for the reason they are present in most indicated areas to the cocoa cultivation, in the Southeast area of Bahia, covering, respectively, around 20 and 11% of the

total mapped area of 88,900 km^2 (Silva *et al*., 1975).

Composed soil samples, in three replications formed by five other simple samples, were collected in the 0-20 cm layer for the mycorrhizal analyses and for the soil properties, trying to maintain the present roots. The collection places were:

B-textural (Bt - Ultisol) – in municipality of Lomanto Junior – state of Bahia, under cocoa plantation, approximately 60 years old, located in the coordinates 14º 44´ 32" South and 39º 23´ 14" West, in approximate altitude of 105 m. Besides cocoa, other trees were present in the area, like: corindiba (*Trema micranta*), eritrina (*Erythrina glauca*), jack tree (*Artorcarpus heterophylla*), orange tree (*Citrus sinensis*), gameleira tree (*Ficus* sp.).

B-latossólico (Bw - Oxisol) - in municipality of Ilhéus - state of Bahia, under cocoa plantation, approximately 30 years old, located in the coordinates 14º 47´ 38" South and 39º 05´ 31" West, in approximate altitude of 63 m. The area also possessed plants of rubber tree (*Hevea brasiliensis*), jack tree, orange tree, jenipapo fruit tree (*Genipa americana*).

For mycorrhizal identification the soil samples were homogenized, taking 50 g for processing by humid sieving technique (Gerdemann and Nicolson, 1963), following by centrifugation in sucrose (Jenkins, 1964). For appropriated identification, the spores were placed on slides with PVLG (polyvinyl-alcohol in lacto glycerol) or with reagent of Melzer + PVLG (1:1) and observed in microscope, based on the manual of Schenck and Pérez (1990) and the site of INVAM (www.invam.wvu.edu). In this process the identification of the species was made. For soil analysis the basic methods had adopted the Embrapa (1997) procedures.

Results and Discussion

The basic characterization of the soils is presented in the Table 1 and the identified mycorrhizae in the Table 2. In the studies of native VAM the most important data are those regarding the diversity. In spite of the same number of species in both analyzed soils, a larger diversity of genera / species was observed in the soil Bt - Ultisol, and the prevalence of the genus *Acaulospora* in the soil Bw - Oxisol.

Some observations could be noted in the visual analysis of the samples: a larger number of spores was verified in the samples of the Oxisol; the species of *Glomus* could not be identified due to the low number of spores; to evaluate the diversity in full detail, is recommended to select a larger number of collection points, samples of thicker layers and to adopt the culture trap.

In the present work the largest diversity, based on the genus, of VAM in the soil Bt - Ultisol, in relation to Bw - Oxisol, can be a consequence of the chemical conditions presented by the soils. In the Oxisol, in spite of the best levels of Ca and Mg, the large levels of available micronutrients could inhibit VAM. Large levels of nutrients in the soil tend to inhibit the symbiosis, especially N and P (Silveira and Cardoso, 1987). P is the largest restrictive; N should be preferentially as nitrate, because the ion ammonium is more poisonous to VAM (Chambers *et al*., 1980).

The mycorrhizae were found among pH 2,7 to 9,2, but the association of the fungi is affected directly by the effects of the pH on the permeability of the membranes of the plant and of the fungi or indirectly by the nutrient availability. In acid soils Al can acts as a fungus repellent, then the lime in general is beneficial for VAM (Maluf et al., 1988). The micronutrients can also be an inhibition factor, when there are high concentrations, particularly Zn and Mn (Hepper, 1979). There is larger formation of VAM in soils under low concentrations of Zn, Cu, Fe and Mn.

The excess of humidity can interfere on spore germination and in the fungi colonization. On the other side, the host presents larger tolerance to the drought in function of the hormonal and nutritional alterations caused by the symbiosis (Silveira, 1992).

Table 1 - Chemical (1A) and physical (1B) properties of the evaluated soils (Bw: Oxisol, and Bt: Ultisol).

(1A)

Solo	pH	Al	H+Al	Ca	Mg	Ca+Mg	K	N	P	Fe	Zn	Cu	Mn
	H_2O	cmolc dm^{-3}						g dm^{-3}	mg dm^{-3}				
Bw	5.0	0.0	4.0	5.1	4.2	9.3	0.14	1.22	4	191	8	67	164
Bt	5.2	0.2	9.1	2.6	3.0	5.6	0.12	1.62	3	162	2	2	8

(1B)

Solo	AG	AF	SI	AT	AN	SI/AT	EU	GF	Dp
	g kg^{-1}							%	g cm^{-3}
Bw	406	242	230	123	61	1.9	166.8	50.3	2.61
Bt	176	114	223	487	51	0.5	313.5	89.7	2.64

AG=Coarse sand; AF=Fine sand; SI=Silt; AT=Total clay; AN=Natural clay; EU=Humidity equivalent; GF=Flocculation degree; Dp=Particle density.

Table 2 – Species of Arbuscular Mycorrhizal Fungi (AMF) in the rhizosphere of cocoa trees (*Theobroma cacao*, L.) in two soil of South of Bahia, Brazil.

Species of AMF	Soil	
	Ultisol - Bt (Argissolo)	Oxisol - Bw (Latossolo)
Acaulospora tuberculata Janos and Trappe	+	+
Acaulospora excavata Ingleby and Walker	–	+
Acaulospora scrobiculata Trappe	–	+
Acaulospora mellea Spain and Schenck	+	+
Glomus spp. Tulasne and Tulasne	–	+
Glomus sinuosum (Gerdemann and Schenck) Almeida and Schenck	+	–
Gigaspora gigantea (Nicolson and Gerdemann) Gerdemann and Trappe	+	–
Scutellospora pellucida (Nicolson and Schenck) Walker and Sanders	+	–

(+) presence; (–) absence.

The present results suggest a relationship between the occurrence of Acaulospora and the sandiest soils, while the largest diversity of species links with larger clay tenors in the soil. Could be searched also about the connection between the inverse relationship of the sand content and the equivalent humidity, and the best environmental condition to Acaulospora.

In general the studied soils don't present adverse conditions, in the sense of inhibiting the mycorrhiza. The data that, more directly can be approached, for influences on VAM, would be large values of potential acidity (H + Al), N, total clay and equivalent humidity in the soil Bt - Ultisol, and of Ca, Mg and micronutrients (Fe, Zn, Cu and Mn) in the soil Bw - Oxisol.

Plants with symbiosis tend to absorb more Ca, Zn, Cu and Fe; and the decrease of Mn and Al in these plants can mean that the symbiosis performs a role of direct protection of the plant to the toxicity of those elements and/or it is involved in the tolerance of the plants to them (Maluf *et al*., 1988).

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