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Original article

Weeds as hosts of arbuscular resident mycorrhizae in a maize-beans successional system

Las arvenses como hospedantes de micorrizas residentes arbusculares en un sistema sucesional maíz-frijol

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ABSTRACT: The diversity of arbuscular mycorrhizal fungi (AMF) is an alternative for biofertilization in agriculture, which makes necessary studies to evaluate the relationship of AMF communities with respect to soil physicochemical and host conditions. On the other hand, weed flora, if properly managed, can act as a host for AMF, maintaining the availability of active propagules in the soil, influencing the rapid colonization of roots of the subsequent crop. In turn, these fungi represent a group of edaphic microorganisms that establish symbiosis with plants, which positively influences their growth and development. The research was carried out with the aim of determining the presence of native AMF in arbaceous arvences plant species. The experimental design was a randomized block design with four replicates. To fulfill the objective of the work, the total number of weed species found was recorded, and after their classification, the dominance or subordinate species was evaluated. For AMF, colonization, visual density and spore count were evaluated. After three field and laboratory experiments, it was determined that the cenosis did not undergo structural changes and that the species *Eleusine indica* (L.) Gaertn.; *Lepidium virginicum* L.; *P. hysterophorus*; *Milleria quinqueflora* L. and *S. halepense* were the main weeds that harbored AMF in the rhizosphere, with a high percentage of colonization.

Key words: colonization, edaphic microorganisms, undesirable plants and roots.

RESUMEN: La diversidad de hongos micorrízicos arbusculares (HMA) son una alternativa de biofertilización en la agricultura, lo que hace necesarios los estudios que permitan evaluar la relación de comunidades de HMA respecto a condiciones fisicoquímicas del suelo y hospedante. Por otra parte, la flora arvense, si es manejada adecuadamente, puede actuar como hospedante de los HMA, manteniendo la disponibilidad de propágulos activos en el suelo, influyendo en la rápida colonización de las raíces del cultivo subsiguiente. A su vez, estos hongos representan un grupo de microorganismos edáficos que establecen simbiosis con las plantas, lo que influye positivamente en su crecimiento y desarrollo. La investigación se realizó con el objetivo de determinar la presencia de HMA nativos en especies de plantas arvenses. El diseño experimental fue de bloques al azar con cuatro réplicas. Para cumplir con el objetivo del trabajo se registró el total de especies de arvenses encontradas, y posterior a su clasificación, se evaluó la dominancia o especies subordinadas. Para los HMA se evaluó la colonización, la densidad visual y el conteo de esporas. Luego de tres experimentos de campo y laboratorio, se determinó que la cenosis no sufrió cambios estructurales y que las especies *Eleusine indica* (L.) Gaertn.; *Lepidium virginicum* L.; *P. hysterophorus; Milleria quinqueflora* L. y *S. halepense* fueron las principales arvenses que albergaron HMA en la rizosfera, con un alto porcentaje de colonización.

Palabras clave: colonización, microorganismos edáficos, plantas indeseables y raíces.

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INTRODUCTION

During the last fifty years, Cuban agriculture has experienced two extreme models of food production intensity (1). One was characterized by an intensive, high-input approach, and the other was oriented towards agroecology and the use of low inputs (2). With respect to the latter, the development of agricultural management methods to harmonize agricultural production, natural resource conservation and rural development is considered an urgent need, with agroecology as a good starting point (1).

One of the components of biodiversity in agroecosystems is constituted by weeds, which are all those plants that grow spontaneously in agricultural systems and they are eliminated because they are considered useless species (3). However, if they are properly managed, they can be used as a source of important ecological benefits (4). For this reason, their conservation should be considered in the spatial and temporal design of ecosystems, in addition to the composition and functions that these types of plants can perform on productive farms. In the Caribbean region, producers manage weeds with chemical products, combined with manual controls; this leads to evident risks for the environment and human health, which contradicts the requirements of good agricultural practices (GAP) demanded by international markets (5).

The soil microbiota, by participating in the decomposition processes of organic material, in the immobilization of molecules and elements in its organic components, guarantees the availability of food for the vegetative cycles and, consequently, the obtaining of better harvests (6). The countless agricultural practices carried out on the soil create a variety of conditions for the proliferation or reduction of biota and their diversity, which is why studies should be carried out to understand the impact of these practices.

AMF are microorganisms that establish symbiosis with more than 80 % of terrestrial plants and have the capacity to provide important ecosystem services, and represent an extremely important advantage in heterogeneous environments, where the allocation of resources is limited between growth and resistance to different stresses, which leads the plant to adapt and survive (7). Despite the large number of ecological studies focused on diversity in terms of eco- and agroecosystems, there is limited information on the presence of AMF in the rhizosphere of arbuscular plants. Considering the above, the objective of the present work was to determine the presence of native AMF in arborescent plant species.

MATERIALS AND METHODS

The research was developed in experimental areas of the National Institute of Agricultural Sciences (INCA), located in San José de las Lajas, Mayabeque province, km. 3½ of Tapaste road, having its center at 22º59'40.79" North Latitude and 82º8'21.88" West Longitude (8), at an altitude of 138 ma.s.l. (9). These soils are dominated by the typical Ferrallitic Red Lixiviated Eutrophic soil, characterized by medium to high fertility (9). Some chemical characteristics of the soil are shown in Table 1.

This soil is moderately deep, with a slightly acid pH. It presents a low percentage of organic matter; the phosphorus and calcium content in the soil is high; however, potassium and magnesium are low (9). In order to respond to the research objective, a field experiment was developed in 2017-2018, which was repeated in time, twice, for which the influence of the corn-bean successional system was studied, in one of the main components of biodiversity; that is, the microfauna associated with the rhizosphere of arbuscular plants.

To determine the species of weeds that appeared in the corn-bean succession, data were collected before each planting, for which the total number of weed species found in the experimental area was recorded, using a frame equivalent to one m^2 that was repeated six times at random (10). The species were classified according to the degree of "weeding", according to their presence in percentage, following Maltsev's scale (10) and including the term without dominance, or subordinate species. The cespitose weeds were estimated by quantifying the percentage of surface coverage within the square frame.

To quantify the presence of microorganisms in the rhizosphere of the weeds, the most frequent species in the production system were selected by means of a sampling carried out in the weed treatment during the entire crop cycle, taking them in their adult stage. For the determination of AMF, roots were sampled and spotted, then washed with running water, eliminating all residual soil, and then air-dried. Subsequently, the finest rootlets were taken and shredded. For the determinations, 200 mg of rootlets per treatment were taken and stained with trypan blue (11). Colonization was also evaluated by the intercept method, visual density and AMF spore count (12). The experimental design was a randomized block design with four replicates. The data obtained were processed by double rank analysis of variance and, where necessary, Duncan's multiple range test at 5 % probability was applied.

RESULTS AND DISCUSSION

The weed community at the end of the maize-bean succession cycle

At the end of the succession cycle, some quantitative and qualitative positional changes were observed in the structural composition of the weed community, with respect to that existing at the beginning of the successional system;

Table 1. Some chemical characteristics of the soil in the INCA experimental area

Depth	pH	O.M	P	K^+	Ca^{2+}	Mg^{2+}
(cm)	(H_2O)	(%)	(mg kg^{-1})		(cmol kg^{-1})	
0-20	6.4	2.11	234	0.52	9.93	1.80

but they did not modify it structurally, so that the dominant species remained in the same positions as at the beginning. The results can be seen in Table 2.

Everything seems to indicate that, in order to produce structural changes capable of modifying the functional structure with the appearance of new species as dominant, a greater number of years with the system is required, or to incorporate as an alternative, crops with a longer cycle. The establishment of successional systems, where corn returns to the surface every two or three years, could perhaps provoke structural changes in the composition of weeds (3).

In addition, rotational or successional system designs should be studied with crop species with a longer cycle, such as *Manihot sculenta* (L.), which, according to the author's observations, causes modifications in the initial composition. The change that occurred in the composition of weeds with the presence of the *M. sculenta* crop was favorable, given the dominant presence of a dicotyledonous weed species (*A. dubius*), which according to is easy to manage (13).

This observation deserves attention for future research aimed at structurally modifying the weed community. However, in the corn-bean successional system, 10 new species appeared, distributed in seven botanical families, of which only three are perennial, which constitutes a symptom of favorable improvement to the productive system and to the agroecosystem in general. These results demonstrate the importance of establishing successional systems that can favor the structural composition of weeds. Weeds are modified with good management, in crop sequence systems or tillage systems, as well as the use of alternatives that provide better agronomic and economic solutions (2).

Presence of Arbuscular Mycorrhizal Fungi (AMF) in weeds

AMF are present in all tropical ecosystems, but their distribution is not homogeneous and there are soils and crops where the natural mycorrhizal potential of AMF is very low to promote plant development (14). Therefore, the recognition of areas where AMF populations are low would allow the evaluation of the contribution that arboresae could make, which could result in information of interest for this field of science.

Table 3 provides information on the percentage of colonization and visual density according to the distribution of resident AMF in the rhizosphere of the 10 new species of weeds evaluated. Although no AMF applications were made at the site where the research was conducted and, therefore, those found correspond to the resident AMF, all the root samples of the different species of arbaceae showed mycorrhizal colonization. Visual density was low in all cases, but the most significant species were *P. hysterophorus* and *L. virginicum*.

The increase of spores depends on the mycorrhization that increases with the increase of colonization and, therefore; in plants inoculated with AMF the percentage of spores in the colonized root is higher than in non-inoculated plants (15). In general, the visual density and the percentage of colonization of resident spores was low in both cases. Although there were significant, differences in the percentage of colonization in roots of these weed species. It is the case of *C. dactylon* that presented the highest quantity, with significant differences with respect to the rest of weeds, followed by *E. colonum*, *S. halepense* and *P. hysterophorus*, obtaining the lowest value of the percentage of colonization in *A. dubius* and *Ch*. *hyssopifolia*.

The result may be related to the characteristics of the root system of these arbaceous species, since in the case of *C. dactylon* it has a profuse root system. In general, arborescent species with non-pivoting roots tend to show greater colonization (13). The fact that *C. dactylon* showed a higher colonization percentage compared to the other weed species studied could be attributed to different factors, among them, the type of host, since this species is a gramineae characterized by having a root system that facilitates the propagation of AMF (15). The low value of colonization, in general, could have been influenced by the

Table 2. Weeds after completion of the successional system in maize and bean crops

Species	Maize	Beans	Dominance
A.caracasana	X	-	Subordinate
A. conyzoides	X	-	Subordinate
I.tilliacea	X	-	Subordinate
C.rotundus	X	-	Dominant
C. plectostachyus	X	-	Subordinate
R.exaltata	X	-	Medium dominance
S.halepense	X	-	Dominant
A. spinosus	-	X	Subordinate
B. pilosa	-	X	Subordinate
C. rotundus	-	X	Dominant
C. diffusa	-	X	Medium dominance
Ch. Hirta	-	X	Subordinate
S .acuta	-	X	Subordinate
C. echinatus	-	X	Subordinate
S. verticillata	-	X	Subordinate
S. halepense	-	X	Dominant

Table 3. Distribution of resident AMF in the rhizosphere of different weed species

Weeds	Colonization (%)	Visual density
C. dactylon	12.25 a	0.14 d
L. virginicum	8.02 cd	0.31 a
E. indica	2.00 ef	0.02 f
Ch. hyssopifolia	6.7 e	0.02 f
A. mexicana	1.22 f	0.02 f
E. colonum	10.95 b	0.20 c
A. dubius	1.15 f	0.02 f
S. halepense	9.20 c	0.27 b
C. rotundus	7.05 d	0.11 e
P. hysterophorus	9.12 c	0.31 a
SEx	**1.23 ***	**0.009 ***

The means followed by different letters, in the column, for each variable in joint analysis, differ from each other with the significance level of 0.05 probability, according to Duncan's test (1955). *** P < 0.001

existence of other rhizospheric microorganisms (bacteria, fungi and actinomycetes), which are related to the diversity of species per unit area within the natural equilibrium (16).

It is known that the percentage of mycorrhizal colonization decreases as available phosphorus levels increase (17). Therefore, the function of AMF can be inhibited either by large amounts of phosphorus applied (above 104 ppm) or by the high level of this nutrient already present in the soil (3). Such statements support the results of this research, in correspondence with the soil analysis carried out in this research, where the availability of this macronutrient was high (Table 1).

Studies carried out on native grasses corroborate these results, where phosphate fertilization negatively affected most of the variables analyzed on mycorrhizal interaction for the two grasses studied (18).

CONCLUSIONS

The maize-beans successional system induced positional modifications for the dominance of the weeds, without structural modifications in the interspecific association, dominated from the beginning by the poaceae. The arvenses harbor AMF in their rhizosphere, whose abundance depends on the type of species, the most outstanding being: *C. dactylon*; *L. virginicum*; *P. hysterophorus*; *E. colonum* and *S. halepense*.

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