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Full Length Research Paper

Effects of arbuscular mycorrhizal inoculation on the growth and the development of sesame (*Sesamum indicum* L.)

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Sesame (*Sesamum indicum* L) has recently been introduced into cropping system in Senegal in the context of crop diversification and poverty alleviation. A pot experiment was conducted to study the response of sesame plants to arbuscular mycorrhizal (AM) inoculation. The experiment was carried out in greenhouse in a complete randomized block with two factors, the variety on 3 levels (32-15, Jaalgon 128 and 38-1-7) and the inoculation on 4 levels of *Glomus* spp isolates. The results indicate that inoculation with mycorrhizal fungi significantly increases leaf number and leaf area of *Sesamum*. The leaf area increased by 136% at the plants inoculated with *Glomus fasciculatum* and number of leaves by 70% at the plants inoculated with *Glomus mosseae*. Moreover, inoculation improved the root system by increasing volume and dry weight of roots. The isolate *Glomus intraradices* increased root volume of Jaalgon 128 by 233%. At the 32-15 associated *Glomus mosseae* one recorded an increase of 115%.

Key words: Arbuscular mycorrhizae, growth, sesame (*Sesamum indicum* L.).

INTRODUCTION

In the semi-arid zones of West Africa, in addition to the lack of water, the arable lands are also low in fertilizing elements like phosphorus (Diem et al., 1981; Mikola, 1987). Moreover, Hayman (1982) to affirm that 95 to 99% of the total phosphorus of the soil exists in insoluble form narrowly limits the agricultural outputs in the grounds of these areas.

Thus, to guarantee food safety in these Sahelian countries, the authorities decided to diversify the cultures by integrating the culture of plants witch require modest water and present high added value. It is in this context that in Senegal, sesame (*Sesamum indicum* L.) was integrated in the National Agricultural Program (Diouf, 1999). Sesame is considered a drought-tolerant crop (Weiss, 2000) and its cultivation is extended beyond the tropic and subtropic zones to temperate and subtemperate zones of the world (Ali et al., 2000). However, the outputs are limited because of the low levels of fertilizer used (weak purchasing power of the producers) and of the care taken to harvest. It is thus advisable to develop cheaper solutions, such as the mycorrhizal inoculation, respectful of the environment and more durable to optimize the mineral nutrition of sesame and consequently to increase its productivity. Several studies have shown that arbuscular mycorrhizal fungi stimulate plant growth and nutrient uptake, especially of phosphorus (McArthur and Knowles, 1993). Moreover, Diouf (1999) has shown that phosphorus is the determinant element for higher yield in sesame.

The objective of the present investigation is to evaluate the influence of arbuscular mycorrhizal (AM) inoculation on the growth of 3 cultivars of sesame pertaining to the ramified botanical type.

MATERIALS AND METHODS

Plant growth conditions

A glasshouse experiment was conducted at Ceraas (Centre d'étude

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Table 1. Characteristics of the soil of study.

Components	Contents
Sand	94.8 %
Clay + silt	5.8 %
Total carbon	2.61‰
Total azote	0.29‰
C/N ratio	9.2
Total potassium (meq/100g)	0.034
Total phosphorus (ppm)	195
Available phosphorus (ppm)	26.77
Calcium (meq/100g)	1.1
Magnesium (meq/100g)	0.47
pH (sol/water ratio 1 :2)	5.2
pH (sol/ KCl ratio 1 :2)	4.3
Moisture at pF 4,2	1.67%

Table 2. Analysis of variance for the number of leaves.

Factor level	Days after sowing (Das)		
	24 Das	31 Das	38 Das
Uninoculated	5^{ab}	14.75^{ab}	30^{abc}
Gv	4.75^{ab}	13.75^{ab}	29.25^{abc}
Gm	6^{a}	28.5^{a}	55.75^{a}
Gf	6^{a}	22.5^{ab}	50^{ab}
Ga	4^{b}	9^{b}	18^{c}
Gi	4^{b}	9^{b}	20.5^{bc}
« Inoculation effect»	***	**	***
32-15	5.25^{a}	18.87^{a}	41^{a}
Jaalgon 128	4.63^{b}	12.62^{b}	24.66^{b}
38-1-7	5^{a}	11^{b}	30^{b}
«Varietal effect »	***	**	***
Interaction	ns	ns	ns

Ga=Glomus aggregatum, Gf = *Glomus fasciculatum,* Gi=*Glomus intraradices, Gm = Glomus mosseae,* Gv=*Glomus verruculosum.*

regional pour l'amélioration de l'adaptation à la sécheresse) in Senegal, using sesame seeds of 3 cultivars (32 - 15, Jaalgon 128 and 38-1-7) pertaining to the ramified botanical type of the Isra (Senegalese institute of agricultural research) collection. The soil used for the experiment was collected at 5 - 30 cm depth from an uncultivated site. The soil characteristics were given in Table 1.

Soil was sterilized by autoclaving at 120°C, for 1h on two consecutive days. Each pot (30 x 28 cm) was filled with 15 kg of soil and wetter to field capacity.

Mycorrhizal inoculums containing indigenous species (*Glomus mosseae Glomus aggregatum Glomus verruculosum, Glomus fasciculatum* and *Glomus intraradices*) obtained from the Laboratory of Fungal Biotechnology (LBC) of the department of Plant Biology (University Cheikh Anta Diop/Senegal) were multiplied by using maize as host plant.

The seeds of sesame were surface sterilized by treatment with 6% solution of sodium hypochlorite for 3 minutes before sowing. 20 g of soil inoculum containing chopped mycorrhizal root pieces (frequency 80%), spores (40 spores/g soil) and hyphae were placed 2 cm below the soil surface over which surface sterilized seeds were sown. Uninoculated plants received similar amounts of autoclaved sterile soil of inoculum. After emergency, the pots were thinned at one plant per pot. The experiment was laid in a randomized block design with 4 replications. Two factors were studied, the variety on 3 levels: sesame cultivars 32-15, Jaalgon 128 and 38-1-7, and an inoculation factor with 4 levels: uninoculated (T), inoculation with *G. mosseae, G. verruculosum* and *G. fasciculatum* for cv.32-15; T, *G. mosseae, G. Fasciculatum* and *G. aggregatum* for 38-1-7; T, *G. aggregatum,* G. *verruculosum* and *G. intraradices* for Jaalgon 128. These specific association belongs to a screening made by Leye (2006). Each experimental unit is represented by two pots. Plants were grown day/night cycle of 12/12h, 32/22°C and 40 - 50% air humidity. During the experiment, the plants were maintained to field capacity.

Followed parameters and measurement techniques

The follow-up of the growth of the plants during the cycle was carried out once per week and had related to the number of leaves on the plants. As of the appearance of the first floral button, one of the two plants of each experimental unit was used to determine the root volume according to the method of Musick et al. (1965). For the aerial part, the leaf area was measured in a fresh state using scanner LC 4800 and the software Winfolia v. 2004. Shoot dry weights were also determined after drying them in an oven at 65°C till they reached a constant weight.

Statistical analysis

Data were subjected to a two-way analysis of variance with the SAS General Linear Models ANOVA (SAS Institute, 2006). In case of significant differences ($P<0.05$) mean separation was carried out by Tukey HSD test.

RESULTS

Effect of AM inoculation on the number of leaves and the leaf area

AM inoculation significantly increased the number of leaves according to AM isolates. The number of leaves per plant increased by 86% at the plants inoculated with *G. mosseae* and by 67% for the plants inoculated with *G. fasciculatum* (Table 2). Figure 1 illustrates the leaf areas according to the various inoculums. AM significantly improved the leaf area which increased by 136% for the plants inoculated with *G. fasciculatum. G. mosseae* and *G. aggregatum* increased the leaf area respectively by78 and 47%. In addition, a highly significant varietal effect was noted (Figure 2). Thus, the leaf area of cv. 38-1-7 is more significant than those of 32-15 and of Jaalgon-128 which are similar.

Influence of AM inoculation on the shoot biomass

The statistical analysis revealed an interaction variety X fungal isolates highly significant. Thus, at cv.32-15 a significant increase in the aerial biomass of 44% is obtained for the plants inoculated with *G. mosseae* com-

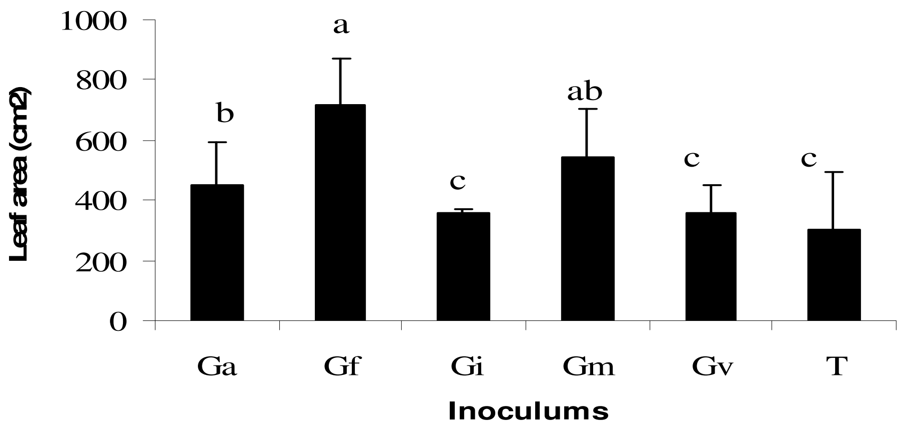

Figure 1. Effect of AM inoculation on the leaf area. *Ga = Glomus aggregatum,* Gf = *Glomus fasciculatum,* Gi = *Glomus intraradices, Gm = Glomus mosseae,* Gv = *Glomus verruculosum.* T = uninoculated.

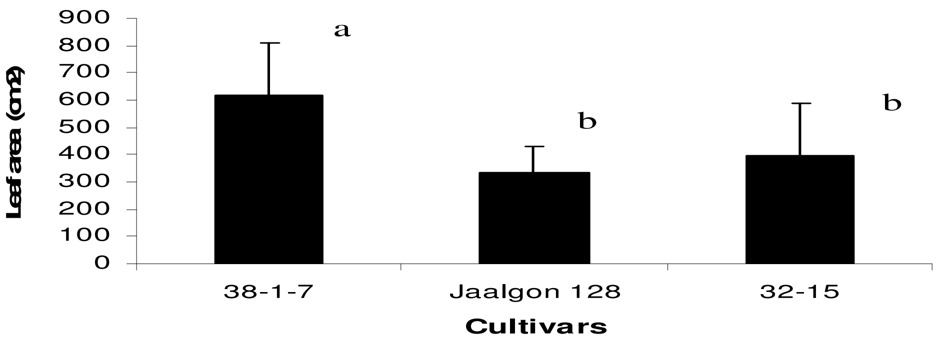

Figure 2. Leaf area according to cultivars.

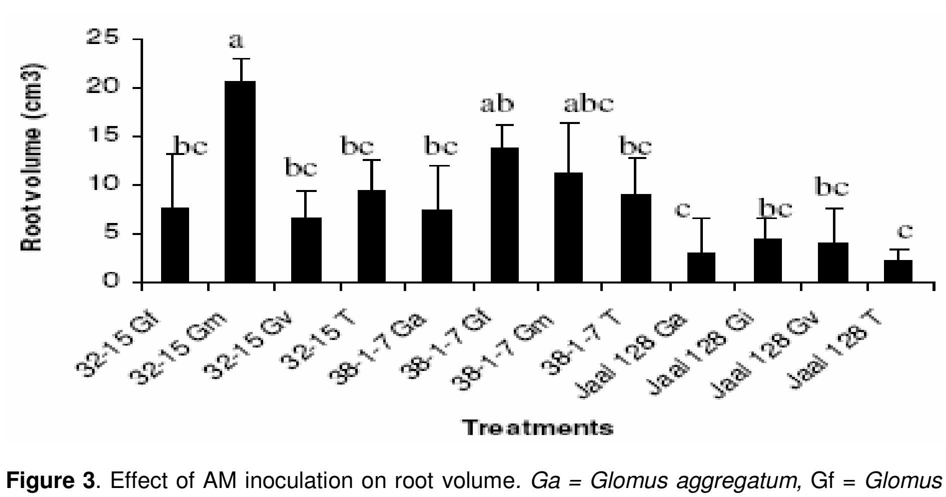

Figure 3. Effect of AM inoculation on root volume. *Ga = Glomus aggregatum,* Gf = *Glomus fasciculatum,* Gi = *Glomus intraradices, Gm = Glomus mosseae,* Gv = *Glomus verruculosum.* T= uninoculated.

pared with the uninoculated plants (Figure 3). Cv.38-1-7 produced significantly more aerial biomass when associated with *G. fasciculatum* with a matter increase dries of 67%. For the cv. Jaalgon 128, all the associated isolates (*G. aggregatum*, *G. intraradices* and *G. verruculosum*) increased the aerial biomass on average of 58%.

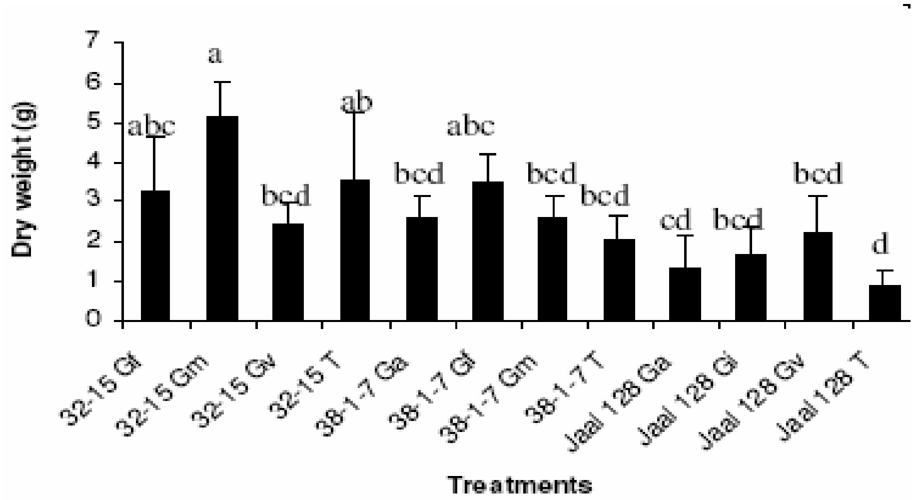

Figure 4. Effect of AM inoculation on shoot biomass. *Ga=Glomus aggregatum,* Gf = *Glomus fasciculatum,* Gi=*Glomus intraradices, Gm = Glomus mosseae,* Gv=*Glomus verruculosum.* T= uninoculated.

Effect of AM on root volume

The root volume determined at the end of the culture (38 das) showed a significant difference between the treatments (Figure 4). The analysis of variance revealed an interaction between the isolates and the cultivars.

Thus, root volume of cv.32-15 significantly increased by 116% when it is inoculated with *G. mosseae*. For the cv.38-1-7 it is the isolate *G. fasciculatum* which significantly increased the root volume by 53%. This increase, even erase very marked for the cv. Jaalgon 128 at which root volume, was multiplied by four (233%) when it is associated with *G. intraradices*.

DISCUSSION

Under our conditions of experiment, the results showed that inoculation by arbuscular mycorrhizal (AM) fungi of these 3 cultivars of sesame had a consistent effect on their growth. Thus AM inoculation significantly increases the number of leaves and the leaf enlargement. Similar results were found in the case of corn (Kothari et al., 1990), lettuce (Tobar et al., 1994b) and maize (Subramanian et al., 1995). A positive response of green leaf area to mycorrhizal inoculation has been all so reported in sorghum (Ebel et al., 1994) and wheat (Panwar, 1993). Higher green leaf area in AM plants may be as a result of enhanced nitrogen acquisition (Tobar et al., 1994b) by host plants through the external hyphal transport of NO_3^- (Tobar et al., 1994a) or nitrogen-assimilating enzymes (Cliquet and Stewart, 1993). Three indigenous species (*G. mosseae, G. aggregatum and G. fasciculatum)* were shown particularly effective.

The increase of the leaf area with AM inoculation would be beneficial by maintaining a higher photosynthetic rate (Augé et al., 1987; Panwar, 1993).

The aerial biomass increased with the inoculation in all cultivars. These results are in agreement with certain works which show that the AM inoculation increases the dry biomass of cowpea (Diallo, 1998), date palm (Meddich et al., 2004) and sesame (Leye, 2006).

The results also state that AM symbiosis influences significantly the rooting area. Thus, root volume of the studied varieties was multiplied by 2 even 4 times according to the isolates and the cultivars. The importance of the root-system was due to the presence of a larger number of rootlets, supporting the notion that AM fungi can increase the rooting zone.

Our data also suggest that the positive effects on root volume could be correlated to improvement of Sesame nutrition since similar results were often recorded in poor fertile soils. Indeed, like certain filamentous fungi species, AM fungi secretes in the rhizosphere some phosphatases (Tarafdar and Marschner, 1994) and organic acids such as the oxalic acid, catalysing the hydrolysis of the connections phosphoesters (Plenchette, 2005) and thus placing phosphorus at the disposal of the plants.

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