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Growth and nutrient uptake of peanut inoculated with the mycorrhizal fungus *Glomus fasciculatum* compared with non-inoculated ones

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Summary In a greenhouse study, inoculation with the mycorrhizal fungus *Glomus fasciculatum* enhanced peanut growth and increased its dry matter more than 2-fold compared with the non-inoculated control, in both sterilized and non-sterilized soil. It also significantly increased uptake of phosphorus and micronutrients such as zinc, copper, manganese and iron.

Introduction

Literature reveals that vesicular-arbuscular mycorrhiza (VAM) occur widely under various environmental conditions and are found in association with major tropical crops. The mycorrhizal fungi are known to augment the nutrient uptake of the host plant, especially of phosphorus[8,17]. In the recent past, their importance has been well emphasized by microbiologists, physiologists and pathologists alike in terms of their possible role in agricultural crop production. There are reports where field inoculation with VAM fungi has increased growth and yield of legumes[1,9,14]. Improvement in the phosphorus status of the legumes by VAM is known to enhance the nitrogen fixation by symbiotic rhizobia[6,15,16]. Field trials with cereals have also indicated increased growth and yield due to mycorrhiza inoculation[4,12].

Peanut is an important oil and protein source and is grown widely in the semi-arid tropics. The fact that peanut is a plant without root hairs suggests that its dependence on mycorrhiza for nutrient uptake would be high[2], and therefore underlines the importance of detailed studies on peanut mycorrhiza. Occurrence of VAM in peanut roots was recorded by Butler[3]. A sand culture experiment showed that VAM can greatly increase nodulation, nitrogenase activity and plant growth[6], but it is apparent today that we still know very little about peanut-mycorrhizal symbiosis.

Materials and methods

Peanut (*Arachis hypogaea* cv 'MGS-7') was grown in a red sandy loam deficient in P (5 mg P kg^{-1} soil extracted with NH_4F + HCl) of pH 5.2. One half of a well-mixed soil lot was sterilized by autoclaving at 1.1 kg cm^{-2} pressure for 1 h and 8 kg of it was filled into 35-cm diameter pots. Similarly, another gradual equal set of 16 pots was filled with non-sterilized (natural) soil. Urea at the rate of 35 mg kg of soil was added to all the pots irrespective of the treatment.

The mycorrhizal fungus, *Glomus fasciculatum* (Thaxter sensu Gerdemann) Gerd. and Trappe was maintained on *Panicum maximum* Jacq. in pots. The mycorrhizal inoculum applied as sand:soil mixture (25 ml) consisted approximately 600 extramatrical chlamydospores and infected root segments of *Panicum maximum*. The inoculum was placed 3 cm below the surface

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Table 1. Mycorrhial association, growth and nutrient uptake of *Arachis hypogaea* cv MGS-7

Soil	Inoculation *	VAM fungi colonization (%)	Spore number (per 100 ml soil)	Dry weight (g/plant)	P (mg/plant)	Zn	Cu	Mn	Fe
						(μg/plant)			
Sterilized	M	96^{a**}	260^{a}	6.46^{a}	17.6^{b}	46.5^{a}	88.4^{b}	401.7^{ab}	851.8^{a}
	NM	0^{b}	0^{b}	3.11^{b}	3.9^{c}	23.0^{b}	30.0^{c}	177.3^{c}	530.8^{b}
Non-sterilized	M	97^{a}	348^{a}	7.03^{a}	22.5^{a}	62.3^{a}	169.4^{a}	560.0^{a}	941.1^{a}
	NM	79^{a}	252^{a}	4.86^{b}	6.2^{c}	51.3^{a}	93.0^{b}	329.6^{b}	738.1^{a}
CV (%)†		23	27	9.0	12.0	26	31	46	52

* M = inoculated with *G. fasciculatum*, NM = Noninoculated

** In a column, virtically any two values without common letters in their superscript are significantly different ($P \leq 0.05$) using F test.

† CV = Coefficient of variability. Values are means of eight replicates

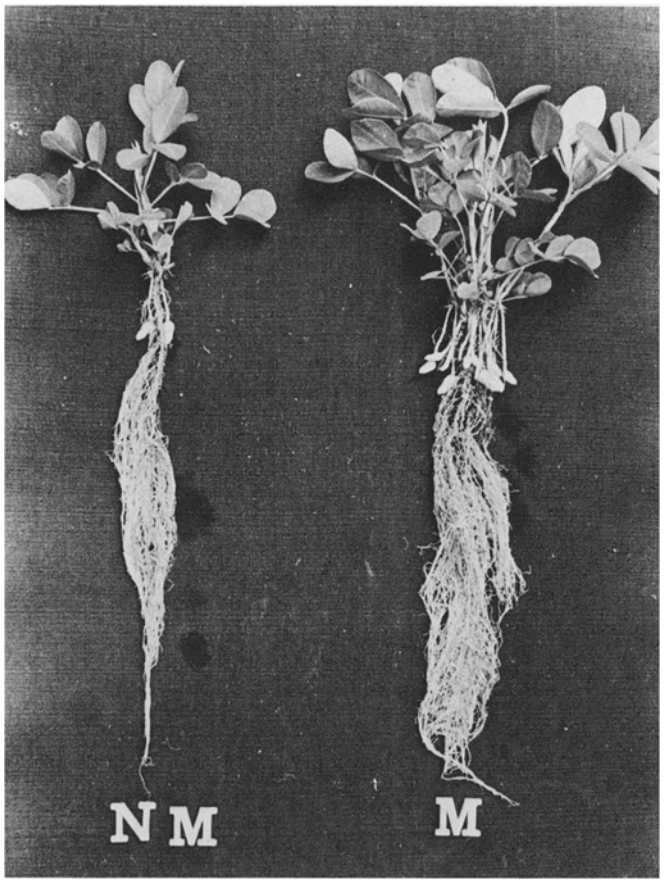

Fig. 1. Mycorrhizal (M) and uninoculated (NM) groundnut plants grown in sterilized soil for 65 days.

of the soil before sowing to produce mycorrhizal plants. Non-inoculated plants served as non-mycorrhizal control. Seedlings (one per pot) were grown in a greenhouse with a mean temperature range of 26–30°C and harvested after 65 days of growth. Eight replicates were maintained for each treatment.

Mycorrhizal colonization in the root was estimated after clearing the roots with 10% KOH and staining with tryptan blue[13] using the formula:

$$\frac{\text{Number of VAM positive segments}}{\text{Total number of segments scored}} \times 100 = \% \text{ colonization}$$

The number of spores of mycorrhizal fungi in the soil was estimated after the wet sieving and decanting[7]. Plant dry matter was recorded after drying to constant weight. Phosphorus content in root and shoot was estimated by the vanadomolybdate method, and Zn, Cu, Mn and Fe by atomic absorption spectrophotometry[10].

Results and discussion

Inoculation with the mycorrhizal fungus, *G. fasciculatum* resulted in extensive colonization of peanut roots (Table 1) both in sterilized and non-sterilized soil. The number of spores of

mycorrhizal fungi in the non-sterilized soil around the roots was higher in inoculated plants compared to non-inoculated ones (Table 1). Inoculation with *G fasciculatum* enhanced plant growth both in sterilized and non-sterilized soil (Fig. 1) and resulted in a significant increase in dry matter accumulation. Working with a sand culture system, Daft and El-Giahmi[6] recorded similar increase in peanut growth and dry matter accumulation due to mycorrhiza in peanut. The increase in dry matter production due to mycorrhiza was greater in sterilized soil than in non-sterilized soil. This could be attributed to the presence of indigenous mycorrhizal fungi which is well supported by the fact that 79% root colonization was caused by them in non-sterilized soil. It is very difficult to differentiate between mycorrhizal strains and thereby to select strains more efficient than the native mycorrhiza. However, the mycorrhizal strain used in the present investigation was obviously effective even in the presence of native mycorrhizal fungi. It is possible that an inoculated strain may compete for colonization sites and spread within the host root with the native mycorrhizal fungi[12].

Uptake of P by inoculated plants was more than four times that of non-inoculated ones in sterilized soil. In non-sterilized soil the difference was still more than three times the control. Studies with P^{32}-labelled phosphate have clearly shown that P is translocated through the fungal mycelium from the soil to the plant root[8], and perhaps the efficiency differs with strain. Mycorrhizal association may also be important in supplementing high phosphorus requirements of nodule bacteria and legume host under natural field conditions. Considering uptake of micronutrients, mycorrhizal peanut plants recorded significantly higher amounts of Zn, Cu, Mn and Fe (Table 1). The above effect was significant in both sterilized and non-sterilized soil. Evidences for hyphal uptake of Zn and Cu have been reported earlier[5] and our results are in agreement with such previous findings.

In conclusion, the present investigation underlines the need for further studies on peanut mycorrhiza in the field and of the importance of the role played by them in nature. This holds especially true for the conditions under which peanut is generally grown in the less fertile and poor soils of the tropics and semi-arid tropics.

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