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Studies on Effects of Arbuscular Mycorrhizal (Am.) Fungi on Mineral Nutrition of *Carica papaya* L.

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Abstract

Experiment was conducted to study the effects of arbuscular mycorrhizal fungi on mineral nutrition of *Carica papaya* var. *Surya*. The experiment comprised of un-inoculated seedlings, seedlings inoculated with *Glomus intraradices* Schenck & Smith, seedlings inoculated with *Glomus mosseae* [(Nicol. & Gerd.) Gerd. & Trappe] and seedlings inoculated with mixed inoculum [*Glomus intraradices* (Schenck & Smith) + *Glomus mosseae* (Nicol. & Gerd.) Gerd. & Trappe]. Studies revealed that total potassium and total phosphorus content of mycorrhizal leaf petiole was higher in inoculated plants as compared to controls and varied significantly within the treatments. *Glomus mosseae* was the most effective species of AM fungi, in influencing mineral nutrition of papaya followed by mixed inoculum (GI +GM) and *Glomus intraradices* respectively.

Keywords: *Carica papaya L*., *Glomus intraradices* (Schenck & Smith), *Glomus mosseae* [(Nicol. & Gerd.) Gerd. & Trappe], leaf petiole, total phosphorus, total potassium

Introduction

Carica papaya L. is a tropical fruit known for its high nutritive value. Papaya breeding programs include inbreeding and selection of varieties for enhanced fruit production (Ram, 1993). It is observed that in high yielding varieties, during reproductive stage, the high demand for P exceeds the capacity of the root system (Dunne and Fitter, 1989). Considerable information is available for enhanced mineral nutrient acquisition by mycorrhizal plants grown on neutral to alkaline soils, but limited for mycorrhizal plants grown on acid soils (Clark, 1997). Higher, P, S, K, Cu and lower Al, Mn, Fe and Zn were noted in sorghum colonized with *Glomus desrticola* than in non-inoculated plants grown on soil pH 4.5 (Raju *et al.* , 1988). The cationic elements are commonly deficient in acidic soils (Ca, Mg and K) and there uptake is greatly enhanced in AM fungi inoculated plants as compared to non-inoculated plants (Clark and Zeto, 1996 a and b). Papaya is known to exhibit a strong growth response to colonization by AM fungi (Sukhada, 1989). Therefore in the present study effects AM fungi are evaluated with respect to mineral nutrition of papaya under P-deficient acidic soil conditions.

Materials and methods

Plant and fungus material

Seeds of *Carica papaya* var. *Surya* were procured from Indian Institute of Horticultural Research (IIHR), Bangalore. *Surya* is gynodioecious, high yielding (50-65 Kg/plant) variety. It is a progeny from the cross between *Sunrise Solo* x *Pink Flesh Sweet*. This variety was released by IIHR, Bangalore and till date not literature exits on its mycorrhization. Sand based pure cultures of *Glomus mosseae* (Nicol. & Gerd.) Gerd. & Trappe and *Glomus intraradices* Schenck & Smith comprising of extramatrical chlamydospores and colonized root segments containing mycelium and vesicles were obtained from The Energy Research Institute (TERI), New Delhi. The inoculum of each culture consisted of 30 spores/2g moist soil.

Growing conditions

The experiment was conducted for the period of four months (May 2002 - August 2002) in a poly-house at agriculture farm located in Mapusa, North Goa. The relative humidity during the study period ranged from 84 % to 93 %. Maximum and minimum temperatures ranged from 31.60C to 29.3 0C and 25.4 0C to 24.10C respectively. Throughout the experimental period, papaya plants were watered thrice a week and fertilized with Hoagland's nutrient solution without phosphorus (Hoagland and Arnon, 1939), at an interval of fifteen days.

Raising of seedlings

Seeds of papaya were sown in plastic trays with sterilized nursery soil (sand soil mixture, 1:1). Garden soil was sterilized for two hours daily at 15lbs pressure for three consecutive days to eliminate naturally occurring endophytes and other contaminants. The soil used for the experiment was acidic with pH 6.1 (pH meter, LI – 120, Elico) and 0.06 m mhos/cm electrical conductivity (conductivity meter, CM-180, Elico). The soil was low (6 Kg/Ha) in available phosphorus and organic carbon (0.42%). Total nitrogen and available potassium content of the soil was 0.4% and 80 Kg/Ha respectively. Available Zn, Cu, Fe and Mn concentrations were 2.67, 3.84, 2.63, and 19.5 ppm respectively. Seedlings were maintained in plastic trays for one month.

Inoculation with AM fungi

At the end of one month, seedlings of uniform length (10cm) were selected for inoculation with AM fungi. The experiment comprised of following four treatments and each treatment had fifteen replicates. Treatment 1 (C) – Un-inoculated papaya seedlings. Treatment 2 (GI) - Papaya seedlings inoculated with Glomus intraradices. Treatment 3 (GM) - Papaya seedlings inoculated with *Glomus mosseae*. Treatment 4 (GI + GM) - Papaya inoculated with mixed inoculum [*Glomus intraradices* + *Glomus mosseae*].

Nursery bags of 0.5 Kg capacity were filled with sterilized soil up to three- fourth of its volume. A small pit was made into soil and 5g of inoculum was placed at a depth of 5 cm. Papaya seedling was then placed in this pit and layered with sterilized soil. One seedling was planted per bag. In case of GI + GM inoculation, equal quantity (75 g each) of inoculum of *Glomus intraradices* and *Glomus mosseae* were mixed thoroughly and then 5g of inoculum was added to each nursery bag. Control plants were inoculated with autoclaved inoculum. The plants were maintained for one and half month (45 days) in sterilized soil.

Transplantation of seedlings in unsterilized soil

After a period of two and a half months of growth (76 days), papaya seedlings were transferred to nursery bags of 3 kg capacity containing unsterilized nursery soil with low nutrient status as mentioned earlier. The plants were further maintained for a period of 45 days. The experiment was terminated at end of 123 days of growth (four months) and papaya plants were subjected to analysis of various parameters.

Nutrient analysis

Mineral status of various treatments was assessed by tissue elemental analysis of sixth leaf petiole (Bhargava *et al.*, 1989) of papaya plants after oven drying (70 0C for 72 hrs). Five replicates per treatment were considered for the study. The oven dried leaf petiole samples were digested with 1N HCl for 15 min. Petiole samples were washed with distilled water and rinsed finally with double distilled water. Washed samples were dried and ground to powder which was further digested in diacid mixture (HNO3 + HCLO4).The solution was filtered and employed for quantification of potassium by using flame photometer (Systronics 3292), while phosphorus content was estimated using citric molybdate acid and quinoline solution.

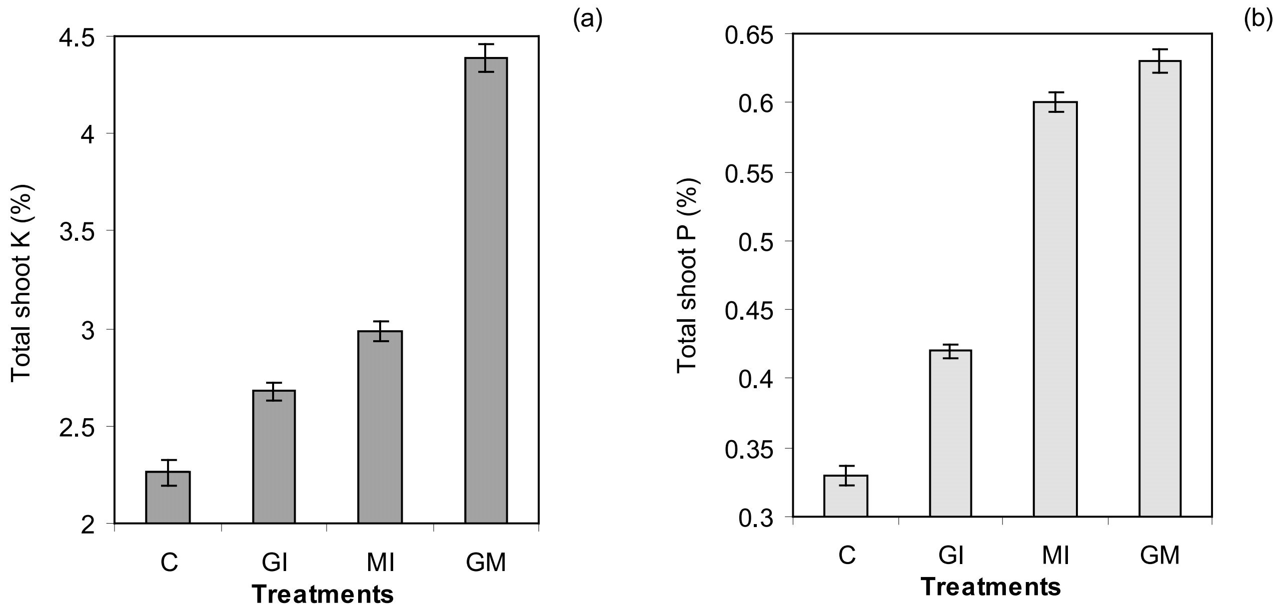

Fig.1. Effects of arbuscular mycorrhizal fungi on total shoot K (a) and total shoot P (b) content in *Carica papaya* L. Error bar indicates ± 1SE

Results

The distinct treatment effect on the mineral element concentrations in leaf petiole of papaya are depicted in Fig. 1a and Fig. 1 b. In the present study, it was observed that the total phosphorus (C. D =0.01; P= 0.05) and potassium (C. D = 0.03; P= 0.05) content varied significantly within the treatments. Observations revealed that total potassium content of leaf petiole was higher in inoculated plants and ranged from 2.68 - 4.39% as compared to control (2.26%) plants (Fig. 1a). Similarly leaf petiole of inoculated plants recorded higher total phosphorus (0.42 – 0.63%) as compared to control (0.35%) plants (Fig. 1b). *Glomus mosseae* was the most effective species of AM fungi, influencing mineral nutrition of papaya followed by mixed inoculum (GI +GM) and *Glomus intraradices* (Fig.1).

Discussion

The beneficial effects of AM fungi on plant growth are attributed to improved nutrient uptake in plant tissue, especially phosphorus (Smith *et al*., 1992; Declerk *et al*., 1995). Results obtained in the present study confirms the above findings since total P content of leaf tissue was significantly higher in inoculated papaya plants that un-inoculated controls. As suggested by Tinker (1975), increased P absorption efficiency by mycorrhizal plants could arise due to following factors: 1) morphological changes in the plant, 2) provision of additional or more efficient absorbing surface in fungal hyphae with subsequent transfer to the host and 3) ability of the mycorrhizal root or hyphae to utilize sources of P not available to non mycorrhizal roots. Further, results obtained from present study corroborate with findings of Onkarayya and Mohandas (1993) and Reddy *et al*. (1996) who reported higher leaf P content in mycorrhizal *Citrus* and papaya respectively. In this study, papaya plants inoculated with *Glomus mosseae* and mixed inoculum accumulated nearly twice the amount of total P than control plants. Sukhada (1992) also reported two fold increases in leaf concentration of papaya inoculated with *Glomus mosseae* and *Glomus fasiculatum* at lower levels of soil P (0g and 4.6g of triple super phosphate) in a glass house experiment. In another experiment conducted by Rosalind Padma and Kandaswamy (1990), 30.85% increase of in total P was recorded in papaya after 90 days of growth by application of 75% of recommended dose of phosphorus along with mixed inoculum (*Glomus mosseae + Glomus fasiculatum + Gigaspora margarita*) than control plants.

In the present study, inoculated papaya plants recorded greater acquisition of potassium in leaf tissue as compared to control plants. Govind Rao *et al*. (1983) also reported increase in potassium content in mycorrhizal finger millet. However Menge (1978) recorded low levels of potassium in mycorrhizal *Citrus* leaf and attributed it to dilution effect caused due to greater leaf volume of larger mycorrhizal seedlings. Furthermore, increased nutrient uptake (P & K) by inoculated papaya plants in the present study may account for increased dry matter accumulation than control plants. Menge *et al*. (1978) and Onkarayya and Sukhada (1993) observed an increase in dry weights of mycorrhizal sour orange and Troyer citrange and enhanced P concentration in leaves. Further increased K levels in mycorrhizal plants may be attributed to the fact that AM fungi may have explored the soil volume in a manner analogous to increasing root density with extraradical hyphae bridging gaps between soil and roots, as well as binding soil particles to each other and to the roots, which is beneficial for the nutrient uptake (Estrada Luna *et al*., 2000). Thus increased potassium content in leaf tissue of mycorrhizal papaya plants recorded during the present study may be due to the contact exchange theory (Tholkappian *et al*., 2000).

Conclusion

In conclusion one species of AM fungi viz., *Glomus mosseae* was the most effective species and significantly influenced mineral nutrition of papaya followed by mixed inoculums (GI +GM) and *Glomus intraradices*. Sanders *et al*. (1977) reported that, AM fungi which are more effective in increasing nutrient uptake colonize the plants more rapidly and extensively. These results supports the contention that the differences in nutrient uptake recorded in the three treatments of AM fungi appeared to be associated with differences in percentage of root colonization. The results of the present study also substantiate the hypothesis that not all combinations of host and endophyte have similar growth stimulating effects and this may be interpreted as a kind of functional host specificity or compatibility.

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