The vesicular-arbuscular (VA) mycorrhiza and its effects on growth of vegetatively propagated Theobroma cacao L.

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Abstract

A greenhouse experiment was conducted to study the effects of mycorrhizal inoculation on growth and nutrient uptake of vegetatively propagated cocoa plants from the Sabah hybrid (NA 33 x PA 7) raised on unsterilized Munchong soils. Inoculation with mixed species of Scutellospora and Glomus, resulted in higher dry matter yield and stem diameter of mycorrhizal plants obtained through budding, air layering or marcotting (a form of asexual plant propagation using vegetative parts and the selection of a healthy branch and scraping off the bark at the lower end of the branch, forcing it to root by covering it with a ball of soil) and stem cutting. Budded and marcotted mycorrhizal plants gave a significant increase in P content of shoots. In contrast, only budded mycorrhizal plants (on both young and old rootstocks) gave a significantly higher Ca concentration in tops, compared to uninoculated plants.

Introduction

Malaysia is now the 3rd largest cocoa producer in the world after Ivory Coast and Brazil (MCGC Annual Report, 1990). Although the acreage under cocoa had increased to 344,000 ha by 1987, the fluctuating price of cocoa beans warrants Malaysian cocoa industry to seek ways of reducing the production cost. Most of the emphasis towards this goal was on breeding high yielding materials and improvement of agronomic practices such as high density planting. Since variation in cocoa productivity has been identified to be due to seedling population, vegetative propagation is a useful alternative in overcoming this problem as well as for maintaining clonal multiplication and high yielding materials (Nair and Nagabhushanam, 1986).

Cocoa has been shown to give a positive response to mycorrhizal inoculation, with the growth of inoculated seedlings significantly increased compared with uninoculated seedlings (Azizah Chulan and Ragu, 1986). The amount of organic fertilizer needed for maximum plant growth was also reduced significantly through mycorrhizal symbiosis (Azizah Chulan, 1991). The main strategy of inoculating plants with the VAM fungi is to induce early infection in seedlings or cuttings by increasing soil infectivity, particularly around the young emerging roots (Mosse, 1991). In fact one of the most efficient and cost-effective methods of producing mycorrhizal plants is to introduce the VAM fungi during the propagation process. This practice is feasible since cocoa is raised in nurseries before transplanting to the field (Azizah Chulan, 1991). With this in view, the experiment reported here aimed to evaluate the effectiveness of field propagated mycorrhizal fungi in enhancing the growth of vegetatively propagated cocoa clones propagated by stem cutting, marcotting and budding.
Materials and methods

Soil preparation

Top soil (0–15 cm) from the Munchong Series (clayey, Tropeptic Haploorthox) with pH 4.8 (determined in a 1:2.5 soil to water ratio), clay content 51.2%, silt 13.3%, coarse sand 7.7%, total N 0.13%, organic C 1.7% and extractable P 3.0 (μg g⁻¹ determined by the Bray II method – HCl and NH₄Cl), was used in this experiment. The soil (sieved to 2 mm) was air-dried for 36 hours and mixed thoroughly to ensure complete homogeneity.

The greenhouse experiment comprised a 4 × 2 × 5 factorial of the following treatments: four sources of vegetative materials (budded young rootstock-YR, budded old rootstock-OR, stem cuttings, and marcotted plants), 2 mycorrhiza treatments (uninoculated, inoculated) and 5 replicates.

Three kg of soil was placed into polythene bags, each measuring 38 cm x 23 cm. Thirty g of an organic fertilizer with N:P:K:Mg content in the ratio of 5:5:5:1 was added to each bag, mixed thoroughly with the soil and then put aside until needed. A total of 40 bags were prepared for this experiment.

Soil inoculum of the two mycorrhizal fungi from the species Scutellospora calospora and Glomus mosseae was initially obtained from pot cultures previously established in the greenhouse at UPM (Azizah Chulan and Omar, 1987). The respective inoculum was further propagated for over a year in a mined sandy land located within the vicinity of the university. Setaria grass was used as the host plant.

Preparation of plant material

The three vegetative propagation techniques used were patch budding (on young (YR) and old (OR) stock plants either without or pre-inoculated with mixed mycorrhizal species for 3 and 6 months respectively), stem cutting (SC) and marcotting (MC).

The cocoa hybrid used was Sabah hybrid NA33 × PA7. The origin of this hybrid was the result of crosses between NA33 (collected as seed by Pound in 1938 (cited from Ang and Lim, 1989) from trees along the Rio Nanay near Iquitos) and PA 7 (collected as seed by Pound in 1938 (cited from Ang and Lim, 1989) in the region of Parinari town).

a. Budding
Cocoa budwoods from the Sabah hybrid NA33 × PA7 were collected from the 4 year old university’s cocoa farm. The budwoods were taken from the fan branch of a semi-hardwood. Healthy branches with uniform diameter and of 3 cm length were collected early in the morning.

For the rootstocks, seeds from similar hybrid (treated with or without the VAM fungi) were sown 6 and 3 months prior to the experiment. A set of parallel, vertical cuts were made on the respective rootstock, about 0.5–1.0 cm apart and about 2.5 cm in length. The cut bark on the stock plant was peeled back and two-thirds of the bark-flap was removed prior to the insertion of the budpatch. Once in place, the budpatch was secured firmly with a polythene tape. The tape was removed 14 days later. The stock plant (5.0 cm above the budpatch) was removed when the scion developed. A total of 40 buddockings were prepared on the respective 3 (YR) and 6 (OR) months old stock plants, and allowed to establish for 2 months before growth data was recorded.

b. Stem cutting (SC)
Healthy branches of 15.0 cm long with 1.0 cm diameter from the Sabah hybrid NA33 × PA7, were collected from the fan branch of the 4 year old cocoa trees. The cut ends were dipped into a 4000 mg kg⁻¹ rooting hormone (B-indole butyric acid) for 20 seconds before air-drying them for 30 minutes. These cuttings were subsequently planted in sterilized sand in sand trays under a mister. A total of 40 cuttings were planted, twenty to a tray each measuring 30 × 60 × 15 cm.

c. Air layering or marcotting (MC)
Healthy and well-shaped fan branch of 6.0 cm diameter from the same Sabah hybrid were selected for this experiment. A 2.0 cm band of bark was cut and removed from the branch. The cambium tissues was gently scraped with a sterilized knife. Seradix II, a rooting-hormone in powder form was dusted onto the exposed wood tissue. The cut portion of the stem was then