ILLUSTRATED CONCEPTS IN TROPICAL AGRICULTURE
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MYCORRHIZAE ENHANCE NUTRIENT UPTAKE FROM INFERTILE SOILS

Fig. 1. Some characteristic features of VA mycorrhizae.
Below, arbuscules in cortical cells of cowpea roots. Above, vesicles and spores with fragments of hyphae within and outside the root.

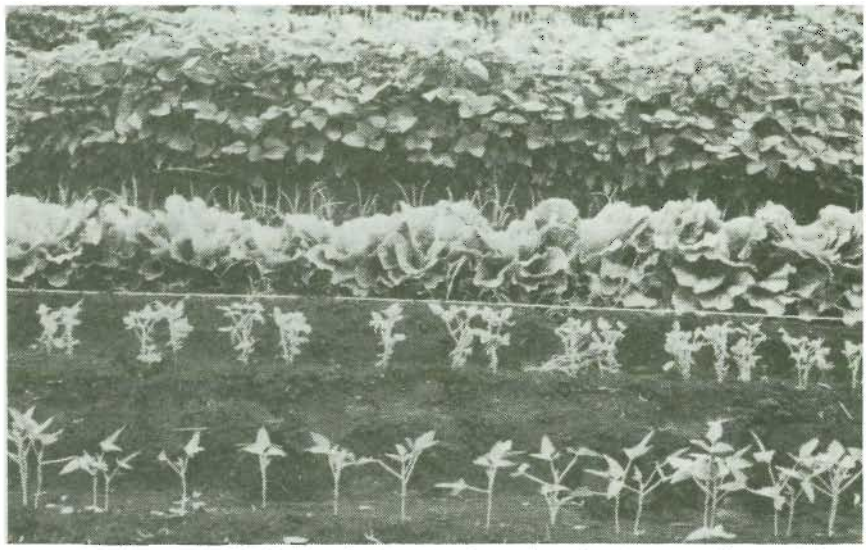

Fig. 2. Growth of soybean (second row) and cowpea (first row) in a fumigated phosphorus-deficient Oxisol of Hawaii. The background is cowpea growing on unfumigated soil. The middle ground is Chinese cabbage, which does not form the mycorrhizal association.

Mycorrhizae are symbiotic associations between plant roots and certain soil fungi. These associations may substantially enhance nutrient uptake by host plants especially from infertile soils.

Mycorrhizal fungi belong to the family Endogonaceae. They have been divided into three groups: those that grow inside the root cells of host plants, those that do not, and others that may.

Members of the group that do not grow inside root cells (*ecto*mycorrhizae) form important symbioses with many forest species, including eucalyptus and pine. The most common mycorrhizae-forming fungi infecting the roots of agricultural speices are *endo*mycorrhizae; they extend into plant root cells. Endomycorrhizae form two characteristic structures within the cortex: (1) vesticles, which are globular structures containing oil (Fig. 1, top), and (2) arbuscules, which are many-branched terminals of hyphae within cortical cells (Fig. 1, bottom). The arbuscules seem to function in nutrient transfer between the host plant and the fungi. Hence, this group of fungi is also known as vesicular-arbuscular (VA) mycorrhizae.

Sometimes hyphae bear large spores by which the fungus can reproduce itself (Fig. 1, top). Hyphae develop along root surfaces and extend into the soil, sometimes as much as several centimeters. Thus, mycorrhizae expand the volume of the rhizocylinder more than is usually accomplished by root hairs. Hyphae are fragile structures: they are difficult to recover from soil. Some fragments are seen in Fig. 1.

The plant nutrient that is most influenced by mycorrhizae is phosphorus; and beacause P plays a crucial role in crop nutrition in the tropics, the contribution of VA mycorrhizae is vital to the P economy of tropical agriculture. The mycorrhizal hyphae apparently draw from the same pool of P in the soil from which the host plant draws. Nutrient uptake increases because the hyphae exploit a large volume of soil. In the case of some species, the hyphae seem to extract phosphorus from soil solutions that are more dilute than the solutions the host plant can utilize on its own. In addition, mycorrhizae may enhance the uptake of other nutrients also, including Zn, S, K, and perhaps Si.

The contribution of mycorrhizae to the phosphorus economy of tropical crops has only recently been evaluated in field experiments. Several crops that normally require only small quantities of phosphate in most soils require much more phosphate if the mycorrhizae-forming fungi are eliminated by soil fumigation with methyl bromide. Cassava, *Stylosanthes hamata,* and cowpea are among those plants. Some crops, which have not been investigated in controlled experiments but are tolerant of low P soils in Hawaii, are heavily infected with mycorrhizae. Pineapple and papaya are noteworthy in that respect.

The influence of mycorrhizae on plant growth and P uptake can be very impressive, as Fig. 2 demonstrates. In field experiments on a very phosphorus-deficient Oxisol (Wahiawa series) at Poamoho, Oahu, Hawaii, P uptake by several plant species was reduced to 1-5% of normal when the mycorrhizae-forming fungi were eliminated by soil fumigation.

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