

PREINOCULATION WITH VA MYCORRHIZAL FUNGI INCREASES PLANT TOLERANCE TO SOIL SALINITY

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ABSTRACT

The loss of land for the production of agricultural crops due to salinity is a major problem worldwide. The means to deal with saline soils by the development of salt-tolerant crops, by leaching, or by using desalinized water are not feasible for many developing areas of the world. VA mycorrhizae (VAM) are known to alleviate salt stress on plants, but a practical method to establish them has not been developed. Preinoculation of lettuce or onion plants with mixtures of VAM fungi cultured from saline or nonsaline soils before transplant into sodic soils was shown to be an effective means of increasing plant tolerance to salt toxicity. This method could be practical for farmers needing to grow crops on saline soils.

INTRODUCTION

In light of the expanding human population of the world and the finite amount of agricultural land useful for food production, there is great need to increase production capacity for the future. Irrigation will play a major role in increasing the land base for agricultural production, but many irrigation systems have failed to increase productivity, and in fact have contributed greatly to the increase in salinity of soils, for various reasons, with the ultimate result of decreasing crop production potential due to salt toxicity. Reducing salinity effects by developing improved salt-tolerant crops, by leaching excess salts with fresh water, or desalinizing seawater for irrigation purposes have been successful in many areas of the world. However, most of those methods are beyond the economic means of the developing parts of the world.

Vesicular-arbuscular mycorrhiza (VAM) is a mutualistic symbiotic association between specialized soil fungi and the roots of most of the plant taxa grown in agriculture. The VAM association is known to reduce the impact of soil salinity on plant growth and productivity. Reports indicate that the effect is primarily one of improving phosphorus (P) nutrition of the host plant, thereby making it more tolerant of salinity. All reports, however, have added salts to the soil after plants were colonized by VAM fungi. Progressive addition of salts does not simulate real farm conditions.

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There are no reports on the preinoculation of transplants with VAM fungi prior to planting in saline soil. We hypothesized that preinoculation would increase salt tolerance and would be a practical approach that farmers could adopt. We also hypothesized that VAM fungi from a saline soil would be more effective than those from a nonsaline soil in reducing deleterious effects of salinity on plant growth. We tested these hypotheses on lettuce and onions in soils amended with sodium chloride (NaCl).

Materials and methods

VAM fungal inoculum mixtures were developed in trap cultures from two sites in Oregon: Burns (saline) or Corvallis (nonsaline) and used at approximately equivalent inoculum levels to inoculate lettuce or onion seedlings in 25 cc plug cells. Seedlings were grown for 18 (lettuce) or 29 (onion) days before transplanting into saline soil treatments. The Newberg series base soil was amended with NaCl solutions to achieve increasing sodic levels: EC 2 (control), EC 4, EC 8, and EC 12 dS/m as measured by electrical conductivity. The experiments were conducted under greenhouse conditions for 10 weeks. Plants were fertilized weekly with nutrient solution without P from week 3-10. All transplants received sufficient nitrogen to avoid deficiency, and were watered daily by weight to avoid leaching. The base soil had 27 ppm available P and had a high P-fixing capacity as determined by limited growth of onion plants treated with high (22.5 mg kg⁻¹ soil) levels of inorganic P.

Measurements on color (chlorophyll) of lettuce leaves were made during the experiment. At harvest, root and shoot mass was determined for both plant species, and the extent of root and soil colonization by VAM fungi was measured. Also, mineral content of plant tissue was analyzed, and the residual salt content (conductivity) in treatment soils was determined. An additional experiment was conducted to determine the effectiveness of added inorganic P fertilizer to alleviate salt damage as compared to the effectiveness of VAM.

Results

Inoculation with either source of VAM fungi (saline or nonsaline) effectively reduced effects of soil sodicity on plant growth of both lettuce and onion. At the highest salt level (EC 12 dS/m), dry mass of nonVAM lettuce shoots was 29% less than for VAM plants; dry mass of lettuce roots was 23% less for nonVAM plants than VAM plants. Dry mass of nonVAM onion shoots was 88% less than for VAM plants; dry mass of nonVAM onion roots was 73% less than for VAM plants (Figure 1). Decrease of chlorophyll content of lettuce leaves at the highest salt level was significantly lessened by VAM. The increased tolerance to salt damage by VAM was greater with onion than lettuce, because onion was more highly responsive to VAM than was lettuce under the P-limiting conditions of the experiment. Adding more P to nonVAM onions only partially alleviated the salt

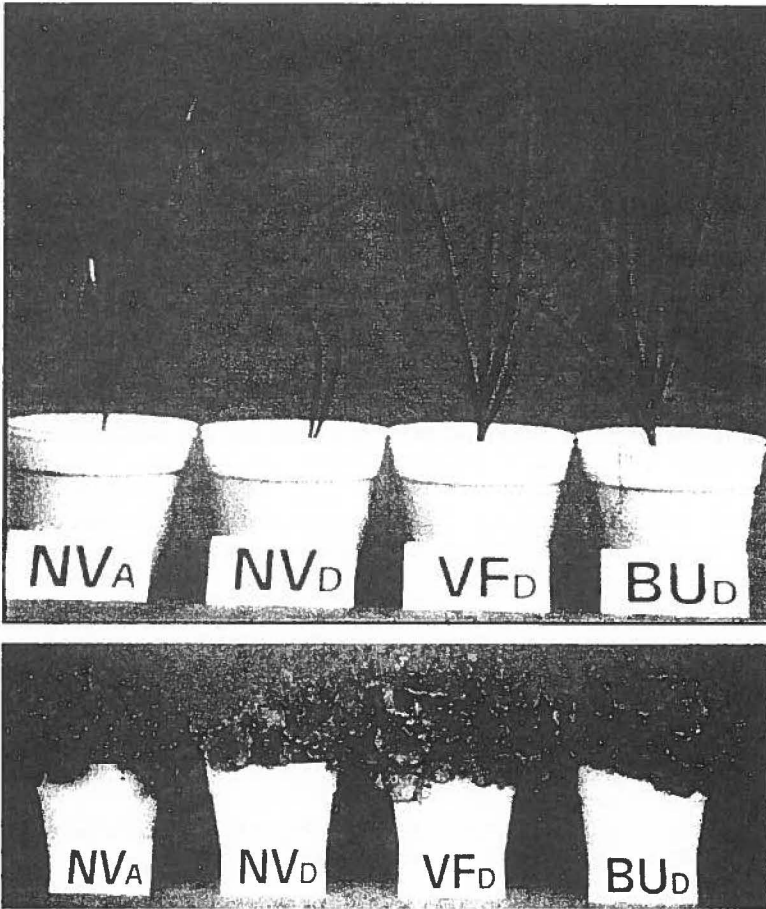


Figure 1 shows onions (above) and lettuce plants (below) grown in soil treated with different levels of NaCl solutions (A= control/ no salt, D= highest level at 12 dS/m). Fungal treatments were: NV= nonVAM, VF= Veg Farm VAM fungi, or BU= Burns VAM fungi. At 12 dS/m, shoot dry weight of NVplants was less (29% for lettuce; 88% for onions) than that of the VAM plants combined from the Veg Farm and Burns inocula.

effects due largely to the high P-fixing capacity of the soil. VAM plants absorbed more nutrient elements (e.g. P, Cu, Zn), including Na, than nonVAM plants, but by some mechanism reduced the impact of higher Na content on plant growth functions. VAM colonization of roots was reduced as salt level increased, more with the nonsaline soil source (Corvallis) than the saline source (Burns). Final EC of noninoculated soil was significantly higher than that of soil inoculated with VAM fungi due to reduced plant uptake.

Conclusions

The hypothesis that preinoculation of transplants with VAM fungi would be an effective means of increasing plant tolerance to soil salinity was verified. The hypothesis that VAM fungi from a saline site would be more effective than those from a nonsaline site was not verified, although there were some differences between the fungal sources in their effects on plant responses (e.g. absorption of some elements). The method of preinoculation with VAM fungi would be an effective and useful tool for farmers to use to overcome effects of soil salinity on plant growth, and it appears to be more effective than adding more P fertilizer, especially in soils with high P-fixing capacity as the one used in our experiment.

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