Mycorrhizal Response to Salinity in Snap Beans

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ABSTRACT

It is well known that plant growth is affected in soils. Arbuscular mycorrhizal fungi play a significant beneficial role in 95% of the vascular plants on the earth. We hypothesize that mycorrhizal fungi reduces salt stress in plants. To prove our hypothesis, a green house experiment was conducted to determine the benefit of mycorrhizal fungi by comparing mycorrhizal fungal inoculated snap beans to non inoculated snap beans under different salt concentrations in soil. Salinity did affect the plant growth with increasing stress rate at higher salt concentrations particularly in non-inoculated plants. Inoculated plants were healthier at low to medium salt concentrations; however, higher salt concentration affected the growth. Mycorrhizal inoculated plants in low to medium salt concentrations had higher root mass and colonization compared to high salt concentration. Further research is needed to study the physiological response of Mycorrhizal plants to salt stress.

INTRODUCTION

The state of Florida is ranked first in the production of snap beans for use in the fresh market in the United States. Over 50% of agricultural land used for snap beans production is located in southern Florida. The soil in this region is rock plowed calcareous soil. The soil depth is very shallow with approximately 15 cm thickness with a high water table close to the surface. Because of the closer proximity to sea and low elevation, salt intrusion is a common problem and affects the soil quality. Conventional intensive farming also enhances the accumulation of soluble salts into the soils. ("14-3 Soil Erosion and degradation.", 2005)

Arbuscular mycorrhizal fungi (AMF) are beneficial symbiotic fungi known to increase the nutrient uptake in plants, particularly phosphorous, sulfur, copper, and zinc. (Abuzinadah & Read 1989, "Soil Fungi." 2005). AMF also know for their role in enhancing root architecture and surrounding soil structure. AMF have been found to protect the roots from pathogen and nematodes. (Bagyaraj, 1984).

The hypothesis of my research is AMF play a significant role in protecting plants from salt stress. To prove my hypothesis, I have chosen snap beans, one of the common vegetable plants in South Florida. The objective of my research project is to document mycorrhizal inoculation protects snap beans from salt affected soil.

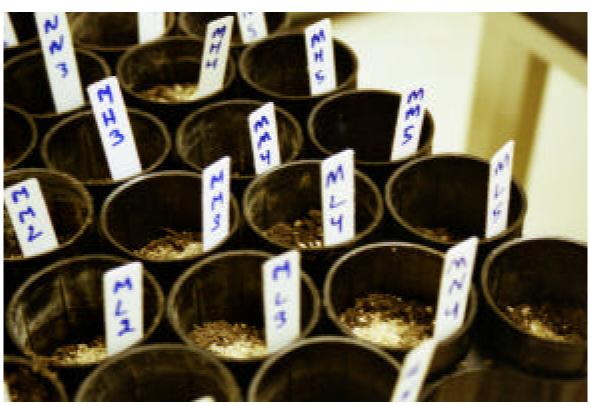
MATERIALS AND METHODS

A green house experiment was conducted between August and December 2006 in the green house facility at Florida International University. Potting soil was purchased from local Home Depot and used as non-sterile substrate. D4 size tubular pots were cleaned and used for potting. 800 g soil was weighed into each pot. There were two main treatments, AMF inoculation and non-inoculation. The sub-treatments were four salt concentrations, control, low, medium, and high. There were 5 replications. AMF inoculum obtained from Fairchild Tropical Garden was used as mycorrhizal inoculums. Approximately 5 g of AMF inoculums was placed 5 cm below the surface of the soil in each AMF inoculated pots. Snap beans seeds one per pot was placed 2 to 3 cm deep from the surface of the soil. Salt solution was introduced according to the levels for each condition once 75% of all plants established first leaf. The salt levels ranging from the control - no salt added, low - 1 mmhos/cm, medium - 3.5 mmhos/cm, and a high - 7 mmhos/cm determined by the use of an electric conductivity meter. These calculations were measured by snap beans yield capacity according to salt level.

Once snap beans germinated, plants were irrigated with 28mL of water on a weekly basis. This amount was determined by 80% fill capacity of the soil in experimental pots. The plants were fertilized once in two weeks with Hoagland's solution without phosphorus. Plant height, leaf count, and overall health were recorded three times a week. After 36 days, plants were harvested, shoots and roots were separated. Fresh weights were recorded and placed in oven at 70 C· for three days. Dry weights were recorded. Roots were cleaned and root length was measured. A portion of secondary and tertiary roots were separated for root staining and root colonization. (Phillips, J.M and D.S. Hayman 1970).

Plant height was determined by measuring from the base of shoot to the highest node to observe the weekly change. At harvest, shoots were cut at the soil base and placed into paper bags to be dried. Roots were carefully separated from soil with water. The roots were stained and scanned using a microscope for determination of percent root colonization.

Labeling for 40 pots



Adding Inoculum

Creation of the Hoagland Solution as Plant Feed

RESULTS

Key:	**Abbreviation**	**Treatment**	**Salt Level**
Inoculated			
	MN	*Mycorrhizal*	*No salt*
	ML	*Mycorrhizal*	*Low*
	MM	*Mycorrhizal*	*Medium*
	MH	*Mycorrhizal*	*High*
Not Inoculated			
	NN	*Nonmycorrhizal*	*No salt*
	NL	*NonMycorrizhal*	*Low*
	NM	*NonMycorrizhal*	*Medium*
	NH	*NonMycorrizhal*	*High*

Identification key: First letter of abbreviation determines treatment, Second Letter determines salt level. Number that follows refers to replication.

(Ex: MN2 – Mycorrizhal treated, No salt added, second replication.)

(The average root length in inches for each treatment group; five individual plants in each group Mycorrizhal groups had longer root length with the exception of high salt treatment.)

Root Length

The roots were separated from shoots, cleaned with water, and measured root length. We observed 9.95 inches total root length in AMF inoculated in background salt concentration treatment. The second longest total root length was measured in AMF inoculated in medium level of salt concentration followed by AMF inoculated in low salt concentration. The shortest total root length was in high salt concentration treatment. These results indicate that increase in salt concentration inhibited the root growth even in AMF inoculated plants; however, the roots were healthier and longer than non-inoculated plants in all salt levels the non-inoculated plants in background salt concentration measured an average total root length of 8.2 inches.

(The fresh and dry biomass average for each treatment, measured in grams. Inoculated plants had higher fresh biomass levels in all salt treatments. Dry biomass was recorded higher in inoculated plants than in non-inoculants plants, however higher salt concentrations did affect both plant biomasses in both inoculated and non-inoculated plants).

Fresh and Dry Biomass

The biomasses of plants are compared in this chart. The inoculated plants had a higher fresh biomass with the exception at higher salt concentration. It is clear from the results that AMF inoculation benefits the plants under low to medium level salt concentrations. However, AMF didn't protect the plants at higher salt concentration. In the no inoculate treatments; there was a decline in fresh as well as dry biomass with increase in stress as salt level increases. In general, fresh and dry biomass was higher in mycorrhizal treatementsthan those of non mycorrhizal treatments.

(Percent AMF Root Colonization observed in inoculated plant roots. Mycorrhizal colonization was higher in background, low, and medium salt concentrations)

Colonization

Percent root colonization by AMF is shown as a percentage of total root segments observed. This observation was made specifically in the inoculated plant roots with the exception of high salt concentration treatment that had no measurable amount of secondary roots. The colonization, total root length, fresh and dry biomass indicate that AMF play a significant role in low to medium salt concentrations by decreasing salt stress on plants, however, AMF did not protect plants from high salt concentration. The interesting observation in this experiment is although AMF inoculated plants in high salt concentration showed poor response, but the root colonization was not affected by high salt level. Further study is needed to explore the physiological response of mycorrhizal fungi under different salt levels in soil.

(Weekly Plant Height according to Treatment, The average plant height in inches measured on three times per week basis, and recorded as a weekly average. AMF inoculated plants were taller at all salt concentrations except at high salt level compared to non-inoculated plants.

Plant Height

Snap bean plants were measured for plant height at three times per week. The results presented shows difference of growth rates of mycorrhizal inoculated and no-inoculated at different salt levels in soil. First week after seeding, there were no salt treatments initiated. All the plants were observed to be normal and there was no significant growth difference between mycorrhizal and non-mycorrhizal plants as one week is too early for the establishment of mycorrhizal symbiotic relationship. In the second week after seeding, AMF plants seem did better than non-mycorrhizal plants; however, it is not possible for AMF to show growth response in two weeks. In the third week, high salt concentration treatments for both mycorrhizal and non-mycorrhizal plants were dead because of salt stress. In the nonmycorrhizal treatments the growth seems very slow with increasing salt concentration. The medium salt concentration plants also died at the end of third week. This clearly demonstrates that salt increases stress on plants without mycorrhizal symbiosis. In fourth week, the mycorrhizal plants in background, low, and medium salt concentrations were the tallest, particularly, the medium salt concentration plants grew 8.9 inches tall. The plants in background salt with out AMF grew 8.4 inches tall followed by the low salt level with 6.5 inches. The final week before harvest showed that that mycorrhizal inoculation increased plant growth with the addition of low to medium salt concentrations.

(Average weekly leaf count, leaves counted daily and shown here as weekly average for each treatment. Inoculated remained high with the exception of high salt concentration. Non-inoculated plants showed a declining trend, higher the salt level the lower the number of leaves).

Leaf Count

The leaf count of both mycorrhizal and non-mycorrhizal inoculation in background salt levels showed similar growth patterns except mycorrhizal plants were healthier than nonmycorrhizal plants. In low salt concentration, AMF inoculation showed increase in leaf number during entire time except in week five. Medium salt concentration increased in the third week. High salt concentrations were constant at the beginning, but plants died at the end of third week due to salt stress.

CONCLUSION

This study has demonstrated that salinity at higher level affect plants. Arbuscular mycorrhizal inoculated plants did well compared to nonmycorrhizal plants in every growth parameters with the exception of background salt treatment. The research demonstrates that Mycorrhizae protect plants from salt stress at certain levels. Mycorrizhae – Snap beans interactions are highly beneficial at background, low, and medium salt concentrations in soil. Farmers could benefit by inoculation mycorrhizal fungi to reduce salt stress on plants and increase yield.

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