Research Application Summary

Effect of selected arbuscular mycorrhiza fungi on the growth of *Calliandra calothyrsus* and *Sorghum bicolor* in eastern Uganda

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Abstract

Successful consistent revegetation of drastically disturbed areas throughout the world has been achieved using biological "tools" including mycorrhizal fungus inoculated tree seeds, seedlings, native shrubs, and grass species. However, the performance of these tools in different environments and plants has not yet been fully explored. This study compared the effect of selected arbuscular mycorrhiza fungi (AMF) genera and their application rates on calliandra and sorghum growth. AMF rich soils were collected from Serere in Soroti District for inoculum production. The soils were screened and four dominant genera (G*lomus*, *Scutellospora*, *Gigaspora* and *Acaulospora*) were identified and tested on calliandra (pot experiment) and sorghum (on-farm). Calliandra performance under two rates (50 spores/pot and 30 spores/pot) of the four genera and their mixture were compared to uninnoculated control using pot experiment. Sorghum performance under the mixture (250 spores/kg of soil) was compared with a control (not inoculated) on-farm. Each of the treatment was replicated three times. *Glomus* and *Acaulospora* application gave the highest increase in height for calliandra; while the biomass was highest for the mixture ($P<0.05$). On-farm the inoculated sorghum had a higher yield increase and was ten times taller than the control nine weeks after germination ($P<0.05$). This study provides a good scope for commercially utilizing the efficient strains of AMF to improve establishment of slow growing seedlings and improved growth.

Key words: *Acaulospora*, AMF diversity, genera spores, *Gigaspora*, G*lomus*, plant growth, *Scutellospora*, *Sorghum bicolor*

Résumé

Le revégétalisation cohérente réussie de zones fortement perturbées à travers le monde a été réalisée en utilisant les “outils” biologiques dont les graines d’arbres inoculées par le champignon mycorhizien, les semis, les arbustes indigènes et les graminées. Cependant, la performance de ces outils dans des environnements et des plantes différents n’a pas encore été pleinement explorée. Cette étude a comparé l’effet des genres des champignons mycorhizes arbusculaires (AMF) et leurs taux de demande de croissance de calliandra et du sorgho. Les sols riches AMF ont été recueillis de Serere, dans le district de Soroti dans la production d’inoculum. Les sols ont été examinés et quatre genres dominants (G*lomus*, *Scutellospora*, *Gigaspora* and *Acaulospora*) ont été identifiés et testés sur Calliandra (expérience en pot) et le sorgho (à la ferme). La performance du Calliandra sous deux taux (50 spores / pot et 30 spores / pot) de quatre genres et leur mélange ont été comparées au contrôle non inoculé en utilisant l’expérience en pot. La performance du sorgho dans le cadre du mélange (250 spores / kg de sol) a été comparée à un contrôle (non inoculé) à la ferme. Chacun des traitements a été répété trois fois. L’application de *Glomus* et *Acaulospora* a donné la plus forte augmentation en hauteur pour Calliandra, tandis que la biomasse était la plus élevée pour le mélange (P <0,05). Dans la ferme, du sorgho inoculé avait une augmentation de rendement plus élevée et a été dix fois plus grand que neuf semaines de contrôle après la germination (P <0,05). Cette étude fournit une opportunité pour le commerce en utilisant les souches efficaces de l’AMF pour améliorer la mise en place de lente croissance des semis et amélioration de la croissance.

Mots clés: *Acaulospora*, la diversité AMF, les spores de genres, *Gigaspora*, G*lomus*, la croissance des plantes, *Scutellospora*, *Sorghum bicolor*

Background

Arbuscular mycorrhizal fungi (AMF) are known to improve plant nutrient and water uptake from the soil, reduce heavy metals toxicity and other pollutants, and improve plants’ resistance to pathological colonization. Indeed, mycorrhizal symbiosis is an important facet of plant health in established ecosystems (Thomas, 2001). There is a growing body of evidence that arbuscular mycorrhiza can increase plant growth, especially in infertile soils, and that such growth-increases are the result of an enhanced ability of infected roots to absorb nutrients (Kung’u, 2004). This study was therefore carried out to determine the best arbuscular mycorrhiza application rate for enhanced calliandra and sorghum growth.

Literature Summary

AMF associations enhance tree and plant performance due to their extramatrical hyphae. Also mycorrhiza are capable of absorbing and translocating of nutrients to the associated plant roots through exploring more soil volume than the non-mycorrhizal roots (Joner and Jakobsen, 1995). That way, they increase the supply of slowly diffusing ions, such as phosphates to the plant. AMF have generally got broad host ranges whereby some species are more effective with particular host plants in increasing nutrient uptake and plant growth. They therefore differ in the manner and extent to which they colonise roots and also differ in their capacity to form propagules (Cornejo *et al.*, 2009). There is therefore need to test the performance of several trees and crops while in association with different AMF species. For this study, sorghum was chosen because it is widely grown in drought prone areas, is a crop of hot, semi-arid tropical environments with 400 - 600 mm rainfall-areas that are too dry for maize, and has the potential for several alternative uses and a common host plant for mycorrhiza (ICRISAT, 1996). Calliandra was selected as the host plant mainly because of its fast growth, ease of establishment, and being a legume, it demonstrates the positive features associated with soil improvement (Powell, 1997) and is an agroforestry tree.

Study Description

The study was conducted in the greenhouse of the Soil Science Department at Makerere University for *Calliandra calothyrsus* and for *Sorghum bicolor* on-farm in Moruapesur and Gweri (Dokolo) villages in Gweri Sub-county, Soroti district. Spores of VAM were isolated from soil by the wet sieving and the decanting technique (Gerdeman and Nicolson, 1963) while inoculants were produced using the traditional pot culture technique (Wood, 1983).

Results

Results showed that the temporal change in calliandra height was highest under *Glomus* followed by *Acaulospora*, *Gigaspora* and then *Scutellospora*. The mixture of all genera showed the lowest temporal change in growth. The temporal trend in height of calliandra for the first 18 weeks was natural logarithmic and the regression coefficients ranged from 0.9484 to 0.9798, the slopes from 1.183 to 1.593 and the intercepts ranged from 2.927 to 3.484. The relative change in calliandra height decreased between 1 and 3 weeks after germination

(WAG) except for the mixture that slowly but steadily increased up to 7 WAG. After week 7, there was a sharp decrease for mixture, *Scutellospora*, and *Acaulospora* mainly at week 8. Gradual increases in the relative calliandra height were observed for most of the genera and the mixture after week 11. Generally seeds with high spore rate had higher height for all genera (Fig. 1)

For sorghum, mycorrhiza inoculated plants performed better than the control (Plate 1) and with a corresponding higher sorghum yield than the control (Fig. 1). The temporal change in sorghum height varied significantly with week, application of AMF and location ($p \leq 0.05$). The temporal trend in sorghum height was a natural logarithm, with an R^2 of 0.975 for

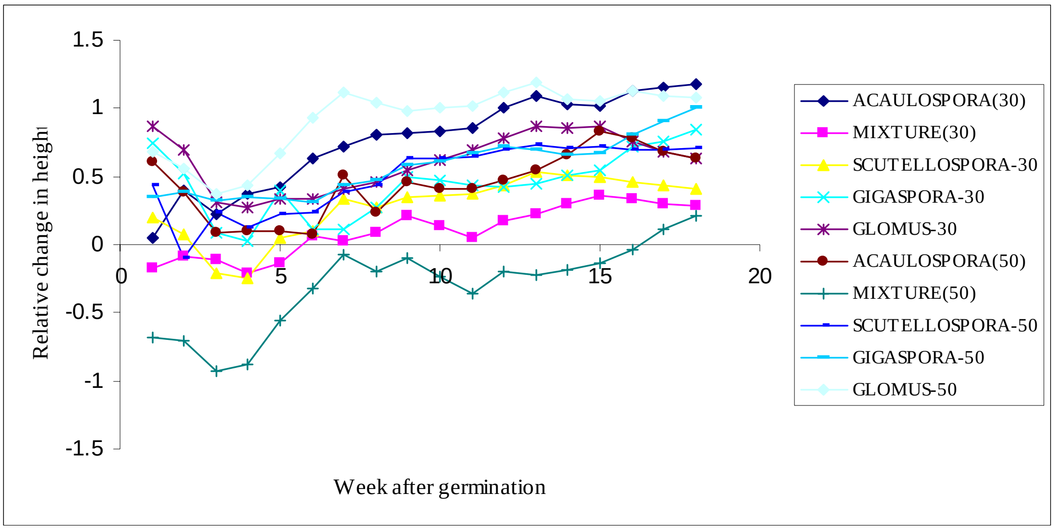

Figure 1. Relative change in Calliandra height.

Plate 1. Mycorrhized sorghum (a) and the control (b) in Soroti.

mycorrhiza (mixture) plants and 0.979 for the control; the slope was 2.70 for mycorrhiza plants and 2.22 for the control. The intercept was 1.21 for mycorrhiza plants and 1.25 for the control. The difference between the inoculated sorghum yield was half that of the control (759.25 kg/ha). The yield from the control plot was close to the average sorghum seed yield in Uganda (1,694 kg/ha).

Research Application

AMF isolates played an important role in the rapid growth of calliandra and sorghum plants in the greenhouse and on-farm. This translated into a subsequent increase in the yield for sorghum and faster restoration when Calliandra was grown in degraded patches of the forest or as an agroforestry tree. Therefore, as a result of mycorrhizal inoculation, there is a corresponding increase in plant yield. The results indicate a good scope for commercially utilizing the efficient strains of AM fungi for beneficial effects due to enhanced plant survival and improved growth/yield. However,

- further research is required to develop a practical technique for large-scale inoculation with these fungi.
- supplementary work is also needed to investigate the effectiveness of single and different combinations of AMF species, and their combination with rock phosphate and different host plants.

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