Research Application Summary

Determination of sugarcane yield advantages of Mycorrhiza inoculants on Ferralsols

Sebuliba, E.[1], Majaliwa, J.G.M.[1], Suresh, R.[2], Kizza, C.L.[1] & Kibirango, S.O.[2]
[1]College of Agricultural and Environmental Sciences, Makerere University, P. O. Box 7062, Kampala, Uganda
[2]Sugar Corporation of Uganda (SCOUL), P. O. Box 1 Lugazi, Uganda
Corresponding author: sebulibaesther@yahoo.com

Abstract

Sugar cane (*Saccharum officinarum* L.) is the source of sugar in all tropical and subtropical countries of the world. Understanding the performance of sugarcane in Uganda is therefore vital in light of the new challenges for the development of agriculture and the growing economic demand for sugar in the tropics. Soil micro organisms' interactions are among the major sugarcane yield determinants, though little is known about it in Uganda. This study thus, determined sugarcane yield advantage of AMF inoculation under ferralsols. A bioassay experiment was set up at Lugazi Sugar Corporation of Uganda Limited with sorghum to trap mycorrhiza spores, which were identified at the botany laboratory of Makerere University. The AMF spores were extracted from 50 cm^3 soil samples by wet sieving and sucrose gradient centrifugation. The number of spores in 1000g of mycorrhized soil was determined. Four treatments (Mycorrhiza alone-T1, mycorrhiza and rock phosphate-T2, rock phosphate-T3and the control-T4) were considered and replicated 4 times randomly. Mycorrhized soil and with rock phosphate was applied in the planting lines. The plots had 10 rows consisting of six lines separated by 1.35 m within the plot and 3 m from one plot to the next. There were six rows per plot. Weeding was carried out regularly and readings were taken every week after one month of germination. The study found six AMF genera in Lugazi dominated by *Acaulospora* and *Glomus*. The phosphorus levels were also very low. Rock phosphate and mycorrhiza combination enhanced significantly sugarcane yield. Results of the study indicate a good scope for AMF inoculum selection and commercially utilising the efficient AMF strains for improved agricultural productivity.

Résumé

Le sucre produit dans tous les pays tropicaux et subtropicaux du monde provient d'habitude de la canne à sucre (*Saccharum officinarum* L.). Ainsi, la compréhension de la performance de la canne à sucre en Ouganda est vitale à la lumière des nouveaux défis pour le développement de l'agriculture et de la demande économiquecroissante pour le sucre dans les régions tropicales. Les interactions des micro-organismes du sol sont parmi les principaux facteurs déterminants du rendement de la canne à sucre, mais on en sait peu à ce sujet, en Ouganda. Cette étude a donc pour but de déterminer le rendement de la canne à sucre avec l'avantage de l'inoculation AMF dans les ferralsols. Une expérience de bio-essai a été mise en place dans la sucrerie de Lugazi en Uganda avec le sorgho pour piéger les spores de mycorhizes, qui ont été identifiées au laboratoire de botanique de l'Université de Makerere. Les spores AMF ont été extraites à partir des échantillons de sol de 50 cm^3 par tamisage humide et centrifugation en gradient de saccharose. Le nombre de spores dans 1000g de sol mycorhizé a été déterminé. Quatre traitements (mycorhizes seules-T1, mycorhizes et phosphate de roche-T2, phosphate de roche-T3 et le contrôle-T4) ont été examinés et répétés 4 fois au hasard. Le sol mycorhizé avec le phosphate de roche a été appliqué dans les lignes de plantation. Les parcelles avaient 10 rangées composées de six lignes séparées par une distance de 1,35 m à l'intérieur de la parcelle et de 3m d'une parcelle à l'autre. Il y avait six rangées par parcelle. Le désherbage a été effectué régulièrement et les mesures ont été effectuées chaque semaine après un mois de germination. Les résultats ont montré que six genres AMF ont été trouvés dans Lugazi, dominés par *Acaulospora* et *Glomus*. Les teneurs en phosphore étaient également très faibles. Le phosphate de roche et la combinaison des mycorhizes ont amélioré le rendement de la canne à sucre de manière significative. Les résultats de l'étude indiquent une bonne ampleurpour la sélection de la substance inoculanteAMF et en utilisant commercialement les souches AMF efficaces pour la productivité agricole améliorée.

Background

Functional microbial biofertilisers have been used in some tropical countries for more than half a century in both small and large farms. Biological nitrogen fixation, plant growth promotion, phosphorus solubilisation, and translocation to host plants are the major benefits of biofertiliser use, observed or claimed by researchers and product developers. (van der Beetz, 2002; Heijden *et al.*, 2006; Potila, 2008) However, a major constraint for the further development of the microbial biofertiliser industry is the demonstration of consistent field effects of the marketed products. Mycorrhiza is a biofertiliser that has been known for a longtime for enhancing water and nutrient uptake by the plants as well as for bio control against plant pathogens and improved tolerance to pollutants and greater resistance to high soil temperature, adverse soil pH and transplant "shock" (Beetz, 2002, Jones *et al*., 2004). They are mutually beneficial (symbiotic) relationships between fungi and plant roots (Kabir, 2009). Their effect on the plant is influenced by their abundance in adequate populations (Leyval *et al*., 2002). In some areas, either the population is too low or the strains are not very effective, which is the case for SCOUL located in the Mabira vicinity. This implies that in order to enhance this population, the organisms have to be introduced. Unluckily, arbuscular mycorrhiza is not easily propagated, a problem that has hampered inoculants production (Jasper, 1994; Wiersma and Carter, 1998). From the restoration study (in vitro experiment) that was carried out at Makerere University, mycorrhizal inoculants and combinations were developed and tested both in the field and in vitro. Results indicated that the performance varied with combinations of strains. During the field work the best inoculants were selected in a participatory manner with the farmers. Inoculation boosted yield 5 to 10 times than the ordinary farmer practice in the semi-arid region of Uganda (Sebuliba, 2010). It was therefore hypothesized that this technology could be used to boost crop production and food security under climate variability and change conditions; one of the projected major challenge to crop production in farmers' fields in Sub-Saharan Africa and Uganda in particular. This study determined sugarcane yield advantage of AMF inoculation on ferralsols.

Materials and Methods

SCOUL is a Small Medium Enterprise (SME) located in Lugazi in the Central part of Uganda (Fig. 1). The main activity of SCOUL is sugarcane growing. The estate was established in the year 1924. Since its inception, it has been playing a key role in the development of the Ugandan economy. Besides being one of the largest employers in the country, it has always kept focus on the product quality, people and its resources. It is the first sugar company to have been certified for ISO 9001 in Uganda, and among few companies to be certified for IS 14001 for environment compliance. The present capacity of sugar production is 50,000 MT p.a. and company has embarked upon its expansion plans for doubling the capacity by 2013.

The soils of SCOUL area are generally well drained, yellowish to brown gravely clay overlying soft, highly weathered metamorphic rock. On upper slopes the gravely layer is thinner. On the lower slopes and in some gently sloping valley heads

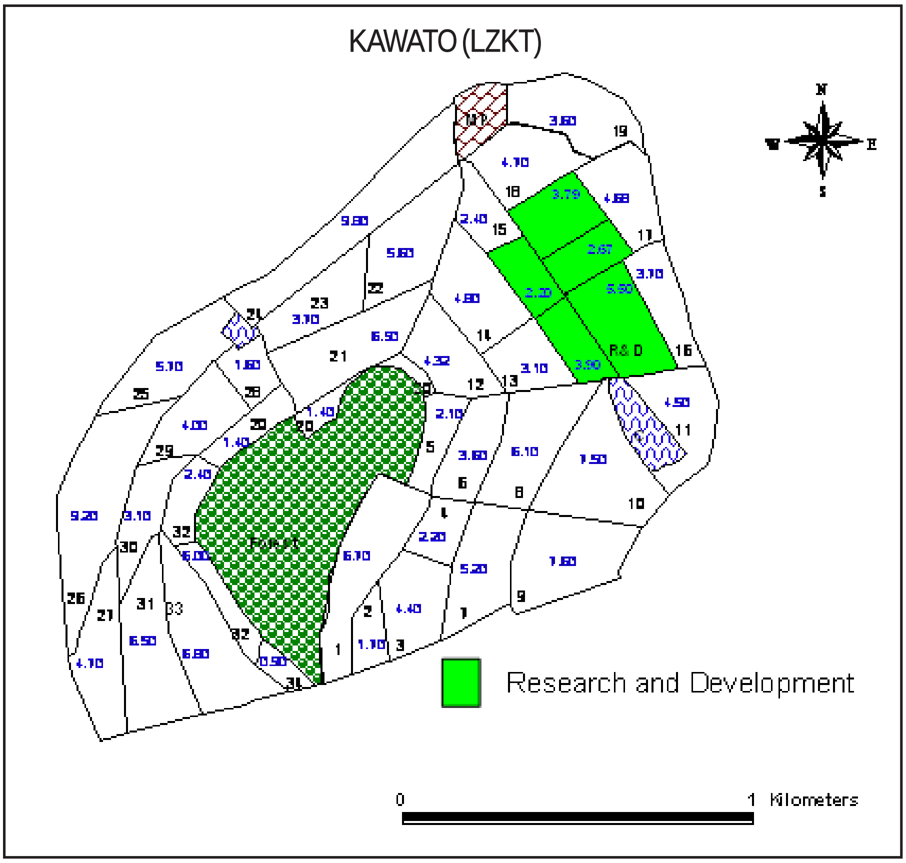

Figure 1. **Map of Lugazi showing the research and development area.**

are deep brownish, gravely, free draining soils. The valley bottoms are poorly drained clay soils. Drainage is a problem in the lowlands. The soil pH is generally acidic with decreasing pH with depth. The cation exchange capacity CEC are medium to high in the top soils but low in the subsoil and parent material. The organic matter content ranges from 1.16 to 3.5 and is considered as low to medium.The soils are generally ferralitic sandy clay loams, with waterlogged clays in the valley bottom.

Wambwa is a mid slope, located 32 0 56’E and 000 24’N and altitude 1,195 meters above sea level. The climate is sub-humid having a, long term mean rainfall of 16600 mm occurring on average of 160 to 170 days each year. The maximum / minimum temperatures is 27.6 / 17.0 0C giving a diurnal variation of 10.60C. The rainfall is bimodal, well-distributed with peaks in March –April, and October-November, but with very high evaporation rate of 3 to 5 mm per day.

A bio-assay experiment was established at SCOUL, Lugazi with sorghum to trap mycorrhiza spores. (Fig. 2) The sorghum was allowed to grow for 8 weeks; after which water supply was denied for 4 weeks in order to stress the sorghum and induce mycorrhiza sporulation (Santos-González *et al.*, 2007).

Taking measurements for the different treatments (mycorrhized soil, rockphosphate)

Monitoring and taking measurements 4 and 6 weeks after planting in the field.

Figure 2. Preparations and sugarcane field demonstration plots in Lugazi.

After sporulation, thorough mixing of the soil from each pot was done; a 50g soil sample was collected from each treatment and transferred to the botany laboratory of Makerere University (MAK) for spore identification and counting. AMF spores were extracted from 50 cm3 soil samples by wet sieving (Gerdemann and Nicolson, 1963) and sucrose gradient centrifugation (Jenkins, 1964), and were counted based on a 50 g soil aliquot taken from each sample (Sylvia, 1994). The spores were counted under a stereomicroscope of x40 magnification, on plates containing concentric grooves (Moreira *et al.*, 2007). The spores were separated according to their morphology.

A completely randomised block design was used with four treatments (Mycorrhiza alone-T1, mycorrhiza and rock phosphate-T2, rock phosphate-T3 and the control-T4) and replicated 4 times. All treatments were applied in the planting lines. Two split doses of nitrogen application in form of urea was applied also in all treatments from 2 -3 months after planting. Each plot in a block had 10 rows consisting of six lines separated by 1.35 m within the plot and 3 m from one plot to the next. There were six rows per plot. Four kg of mycorrhized soil was applied in sub plot with 33120 spores' mycorrhiza. Application of rock phosphate and Urea were as per SCOUL fertiliser policy. The trial was established on 30th August 2010. Weeding was carried out regularly and readings were taken every week after one month of germination.

The data collected for the sugarcane were percent germination and shoot counts at 30, 45 and 60,90,120,150,180 days after planting, respectively. In addition, biomass yield, purity , sucrose percent in juice, brix (total soluble solids) and productivity were also determined.

In addition the soil of the experimental plot was characterised. A composite soil sample was collected from 0-30 cm soil depth.

Results

Acaulospora was the most abundant genera followed by *Glomus*, then *Scutellospora*, *Gigaspora*, *Archaespora* and *Entrophospora* which was the least abundant. Generally, the mean value of spores found in 100g of soil was 138.

Table 1. AMF abundance in SCOUL, Lugazi.

AMF Genera	Sample 1	Sample 2	Sample 3	Mean
	/100g of soil			
Acaulospora	68	28	46	47
Glomus	44	36	47	42
Scutellospora	36	23	26	28
Gigaspora	22	9	4	12
Archaespora	14	9	1	8
Entrophospora	0	2	0	1
Total	184	107	124	138

Performance. Figure 3 show that the combination of mycorrhiza and rock phosphate (T2) resulted into the greatest sugarcane growth, followed by mycorrhiza alone (T1), rock phosphate (T3) and then the control (T4) which was lowest.

Relative change in sugarcane height. The relative change in sugarcane height varied significantly ($P \leq 0.05$) with treatments

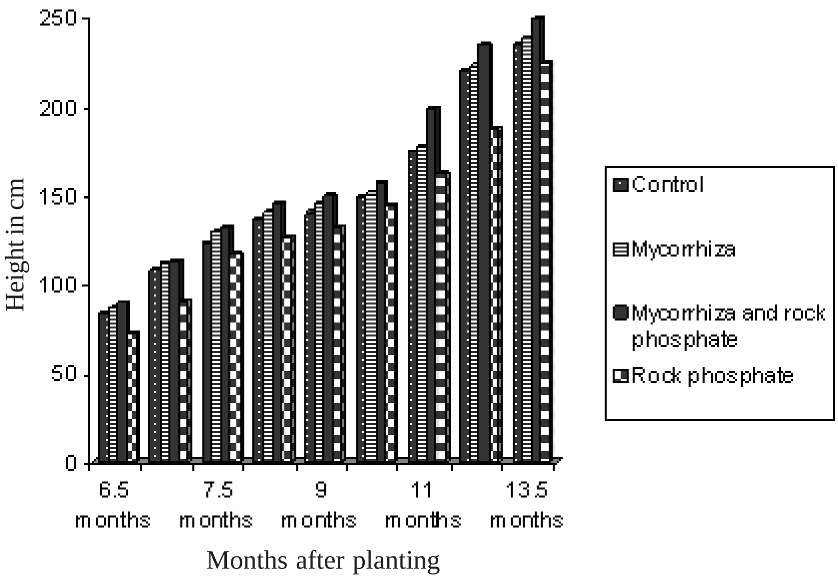

Figure 3. The effect of Mycorrhiza application and other treatments on height of sugarcane.

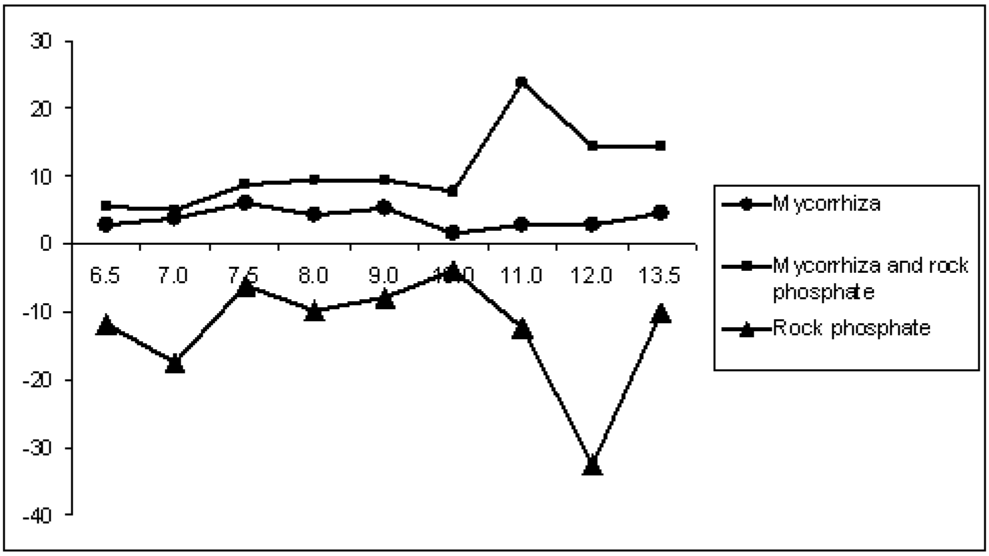

Figure 4. Relative change in sugarcane height by different treatments.

(Fig. 4). The relative change in sugarcane height was significantly higher for the rock phosphate-mycorrhiza combination, followed by mycorrhiza alone and lowest for rock phosphate alone. It decreased at weeks 3 and 9 of measurement after which it increased steadily.

For all genera the relative change in height decreased a few weeks after germination (WAG), increased steadily up to 7 weeks and then increased steadily until the 18th WAG. The increment rate varied from one treatment to another. The single mycorrhiza input change in height was lower than that of the rest but then at week 12 is overtook single rock phosphate input. The inflection point was the same at weeks 3, 9 and 11 for all treatments but slightly varied at week 4 for the mycorrhiza-rock phosphate combination and at weeks 6 and 10 for the single input of rock phosphate.

Sugarcane efficiency/biomass. Figure 5 shows that both the fresh weight and dry weight were significantly higher for the control and the combination of mycorrhiza and rock phosphate followed by mycorrhiza and rock phosphate as single inputs.

Figure 6 shows that the sugarcane biomass was significantly higher for the combination of mycorrhiza and rock phosphate followed by mycorrhiza and then rock phosphate was lowest throughout.

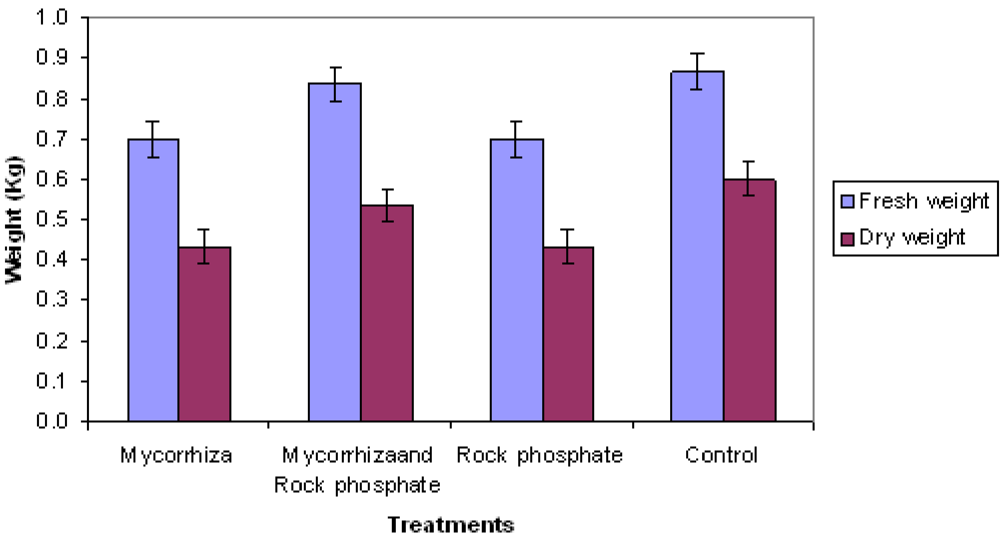

Figure 5. Sugarcane biomass 6 months after planting as affected by different treatments.

Research Application

This study has paved a way to an industrial production of bio-fertiliser at Makerere University to satisfy the rapid growing sugar industry needs. The sugarcane firm (SCOUL) has also adopted mychorrhizal application to enhance sugarcane production. The joint partnership with Makerere University increased the visibility and relevance of the University in research for development process.

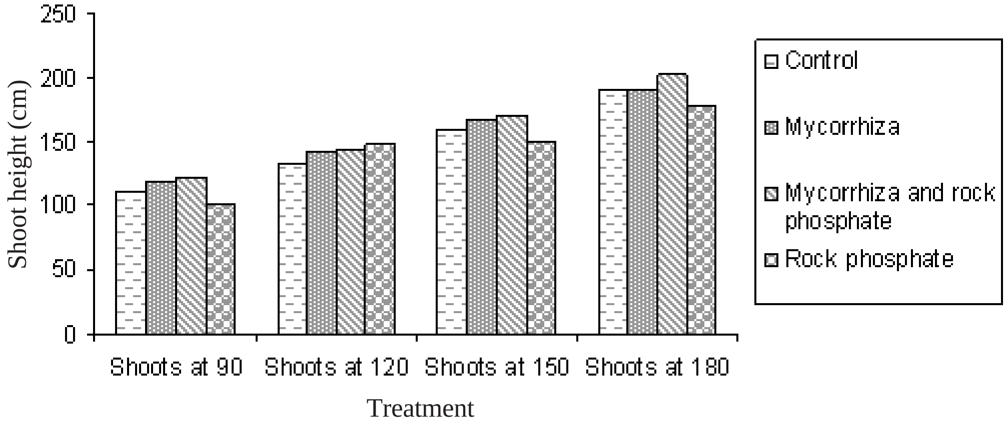

Figure 6. Cane weight.

Conclusion and Recommendation

- Application of the AMF inoculum enhanced sugarcane growth
- The combination of AMF and rock phosphate produced the best results for sugarcane growth and biomass.

Acknowledgement

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