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EFFECTS OF ALLEY CROPPING AND ARBUSCULAR MYCORRHIZAL INOCULATION ON THE GROWTH AND YIELD OF MAIZE (*Zea mays* L.) cv TZ SWAL-1

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ABSTRACT

A field experiment was conducted in a Rhodic Kandiustalf (Balogun series) soil in southwestern Nigeria to investigate the effects of *Glomus deserticola* on alley cropped maize. Inoculated maize performed best in *Gliricidia sepium* alleys with dry grain yield of 1108.4kgha^{-1} compared to 961.4, 661.2 and 472.1kgha^{-1} from *G. sepium* interplanted with *Senna siamea* ,*Senna siamea* alone and control subplots respectively. For the uninoculated, the lowest yield was obtained from *S. siamea* while the highest yield was obtained in *Gliricida* interplanted with *Senna* subplots.

KEY WORDS: Alley – cropping, *Glomus deserticola, Gliricidia sepium,* maize, *Senna siamea*

INTRODUCTION

Alley-cropping consists of planting arables between hedgerows of trees or shrubs which are periodically pruned to prevent shading during the cropping season while the mulch is provided to the associated arables (Kang *et al, 1990)*. Arbuscular mycorrhizal (AM) fungi are ancient Zygomycetes which are known to form symbiotic associations with the roots of about 80% of plant species (Bonfante and Perotto, 1995). They have been found to partly reduce or replace the fertilizer requirements of plants in degraded soils (Dixon, 1997) and have been assessed to be the most suitable type for development of low-input agriculture programmes (Bethlenfalvay and Linderman, 1992). The most important role of arbuscular mycorrhizal fungi is that of improving the mineral nutrition of the host plants (Schellenbuam *et al,* 1998) while depending on them for their own carbon requirements (Smith and Read, 1997). Increased uptake of phosphorus (P) has been reported to be responsible for the enhanced plant growth caused by arbuscular mycorrhizal fungi (Jakobsen, 1992). Arbuscular mycorrhizal fungi hyphae have great potential to grow and exploit the soil beyond phosphorus depletion zone (Sieverding, 1991) which quite often develop in the vicinity of plants roots in phosphorus deficient soils (Mosse, 1981). This way, they absorb and transfer phosphorus to the host roots (Cooper and Tinker, 1981).

Maize (*Zea mays L.)* is an important staple food and industrial crop in Nigeria as well as most other countries of the world. The need for its increased production resulting from the high demand for industrial utilization has made it mandatory that more nutrients be provided to this crop to improve its yield. Although yields of over 4.5tha^{-1} have been obtained with up to 90kgha^{-1} nitrogen fertilizer application (IITA, 1992), the low-income farmers cannot afford such luxuries due to high cost and transportation problems. Organic mulch application readily becomes an effective alternative at a very reduced cost. Huge savings from nitrogen fertilizer have been reported with alley cropping of maize with woody legumes (Ngambeki, 1985). The integration of arbuscular mycorrhizal fungi which enables plants to explore larger areas of soil to extract nutrient and water, with alley-cropping will increase the yield of maize even in areas with fertility and soil moisture constraints. This research was carried out to evaluate the effect of *Gliricidia sepium, Senna siamea* mulch and their mixtures on the yield of alley – cropped maize inoculated with *Glomus deserticola.*

MATERIALS AND METHODS

This field experiment was carried out in a Rhodic Kandiustalf (Balogun series) soil of University of Ibadan Research farm, Ajibode in south western Nigeria (7^{0}43'N, 3^{0}9'E). Prior to this experiment, the site has been on continuous cropping with maize, cassava and yam for over five years without any form of fertilizer application. The soil

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is typically poor in nutrient contents with 1.17mgkg^{-1} P, 0.036% N, 0.19 meg^{-1}K and pH 6.50 in the top soil.

Experimental Design and Layout

The experiment was conducted in a one year old alley-cropping plot. Treatments were laid out in a split-plot design. Each treatment was replicated three times. The main plots consisted of arbuscular mycorrhiza inoculation arranged in blocks to reduce possible mycorrhizal contamination of the uninoculated plots.Treatments were split on hedgerow tree species as subplots. Each sub-plots(12m x12m) consisted of three rows of *Gliricidia sepium, Senna siamea* or both interplanted as mixture at 4m interrow spacing and 0.5m intrarow spacing to give a population of 5,000 trees per hectare and a treeless control established 10m away from the last hedgerow.

Maize(Zea mays L.) cv TZ SWAL-1 was planted on ridges in the alleys at a spacing of 1m apart within rows to give a population of 7,500 maize plants per hectare in the hedgerow sub-plots and 10,000 stands per hectare in the treeless control sub-plots. Mycorrhizal plots were inoculated with *Glomus deserticola,* Trappe, Bloss and Menge obtained from Dr. Pat Millner of USDA-ARS, Beltsville. Twenty grams crude inoculum consisting of soil containing spores, hyphae and infected maize root fragments were applied directly in the planting holes for the maize grains before being covered with soil at sowing, while the uninoculated plots were given autoclaved equivalent.

At the beginning of the experiment, all the hedgerow subplots were mulched with 0.5t ha^{-1} dry matter equivalent of mulch from their respective hedgerow trees. Weeding was done manually whenever necessary throughout the growing period.

Growth measurements

The height and diameter of maize were measured two months after planting. At harvest, the maize plants were cut at ground level and separated into stem with male inflorescence, leaves and cobs. These were separately oven-dried at 70^{0}C for four days to determine the dry weights. Later, the grains were removed from the cobs and their dry weights were determined for each treatment.

Table 1:Effect of alley cropping and *Glomus deserticola inoculation on the growth of maize*

Hedgerow Tree (H)	**Height** (cm)	**Diameter** (mm)	**Leaf** ←	**Stem** (Dwt. kgha^{-1})	**grain** →
S. siamea	M^+ 223.2b	18.3d	320.6c	571.0c	661.2c
(Ss)	M^- 152.3b	12.9f	144.5c	173.9h	266.3c
G. sepium	M^+ 260.8a	20.8b	486.6a	720.1a	1108.4a
(Gs)	M^- 217.8b	20.5c	240.8d	272.7f	724.5c
Gs + Ss	M^+ 264.9a	22.7a	434.6b	628.7b	961.4b
	M^- 185.0c	19.0cd	339.2c	368.0c	782.9c
Control	M^+ 246.3a	21.3ab	282.9cd	433.3d	472.1d
	M^- 165.0d	16.3e	212.6d	221.0g	370.0d
LSD	18.33	1.51	44.4	45.21	129.5
Main effect					
M	**	**	*	***	*
H	***	***	***	***	***
Interaction					
M x H	***	***	***	***	**

M^+: arbuscular mycorrhizal fungus inoculated;
M^-. arbuscular mycorrhizal fungus uninoculated;
M x H: mycorrhiza x hedgerow tree species.

Mean values within each column followed by different letters are significantly different at $P < 0.05$ according to Duncan's multiple range test. * $P < 0.05$; ** $P<0.01$; *** $P < 0.001$.

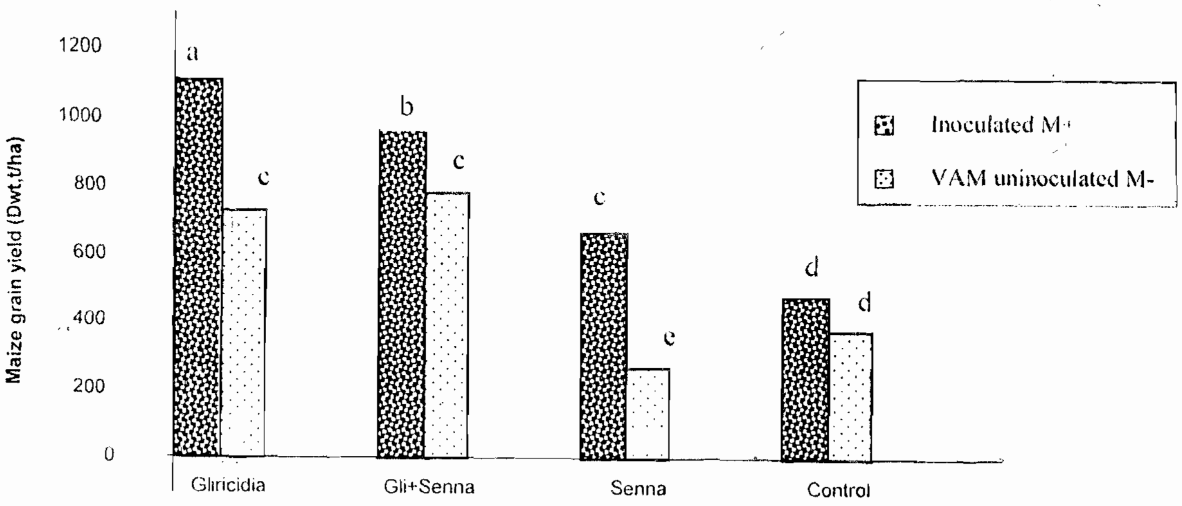

FIGURE 1

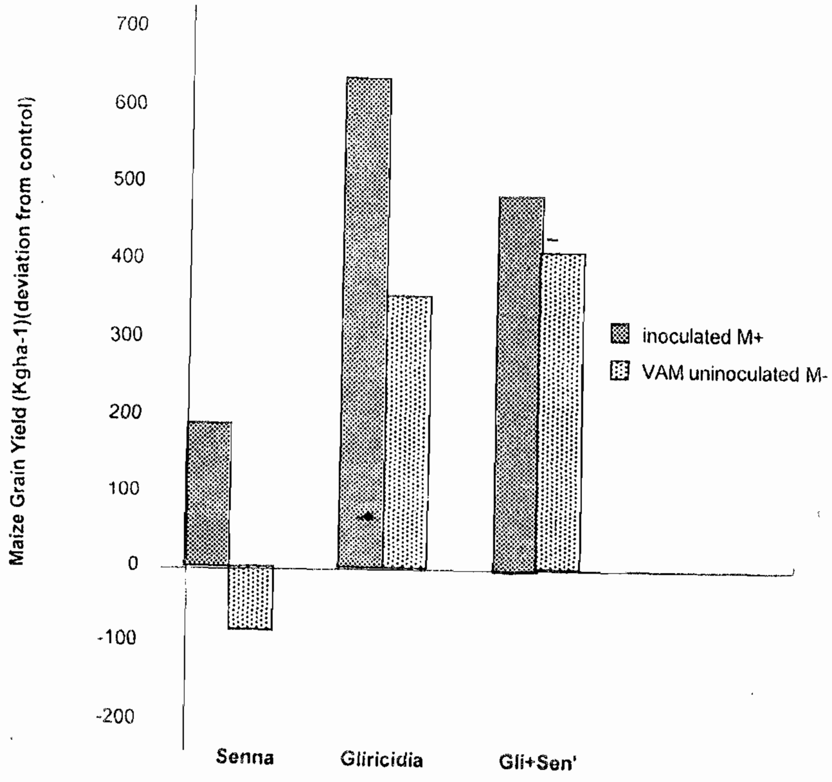

FIGURE 2

RESULTS

Inoculation with *Glomus deserticola* significantly increased plants height and diameter in all the hedgerow treatments (Table 1). Except for *Senna* sub-plots, there was no significant differences in the height of maize in all inoculated plots. Stem, leaf and grain dry matter were all significantly increased by arbuscular mycorrhizal fungus inoculation (Table 1). The highest grain yield was obtained from *Gliricida* alleys inoculated with arbuscular mycorrhizal fungus, followed by the *Gliricidia* interplanted with *Senna* alleys (Fig. 1). Uninoculated *Senna* alleys gave the lowest grain yield (Figs.1&2). Interactions between arbuscular mycorrhizal fungus inoculation and hedgerow tree species showed that both factors significantly contributed to increased growth characteristics and grain yield of maize.

DISCUSSION

Maize yield was higher in inoculated treatments apparently due to enhanced phosphorus and other nutrients uptake (Nielsen *et al*, 1998) as well as other improved physiological (Godara *et al*, 1996) and morphological alterations caused by mycorrhizal inoculation (George *et al*, 1992). The highest grain yield obtained from *Gliricidia* inoculated plots alleys could have been due to the high nutrient yield notably nitrogen and potassium as well as the fast decomposition and nutrient release of *Gliricidia* prunings (Tian *et al,* 1992). Besides, it has been suggested that when in close proximity, nitrogen fixing tree root nodules may provide nutrients directly to the non-nodulating plants by releasing biologically fixed nitrogen during nodule senescence (Fagbola *et al,* 1998). These would have provided adequate nutrients for the fast growing maize. *Senna* prunings wherever used gave a lower yield probably due to its initial nitrogen immobilization (Tian *et al,* 1992).

The generally increased grain yield in alley-cropped plots over the treeless control plots is an indication of the positive crop production enhancing effect resulting from improved soil condition caused by alley cropping while the higher yield in conjunction with arbuscular mycorrhizal fungus inoculation is probably due to organic matter protection within the soil aggregates by the presence of arbuscular mycorrhizal fungus (Miller and Jastrow, 1992). These findings suggest the profitability of arbuscular mycorrhiza – alley cropping integration technology in maximizing nutrient availability with reduced inorganic fertilizer input for an effective sustainable agricultural practices.

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