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# EFFECTS OF ARBUSCULAR MYCORRHIZAL FUNGUS AND PRUNING REGIMES OF WOODY LEGUMES ON THE TUBER YIELD OF ALLEY-CROPPED CASSAVA.

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**ABSTRACT**

The effects of arbuscular mycorrhizal fungus (AMF), *Glomus deserticola,* Trappe, Bloss and Menge (INVAM, CA113), on the tuber yield of cassava (*Manihot esculenta* Crantz*)* as influenced by two hedgerow tree species and their mixture pruned at two-and three monthly intervals were investigated in an alley cropping experiment. In alley-cropped plots, inoculation with *G. deserticola* increased cassava root tuber yield by 205% over non-inoculated plants at two-monthly pruning regime and 19-81.8% higher tuber yield than three-monthly pruning regime. Mixing the two tree species, *Gliricidia sepium and Senna siamea* in the same hedgerow, particularly with AMF inoculation, significantly improved cassava tuber yield compared to either of the tree species planted alone.

**KEYWORDS**: Alley-cropping. Cassava. Mycorrhiza. Pruning.

## INTRODUCTION

Cassava (Manihot esculenta Crantz) extracts considerable amounts of nutrients from the soil which have to be replaced by fertilization or mineralization of organic substances if productivity is to be sustained. (Howeler,1991). In many parts of the tropics, cassava is grown in poor, infertile soils by resource-poor farmers who cannot afford soil amendments with inorganic fertilizers. These farmers would welcome alternative nutrient sources to bring down the cost of cassava production.

Some attention has been given to improvement of indigenous farming practices through alley cropping systems (Kang *et al.*, 1985; Osonubi *et al.*, 1995) in which N-fixing trees and shrubs provide green manure for soil fertility maintenance and crop yield improvement. Much of the research on alley cropping has involved experiments with individual trees or shrubs. In the traditional bush fallowing, multiple tree and shrub species are involved in soil nutrient recycling. Advantage is thus taken of the differential decomposition rates of leaves as well as nutrient recycling ability of these species. It is therefore necessary to consider the incorporation of this traditional system into the more organized alley cropping practices. However, critical data are lacking on the extent to which individual tree species and their mixtures in the same hedgerow affect the yield of cassava mulched with their prunings.

The importance of arbuscular mycorrhizal fungi (AMF) associations in agriculture has been recognized (Fagbola *et al.*, 2001; He *et al* 2003; Takacs and Voros, 2003). Cassava depends heavily on AMF (Howeler *et al.*, 1987). An understanding of the relationship of cassava with AMF can complement the alley cropping efforts by improving the efficiency of uptake of mineralized nutrients from prunings, thereby making the system economically attractive to the farmers who cannot afford the high cost of inorganic fertilizers.

The objectives of this study were to test the agronomic importance of AMF in a cassava based alley cropping system and to determine the best hedgerow species or their mixture for increased cassava tuber yield.

## MATERIALS AND METHODS.

This experiment was conducted at the University of Ibadan Research Farm, Ajibode in southwestern Nigeria(Latitude $7^0$ 30′ N, Longitude $3^0$ 54′ E). The soil type is a Rhodic Kandiustalf, an Alfisol of Balogun series with a pH ($H_20$) of 7.2, 2.77% total N, 4.3mg kg $^{-1}$ extractable P(Bray $-^1$) and 0.23 meq100 $g^{-1}$ K at 0-20cm topsoil.

The experiment was done in a one-year old fallowed hedgerow plot and laid in a split-split plot design with each treatment combination replicated thrice. It consisted of AMF inoculation ($M^+$) or without inoculation ($M^-$) as the main plots with the hedgerow species: *Gliricidia sepium* (Jacq), *Senna siamea* (Irwin and Barneby*)*, interplanted *G. sepium* and *S. siamea* as well as a treeless control as subplots. Each subplots (12 x12m) consisted of three rows of each hedgerow tree species or their mixtures at 4m interrrow spacing and 0.5m intrarow spacing at a rate of 5,000 treesha$^{-1}$. Each subplot was split into 12x6m experimental units (sub-subplots) for two-and three –monthly pruning treatments.

Cassava (*Manihot esculenta* Crantz*)* cv TMS 4(2)1425, cuttings 0.2m long, were planted on ridges 1x1m apart within each alley at a rate of 7,500 stands ha$^{-1}$ and 10,000 stands ha$^{-1}$ in the treeless control subplots. AMF inoculation was done by placing the cassava cutting on top of 20g crude inoculum consisting of 440-610 spores in 100 g dry soil of *Glomus deserticola* (INVAM, CA 113) in the planting hole while for the trees the inoculum was applied in the bands of hedgerows.

At the beginning of the experiment, all the trees were cut at 50cm above the ground level and fresh prunings equivalent to 0.5 t ha$^{-1}$ dry matter were applied as mulch to their respective subplots. Subsequent pruning and mulching were done at two-and three monthly intervals as designated for each sub-subplot. A basal fertilizer (NPK 25:10:10) dressing of 25kgha$^{-1}$ was applied to the cassava two months after planting.

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**Table 1: Effect of Pruning regime and AMF inoculation on the colonization and tuber yield of cassava.**

| | | AMF Colonization (%) | | Fresh Tuber Yield ($t ha^{-1}$) | |
|---|---|---|---|---|---|
| | | 2mo | 3mo | 2mo | 3mo |
| S. siamea | $M^+$ | 53.3±3.3e | 36.8 ± 1.0gh | 12.3±0.6d | 10.0±0.3f |
| | $M^-$ | 25.0±1.3j | 20.0±1.3j | 5.0±0.7l | 3.0±1.2m |
| G. sepium | $M^+$ | 81.5 ±1.9b | 67.5±4.1c | 20.0±3.8c | 11.0±0.3e |
| | $M^-$ | 33.7 ±3.9h | 39.5±1.9g | 7.5±0.8hi | 6.3±0.7jk |
| Gs+ Ss | $M^+$ | 86.7±2.1a | 77.6 ±5.7b | 33.3±3.2a | 25.5±2.8b |
| | $M^-$ | 59.9±3.3d | 49.0±1.5f | 8.3±1.4gh | 6.8±1.1ij |
| Control | $M^+$ | 60.4±2.0d | | 8.8±0.7g | |
| | $M^-$ | 18.7±2.4j | | 5.7±0.6kl | |

**$M^+$: Inoculated; $M^-$: non-inoculated; 2mo and 3mo: two- and three- monthly pruning regimes (Pr) respectively. * Values are means of three replicates ± se. Means within each parameter followed by different letters are significantly different at $P<0.05$.**

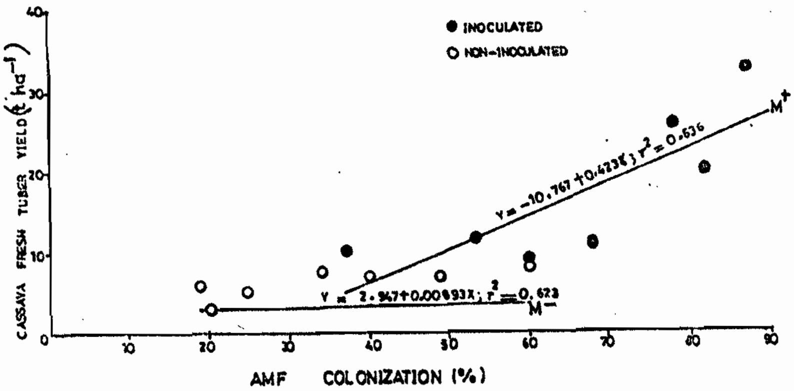


Fig. 1: The relationship between root tuber yield and AMF root colonization in inoculated and non-inoculated cassava. $M^+$: Inoculated; $M^-$: non – inoculated.

Cassava was harvested 12months after planting and fresh weights of tubers were determined. Tuber nutrient yield (N, P, K) was determined using Juo (1979) methods of plants analysis while AMF root colonization was assessed in triplicates for each treatment according to Giovanetti and Mosse (1980) after they have been stained with trypan blue.

All data were subjected to combined analyses of variance. Standard errors were calculated based on variability within experimental units to which treatments were applied. Regression analysis was used to evaluate the relationship between cassava tuber yield and root colonization.

## RESULTS AND DISCUSSION.

Cassava roots were colonized by AMF in all the treatments with roots of inoculated plants having significantly higher percentage than those of non-inoculated ones (Table 1). Colonization was significantly lower in three-monthly pruning regime subplots cassava roots than in two-monthly pruning regime except in non-inoculated *G. sepium* sub-subplots. This generally low percentage of AMF colonization of cassava roots from three monthly pruned hedgerow plots was probably due to shading by the trees. Investigations have shown that the growth of AMF is reduced by a reduction in photon irradiance or shadding (Smith and Gianinazzi- Pearson, 1990; Thompson *et al.*, 1990). It is possible that the shaded cassava in three-monthly pruned hedgerow plots had a lower carbon production which led to a lower AMF colonization compared to those under the two-monthly hedgerow pruning regime.

Inoculation with AMF significantly increased

**Table 2: Effect of pruning regime and AMF inoculation on tuber nutrient yield of cassava.**

| | | N | | P ($kgha^{-1}$) | | K | |
|---|---|---|---|---|---|---|---|
| | | 2mo | 3mo | 2mo | 3mo | 2mo | 3mo |
| S. siamea | $M^+$ | 11.3±0.9gh | 12.6±1.0fg | 3.3±0.3c | 2.2±0.2f | 22.3±1.7d | 14.2±1.3ef |
| | $M^-$ | 5.4±0.7j | 2.9±0.7k | 1.2±0.1i | 0.9±0.2j | 6.8±0.8gh | 4.9±1.3h |
| G. sepium | $M^+$ | 38.7±1.9b | 29.0±1.4d | 5.0±0.2b | 3.0±0.1d | 29.5±1.5c | 20.9±0.5d |
| | $M^-$ | 8.9±0.2i | 9.6±0.1hi | 1.4±0.1hi | 1.8±0.1g | 10.5±0.2fg | 10.4±0.2fg |
| Gs +Ss | $M^+$ | 58.2±4.2a | 35.8±1.7c | 8.1±0.6a | 5.2±0.3b | 114.5±8.2a | 36.2±1.7b |
| | $M^-$ | 15.3±0.8e | 8.6±0.3i | 2.7±0.1e | 1.6±0.1gh | 15.5±0.8e | 10.4±0.3fg |
| Control | $M^+$ | | 14.2±1.1ef | | 1.9±0.1fg | | 11.2±0.9ef |
| | $M^-$ | | 8.2±0.2i | | 1.3±0.2i | | 12.3±1.9ef |

**$M^+$: Inoculated; $M^-$: Non-inoculated; 2mo and 3mo: two-and three-monthly pruning regimes (Pr) respectively. Values are means of three replicates ± se. Means within each parameter followed by different letters are significantly different at P <0.05.**

**Table 3. Interactions between AMF inoculation and pruning of each hedgerow tree species**

| | AMF colonization (%) | Fresh tuber yield ($t\ ha^{-1}$) | NPK ($kg\ ha^{-1}$) | | |
|---|---|---|---|---|---|
| S. siamea (Ss) | | | | | |
| Inoculation (M) | *** | *** | *** | *** | *** |
| M x Pruning (Pr) | *** | *** | *** | *** | *** |
| G . sepium (Gs) | | | | | |
| Inoculation (M) | *** | *** | *** | *** | *** |
| M x Pruning (Pr) | *** | *** | *** | *** | *** |
| Gs + Ss | | | | | |
| Inoculation (M) | *** | *** | *** | *** | *** |
| M x Pruning (Pr) | *** | *** | *** | *** | *** |

*** values significantly different at P<0.001

cassava tuber yield in all the hedgerow and pruning treatments (Table 1). This can be attributed to improved nutrient (Table 2) and water uptake due to increased colonization (Smith and Read, 1997; Nielsen *et al.*, 1998) as well as efficient maintenance of nutrient reserve in organic matter in the soil aggregate by the AMF hyphae and improved root system (Miller and Jastrow, 1992). One of the implications of AMF inoculation in alley cropping system is to optimize the use of mineralized nutrients from the prunings (Osonubi *et al.*, 1995). Inoculation with G. *deserticola* thus complemented the indigenous AMF population in improving cassava tuber yields. This is supported by the significant positive relationships between cassava tuber yield and AMF root colonization (Fig. 1).

Pruning the hedgerow trees at two-monthly intervals significantly increased the tuber yield compared to those in three-monthly pruned hedgerow sub-subplots (Table 1). This can be explained as follows: (a) Two-monthly pruning regime of the hedgerows reduced shading on the cassava thereby allowing adequate sunlight for photosynthesis, (b) frequent addition of prunings to the soil surface kept it almost continuously covered and supplied with nutrients while suppressing weeds as well as providing a conducive condition for increased AMF colonization of roots (Table 2) and (c) frequent pruning increased soil nutrients through the dying back of fine roots of each pruning (Haggar and Beer, 1993).

Alley-cropping cassava with *G. sepium* and mixture of *G. sepium* and *S. siamea* consistently gave higher tuber yield than those alley cropped with *S. siamea* alone (Table 1) The low tuber yield in *S. siamea* alleys must have been caused by competition for nutrients from the same soil depth (Ruhigwa *et al.*, 1992) or the usual initial immobilization of nitrogen by *S. siamea* mulch (Tian et al 1992). The significantly higher tuber yield in the mixture of *G. sepium* and *S. siamea* plots than the former alone was probably due to a slowed decomposition and gradual nutrient release from the mulch mixture which Vinod and Nair (1992), reported to be of positive effect on the growth and yield of cassava.

There were significant interactions between AMF inoculation and all other factors (Table 3) indicating that mycorrhizal symbiosis was more beneficial to cassava growth with these agronomic practices than their absence. Our data have demonstrated that the potential of alley cropping technology to increase cassava production can be improved by AMF inoculation. However, the best tuber yield can be obtained with a mixture of hedgerow tree species possessing leaves of different decomposition rates and a pruning regime which disallows shading on the cassava. Alley cropping of cassava with *G. sepium* and *S. siamea* mixed hedgerows and two-monthly pruning regime should therefore be preferred for greater cassava tuber yield to resource poor farmers in this type of tropical soil.

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