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Varietal response of Bambara groundnut (*Vigna subterranea*) to mulching and AMF inoculation in Central Nigeria

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ABSTRACT

A trial was carried out in pots at the University of Abuja, Teaching and Research Farm (TRF) to evaluate the response of Bambara groundnut varieties (TVSu 460, TVSu 617, TVSU 622) to mulch and mycorrhizal inoculation. Arbuscular mycorrhizal fungal inoculum (*Glomus mosseae*) and leguminous mulch (*Calopogonium mucunoides* Desv) were respectively applied at 10 g and 100 g per pot, 2 weeks after planting. The experiment was laid out in a factorial combination in a completely randomized design with 3 replications. Plant biomass and nodulation were assessed at harvest and subjected to analysis of variance using statistical package Genstat Discovery Edition. The study revealed that combined application of mulch and *G. mosseae* increased the fresh root weight for all varieties ranging from 10.3 - 62.5 %. *G. mosseae* inoculation significantly increased the nodulation and root weight of TVSu 617 and TVSu 622 but TVSu 460 was not favored by inoculation. The enhanced shoot and root weight recorded under mulch and mycorrhizae treatments on Bambara groundnut varieties particularly could be as a result of an improved soil environment occasioned by these treatments.

Indexing terms/Keywords

Vigna subterranea, AMF inoculation, mulching, *Glomus mosseae*, *Calopogonium mucunoides*.

Academic Discipline And Sub-Disciplines

Soil science, Soil Microbiology, Soil fertility management.

SUBJECT CLASSIFICATION

Organic farming

TYPE (METHOD/APPROACH)

Research article

INTRODUCTION

The intensification of agriculture through dependence on inorganic fertilizers are considered as a means of solving current soil fertility issues *vis-à-vis* of the increasing rural population pressure on available arable land in sub-Saharan Africa (Santos *et al* 2012).

Food security attainment in sub Saharan African is however not feasible with commercial fertilizers because it remains out of reach of most small-scale farmers. Besides the high cost of commercial fertilizer, it has adverse effect on the entire soil system (Youssef and Eissa, 2014). Affordable soil nutrient sources such as farm-derived biological materials inform organic mulches like grasses or leguminous mulch together with the use of mycorrhizal inoculants as biofertilizers may be a better alternative in solving soil fertility problems. These materials, besides increasing soil nutrient statues with no adverse effects on the ecosystem, it enhances water holding capacity as well as the biodiversity of the soil (Yao *et al*., 2005; Megali *et al*, 2014).

Bambara groundnut (*Vigna subterranea*), an under-utilized crop of Fabaceae family, is an important grain legume in West Africa, with high socio-cultural roles (Bamshaiye et al., 2011). Its agronomic traits includes high nutritional and yield potential, drought tolerance and adaptations to marginal soils, and soil fertility improvement (Collinson *et al*., 1996, Berchie *et al*., 2010; Mohale *et al*., 2014). Through atmospheric nitrogen fixation, it could improve soil nitrogen supply which is of benefit to other crops (Mukurumbira, 1985; Mohale et al., 2014). Consequently, soil fertility improvement as well sustainable agriculture could be promoted if leguminous crops such as Bambara groundnut are cultivated using eco-friendly practices such as organic mulching and/or inoculation with biofertilizer like AMF inoculant in the field (Makoto and Yoshida, 1994, Nyemba and Dakora 2010; Ngakou *et al* 2012). Therefore, the use of soil amendment such as mulching and arbuscular mycorrhizal fungi (AMF) could satisfy its host plant nutrient requirements, thus resulting in sustainable yield improvement of valuable crops, so as to substitute inorganic fertilizer input. This study was set up to evaluate the effects of mycorrhizal inoculation and leguminous mulch on the growth and biomass yield of Bambara groundnut.

1 MATERIALS AND METHODS

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1.1 Experimental Site Description

The study was carried out at the Teaching and Research Farm (TRF) of the University of Abuja which lies between latitude 8°51′ and 9° 37'N and longitude of 7°20′ and 7°51′E with a moderate rainfall and a temperature of 28-32 °C. Soil used was of clay loam textural class, with slightly acidic pH of 6.3, moderately available P (15 mg/kg), low total N (0.03g/kg) and low in exchangeable cations.

1.2 Collection and Preparation of Samples

A pot study was carried out on soil collected randomly at a depth of 0-15 cm within the farm. From the composite sample, a representative sub-samples was taken to ascertain the soil physico-chemical properties such as pH, particle size, exchangeable cations, phosphorus and exchangeable acid. Soil sample was sieved through a mesh size of 2 mm and thereafter, 36 pots were filled with soil of 5 kg each.

1.3 Experimental Design and Treatments

The treatments were 3 varieties of Bambara groundnut (TVSu 460, TVSu 617 and TVSU 622), mycorrhizal inoculation (with and without inoculum) and mulch (mulched and unmulched) treatments. Bambara groundnut varieties were collected from the IITA, Ibadan gene bank. Planting was done at 2 seeds per pot at 2 cm depth and later thinned to 1 at 2 weeks after planting (WAP). Mycorrhizal inoculum (*Glomus mosseae*) collected from the Department of Agronomy; University of Ibadan was applied at 10 g per pot. Leguminous mulch materials were air dried *Calopogonium mucunoides* shoots gathered from the TRF, University of Abuja and was applied at 100 g per pot. All treatments were applied at 2 WAP. The factorial treatment combinations were laid out in a completely randomized design (CRD) and replicated three times. Weeding was done regularly by hand pulling during the period of the experiment, which lasted for 9 weeks.

1.4 Data Collection and Analysis

Plant shoots were cut at the base prior to emptying each pot unto a 2 mm mesh sieve. Nodules were detached from the root, filled in to glass vials and counted. Harvested roots were carefully washed with water. Fresh shoot, root and nodule weight were recorded and thereafter oven dried at 80 °C to a constant weight and their dry weight recorded. All data were subjected to analysis of variance (ANOVA) using Genstat Discovery. Means were separated using Duncan multiple range test at P < 0.05.

2 RESULTS

2.1 Effects of AMF inoculation and mulching on the nodulation, shoot and root yield Bambara groundnut varieties

The main effect of Bambara groundnut variety unlike mulch and mycorrhizal inoculation treatments; did not significantly influence plant shoot weight. However, a highly significant ($p \leq 0.001$) varietal effect was observed on nodulation. Mycorrhizal treatment varied significantly ($p \leq 0.05$) with variety across the measured parameters while mulch by variety interaction influenced fresh shoot weight and nodulation (Table 1).

Table 1: Summary of the analysis of variance (mean squares) for the three varieties of Bambara groundnut

Source of Variation	DF	Shoot weight		Root weight		Nodules	
		Fresh	Dry	Fresh	Dry	number	Weight
Variety (V)	2	15.1ns	3.6ns	2.9**	0.01ns	2235.3***	1.15***
AMF (M)	1	290.1***	32.3***	1.9*	0.09*	277.8*	0.08ns
Mulch (LM)	1	361.0***	21.3***	20.6***	0.09*	4138.9***	1.8***
V*M	2	97.8**	16.6***	5.1***	0.14**	1323.8***	0.36**
V*LM	2	19.5ns	0.7ns	3.20***	0.01^{ns}	254.5*	0.52**
M*LM	1	240.3***	13.1**	0.01^{ns}	0.02^{ns}	4400.1***	0.12ns
V*M*LM	2	79.1**	1.5ns	3.1***	0.06^{ns}	854.9***	0.10ns

*, **, and ***represents significant at p ≤ 0.05, 0.01, 0.001 ns' not significant at p = 0.05

TVSu 460 recorded a significant highest nodulation while TVSu 622 maintained a low root fresh weight and nodulation variables. AMF inoculation and mulching significantly affected the measured parameters. The main effects of *G. mosseae* inoculation favored fresh root weight but not shoot biomass and had no effect on Bambara groundnut nodulation. Mulching had a negative significant effect on Bambara groundnut nodulation, it however increased shoot and root weights (Table 2).

Tables 2: Effect of AMF inoculation and mulching on biomass and nodulation of Bambara groundnut varieties.

Treatments	Shoot weight (g)		Root weight		Nodules	
	Fresh	Dry	Fresh	Dry	Weight (g)	Number
Varieties						
TVSu 460	15.15a	4.7a	2.71a	0.4a	0.74a	47.4a
TVSu 617	12.96a	3.7a	3.18a	0.5a	0.39b	39.6b
TVSu 622	14.46a	3.8a	2.20b	0.4a	0.13c	20.8c
AMF Inoculation						
Inoculated	11.35b	3.1b	2.9a	0.4b	0.37a	38.70a
Non-inoculated	17.03a	5.0a	2.47b	0.5a	0.46a	33.20a
Mulch						
Mulched	17.36a	4.8a	3.45a	0.5a	0.19b	25.20b
No mulch	11.02b	3.3b	1.94b	0.4b	0.64a	46.70a

Means with the same letter for each parameter within each treatment are not significantly different p≤ 0.05.

2.2 Assessment of the interaction between varieties, AMF inoculation and mulches on the root weight and nodulation of Bambara groundnut

Mulching significantly increased the fresh root weight for all varieties ranging from 10.3- 62.5% but did not favor nodulation (Table 3). *Glomus mosseae* inoculation significantly increased the nodulation and root weight of TVSu 617 and TVSu 622 while TVSu 460 was not favored by inoculation.

Table 3: Interactive effects of mulch and mycorrhizal inoculation on root weight and nodulation of Bambara groundnut.

Variety	Treatment	No. of nodules	Nodule weight	Fresh root weight
Mulch				
TVSu 460	mulched	32.0b	0.3b	2.9a
	no mulch	62.7a	1.2a	2.6b
TVSu 617	mulched	29.0b	0.2b	4.3a
	no mulch	50.2a	0.6a	2.1b
TVSu 622	mulched	14.7a	0.1b	3.2a
	no mulch	27.0b	0.2a	1.2b
AMF Inoculation				
TVSu 460	Inoculated	39.5b	0.5b	2.2b
	Uninoculated	55.2a	0.9a	3.2a
TVSu 617	Inoculated	52.8a	0.5a	3.7a
	Uninoculated	26.5b	0.3b	2.7b
TVSu 622	Inoculated	23.9a	0.1a	2.9a
	Uninoculated	17.8b	0.1a	1.5b

Means with the same letter column wise within Bambara groundnut variety for are not significantly different p≤ 0.05.

Figure 1 shows interaction effects of mycorrhizal inoculation and mulching on the fresh root weight of the 3 varieties. Mulch effect on the fresh root weight of TVSu 460, was not influenced by mycorrhizal inoculation. However, in TVSu 617 and TVSu 622, mulch and mycorrhiza interaction effect on fresh root weight was positive. There was a meaningful synergistic effect of mulching x AMF inoculation on the root fresh weight of TVSu 622. The root fresh weight of TVSu 622 increased with *G. mosses* inoculation and mulch application. Root Fresh weight under inoculated and mulched treatment increased by 66% and 53.5% over inoculated with no-mulch and uninoculated mulched treatments respectively.

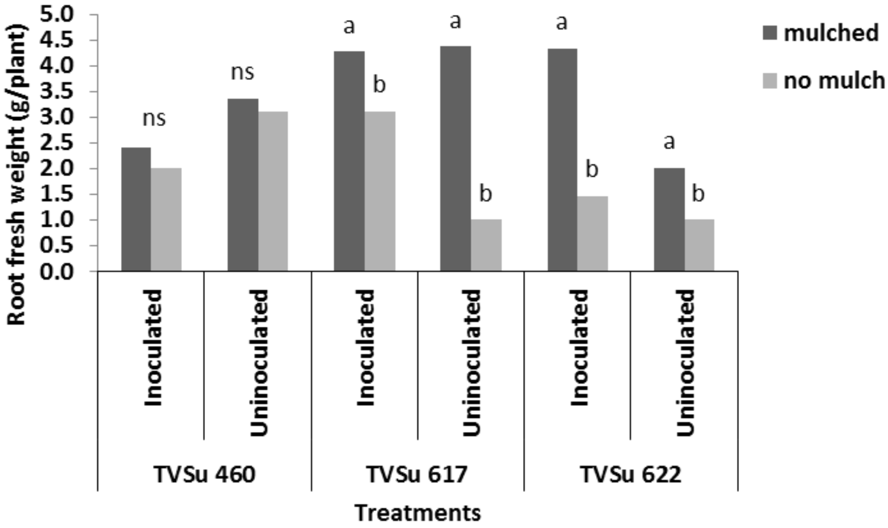

Fig 1: Effect of muching and mycorrhizal inoculation on the root weight of Bambara groundnut varieties

(Bars with the same letter within Bambara groundnut variety and AMF inoculation are not significantly different p ≤ 0.01).

The interaction between Bambara groundnut varieties, AMF inoculation and mulching had significant effect on fresh shoot biomass (Table 1). TVSu 460 was not significantly influenced by the combined effect of mulch and AMF inoculation (Figure 2). Combined application of mulch and AMF inoculum was not favorable to TVSu 617; while significantly lower shoot biomass was recorded under inoculated and mulched treatment; shoot biomass under mulched but without inoculation was significantly high compared to no mulch uninoculated treatment. Variety TVSu 622 showed a substantial increase in shoot weight both with mulched inoculated and uninoculated treatments.

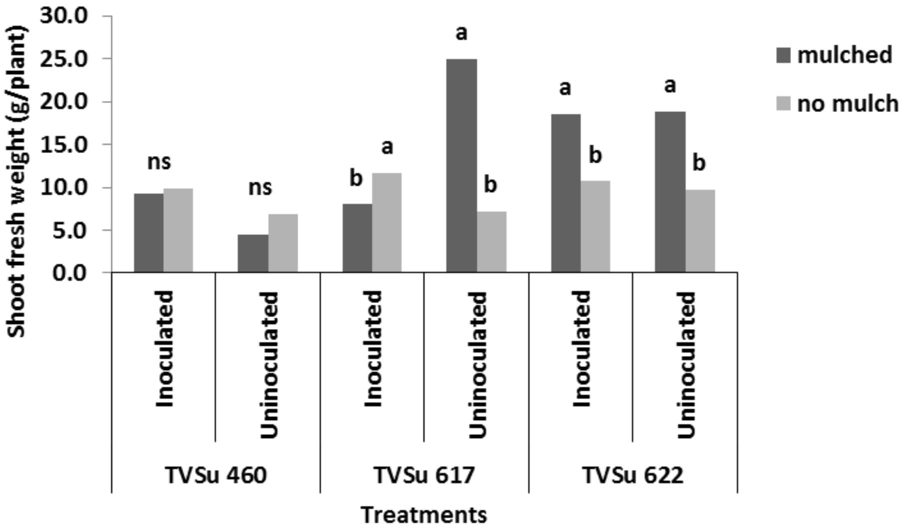

Fig 2: Effect of muching and mycorrizal inoculation on the shoot weight of Bambara groundnut varieties (Bars with the same letter within bambara groundnut variety and AMF inoculation are not significantly different p = 0.01).

3 DISCUSSION

In this experiment, significant varietal effects were observed on the fresh shoot weight and nodulation variables between the 3 Bambara groundnut varieties tested. This could be due to their genetic resources. In fact, Amadou et al (2001) had earlier observed a high genetic diversity among African Bambara groundnut accessions which could be related to geographic origin. This was later confirmed by the studies of Olukolu et al (2012) in which a high genetic divergence were observed among accessions from Nigeria and Cameroon in Africa.

The interaction effect between AMF inoculation and Bambara groundnut variety significantly positively influenced the nodulation and root weight of TVSu 617 and TVSu 622. . TVSu 460 variety was however not favored by mycorrhizal inoculation. Increased nodulation among varieties TVSu 617 and TVSu 622 under inoculation could be due to the symbiotic compatibility between the used AMF species - *Glomus mosseae* - and these varieties. Earlier studies have recorded selective AMF symbiosis among crop varieties (Krishna et al, 1985; Hetrick *et al*, 1992, An *et al.*, 2010). This symbiosis with AMF increase P uptake providing more energy for nodulation of these varieties. Smith and Read (1997) attributed the increase in plant shoot and root biomass of AMF inoculated plants over uninoculated to increased nutrient uptake through extraradial mycelium hypha. As these hypha helps in extension of plant root hairs, absorptive surface area increases for better utilization of soluble nutrients and water. Previously, Rilling (2004) and Yao et al. (2005) in their studies have linked these positive effects of AMF inoculation on crop growth and yield to enhanced photosynthesis, host plant hormones, and soil physical properties.

Use of *Calopogonium mucunoides* as mulch resulted in significant increase of 10.3 - 62.5 % in fresh root weight across the 3 varieties. The observed increase in plant root biomass resulting from organic mulch could be associated with the increased soil organic matter and its moisture conservation effects in the rhizosphere which in turn enhances root activities and a range of microbial diversity **(**Berg and Smalla 2009; Megali et al., 2014).

Varietal differences were observed with the combination of mulch and *G. mosseae* on root and shoot fresh weigh. TVSu 460 was not significantly influenced by the treatment combination. TVSu 617 was as well not favored by mulch and AMF combination. A positive synergistic effect was however observed with TVSu 622. The combination of mulch and *G. mosses* inoculation increased the root weight of TVSu 622 by 66 % and 53.5 % over the inoculated with no-mulch applied treatment and the uninoculated but mulched treatments respectively. Mulch and AMF combination may not always have immediate favorable effects on growth and yield of some crop varieties, could be useful to other crops in succession. The beneficial effect of combined application of mulch and mycorrhizae on soil environment cannot be ignored. Their joint application may not always directly enhance the growth and development of crop yield, but could be of benefit to subsequent crop.

CONCLUSION

Appropriate soil management practices such as combination of organic resources like leguminous mulch materials and biofertilizer introduction (mycorrhizae) among small holder farms in SSA could be indeed a cheap and sustainable path towards solving food insecurity problems. Among the studies varieties, TVSu 616 and 622 responded positively to mulch and AMF inoculation.

REFERENCES

1. Amadou, H.I., Bebeli P.J., and Kaltsikes P.J. 2001. Genetic diversity in Bambara groundnut (*Vigna subterranea* L.) germplasm revealed by RAPD markers. *Genome* 44, 995-999.
2. An, G.H., Kobayashi, S., Enoki, H., Sonobe, K., Muraki, M. and Karasawa, T. 2010. How does arbuscular mycorrhizal colonization vary with host genotype? An example based on maize (*Zea mays*) germplasms. *Plant Soil* 327, 441–453.
3. Bamshaiye, O.M., Adegbol, J.A. and Bamishaiye, E.I. 2011. Bambara groundnut: an Under-Utilized Nut in Africa. *Advances in Agricultural Biotechnology* 1, 60-72.
4. Berchie, J.N., Sarkodie, A.J., Adu-Dapaah, H., Agyemang, A., Addy,S., Asare, E., and Donkor, J. (2010). Yield evaluation of three early maturing Bambara groundnut (*Vigna subterranea* L. Verdc) land races at CSIR-Crops Research Institute-Kumasi, Ghana. *Journal Agron*., 9, 175–179.
5. Berg, G. and Smalla, K. 2009. Plant species and soil type cooperatively shape the structure and function of microbial communities in the rhizosphere. *FEMS Microbiology Ecology* 68, 1–13.
6. Collinson, S.T., Azam-Ali, S.N., Chavula, K.M., and Hodson, D.A. 1996. Growth, development and yield of bambara groundnut (*Vigna subterranean*) in response to soil moisture. *Journal of Agric. science* 126, 307-318.
7. Hetrick, B.A.D., Wilson, G.W.T. and Cox, T.S. 1992. Mycorrhizal dependence of morden wheat cultivars, and ancestors. *Canadian Journal of Botany* 70, 2032 - 2040.
8. Krishna, K.R., Shetty, K.G., Dart, P.J. and Andrews, D.J. 1985. Genotype dependent variation in mycorrhizal colonization and response to inoculation of pearl millet. *Plant Soil* 86,113-125
9. Olukolu, B.A., Mayes, S., Stadler, F, Ng, Q.N., Fawole, I., Dominique, D., AzamAli, S.N., Abott, G.A., Kole, C. 2012. Genetic diversity in bambara ground (*Vigna subterranean* (L) Verdc.) as revealed by phenotypic descriptors and DArT marker analysis. *Genetic Resources and Crop Evolution* 59, 347-358.
10. Rilling, M.C. 2004. Arbuscular mycorrhizae, glomalin and soil aggregatiom. *Canadian Journal of Soil Science* 84, 335 - 363.

11. Santos, V.B., Araujo, S.F., Leite, L.F., Nunes, L.A. and Melo, J.W. 2012. Soil microbial biomass and organic matter fractions during transition from conventional to organic farming systems. *Geoderma* 170, 227–23

12. Smith, S. and Read, D.J. 1997. Mineral Nutrition, Heavy Metal Accumulation and Water Relation of VA Mycorrhizal Plants, 3rd Edn. Academic Press, New York. P. 160.

13. Makoto K. and Yoshida, S. 1994. Mulching effect of plant residues on soybean growth and soil chemical properties. Soil Science and Plant Nutrition, 40:2, 211-220

14. Mukurumbira, L.M. 1985. Effects of rate of fertilizer Nitrogen and previous grain legume crop on maize yields. *Zimbabwe Agric Journal* 82, 177- 179

15. Megali, L. Glauser, G. and Rasmann, S. 2014. Fertilization with beneficial microorganisms decreases tomato defenses against insect pests. *Agronomy for Sustainable Development* 34 (3), 649-656

16. Mohale. K.C., Belane, A.K. and Dakora, F.D. 2014. Symbiotic N nutrition , C assimilation and plant water use efficiency in bambara groundnut (*Vigna subterranea* L. Verdc) grown in farmers field in South Africa, measured using 15N and 13C natural abundance. *Biology and fertility of Soils* 50, 307-319.

17. Ngakou A, Ngo Nkot L, Doloum, G, Adamou, S. 2012. Mycorrhiza-*Rhizobium*-*Vigna subterranea* dual symbiosis: impact of microbial symbionts for growth and sustainable yield improvement. Int. J. Agric. & biol. 14 (6): 915-921.

18. Nyemba R.C. and Dakora, F.D. 2010. Evaluating N_2 fixation by food grain legumes in farmers' fields in the three agro-ecological zones of Zambia, using ^{15}N natural abundance. Biol. Fertil. Soils 46:461-470.

19. Yao, Q., Zhu, H.H. and Chen, J.Z. 2005. Growth responses and endogenous IAA and iPAS changes of Litchi (Litchi chinensis Sonn.) seedlings induced by arbuscular mycorrhizal fungal inoculation. *Scientia Horticulturae* 105,145-151.

20. Youssef, M.M.A. and Eissa, M.F.M. 2014. Biofertilizers and their role in management of plant parasitic nematodes. A review. *Journal of Biotechnology* and *Pharmaceutical Research* 5, 1–6.

Author' biography with Photo

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