COMPARISON OF SOIL FERTILITY IMPROVEMENT ABILITY OF *VOANDZEIA SUBTERRANEA* AND *ARACHIS HYPOGEA*

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ABSTRACT

An experiment was conducted in the Department of Range and Wildlife Management, Faculty of Renewable Resources, University of Development Studies, Nyankpala Campus, Tamale, Ghana during 2013 to determine the soil fertility improvement potentials of *Voandzeia subterranea* and *Arachis hypogea*. Three soil samples were taken from two plots grown under *V. subterranea* and *A. hypogea* at flowering stage and after incorporation plant material using grid method. The soil samples were then analyzed for some selected nutrients in the laboratory using standard methods. The results showed that mean values of samples taken after incorporation plant material were significantly higher (P<0.05) than those collected at flowering stage for *A. hypogea* with regards to nitrogen (31.6%), potassium (20.47 mg/kg), organic carbon (8.6%) and pH levels (7.0). However, other nutrients i.e. magnesium (0.57 mg/kg), calcium (1.43 mg/kg) and phosphorus (5.35 mg/kg) were not improved significantly. Also mean values of soil samples recorded after incorporation were significantly higher (P<0.05) than at flowering stage for *V. subterranea* with regards to nitrogen (30.53%), potassium (21.73 mg/kg), organic carbon (9.67%) and pH levels (7.22), but magnesium (0.5 mg/kg), calcium (1.40 mg/kg) and phosphorus (3.07 mg/kg) were not improved significantly. It is recommended that any of these two legumes can be incorporated into the soil to improve soil fertility of rangelands for pasture growth ensuring nutritious and sustainable feed for animals.

KEYWORDS: ***Voandzeia subterranea; Arachis hypogea;*** **soil fertility; nutrients; phosphorus; organic matter; calcium, magnesium; Ghana.**

INTRODUCTION

Replenishing lost nutrients in farmlands has become very critical and important. It is a known fact that legumes add nutrients to the soil and benefits man in protection of top soil especially when grown during the fallow

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period, mostly during dry season. This serves as cover crop as it uses its spreading ability to cover the soil and prevent direct raindrops onto the soil. Some farmers resort to the use of chemical fertilizers to improve production ever growing demand of farm produce. However, these chemicals have long term negative effects on crops produced, fertility of soil, surrounding rangelands and environment as a whole.

Vast areas of tropical lands that were once fertile, have been rendered unproductive due to continuous cultivation and erosion which causes physical degradation, loss of soils organic matter and decreased cation exchange capacity (CEC) as well as increased aluminium (Al) and magnese (Mn) toxicity. As soils continue to suffer from multi-nutrient deficiencies, application of mineral fertilizers has become mandatory to increase crop yields. However, mineral fertilizers are commonly scarce, costly, have imbalanced nutrition and their use could exacerbate the problem of soil acidity (13, 14). The problem is worsened by the continuous removal of government subsidies on fertilizers and poor distribution systems. This is why Aduayi (1) and Agbim and Adeoye (2) recommended the use of crop residue and other organic wastes as supplements to inorganic fertilizers to improve or maintain soil fertility.

Many farmlands have been rendered infertile or uncultivable by bad farming practices such as continuous cropping, improper fertilizer application and burning residue of crops. Also high cost of fertilizers increases the cost of production which leads to increased prices of produce. Therefore, there is need to search for an alternative to replenish lost nutrients after farming. The integration of leguminous cover crops into the existing farming systems has been very successful for this purpose because of high agronomic benefits achieved from the use of these legumes (12). Organic fertilization using legumes potential to replace and even improve farmlands but there is no clear indication as to which of these two legumes (*V. subterranean* and *A. hypogea)*, improves the soil best.

The objective of this study is to investigate the potentials of *Voandzeia subterranean* and *Arachis hypogea* for improving soil fertility in terms of nitrogen (N), phosphorus (P), potassium (K), soil pH, organic carbon, magnesium (Mg) and calcium (Ca) contents.

MATERIALS AND METHODS

This study was conducted in the Department of Range and Wildlife Management, Faculty of Renewable Resources, University of Development

Studies, Nyankpala Campus, Tamale, Ghana from March to June 2013. Nyankpala lies within the Guinea Savannah Agro-ecological zone. It is 16 km from Tamale. This area lies within latitude 09˚-25' north and longitude 00˚-55' west and altitude of 183 m above sea level. The area experiences single rainfall season in a year. The rains start from May and ends in October. Mean annual rainfall is 104.3 mm with mean day time RH of 54%. Temperatures generally fluctuate between 15˚ to 45˚C with an average temperature of 28˚C. Generally the area is characterized by large areas of grassland interspersed with few economic trees such as Shea (*Vitellaria paradoxa*) and Dawadawa (*Parkia biglobosa*) (3). Basically soils of this area are of sandy loam type, except in low lands where alluvial deposits are found.

The grid method was used by laying two plots of 15m x 20m as sampling field for the experiment. The first plot was cultivated with *Voandzeia subterranea* and the second plot with *Arachis hypogea*. On each plot, three garden lines with 10m length were laid along the plot parallel to each other. The garden lines were supported by pegs and distance between them was 5m. Garden lines were also laid across to meet the first lines previously laid with similar intervals. The garden lines formed four perfect squares. In each plot, four squares were obtained and this process was repeated on the other plot. Soil samples were taken from nine points which were later put into a composite sample of three. Thus, three samples from each plot. Soil samples were taken at flowering stage of plant growth and were repeated after four weeks of incorporation of plant material.

Soil analysis: The soil samples collected from the field were air-dried in a well ventilated area and analysed using standard methods. Soil pH was determined using pH meter and nitrogen was determined using Kjeldahl method (4, 10). The organic carbon (CO) content of soil was determined using Walkley and Black method (17). Phosphorous content of soil was determined by Bray 1 method (10). The concentration of potassium in the soil extract was determined using flame photometer.

For determining the levels of calcium, 10ml aliquot of sample solution was extracted and filtered. 10ml of 10% KOH solution and 1ml of 30 percent triethanolamine was also added. Three drops of 10% KCN solution and a few crystals of Cal-red indicator were also added to the solution. The solution was shaken vigorously for uniform mixture. The mixture was then titrated with 0.02 N EDTA solutions from a red to blue end point.

Finally for determining calcium (Ca) and magnesium (Mg) content, 10ml aliquot of same sample solution was obtained in a 100ml conical flask and

5ml of ammonium chloride-ammonium hydroxide buffer solution and 1ml of triethanol amine were added to the solution. Three drops of 10% KCN solution and a few drops of EBT indicator solution were also added. The solution was shaken vigorously for uniform mixture. The mixture was titrated with 0.02 N EDTA solutions from a red to blue endpoint.

Data analysis: The data collected from the experiment were analyzed using Genstat software where the data was subjected to single paired t-test.

RESULTS AND DISCUSSION

Contribution of *V. subterranea* and *A. hypogea* to soil nitrogen

The level of nitrogen added to the soil by *V. subterranea* and *A. hypogea* was significantly higher ($P<0.05$) after incorporation than flowering stages (Fig. 1). However, level of nitrogen added to the soil by *A. hypogea* and *V. subterranea* plots did not differ significantly ($P>0.05$) at both stages. The higher level of mean nitrogen value after incorporation stage in both legumes may be attributed to the fact that nitrogen in whole plant was added to the soil. Thiessen-Martens *et al.* (16) also reported that leguminous plants add higher level of nitrogen when incorporated into the soil because of high rate of biomass decomposition and subsequent mineralization of biomass. The marginal nitrogen increase between legumes can be attributed to varied crop responses to climate and biological processes. These findings agree to those of Cline and Silvernail (8), Balkcom and Reeves (6) who reported that nitrogen accumulation is highly variable when factors such as environmental conditions, legume selection and crop management are considered.

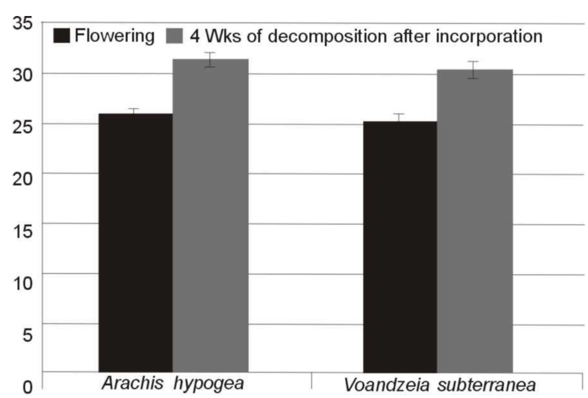

Fig. 1. Effect of *V. subterranea* and *A. hypogea* on soil nitrogen.

Contribution of *V. subterranea* and *A. hypogea* to soil potassium

The level of potassium added to the soil by *V. subterranea* and *A. hypogea* were significantly higher (P<0.05) at incorporation stage than at flowering stage (Fig.2). Although, level of potassium added to the soil by *A. hypogea* and *V. subterranea* was not significantly different (P>0.05) at both stages. The higher potassium level after incorporation may be due to high level of mineralization resulting from plant matter decomposition which is facilitated by microbial activities and release of potassium. This confirms the work of Feichtinger *et al.* (9).

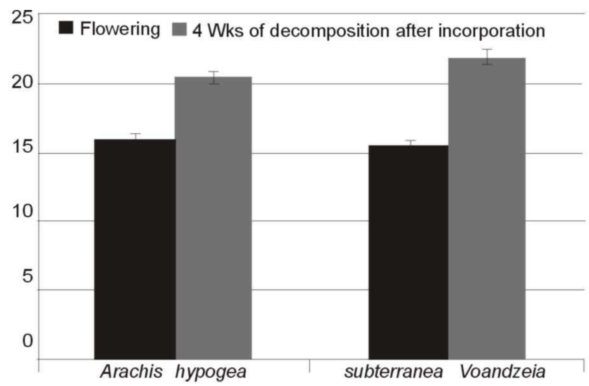

Fig. 2. Contribution of *V. subterranea* and *A. hypogea* to soil potassium.

Contribution of *V. subterranea* and *A. hypogea* to soil OC

The data revealed significant differences (P<0.05) between the stages in case of both legumes (Fig. 3). There were, however, no significant differences (P>0.05) between levels of organic carbon (OC) added to the soil during flowering stage or after incorporation stage by both *V. subterranea* and *A. hypogea*. The increase in mean values of OC by both legumes could be attributed to the fact that they developed an organic layer above the mineral soil and this layer generally improved physical soil conditions and biological activities in the soil. Similar results have also been reported by Juo *et al.* (11).

Contribution of *V. subterranea* and *A. hypogea* to soil pH

The data showed no significant difference (P>0.05) in soil pH level between the plots of *V. subterranea* and *A. hypogea*. Meanwhile significant difference (P<0.05) existed between stages for both legumes. The increase in mean pH level may be due to plant biomass incorporated into the soil at incorporation stage which converted organic element into inorganic form resulting into subsequent increase in pH. Shoko and Tagwira (15) also reported that legumes have the potential to improve soil pH and availability of organic matter exchangeable bases.

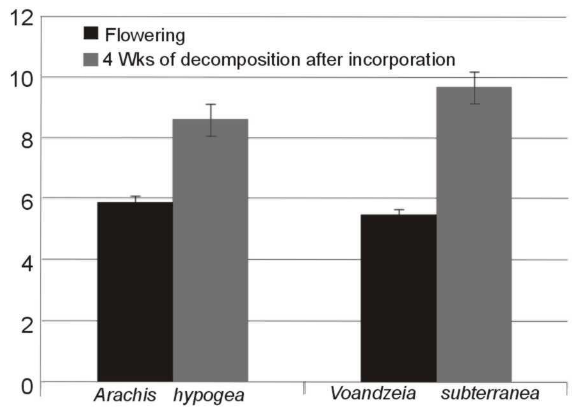

Fig. 3. Contribution of V. subterranea and *A. hypogea* to soil organic carbon.

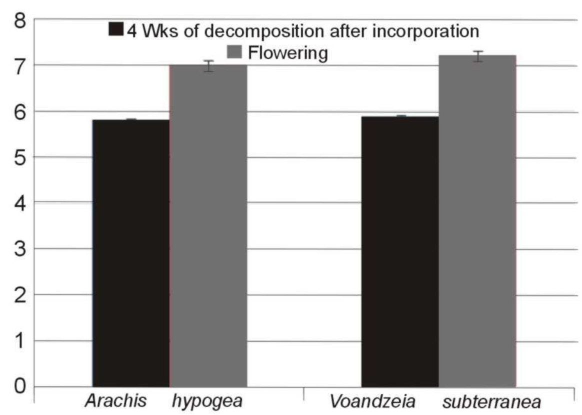

Fig. 4. Comparing the Contribution of *V. subterranea* and *A. hypogea* to soil pH.

Contribution of *V. subterranea* and *A. hypogea* to soil magnesium

The level of magnesium added to the soil by *A. hypogea* was significantly higher (P<0.05) at incorporation stage than that of flowering stage (Fig.5). However, there was no significant difference (P < 0.05) in Mg level added to the soil by *V. subterranea* between the stages, even though there appear to be a slight change in the level of Mg from the flowering to that of after incorporation. The equal weather and other environmental factors can determine development of legume subsequently affecting nutrient release into soil. This could be the reason that Mg mean value after incorporation was not significantly different (P<0.05) than flowering stage. Weischt and Claviecles, (18) also observed that some nutrients released by legumes were significantly different from same legumes which were given the same treatment.

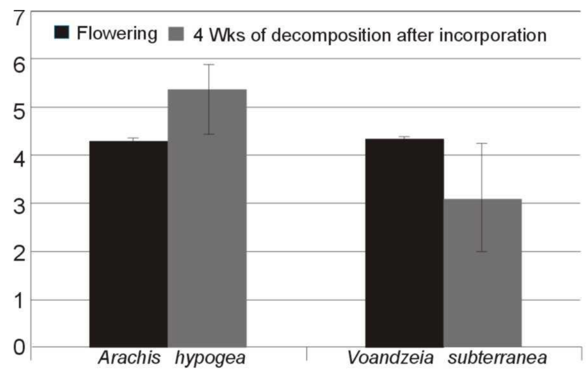

Fig. 6. Contribution of *V. subterranea* and *A. hypogea* to soil phosphorus.

Contribution of *V. subterranea* and *A. hypogea* to soil phosphorus

There were no significant difference (P<0.05) between the plots of *V. subterranea* and *A. hypogea* at flowering and after incorporation stages (Fig.6). However there was no significant difference (P>0.05) in soil P between *V. subterranea* and *A. hypogea* at flowering and after incorporation stages. This may be due to the fact that both crops contributed less P to the soil and amount of P recorded in both plots could have come from the soil, hence the insignificant values. It may also be attributed low pH level in the soil (7). There was no significant difference in soil P added by both these legumes at flowering stage (P<0.05). However, *A hypogeal* added significantly higher P than *V. subterranean* at incorporation stage (Fig. 6).

Contribution of *V. subterranea* and *A. hypogea* to soil calcium

There was no significant difference (P>0.05) in soil calcium between *V. subterranea* and *A. hypogea* at both flowering and after incorporation stages (Fig.7). Also, non-significant difference (P>0.05) was recorded in the level of Ca between flowering and after incorporation stages of *A. hypogea and V. subterranea*. This may be attributed to the low pH value recorded in both plots, resulted in the poor release of Ca in the soil. This is in line with the results reported by Badawia *et al.* (5) also reported similar results.

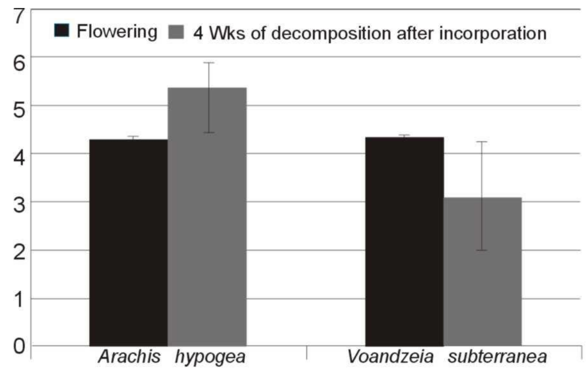

Fig. 6. Contribution of *V. subterranea* and *A. hypogea* to soil phosphorus.

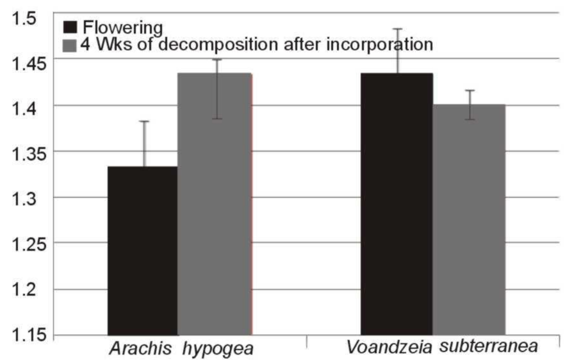

Fig. 7. Contribution of *V. subterranea* and *A. hypogea* to soil calcium.

CONCLUSION

Voandzeia subterranea and *Arachis hypogea* have the potential to improve soil fertility by improving pH level and nutrients such as nitrogen, potassium and organic carbon, at the incorporation stage than flowering stage. Therefore, any of these legumes may be used to replenish lost soil fertility or maintain soil fertility. Based on the results, it is recommended that pasture growers as well as crop farmers should use any of these legumes to improve the fertility of rangelands for pasture and feed crop growth.

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