

Nodulation and Nitrogen Fixation by Landrace Legumes in Yam/Cassava Based Cropping Systems of the tropical rainforest

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Abstract: The study assessed the nodulation / nitrogen fixation of landrace legumes: the velvet bean (*Mucuna pruriens* Var. *utilis*), African yam bean (*Sphenostylis sternocarpa*) and lime bean (*Phaseolus lunatus*) for increased yield in yam/ cassava based cropping systems of the tropical rainforest of Southeastern Nigeria. In both sole cropping and formed systems the landrace legumes formed nodules within 4 WAP. Dry nodule weight was higher in sole legumes than in yam/cassava based crop mixtures and further decreased with increasing number of crops in the mixture. *Mucuna pruriens* fixed significantly more N, had higher symbiotic dependence ranging from 57.02% in yam/maize/cassava/mucuna to 57.62 in sole cropping than the other legumes used the experiment. African yam bean had significantly more efficient nodules than mucuna and lima bean either in sole cropping or intercropping. Also, there were significant differences in the dry matter per plant between cropping systems and within the landrace legume species and *Mucuna* had the highest (8.8 g) in sole cropping system. [New York Science Journal. 2008;1(1):1-12]. (ISSN: 1554-0200).

Keywords: Nodulation and Nitrogen Fixation, Landrace Legumes, Yam/Cassava Based Cropping Systems, Tropical Rain Forest

Introduction:

The agro-ecological zones of the world are made up of different cultures practicing different cropping systems for the sustenance of their environment. In many parts of the developing countries of the world, there is an increasing deficit of nitrogen. It is estimated that between 20 and 70 kg N ha⁻¹ yr⁻¹ may be imported every year by developing countries in sub-Saharan Africa and Latin America (Giller2001) Nitrogen is lost mainly through leaching, volatilization and denitrification, and to the atmosphere through burning. These losses must be replaced if agricultural productivity is to be sustained.

In agricultural production systems, adequate levels of nitrogen (N) are essential for proper plant growth as it is useful for chlorophyll, enzymes as well as for the amino acids and proteins used for building plant tissues and cell organelles (Brady, 1990). In many tropical agricultural systems, the importance of nitrogen is second only to water and the N content of most surface mineral soils is about 0.02 – 0.5% (Webster and Wilson, 1998). However, most of the soil N is in Organic form associated with humus and silicate clays and only about 2-3% of this is mineralized each year (Brady 1990). Amongst the soil nutrient elements, nitrogen (N) is so important to plants that after photosynthesis, biological nitrogen fixation is probably the second most important biological process on earth (Brady 1990). Biological nitrogen fixation through legumes has a great potential to contribute to the productivity and sustainability of the tropical agricultural systems by substituting for fertilizer inputs (Boddey et al 1997). The southeastern Nigeria agro ecological zone is characterized by varying seasonal temperatures, rainfall, humidity, low soil pH and organic matter levels, poor soil fertility status particularly Nitrogen. There is minimal external input use by small-scale farmers, practicing mostly yam and or cassava based cropping systems with maize, legumes and some vegetables, predominating the zone. This farming system had received limited attention from the research communities as early efforts were focused on fertilizer trials instead of exploiting the landrace legumes to improve our farming systems, as practiced by traditional smallholder farmers. The contemporary research efforts to improve soil fertility is directed towards the introduction of edible and non-edible leguminous species into our farming systems to harness fertility potentials with yam and or cassava as the base crops.

The Velvet bean, *Mucuna pruriens* is a leguminous plant indigenous to Southeastern Nigeria. It is called “Agbiri” (Igbo) because of the itching nature of the pod trichomes when in contact with the human skin. It is a vigorously growing and twining annual plant and has a number of species and hybrids. (Qudhia, 2001a). *Mucuna pruriens* apart from having some medical properties fixes nitrogen and serve as a green

manure and cover crop (Oudhia 2001b). Providing support to the plant helps to increase the yield by 25% and reduces pest infestation (Oudhia and Tripathi 2001) and yield of 500kg ha⁻¹ have been obtained from well, managed irrigated farms (Singh *et al* 1995, Farooqi *et al* 1999)

The lima bean *Phaseolus lunatus* L is a warm season crop belonging to the family legumenoeseae. It is propagated by seed (Van der Maeseen and Sadikin 1989, Darbie *et al* 1999). There are three culti-groups of the lima bean, sieve, potato and the big Lima. However the fourth culti- group called sieve big Lima type exists (Liol *et al* 1991). Lower yield of 200 – 300 kgha⁻¹ has been reported in India while in Western Nigeria under experimental condition yield of over 300 kgha⁻¹ have been reported indicating potentials of the crop in the humid tropics (Daisy 1979). It is often planted along with yam and the beans, using the same stakes as the yam for support (Ibeawuchi and Ofoh 2000)

The African yam bean *Sphenostylis sternocarpa* is a vigorous growing herbaceous plant that climbs and twines to height of over 3m and requires staking. Small-scale cultivation is practiced throughout Southeastern Nigeria where the plant is adapted for low land conditions. The African yam bean has trifoliate leaves and flowers profusely in 100-150 days after planting (IPGRL FAO 2001). Its management is the same as employed traditionally by farmers in Africa where it is always found in mixed culture and scattered in small plots (NAS 1979).

Yam, *Dioscorea species* is a monocot and it is wide spread in West Africa of which Nigeria is the center of production (Onwueme- and Sinha 1991. Lothar 1983). Over 59% of yams and 75% of maize grown in Nigeria are intercropped (Okigbo and Greenland 1975). In the soils of the rain forest zone of Nigeria, yam / maize /melon and yam/maize/cassava are the must dominant yam based crop combinations (Agboola 1979, Ezeilo *et al* 1975). In most traditions practicing yam based farming systems, yam is usually the first or one of the first crops to be planted after the land is cleared from bush fallow (Degrass 1993).

Cassava, *Manihot esculenta* (L) Crantz is a dicotyledonous plant growing 1-3m high. It belongs to the family Euphorbiceae (Pierre 1989, Howard 1988) Cassava based cropping systems are found mainly on poor sandy soils of the coastal belt where food crops other than cassava hardly give satisfactory yield except coconut or oil palm. Cassava is the predominant staple food crop in southeastern Nigeria replacing especially cocoyam, potato and even yam to some extents.

The yam/cassava based cropping systems with landrace legume is expected to be a good crop combination for soil improvement. This cropping system may help in biological nitrogen fixation and availability to the companion or a subsequent crop. Legumes apart from serving as food has a variety of other uses including their ability to harbour nitrogen fixing bacteria (rhizobia) and serve as green manure crop to improve soil fertility and soil organic matter content. The potentials of legumes to fix nitrogen in the soils of low land humid environment have not fully been exploited especially using the landrace legumes of the rainforest belt of Nigeria. The Nitrogen benefit from leguminous plant in an intercropping system will depend on the active symbiotic activity under such a system. The relevance of yam and or cassava intercropping with landrace legumes such as *Mucuna pruriens*, *Sphenostylis sternocarpa* and *Phaseolus lunatus* in Southeastern Nigeria agro ecological zone lack scientific information.

This work therefore, was designed to develop farming technologies using such edible and non-edible landrace legumes to assess their potentials in nodulation/ Nitrogen fixation in a yam/cassava based cropping systems in Southeastern Nigeria.

Materials and Methods

The experiment was conducted at the Teaching and Research farm of the School of Agricultural Technology, Federal University of Technology Owerri, Nigeria, located between latitude 5° 23' 8.7" N and longitude 6° 59' 39. 4" E., which is in the tropical rainforest zone of Southeastern Nigeria. The areas have a minimum and maximum annual ambient temperature of 20 C and 32 C, respectively and mean annual rainfall of 2500mm (Nwosu and Adeniyi 1980).

The soils have been developed from deep unconsolidated marine sediments of Pleistocene age, often known as coasted plain sands (Ofomata 1975) and classified as Ultisols with low mineral reserve and are therefore low in fertility (Eshett 1993). The experimental site was under fallow for 2 years and it was previously cropped with cassava and maize to which NP K fertilizer was applied. The soil physical properties showed 84% sand, 10.5% silt and 6.5% clay while the chemical analysis revealed that the soil had 0.05% Total N, 10.9 ppm P, and available cations K, Ca and Mg of 0.76, 0.47 and 0.70 Cmol/kg respectively. The soil reaction (pH in water) was 4.56.

Planting materials

Three land race legumes were used namely: African yam bean – *Sphenostylis sternocarpa*; Lima bean – *Phaseolus lunatus*; and the velvet bean-*Mucuna pruriens* var. utilis. *Mucuna* grows in the wild but the black seed were collected from the SAAT gene bank while lima bean and African yam bean were bought from the rural markets in Owerri agricultural zone. Other planting materials: cassava - (TMS 30555); Seed yams (white) obiaeturugo– local cultivar; TZSR yellow, Cassava cuttings and maize were bought from the Imo Agricultural Development Project Headquarters Okigwe Road, **Owerri**. For the repeat of the experiment, seeds of the land race legumes, maize seeds, seed yams and cassava cuttings harvest were got from the previous plantings

Land preparation

For the two years of the research work, land preparation was done manually with machetes, spades and rakes since minimum tillage was used. The dry trash was later packed and removed from the site. The field was thereafter marked out for planting. The experiment was laid out in a randomized complete block design replicated 3 times. Each plot measured 3 x 4 m with 1 m between plots and 2 m between blocks and 1 m experimental guard areas. The treatments included sole crops each component crop and their combinations as follows:

Yam/ maize-Based:

1. Yam/maize/mucuna (y/m/mp)
2. Yam/maize/lima (y/m/l).
3. Yam/maize/African yam bean (y/m/Ayb)
4. Yam/maize, (y/m).

Cassava/ maize - based

5. Cassava/maize/mucuna (c/m/mp)
6. Cassava/maize/lima (c/m/l)
7. Cassava/maize/African yam bean (c/m/Ayb)
8. Cassava/maize (c/m).

Yam/ maize cassava-based

9. Yam/maize/mucuna (y/m/ cassava mp).
10. Yam/maize/cassava/lima (y/m/c/l)
11. Yam/maize/cassava/African yam bean (y/m/c/Ayb)
12. Yam/maize/cassava (y/m/c)

Sole Cropping

13. Yam (y)
14. Cassava (c)
15. Maize (m)
16. Mucuna (Mp)
17. Lima bean (L)
18. African yam bean (Ayb)

Planting and spacing

Two seeds of each landrace legume were planted 2-3cm deep and spaced 50 x 50 cm. These were later thinned down to 1 plant per hole after emergence giving 20,000 plants per hectare for sole and intercropped plots of each legume.

Two maize seeds were planted per hole at a depth of 2-5cm at 1 x 1m spacing. This was later thinned down after germination and emergence to 1 plant per stand giving 10,000 plants per hectare.

Yam: *Dioscorea rotundata* (white) obiaeturugo, seed yams weighing 200-300 g were planted in holes measuring 30 x 30 x 30 cm at a spacing of 1 x 1m on flat. This gave a plant population of 10,000 plants per hectare.

Cassava: (TMS 30555). Cassava cuttings measuring 20cm long were planted on flat at 1 x 1 m spacing giving a plant population of 10,000 plants/ha.

Soil samples

At the beginning of the experiment, soil samples were randomly collected with soil auger at a plough layer of 0 – 20 cm from different spots of the experimental field. The soil samples were bulked and analysed. Also, at the end of each experiment soil samples were collected with soil auger from each plot and samples from plots carrying the same treatments were bulked and analyzed.

Soil pH was determined in distilled water at 1:2.5 soil: water solution ratios using the Beckman zeromatic pH meter.

Organic matter (OM) was determined by the chromic acid oxidation method (Walkley and Black, 1934).

Nitrogen (N) was determined by the micro-kjeldahl digestion method (Bremner, 1965).

Available phosphorus (P) and exchangeable potassium (K) were determined by the Bray II (and the flame photometry, respectively). Atomic Absorption Spectrophotometry (AAS) determined calcium (Ca) and Magnesium (Mg).

Plant and Soil Sampling.

Two plants each of *Mucuna pruriens* var. utilis (Mucuna Black seed utilis), *Phaseolus lunatus* (Lima bean) and *Sphenostylis sternocarpa* (African yam bean) were sampled from each plot at 2 weekly intervals starting from 4-12 weeks after planting and at harvest.

At each sampling, nodule number, nodule weight, and total dry matter yield were assessed. Also, nodule colour was determined in the field using colour chart. The legume samples were dried to a constant weight at an oven temperature of 60°C for 48 hours.

At each sampling time, the residual soil N and plant N accumulation were determined thus:

$N\text{-accretion} = \text{Total N in the system at harvest} - \text{net change in soil N} + \text{seed N.}$

$N\text{ in the system at harvest} = \text{Sum of soil N} + \text{total plant N.}$

$\text{Net change in soil N} = \text{Soil N after harvest} - \text{soil N before planting.}$

$N\text{ accretion} = \text{Gradual addition of N in nature (soil).}$

In yam, maize, cassava intercropping with the three legumes, soil samples were taken at harvest and analyzed

Nodule counts

Two legume plants in each plot were sampled each time by digging up the entire plant and immersing the root into a bucket full of water to clear roots of soil. Thereafter, the number of nodules per plant were counted and recorded. Subsequently, the nodules were scratched to note the colour.

Dry matter.

The sampled legume plants from the plots were oven dried at 60°C for 48 hours to a constant weight and recorded. At harvest, the samples (plant and grain) were also oven dried analysed and recorded. All samples were oven dried to a constant weight and recorded.

Plant analysis

At each sampling, the oven-dried materials were analyzed for plant N.

Harvesting was done at the maturity of each crop.

Data analysis

The data collected were collated and statistically analyzed using the Megastat, developed by Orris (2000) and Microsoft Excel (2000) packages. Simple linear regression equation as detailed by Koutsoyiannis (1996) was fitted into the data collected for evaluation of total dry matter and nodule weight. Wahua (1999) was used for data analysis and interpretation.

Results

Table 1 shows the mean nodule dry weight, (mg/plant) nodule number and total dry matter/plant (g/plant) for yam, cassava, and yam/cassava-based cropping systems and the sole cropping of the three-landrace legumes. The sole cropped landrace legumes had significantly higher number of nodules per plant

than the other cropping system Nodule number decline with increased number of crops per crop combination, with the least nodule number of 25/plant from yam/maize/cassava/ mucuna. There were significant differences in nodule dry weight within and between the different yam and cassava-based cropping systems. In yam-based cropping system, *Mucuna pruriens* had significantly higher nodule dry weight than lima bean (*Phaseolus lunatus*) but, similar to that *Sphenostylis sternocarpa* (the African yam bean). In Cassava and yam/cassava-based cropping system no significant differences existed among the cropping systems. However, the sole cropping of the landraces showed significantly higher number of nodule dry weight per plant for *Mucuna pruriens* than *Phaseolus lunatus* and *Sphenostylis sternocarpa*.

Furthermore, there were differences in the quantity of dry matter produced per plant between cropping systems and within the land race species. The highest was got from *Mucuna pruriens* under sole cropping (8.8g/plant) and it was significantly ($P \geq 0.05$) higher than those of others in the crop mixtures and the sole cropping of *Phaseolus lunatus* and *Sphenostylis sternocarpa*. The results also show a change in the dry matter of Mucuna, which was reduced by 22.72% when planted in association with yam and maize, or by 28.98% when planted in association with cassava and maize or by 26.14% when in association with yam/maize/cassava. The dry matter of lima bean was reduced by 25.22 % when associated with yam/maize, by 11.30% and 28% in cassava/maize and yam/maize/cassava, respectively. African yam bean dry matter was depressed by 25% when in association with yam/maize, by 11.21% in association with cassava/maize and by 29.83% in yam/maize/cassava association.

Figure 1 shows the relationship between mean dry nodule weight and nodule numbers for tuber-based cropping mixture. A relationship exists between them and that dry nodule weight increased with increasing number of nodules indicating that the relationship will enhance the fixation potentials of the landrace legumes.

Table 2 shows regression analysis of impact of total dry matter on mean nodule weight for tuber-based cropping systems and sole cropping of the three-landrace legumes. The results of the regression analysis are shown in the equation;

$$Y = 53.78 + 19.10X_1 \text{ ----- (1)}$$

Where y = mean nodule dry weight (mg/plant) and

X_1 = Total dry matter (g/plant).

Test carried on this regression estimate showed that a significant relationship existed between the mean nodule dry weight and total dry matter. The empirical relationships between these two variables (nodule dry weight and total dry matter) show that each mg nodule weight requires 19.1g dry matter to form. From the same equation 59.7% (R^2 = coefficient of determination) of the variation in the nodule weight was explained by the total dry matter per plant. It showed that the t-ratio, which is coefficient/standard error, was significant at ($P \leq 0.01$) indicating a strong relationship between total dry matter and nodule dry weight.

Figure 2 shows a significant relationship between nodule dry weight and fixed nitrogen. Fixed nitrogen increased with increase nodule dry weight, which was significantly different ($P \leq 0.05$) in sole planted Mucuna.

Total fixed -N, and symbiotic dependence (SD).

Table 4, shows that among the three landrace legumes *Mucuna pruriens* fixed significantly ($P \geq 0.05$) more nitrogen than the other legumes either as sole or when intercropped. *Mucuna* also had the highest symbiotic dependence (SD) in all the cropping systems, In Mucuna SD ranged from 57.02% in yam/maize/cassava/Mucuna to 57.62 in sole cropping. In lima bean SD ranged from 45.15% in yam/maize/cassava Lima to 45.63% in sole cropping while African yam bean had 50.05% in yam/maize/African yam bean to 56.47% under sole cropping.

Nodulation Efficiency and Specific Nodule Activity.

Nodulation efficiency (NE) shows that *Sphenostylis sternocarpa* (African yam bean). had significantly ($P \geq 0.05$) more efficient nodules than the other legumes either in sole cropping or in intercropping (Table 5). The results show that there is high specific activity of nodules in the yam/cassava-based cropping system 0.38 and 0.36 for Mucuna and African yam bean, respectively, which they were significantly ($P \geq 0.05$) different from those of other legumes in the cropping system.

Table 1. Mean nodule weight (mg/plant); Fixed N (mg/plant); nodule no/plant, and total dry matter, (g/plant) for yam/cassava- based cropping system and sole cropping of the three-landrace legumes.

| Treatments/Cropping System | Dry Nodule weight (mg/plant) | Total Dry Matter (g/plant) | Nodule No./ plant | Fixed N (mg/plant) |
|--------------------------------|------------------------------|----------------------------|-------------------|--------------------|
| yam/maize/mucuna | 168.8 | 6.8 | 38 | 57.1 |
| yam/maize/lima | 146.2 | 4.3 | 31 | 39.5 |
| yam/maize/African yam bean | 159.9 | 4.35 | 35 | 45.2 |
| Cassava/maize/mucuna | 156.6 | 6.25 | 36 | 58.3 |
| Cassava/maize/lima | 138.64 | 5.1 | 31 | 41.2 |
| Cassava/maize/African yam bean | 138.8 | 5.15 | 31 | 47.7 |
| yam/maize/cassava/Mucuna | 139.9 | 6.5 | 25 | 52.8 |
| yam/maize/cassava/lima | 124.35 | 4.14 | 28 | 38.3 |
| yam/maize/cassava/ayb | 124.36 | 4.07 | 28 | 44.2 |
| Mucuna pruriens | 240.2 | 8.8 | 66 | 65.8 |
| lima beans | 187.8 | 5.75 | 56 | 47.5 |
| African yam bean | 199.9 | 5.8 | 57 | 54.2 |
| LSD(0.05): | 18.65 | 1.78 | 12.5 | 10.8 |

Table 2. Regression Analysis showing the relationship between dry matter and nodule weight for yam/ cassava-based cropping system & sole cropping of the three-landrace legumes.

| | |
|------------|------------------------|
| 0.597 | R ² |
| 0.773 | R |
| 22.820 | Std. Error of estimate |
| 12 | Observations |
| 1 | Predictor variable |
| (mg/plant) | Dependent variable |

Regression equation: $Y = 53.78 + 19.10X_1$

Standard error of coefficient ----- (4.96)

The t-ratio (coeff./std.error)-----3.85***

Y = Mean Nodule Weight (mg/plant);

X_1 = Total Dry Matter (g/plant);

Table3. Nodulation count, Nodule Weight, Plant Dry matter, Soil N and Plant N at 4 WAP

| Cropping System | Nodule Number | Nodule wt (mg) | Plant total Dry matter(g) | Soil N. mg/100g | Plant N mg/100g |
|------------------------------------|---------------|----------------|---------------------------|-----------------|-----------------|
| Yam-based | | | | | |
| Yam/Maize/Mucuna | 2.0 | 0.28 | 0.18 | 7.0 | 8.7 |
| Yam/Maize/Lima | 1.0 | 0.09 | 0.08 | 7.0 | 7.2 |
| Yam/Maize/African Yam bean | 1.5 | 0.11 | 0.16 | 7.0 | 6.5 |
| Cassava-based | | | | | |
| Cassava/Maize/Mucuna | 1.0 | 0.20 | 0.18 | 7.0 | 8.6 |
| Cassava/Maize/Lima | 1.0 | 0.07 | 0.17 | 7.0 | 7.2 |
| Cassava/Maize/African yam bean | 1.0 | 0.05 | 0.17 | 7.0 | 6.5 |
| Yam/Cassava-based. | | | | | |
| Yam/Maize/Cassava/Mucuna | 2.0 | 0.03 | 0.17 | 7.0 | 8.7 |
| Yam/Maize/Cassava/Lima | 2.0 | 0.19 | 0.16 | 7.0 | 7.2 |
| Yam/Maize/Cassava/African yam bean | 2.0 | 0.22 | 0.16 | 7.0 | 6.5 |
| Sole Cropping | | | | | |
| Mucuna pruriens | 2.5 | 0.03 | 0.19 | 7.0 | 8.7 |
| Lima bean | 2.0 | 0.120 | 0.17 | 7.0 | 7.2 |
| African yam bean. | 2.0 | 0.22 | 0.18 | 7.0 | 6.5 |
| LSD(0.05) | 0.25 | NS | NS | NS | NS |

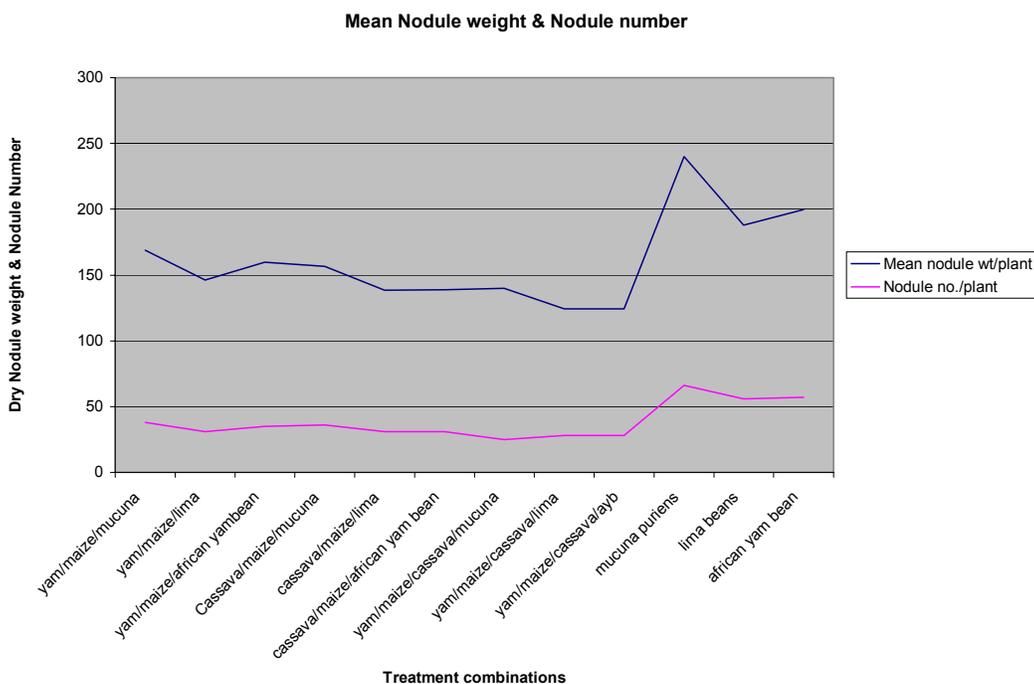


Figure 1. Relationship between mean nodule weight & nodule numbers for yam /cassava-based cropping systems & sole cropping of the three landrace legumes

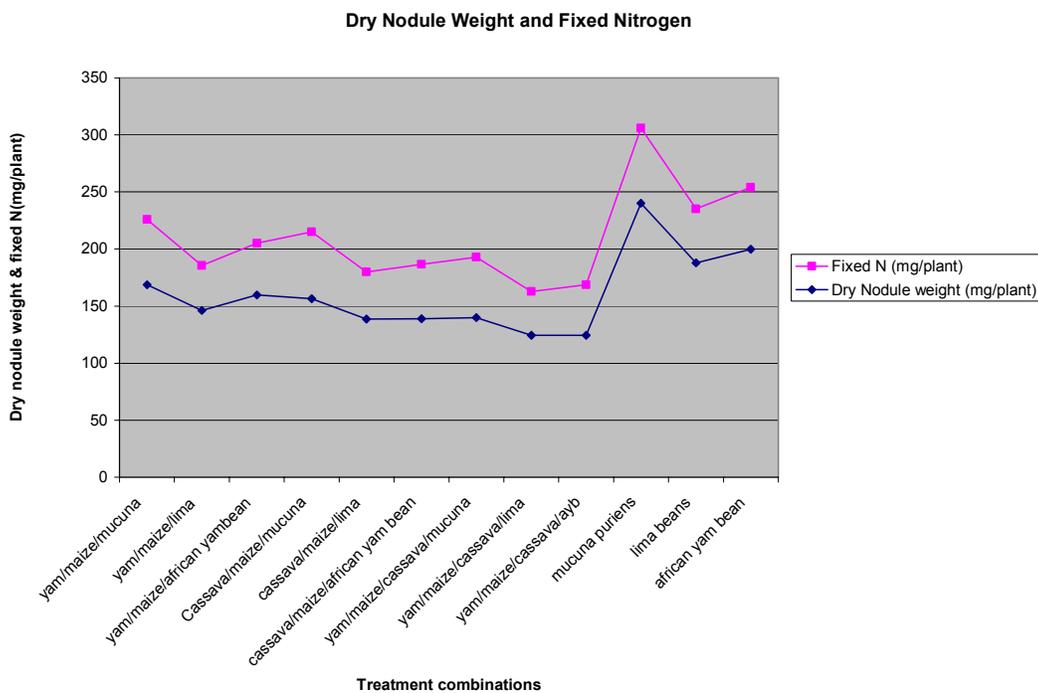


Figure 2. Relationship between mean dry nodule weight & Fixed N (mg/plant) for yam/cassava-based cropping system & sole cropping of the three landrace legumes.

Table 4: Mean value of fixed N, Symbiotic dependence (SD), Nodulation Efficiency (NE), and specific activity as influenced by cropping systems.

| <u>Cropping Systems</u> | <u>Fixed N</u> (mg/plant) | <u>Symbiotic</u> <u>Dependence(SD)</u> (Fixed N/Total Plant N)*100 | <u>Nodulation</u> <u>Efficiency(NE)</u> (Nodule dry wt.(mg)/(plt dry wt(g)) | <u>Specific Nodule</u> <u>Activity</u> (Fixed N(mg)/Nodule Dry wt(mg)) |
|-----------------------------------|------------------------------|---|---|--|
| <u>Yam-based:</u> | | | | |
| yam/maize/Mucuna | 57.1 | 57.44 | 24.82 | 0.34 |
| yam/maize/lima | 39.5 | 45.56 | 34 | 0.27 |
| yam/maize/African yam bean | 45.2 | 50.05 | 36.76 | 0.28 |
| <u>Cassava-based:</u> | | | | |
| Cassava/maize/mucuna | 58.3 | 57.44 | 25.06 | 0.35 |
| cassava/maize/lima | 41.2 | 45.3 | 27.18 | 0.3 |
| cassava/maize/African yam bean | 47.7 | 50.32 | 26.96 | 0.34 |
| <u>Yam/Cassava based :</u> | | | | |
| yam/maize/cassava/Mucuna | 52.8 | 57.02 | 21.51 | 0.38 |
| yam/maize/cassava/lima | 38.3 | 45.15 | 30.04 | 0.31 |
| yam/maize/cassava/Ayb | 44.2 | 50.05 | 30.56 | 0.36 |
| <u>Sole Cropping:</u> | | | | |
| mucuna puriens | 65.8 | 57.62 | 27.3 | 0.27 |
| lima beans | 47.5 | 45.63 | 32.63 | 0.25 |
| African yam bean | 54.2 | 56.47 | 34.47 | 0.27 |
| LSD (0.05) | 10.8 | 11.75 | 11.39 | 0.06 |

NB: SD= (Fixed N)/(Total Plant N) x100/1

NE = (Nodule dry weight /Plant)/(Plant dry Weight)

SNA =(Fixed N)/(Nodule dry Weight)

Discussion

Nodule Dry Weight and Nodule Number

Nodule formation was noticed within 4 WAP. Field records show that some nodules were green, white or grey while some were pink or red when scratched with finger. The pink or red nodules are those believed to have leghemoglobin and capable of N- fixation. Lindemann and Glover (1998) reported that young nodules were white or grey and were not fixing nitrogen but as they grew they turned pink or reddish in colour indicating that nitrogen fixation has started. Nodule dry weight and number decreased with increasing numbers of plants population in each crop combination with the lowest in yam / cassava-based cropping system. It may be that nodule weight and number are energy dependent. This agreed with the report by Tang *et al* (2001) that phosphorus increased nodule number 35 WAP. However, nodule number and weight could be as a result of legumes genetic character to have up-to a certain number if favoured by environmental factors. Simple relationship exists between nodule dry weight and nodule number per plant as they are indices of N – fixation (Vincent – Chandlar *et al* 1964; Oti and Agbim 2000a).

Nodulation Efficiency (N.E) and Specific Nodule Activity (SNA).

These are derived technical expressions of the symbiotic permanence of the landrace legumes and point out the effectiveness or otherwise of nodules and their relationship with fixed-N₂. Therefore, the nodulation efficiency (NE) could be more dependent on the genetic inheritance of the legumes while specific nodule activity (SNA) seems more an environmentally controlled factor since it was significantly affected by the different cropping systems and the former was not. This view was shared by Oti and Agbim (2000b) who reported, that nodulation efficiency tended to be more an inherent attribute of legumes while specific nodule activity was more controlled by environmental factors

Total Dry Matter.

Dry matter accumulation is one of the measures of plant growth, (Noggle and Fritz 1983) and reflects the relative growth rate as regards to net assimilation rate. Dry matter is a function of crop species and soil fertility (Jones 1976; Oti and Agbim 2000(b)). The result suggests that inter-cropping system influenced dry matter accumulation. The inter-cropping systems involving yam and cassava, which have high demand for soil P and K (Ustimenko – Bakumovsky 1983, Onwueme and Sinha 1991), must have affected adversely the performance and growth of the land race legumes. This agreed with the report by Vincent – Chandlar *et al* (1964), Oti and Agbim (2000a) that low P in soils or its deficiency limits legumes growth and performance in tropical soils. However, large quantities of dry matter were obtained from sole cropping systems. This has its agronomic significance since total dry matter is one of the key factors in soil nitrogen fixation (West and Wedin 1985).

Fixed – N and Symbiotic Dependence (SD)

The significantly high quantity of N-fixed by the sole planted legumes reflected the number of nodules per plant, dry nodule weight and total dry matter content per plant. This observation agreed with the results obtained by Ibeawuchi *et al* (2004), who reported that nodule weight, nodule numbers and total dry matter are all indices of nitrogen fixation since they have either direct or indirect relationship. The high nodule weight and number of mucuna planted sole in the trial and its ability to fix-high quantity of N in the experiment is an indication of the importance of their relationship in N-fixation. This agreed with the report by Miller *et al* (1982) who reported that nodule weight was a major contributing factor to N-fixation activity while nodule numbers was important in its relationship with nodule weight. Symbiotic dependence (SD) being a mathematical expression in percentage of the fixed-N per total plant nitrogen may not be a dependable measuring technical attribute for nitrogen fixation potentials of the landraces. This observation agreed with Oti and Agbim (2000b) who stated that symbiotic dependence is influenced by soil and may not be a reliable indicator of screening the N- fixing potentials of legumes.

Conclusion:

Landrace legumes had been found to fix reasonable quantities of nitrogen in the soil and by implication help to improve soil fertility. This will go a long way in reducing the use of chemical fertilizers, thus sustaining our environments. Our farming environment is governed by high rainfall and temperature, which encourages leaching and volatilization losses. The soil being a living body is dynamic and these factors will not allow one to give accurately the N status of the soil at any particular point in time. However, farmers are encouraged to practice intercropping with landrace legumes since they have been found to fix large and economical amounts of nitrogen and dry matter which decay to sustain soil organic matter content. *Mucuna pruriens* is a crop of the future and emphasis should be laid on its research as human food and other endeavours of human life.

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References

1. Agboola, S.A. (1979). An Agricultural Atlas of Nigeria: London, Oxford University Press. Pp 16-47
2. Brady, N. (1990) Nature and Properties of Soils. Macmillan publishing company, New York.
3. Bremner, J.M. (1965) Total nitrogen. In: C.A. Black et al (ed) Methods of soil analysis Part 2. Agron No. 9. American Society of Agronomy, Madison, Wisconsin USA pp1149-1178.
4. Boddey, R.M, Sa, J.C, D.M, Alues, B JR and Urquiaga, S. (1997). The contribution of biological nitrogen fixation for sustainable agricultural systems in the tropics. Soil biology and biochemistry 29 (5/6) 287-799.
5. Daisy E.K. (1979) Food legumes: TPI Crop Product Digest. No. 3. Tropical Product Institute Circular 716.
6. Darbie, M; William, T.K and George, (1999). Lima bean :Commercial Vegetable Production. Goeogia Extention Services Publicarion Circular 716.
7. Degras. L. (1993) The Yam: A Tropical Root Crop. The Macmillan Press Ltd, London, pp.1-344.
8. Eshett, E.T. (1993) Wetlands and ecotones studies on land water. National Institute of Ecology, New Delhi and International Scientific Publications, New Delhi pp 232-234.
9. Ezeilo, W.N.O, Klinn, J.C. and Williams, L.B. (1975) Cassava Production in the East Central State of Nigeria. IITA Ibadan, Nigeria. Pp.27.
10. Farooqi, A.A., M.M. Khan and Asundhara (1999) Production technology of medicinal and aromatic crops. Natural Remedies. Put Ltd., Bangalore, India pp 26-28.
11. Giller K .E (2001) Nitrogen fixing in tropical cropping systems. 2nd Edition .CAB International , Wallford . Pp. 423.
12. Howard Bradbury. J. and Warren D. H. (1988). Chemistry of Tropical Root Crops. Significance for Nutrition and Agriculture in the Pacific. Ware Printing Melbourne ACIAR Monograph No. 6. pp. 27-37.
13. Ibeawuchi, I.I Obiefuna J.C; Ofoh, M.C.; Ihejirika, G.O; Tom, C.T, Owneremadu, E.U and Opara, C.C (2004) An Evaluation of four soybean varieties intercropped with Okra in Owerri Ultisol of Southeastern Nigeria. Pakistan Journal of Biological sciences (PJBS) 70 2004 ISSN 1028-8880.(In press.)
14. Ibeawuchi, I.I. and M.C. Ofoh (2000) Productivity of maize/cassava/food legume mixtures in south eastern Nigeria. J. Agric. and Rural Dev. 1(1): 1-9.
15. IPRI – FAO (International Plant Genetic Resources Institute – Food and Agricultural Organisation) (2001) Cultivation and use of African yam bean (*Sphenostylis stenocarpa*) in the Volta regions of Ghana. PGR Newsletter No. 124 pp 13-16.
16. Jones, R.J. (1976) Yield potential for tropical pasture legumes NIFTAL college of tropical Agriculture Misc . Publ. 145:39-55
17. Koutsoyiannis, A (1986) Theory of Econometrics: An introduction of Econometric methods: 2nd Edition. Macmillan Education Ltd, London. Pp :11-666.
18. Liol, L., Esquivel M. and Castineiras, L. (1991) Lima bean (*Phaseolus lunatus* L.) landraces from cuba, electrophoretic analysis of seed storage protein. Biologiches Zen tralolatt 110 (1) 76-79.
19. Lothar, D. (1982) Smallholder Farming System with yam in the Southern Guinea Savannah of Nigeria. GTZ. No. 126. Pp. 1-221.
20. Micro Soft Excel Package (2000) Microsoft Inc. USA
21. Miller, J.C, J.S. Scott, K.W Zary and S.K O' Hair 1982. The influence of available nitrate levels on N-fixation in 3 cultivars of cowpea Agron. J. 74:14-19
22. NAS (National Academy of Sciences) (1979b) Microbial Processes. Promising Technologies for Developing Countries. National Academy of Sciences, Washington D.C. Pp. 47-71

23. Noggle, G.R. and G.J. Fritz(1983) Introductory plant physiology. 2nd edition prentice-Hall Inc. Engle wood cliffs. New Jersey Pp 625.
24. Nwosu, A.C. and E.O. Adeniyi (1980) Imo state: A survey of resources for development. Nigeria Institute for Social and Economic Research (NISER), Ibadan, Nigeria pp 310.
25. Ofomata, G.E.K. (1975) Nigeria in maps. Eastern states. Ethiope Pub. House, Benin City, Nigeria pp 33-40.
26. Okigbo, B.N. and Greenland, D, J. (1976) Intercropping Systems in Tropical in Africa. In; R.L. Papendick, A. Sanchez and G..B triplet (Editors). Multiple Cropping ASA. Special publication No. 27., Madison W.I. USA Pp. 63-101.
27. Onwueme I.C. and T.D. Sinha (1991) Field Crop Production in the tropical Africa CTA. Ede Netherlands. Pp. 1-319.
28. Oris J. B.(2000) Megastat (8.8) Microsoft Inc.2000.
29. Oti, N.N and Agbim N.N (2000a) Comparative studies of Nitrogen fixing potentials of some wild and cultivated legumes 1 Green house trial. J. Agric and Rural Dev 1(1) 27-44.
30. Oti, N.N. and Agbim, N .N (2000b) comparative studies of Nitrogen fixing potentials of some wild and cultivated legumes 2. Field Evaluation. J. Agric and Rural Dev. (1) 79-89.
31. Oudhia, P. (2001a) Records of *Aphis craccivora* Koch (*Hemiptera* aphididea) on medicinal crop *Mucuna pruriens* L., Chhattisgarh (India) Insect Environ. 7 (1): 24-36
32. Oudhia, P. (2001b) Kapikachu or cowhage (*Mucuna pruriens*). Society for Parthenium Management (SOPAM) 28-A Geeta Nagar Raipar 492001, India.
33. Oudhia, P. and Tripathi, R.S. (2001) The possibilities of commercial cultivation of rare medicinal plants in Chhattisgarh In: Abstract of the VII National Science Conference, Bhartiya Krishi Anusandhan Samittee, Directorate of cropping system research, Meerut, India.
34. Pierre, S. (1989) Cassava: The Tropical Agriculturist. CTA Macmillian London and Basingstoke pp 22-64.
35. Singh, B.M; V.K. Srivastava; M.A. Kidwai; V. Gupta and R. Gupta (1995), Aloe, Psoralea and Mucuna Pp 515 -525 In K L Chadha and Rajendra Gupta (eds), Advances in Horticulture Vol;II Medicinal and aromatic plants, 1995 Malhotra publ. House ,New Delhi
36. Statistical Package for Social Scientists (SPSS) (2004).SPSS Inc. Northern Michigan Avenue – Chicago. Version 11.
37. Tang, C; Hinsinger P; Drevon, J.J. and Jaillard B (2001): Phosphorus Deficiency impairs early nodule functioning and enhances proton Release in Roots of medical *truncutula* L.
38. Ustimenko-Bakumovsky, G.V. (1983) Plant Growing in the tropics and sub tropics MIR Publishers. Moscow Pp. 28-264.
39. Van der Measeen, L.J.G. and Sadikin, S. (1989) (eds) Plant resources of south east Asia No 1 Pulses Pudoc Wageningen. Pp56-60.
40. Vincent- Chandler JR, R .W Car-Coastas, R.W Pearson, F. Abruna, J. Figarella and S. Silva (1964). The intensive management of tropical forages in Puerto-Rico University of Puerto-Rico Agr Exp sta Bull NO 187.
41. Wahua, T.A.T. (1999) Applied statistics for scientific studies. Afrika-link books Aba Nigeria
42. Walkley, A.A. and J.A. Black (1934) An examination of the Degtjareff method for determining soil organic matter and proposed modification of chromic acid titration method. Soil Science. 37: 29-38.
43. Webstar, C and Wilson, P. (1998) Agriculture and tropics. Blackwell science, Oxford.
44. West, C.P and Wedin, W.F (1985) Dinitrogen fixation in Alfalfa orchard grass pasture Agron. J. 77:89-94.