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EFFECTS OF NUTRIENTS AND CROPPING DENSITY ON CASSAVA FOLIAGE IN CASSAVA-GROUNDNUT INTERCROPPING

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ABSTRACT

The study was aimed at evaluating the relative effects of nutrient sources, cropping density and intercropping on selected soil variables and cassava crop foliage attributes It was conducted at Teaching and Research Farm of the Delta State University, Abraka (latitude 5^0 46' and longitude 6^0 5') July 2008 to June 2009, in the humid rainforest zone of Southern Nigeria. The experimental design was a 4x3x3 factorial experiment in RCBD pattern using three replicates, consisting of four nutrient levels, three cropping densities and three cropping patterns. The 4 nutrient levels were zero application, 200kg NPKMg, 40 tons of water hyacinth/poultry manure-based vermicompost (VPM) and 40 tons of water hyacinth/cow dung-based vermicompost (VCD). The 3 cropping densities were 50,000, 100,000, and 200,000 plants ha^{-1}, while the three cropping patterns were sole groundnut, sole cassava and cassava-groundnut intercrop. Rate of leaf formation, leaf area index and stay green core of cassava were significantly increased by vermicompost application.

Keywords: *cassava, leaf area index, stay green score,*

INTRODUCTION

The vegetative growth and yield of the crop has been found to be greatly influenced by the abiotic factors. Several researchers have indicated that the combination of biotic and abiotic factors determines the emergence, growth and yield of crops (Kerang, 2002; Odjugo, 2008; Gelon *et al.,* 2003). The growth cycle of cassava consist of two major alternating periods; the vegetative growth and carbohydrate storage in the roots. The main organ of photosynthetic production in cassava is the foliage. Early vegetative phase, flowering pattern and storage of assimilate in the vegetative parts are greatly affected by leaf loss ((Alves, 2002).

In other to achieve maximum crop productivity there must be equilibrium between the sink capacity (photosynthetic assimilate of active leaves) and the source activity (storage roots) during the growth cycle of cassava (Thandar, 2011). Since the sink capacity usually determine the source activity, farming systems that will sustain the productivity of the sink capacity, which is the crop foliage, becomes very significant. Leaf formation and leaf size are affected by temperature, and consequently the general plant growth. Rate of leaf production is delayed at low temperatures (16^0C), and leaf area development decreases with reduced temperatures (Cock and Rosas, 1975). This is because the maximum size of each leaf is smaller and fewer leaves are produced at each apical region, although longevity of leaf is increased.

The cassava plant has greater water use efficiency and water shortage tolerance ability when compared with other crops (El-Sharkawy and Cock, 1986). This response is due to its capacity to control stomata closure which reduces the rate of photosynthesis and reduction in transpiration losses. Under prolonged water shortage, cassava can reduce leave canopy by reducing the total leaf area (El-Sharkawy, 2007). Decline in shoot growth by 37%, and other shoot components such as plant height, leaf size and stem girth, due to moisture stress has been reported (Okogbeni *et al.* 2003; Aina *et al.,* 2007). Alves and Setter (2004) also observed reduced leaf canopy and size and leaf fall as water conservation mechanisms in cassava. The rate of leaf formation per apex, apex number per unit area and leaf size and longevity has been shown to determine leaf area index (Lebot, 2009). High positive correlations have been shown to exist between leaf longevity, root yield and LAI, and rate of leaf formation in cassava (Lahai *et al.,* 1999).

This study was therefore aimed at evaluating the variation foliage attributes of cassava as influenced by intercropping, crop population and nutrients.

MATERIALS AND METHODS

The study was carried out at experimental field of Teaching and Research Farm of the Delta State University, Abraka (latitude 5^0 46' and longitude 6^0 5') July 2008 to June 2009, in the humid rainforest zone of Southern Nigeria. The experimental design was a 4x3x3 factorial experiment with a randomized complete design in three replicates, consisting of four nutrient levels, three cropping densities and three cropping patterns. The 4 nutrient levels were zero application, 200kg/ha NPKMg 12:12:17:2, 40 tons of water hyacinth+poultry manure-based vermicompost (VPM) and 40 tons of water hyacinth+cow dung-based vermicompost (VCD). The proportion of dry water hyacinth to dry cow dung in the vermicompost was 75% to 25% respectively. The 3 cropping densities were 50,000, 100,000, and 200,000 plants ha^{-1}, while the three cropping patterns were sole groundnut, sole cassava and cassava-groundnut intercrop. Intercrop ratio of cassava (*Manihot esculenta Crantz*) and groundnut (*Arachis hypogea L.*) was 1:2 for all densities. Improved cassava (TMS 30572) and groundnut (Spanish 205) varieties were used for the study and planted on 6 x 4.5m^2 plots.

This study evaluated selected crop foliage attributes in cassava such as rate of leaf formation, leaf area index (LAI) and stay green score (SGS). Rate of leaf formation was expressed as change in number of leaves in between measurements. Leaf area was estimated using the formula [Y=5.81(L x W)0.86], where Y, L and W are leaf area, maximum length and width of lobe respectively, Sutoro and Wargiono (1988). LAI was calculated as leaf area (m^2)/ground area (m^2). Stay green score (SGS) was visually rated on a scale of 1 to 9 as earlier described by Ekanayake (1996). SGS is usually a combined effect of leaf ageing, drought or excess moisture condition, low night temperatures and harmattan winds (Ekanayake, 1996 and Lahai *et al.* 2013).

Data were subjected to an analysis of variance (ANOVA). Comparison of means was done by the least significant difference (LSD) at 5% level of probability. Correlation analysis of agro-environment variables and cassava foliage attributes was done using SPSS V. 16.

RESULTS AND DISCUSSION

Rate of Leaf Formation

Rate of leaf formation was more pronounced in soils with vermicompost organic amendments relative to mineral fertilizer and control treatments. Relative to the control, cassava leaves were formed at a faster rate in the vermicomposts (VP and VC) during the growing season. Higher rate of leaf formation in the vermicompost was more evident in September/October with increase of 23.5% and 18.8% in VP (water hyacinth +poultry manure vermicompost) and VC (water hyacinth +cow dung vermicompost) respectively. Increased rate of leaf formation in vermicomposts confirms the report of other researchers (Akanbi *et al.,* 2000; Ghosh *et al.,* 2006) that nutrient availability is a major determinant of plant photosynthetic capacity. Although no observed significant effect of plant population, rate at which new leaves were formed only decreased when plant population was above 100000 plants /ha. Monocropped cassava had better rate of leaf formation than those intercropped with groundnut, although cropping system did not show any significant effect.

Table 1: Effect of nutrient sources and plant population on rate of leaf formation (day-1 plant-1) of cassava in cassava-groundnut intercropping

	Jul/Aug	Sep/Oct	Nov/Dec	Jan/Feb	Mar/Apr	May/Jun
Treatments Nutrients						
0kg	1.2	1.3b	1.1d	0.9b	1.1c	1.1c
NPK (200kg/ha)	1.3	1.4b	1.3c	1.3a	1.3b	1.3b
VP (400kg/ha)	1.4	1.7a	1.4b	1.4a	1.5a	1.5a
VC (400kg/ha)	1.3	1.6a	1.5a	1.4a	1.5a	1.5a
LSD (5%)	ns	0.2	0.1	0.2	0.1	0.1
Density (plants /ha)						
50000	1.3	1.6	1.3	1.2	1.3	1.3
100000	1.4	1.5	1.5	1.3	1.4	1.4
200000	1.3	1.4	1.3	1.2	1.3	1.3
LSD (5%)	ns	ns	ns	ns	ns	ns
Cropping system						
Sole cassava	1.3	1.6	1.4	1.3	1.4	1.4
Cassava+ groundnut	1.3	1.4	1.3	1.2	1.3	1.3
LSD (5%)	ns	ns	ns	ns	ns	ns
Interactions						
Nutrient x density	0.14ns	4.67*	5.01*	2.01ns	0.44ns	0.44ns
Nutrient x cropping system	2.83ns	6.11*	7.11*	6.27**	5.11*	5.11*
Density x cropping system	1.98ns	2.7ns	3.01ns	4.11*	0.21ns	0.21ns
Nutrient x density x cropping system	0.77ns	9.01*	12.01**	10.13**	9.84**	9.84**

*, ** Significant at 5% and 1% respectively.

Means with the same letters within the column are not significantly different (P <0.05)

Leaf Area Index

Organic nutrient applications showed significant effect on leaf area index (LAI) of cassava (Table 5). In the water hyacinth+ poultry manure vermicompost (VP), LAI increased over the control by 90% (Jul/Aug), 67% (Sep/Oct), 100% (Nov/Dec), 100% (Jan/Feb), 47% (Mar/Apr) and 100% (May/Jun), while in water hyacinth+ cow dung vermicompost (VC), LAI increase was observed to be 80%, 58%, 100%, 47%, 100% and 100% at same time. Planting density and cropping system did not have any significant effect. Wider spacing with plant population at 50000 plants / ha showed lowest LAI during crop growth season. The reduced LAI in high plant densities may be due to increased competition. This confirms the observations of Fereira *et al.* (2008) and Rizzardi (2001) that under competition plant tends to have reduced leaf dimensions resulting in slower development of leaf area. However no consistent trend was observed with cropping system. LAI positively correlated with soil moisture, soil nitrogen mineralization and rate of leaf formation, indicating that an increase in these parameters will result in increased LAI. The positive correlation of LAI with moisture is expected since progressive increase in hydro-stress has been shown to induce dechlorophyllated and yellowed leaves in cassava (Nuwanmaya, *et al.* 2014) which further promotes leaf size reduction and defoliation. However the converse was the case with soil temperature and SGS which were negatively correlated with LAI (Table 7).

Table 2: Effect of nutrient sources and plant population on leaf area index (LAI) of cassava in cassava-groundnut intercropping

	Jul/Aug	Sep/Oct	Nov/Dec	Jan/Feb	Mar/Apr	May/Jun
Treatments Nutrients						
0kg	1.0c	1.2c	0.9b	0.8c	0.9b	0.9b
NPK (200kg/ha)	1.6b	1.7b	1.6a	1.5b	1.6a	1.6a
VP (400kg/ha)	1.9a	2.0a	1.8a	1.6ab	1.7a	1.8a
VC (400kg/ha)	1.8a	1.9ab	1.8a	1.7a	1.8a	1.8a
LSD (5%)	0.2	0.3	0.3	0.2	0.4	0.4
Density (plants /ha)						
50000	1.4	1.6	1.4c	1.3b	1.4c	1.4c
100000	1.7	1.8	1.6ac	1.5a	1.6a	1.7a
200000	1.7	1.7	1.5b	1.3b	1.5b	1.5b
LSD (5%)	0.1	ns	0.1	0.2	0.1	0.1
Cropping system						
Sole cassava	1.6	1.7	1.5	1.5	1.4	1.5
Cassava+ groundnut	1.5	1.7	1.5	1.4	1.5	1.6
LSD (5%)	ns	ns	ns	ns	ns	ns
Interactions						
Nutrient x density	5.07*	4.08*	5.11*	7.51**	2.13ns	2.13ns
Nutrient x cropping system	6.11*	2.84ns	11.05**	3.18ns	1.09ns	1.09ns
Density x cropping system	2.15ns	5.17*	3.04ns	2.19ns	6.11*	6.11*
Nutrient x density x cropping system	1.59ns	2.14ns	6.15*	5.91*	5.01*	5.01*

*, ** Significant at 5% and 1% respectively.

Means with the same letters within the column are not significantly different (P <0.05)

Stay Green Score

One of the main strategies of maintaining high cassava root yield under abiotic stress is sustaining photosynthetically active leaf area duration throughout the crop growing season. Stay green score (SGS) is the indirect way of measuring LAD (Ekanayake *et al.,* 1996; Lenis *et al.,* 2005). Except nutrient treatments, cropping density and cropping system showed no significant effect on stay green score or leaf area duration (LAD) of cassava foliage (Table 6). SGS was lower in vermicompost treatments compared to the control and mineral fertilizer. Lower crop densities and sole cassava maintained lower SGS during the crop growing season. With reduced SGS, there is a corresponding increase in LAD, which indicates that organic nutrient applications in form of vermicomposts, lower plant population and sole cassava cropping gave higher LAD. SGS correlated negatively with soil moisture, soil mineralized nitrogen, rate of leaf formation and leaf area index, indicating that these soil and cassava foliage attributes increases with LAD, while higher soil temperatures reduces LAD (Table 7). This agrees with the observations of previous studies (El-Sharkawy *et al.* 1990; Osiru *et al.* 1995) that farming practices that positively enhance leaf longevity also influence leaf net photosynthetic activity and performance in cassava.

Table 3: Effect of nutrient sources and plant population on stay green score (SGS) of cassava in cassava-groundnut intercropping

	Jul/Aug	Sep/Oct	Nov/Dec	Jan/Feb	Mar/Apr	May/Jun
Treatments Nutrients						
0kg	3.2a	3.6a	3.9a	4.1a	3.6a	3.5a
NPK (200kg/ha)	3.0bc	3.1b	3.6b	3.9a	3.5a	3.2b
VP (400kg/ha)	2.7d	2.7c	3.0c	3.1b	3.0b	3.0c
VC (400kg/ha)	2.9c	2.9bc	2.7d	2.9b	2.9b	2.7d
LSD (5%)	0.2	0.4	0.3	0.5	0.3	0.2

	Jul/Aug	Sep/Oct	Nov/Dec	Jan/Feb	Mar/Apr	May/Jun
Density (plants /ha)						
50000	2.9	3.0	3.0	3.4	3.2	3.1
100000	2.9	3.0	3.2	3.5	3.3	3.1
200000	3.1	3.1	3.5	3.7	3.4	3.4
LSD (5%)	ns	ns	ns	ns	ns	ns
Cropping system						
Sole cassava	2.9	3.0	3.2	3.5	3.2	3.1
Cassava+ groundnut	3.0	3.1	3.2	3.6	3.3	3.2
LSD (5%)	ns	ns	ns	ns	ns	ns
Interactions						
Nutrient x density	6.11*	12.01**	7.54*	6.23*	5.75*	11.58*
Nutrient x cropping system	3.07ns	5.22*	5.00*	2.81ns	3.04ns	2.90ns
Density x cropping system	2.01ns	1.89ns	2.75ns	3.01ns	1.08ns	5.15*
Nutrient x density x cropping system	5.11*	6.01*	9.12*	3.21ns	6.89*	7.12*

*, ** Significant at 5% and 1% respectively.

Means with the same letters within the column are not significantly different (P <0.05)

CONCLUSION

The results obtained from the study has shown that farming practices which increase soil organic matter such as application of vermicompost can have positive effects on soil microclimate and enhance foliage attributes which further promote the photosynthetic capacity of the crop.

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