Effects of Integrated Nutrients Management on Weed Infestation, Growth and Yield of Cowpea Varieties (*Vigna unguiculata L.*) in Moist Savanna of Nigeria.

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Abstract

A field experiment was conducted during the late cropping seasons of 2018-2019 at the Teaching and Experimental Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology, Gidan-kwano campus, Minna. The aim was to evaluate the effect of five various nutrient(s) combinations (Control, 30kg urea N, 30kg urea N + Agrolyser, Rhizobium inoculant Gw5, 30kg urea N + Agrolyzer + Rhizobium inoculant Gw5) on weed infestation, growth and yield attributes of three cowpea (Vigna unquiculata L.) varieties (Kanado white, sampea 15 and sampea 16). The results showed that the local check (kanado white) had the lowest weed infestation, higher leaf number and leaf area index per plant, higher pod weight and grain yield per plot which were not statistically different ($P<0.05$) from sampea 16 compared to sampea 15. Application of 30kg urea N significantly increased leaf number, leaf area index, dry shoot weight and nodule number per plant compared to application of 30kg urea N + agrolyzer + rhizobium inoculant Gw5 while the Rhizobium inoculation significantly increased pod number per plant, dry pod weight and grain yield per plot compared to the control. Thus, the application of 30kg urea N can be recommended for enhancing the growth parameters while rhizobium inoculation can be recommended for enhancing the yield parameters.

Key words: *integrated, nutrient, management, weed, infestation, growth, yield, cowpea, varieties, savanna*

INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is a warm-season, annual herbaceous legume that belongs to the family of *Fabaceae* otherwise known as *Leguminosae* and the genus *Vigna*. Its growth characteristics made it a versatile crop adapted to a wide array of soils and moisture regimes. It also smoothers weeds and prevents soil erosion (Suh and Simbi, 1983). It fits into different cropping systems, rotational regimes and marginal lands unsuitable for some of the major crops. It has expansive potential and offers opportunities for small-scale farmers to practice intensive cropping in their farms as a means of improving their income and food security (AATF/NGICA, 2006).

Being a leguminous crop, cowpea is blessed with a natural character of biological nitrogen fixation that leads to improvement in the soil fertility. Besides, it is also known to add considerable amount of organic matter through root biomass, leaf-fall and deep root systems, mobilization of nutrients, protection of soil against erosion, improving microbial biomass and controlling the establishment of weeds (Adu-Gyamfi *et al.*, 2007; Marimuthu1 and Subbian, 2013). Not only these, cowpea keeps soil productive and alive by bringing qualitative changes in physical (bulk density, water retention capacity, higher hydraulic conductivity), chemical (soil organic carbon, soil reaction, macro and micro nutrient balance) and biological properties (microbial biomass, diversity, function and soil enzymatic activities) (Parihar *et al.*, 2016; Yadav *et al.*, 2016; Ali and Singh, 1997).

Despite the fact that cowpea has a wide range of uses and constant increase in its importance as both food and cash crop in Nigeria, yields on farmers' fields have remained relatively low. Poor soil fertility, inadequate N fixation and weed infestation are often cited among the major causes of low yield (Osunde *et al.*, 2003). Yield losses caused by weeds alone in cowpea production can range from 25 % to 76 % depending on the crop cultivar, weed type and density, weed persistence, duration of weed interference, crop management practices and environment (Adigun *et al.*, 2014; Gupta *et al.*, 2016; Ugbe *et al.*, 2016; Osipitan & Dille, 2017). Although, cowpea can supply its own nitrogen biologically, but such N supply is not adequate due to low population and ineffectiveness of indigenous rhizobia. No wonder yield loss of cowpea due to nitrogen deficiency is approximately 50% (Haruna and Usman, 2013). Biological nitrogen fixation (BNF) has been found to be 3 to 4 times efficient over the N fertilizers, besides BNF offering an environmentally sound source of N to cropping systems (Ernest *et al.*, 2016). BNF can therefore be used as a good supplement reducing amount of N fertilizers used by smallholder farmers thus reducing both economic and environmental costs (Mugendi *et al.*, 2010; Ernest *et al.*, 2016). This research provides an option of BNF alone or in combination with 30kg N ha^{-1} or 900g ha^{-1} of a mixture of micronutrients (Agrolyzer) combining in an Integrated Nutrient Management (INM) manner thus giving the farmers a wider range of options. The basic concept of integrated nutrient management system is the maintenance of plant nutrients supply to achieve a given level of crop production by optimizing the benefits from all possible sources of plant nutrients in an integrated manner, appropriate to each cropping system and farming system (Mahajan and Sharma 2005) on this account, this study was undertaken to determine the effects of integrated nutrients management on weed infestation, growth and yields of the cowpea varieties in moist savanna of Nigeria.

MATERIALS AND METHODS

Study Area: Field experiment was undertaken during the cropping season of 2018 at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology, Gidan-kwano campus, Minna. Minna is located at longitude 006⁰ 27' 240''E and latitude 09⁰ 31' 735''N, at an elevation of 208m above the sea level, and has a sub-humid climate with a mean annual rainfall of 1284mm (90% of which falls between the month of June and August). The mean maximum temperature remains high throughout at about 33.5°C particularly in March and June (Ojanuga, 2006).

Soil Sampling and Analysis: Soil samples from the study area were carefully collected at different points in each plot at the depth of 0-15cm using soil auger. Twenty soil samples were collected from the field, bulked, thoroughly mixed to form a composite which was neatly packaged in a properly labeled sampling bag. In the laboratory, soil was crushed and screened to pass through a 2 mm and 0.05 mm sieve for determination of soil physical and chemical properties according to the methods described by ISRIC/FAO (2002) as follows.

Particle size analysis were determine using Bouyoucos hydrometer method. Soil pH was measured with a glass electrode pH meter in 1:2.5 soil to water ratio. Total nitrogen was determined by micro Kjeldahl method, available P was also determined from the extract using Bray P1 method. Organic carbon and organic matter were determined by Walkley – Black method. Exchangeable cations (Ca, Mg, K and Na) were extracted with neutral 1N NH_4OAC solution. Sodium and Potassium in the extract were determined using flame photometry, while calcium and magnesium were determined using Atomic Absorption Spectrophotometer. Exchangeable acidity was extracted with 1NKCl and titrated against 0.01 N NaOH. Effective cation exchangeable capacity (ECEC) was obtained by the summation of the exchangeable cations and exchangeable acidity.

Treatments and Experimental Design: The treatments consisted of five nutrients levels (control; N_1, 30kg urea; N_2, urea + micronutrient; N_3, bio-inoculant; N_4, urea + micronutrient + inoculant; N_5) and three varieties of cowpea (Kananado white; V_1, Sampea 15; V_2, and Sampea 16; V_3) which were laid out in Randomized Complete Block Design (RCBD) replicated three times in 4 m x 3 m plots. The cowpea cultivar used in this experiment, Sampea 15 and Sampea 16 were obtained from the seed production unit, Institute of Agricultural Research (IAR), samara, Zaria, Nigeria. The local check (Kananado white) that is widely cultivated in the moist savanna agro-ecology of Nigeria was obtained from Niger State Agricultural Development Program area office Maitumbi, Minna, Niger state.

Fertilizer Application: All plots received a basal dose of phosphorus (30kg ha^{-1} which is equivalent to 412.2g per plot) at the time of sowing seeds, while basal dose of urea (20kg ha^{-1} which is equivalent to 78.26g per plot) was applied at one week after sowing and immediately after thinning. At two weeks after sowing, seedlings were treated with nutrients at different combinations as earlier described. The source of nitrogen were urea and GW5 rhizobia isolate while the source of phosphorous and micronutrients were Single Supper Phosphate and Agrolyzer respectively. GW5 is a rhizobium isolate that has about 96.32% similarity with BGC8 which was originated from Bangladesh, GW5 has a percentage symbiotic effectiveness of 120% i.e., its Biological Nitrogen Fixation ability is superior to the application of urea at the rate of 100kg N ha^{-1}.

Weed and Pests Control: Plots were weeded manually by hand picking and hoeing after taking weed data at 3, 6 and 9 weeks after planting. As for the pest control, application of organophosphate insecticides commenced immediately as the plants were 4 weeks after sowing at five days interval at the rate of 1.5 litres per hectare. The active ingredients contained in the organophosphate insecticides are lambda-cyhalothrim 2.5% E.C. and dimethoate at the rate of 15g/l and 300g/l respectively.

Data Collection: Weed species were assessed at 3, 6 and 9 weeks after sowing, from $0.25m^2$ quadrat placed randomly within each plot at four different spots. Weeds observed in the quadrat were identified, cut at soil level, bulked into one sample and counted to obtain the weed density in number per meter square. Five plants were randomly selected and tagged consecutively from the net plot of each treatment plot, these five plants were used as a means of data collection for crop parameter throughout the experimental period. The growth parameters were collected on number of leaves per plant, number of branches per plant at 3, 6 and 9 weeks after sowing while yield and yield components were collected at physiological maturity when about 75% of the pods had turned brown and the leaves had senescenced. The parameters collected includes: number of pods per plant, pod length, number of seeds per pod, 100 seed weight and yield per hectare.

Shoot and Nodule Assessments: Eight plants within the two inner ridges were destructively sampled for nodulation and shoot biomass. The plant shoots were cut at soil level using a clean pair of shears. The shoots from each treatment plots were packed separately into paper envelopes, while the plant roots were carefully dug out and the soil gently washed with water from the roots over a metal sieve. Nodules were detached from the roots gently, counted and packed separately in paper envelopes per treatment plots. All the enveloped plant materials (shoots and nodules) were then taken to the laboratory, oven dried at 75°C to constant weight for 48 hours. Thereafter, the shoot and nodule dry biomass were determined and recorded.

Statistical Analysis: All the data collected and variables calculated were subjected to two-way Analysis of Variance (ANOVA) using the GLM procedure of SAS package version 9.0 (SAS Institute, 2002) and where the F-values were found to be significant, the treatment means were separated by Least Significant Difference (LSD) at 5% probability level.

RESULTS AND DISCUSSION

The physical and chemical properties of the soil of the experimental field are presented in Table 1. Compared with the established critical level of soil in the southern guinea savanna of Nigeria, the soil was revealed to be slightly acidic loam, very low in organic carbon and total nitrogen.

The available phosphorous of 6.33 mg kg^{-1} was less than the soil critical available P level of 7.0 mg kg^{-1} required for proper growth and development of cowpea (Aune and Lai, 1995). This necessitated the application of SSP fertilizer at the rate of 30kg ha^{-1} as recommended by Haruna and Usman (2013) as a basal dose for enhancing N2 fixation in cowpea. On the other hand, the low soil total nitrogen indicate the need for external N input to compliment Biological Nitrogen Fixation (BNF). Organic carbon content of the soil was low according to Esu rating (1991) and this may be due to low organic inputs. This may also be responsible for the low level of soil nutrients observed.

This is consistent with the report of Ayodele and Oso (2014) who reported that soil organic matter influenced nutrient retention and should be managed to prevent rapid depletion of soil nutrients.

Table 1: Initial physical and chemical properties of the soil in the experimental field.

Parameters	Values	Rating
Sand (g kg^{-1})	429	
Silt (g kg^{-1})	488	
Clay (g kg^{-1})	83	
Textural class	Loam	
pH (H_2O)	6.47	Slightly acidic
pH ($CaCl_2$)	5.39	Acidic
Total Nitrogen (g kg^{-1})	0.19	Medium
Available P (mg kg^{-1})	6.33	Low
Organic Carbon (g kg^{-1})	0.68	Very low
Exchangeable Bases (cmol kg^{-1})		
Ca^{2+}	1.57	Low
Mg^{2+}	0.48	Medium
K^{+}	0.10	Low
Na^{+}	0.61	High
Exchangeable Acidity (cmol kg^{-1})	0.60	
ECEC (cmol kg^{-1})	3.36	Low

Rating adopted from Esu (1991)

The effects of integrated nutrient management on weed density in the cowpea varieties was shown in Table 2. Sampea 16 produced the lowest weed infestation at 6 and 9 weeks after planting though it was not statistically different (p>0.05) from the local check (kananado white) while sampea 15 had the highest weed infestation.

Table 2: Effects of varieties and nutrient combination on the weed density among the cowpea varieties.

Treatments	3 WAS	6 WAS	9 WAS
Varieties (V)			
Kananado white	70.33[a]	57.07[b]	41.07[b]
Sampea 15	65.80[a]	69.53[a]	64.27[a]
Sampea 16	72.13[a]	54.80[b]	46.27[b]
LSD (0.05)	15.75	*	*
Nutrient Management (INM)			
Control	64.78[a]	61.11[a]	52.44[a]
Urea	65.56[a]	62.11[a]	45.33[a]
Urea + Micronutrient	68.89[a]	55.11[a]	51.78[a]
Bio-fertilizer	74.56[a]	64.11[a]	52.33[a]
Urea + Micronutrient + Bio-fertilizer	73.33[a]	59.89[a]	50.78[a]
LSD (0.05)	20.33	14.77	11.96
Interaction			
V * INM	NS	NS	NS

Means followed by the same letter down the column are not significantly different ($P > 0.05$). * significant at $P < 0.05$
WAS = Week after sowing NS = Non significant

The observed significant performance in sampea 16 and the local check (kananado white) may be due to differences in their anatomy, morphology and physiology which differentiated their ability to absorb nutrients and water from the soil and carry out effective photosynthetic process to form wider canopies compared to Sampea 15. This observation supports the report of Aaron (2009) who stated that crop varieties can vary substantially in response to weed competition, with those that form canopy earlier and provide more shading being the most competitive. On the other hand, nutrient combination had no significant effect on weed infestation across the sampling period. Similarly, the interaction between crop varieties and nutrient combination did not significantly (p>0.05) affect weed density across sampling period. This further supports the fact that with or without addition of nutrients, there will be a significant reduction of weed density by Sampea 16 and Kananado white over sampea 15. The bio-fertilizer application increased weed density more than the other combination of nutrients suggesting a synergy in the exudates released by their roots and the rhizobium in the bio-fertilizer. The control treatment representing inherent soil fertility and the presence of natural rhizobia produced the lowest weed density implying that these weeds are nutrient sensitive and may likely compete with crops for nutrients applied.

Table 3 show the effect of varieties and nutrient combination on the number of leaf, and leaf area index per cowpea plant. Leaf number was significantly affected by varieties showing that Sampea 15 and 16 were significantly different at 6 and 9 weeks respectively and were both not significantly different from kananado white

(Table 3). Leaf area index was not significantly affected by varieties showing that Sampea 15 and 16 were not significantly different from each other while Sampea 16 was not significantly different from kananado white especially at 6 and 9 WAS (Table 3).

Inoculating with GW5 (Bio-fertilizer) significantly increased leaf number and leaf area index of cowpea varieties above urea + micronutrient + bio-fertilizer combinations in particular suggesting that the three nutrient combinations, within this sampling periods depressed number of leaf, and leaf area index significantly by increasing plant height significantly. Physiologically, there is a negative correlation between plant height and leaf number, leaf area and leaf area index. The lesser the leaf number and leaf area index, the taller the plants. This is because assimilates that should have been distributed to a branch and a leaf respectively is channeled to the growth of the stem without a branch or a leaf. That may explain why pruning branches increases the height of a plant.

Shoot biomass and nodule number of cowpea plants were not significantly affected by cowpea varietal difference (Table 4) showing that these varieties were marginally different in their accumulation of dry matter. This is worrisome and tends to suggest that Sampea varieties may be crosses of kananado white or very close relative.

The shoot weights were heavier (36.4g per plant) when the cowpea plants were fertilized with 30kg N ha^{-1} of urea and significantly lowest when treated with Bio-fertilizer (21.0g per plant). This is misleading knowing that Bio-fertilizer GW5 has an SE (symbiotic effectiveness) of 120% i.e., its Biological Nitrogen Fixation ability is superior to the application of urea at the rate of 100kg N ha^{-1}. It is therefore worth noting that BNF can be affected by several factors including crop management and competitiveness of rhizobia (Peoples *et al.*, 2009). Peoples *et al.* (2009) further stated that the formation of working symbioses between legumes and rhizobia is dependent upon many factors and does not occur as a matter of chance.

Table 3: Effects of varieties and nutrient combination on the number of leaves and leaf area index of the cowpea.

Treatments	Number of leaves per plant			Leaf Area Index (LAI)		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS
Varieties (V)						
Kananado white	13^{a}	42^{ab}	66^{a}	0.143^{a}	0.024^{a}	0.026^{a}
Sampea 15	14^{a}	34^{b}	41^{b}	0.007^{c}	0.017^{b}	0.019^{b}
Sampea 16	14^{a}	43^{a}	65^{a}	0.012^{b}	0.021^{ab}	0.023^{ab}
LSD (0.05)	3.54	*	*	*	*	*
Nutrient Management (INM)						
Control	15^{a}	33^{bc}	44^{b}	0.012^{a}	0.022^{a}	0.024^{a}
Urea	14^{ab}	46^{a}	66^{a}	0.012^{a}	0.022^{a}	0.026^{a}
Urea + Micronutrient	13^{ab}	48^{a}	72^{a}	0.012^{a}	0.022^{a}	0.024^{a}
Bio-fertilizer	16^{a}	43^{ab}	64^{a}	0.012^{a}	0.022^{a}	0.025^{a}
Urea + Micronutrient + Bio-fertilizer	10^{b}	29^{c}	42^{b}	0.008^{b}	0.015^{b}	0.01^{b}
LSD (0.05)	*	*	*	*	*	*
Interaction V * INM	NS	NS	NS	NS	NS	NS

Means followed by the same letter down the column are not significantly different ($P > 0.05$).
WAS = Week after sowing NS = Non significant * significant at P< 0.05

Any soil condition that adversely affect the root of plants will adversely affect BNF. This is evident in the lowest root weight observed with inoculated plants. Fortunately, nodule weight of inoculated plants was not adversely affected and was even superior to the nodule weights of cowpea plants receiving other treatments with the exception of control. The superior nodule weight and number observed with the control plants suggest that the natural rhizobia in Gidan-kwano soil were infective and the nodule formed were probably effective. Application of urea alone at the rate of 30 kg ha^{-1} depressed nodule number. This is unexpected knowing that the recommended level for inorganic N supply to legumes is between 20kg – 30kg N ha^{-1} (Budhani *et al.,* 2018). Again, poor plot or field management might have produced an adverse effect of applied nutrients on crops. Studies have shown that in a poorly drained soil, nitrite can accumulate to toxic levels thereby inhibiting nodulation (Wanek and Arndt, 2002). Inclusion of micronutrients to urea must have improved nitrate uptake by plant roots and reduced conversion of nitrate to nitrite in a waterlogged soil or poorly drained soil. That may explain why nodules were more and heavier in plants treated with urea + micronutrients than those treated with urea alone.

Table 4: Effect of varieties and nutrient combination on Growth, Nodulation and Yield of cowpea varieties.

Treatments	DSW (g plant^{-1})	NNPP	NPPP	NSPP	DPW (t ha^{-1})	TGY (t ha^{-1})
Varieties (V)						
Kananado white	24.78^{a}	27^{a}	16^{a}	12^{a}	1.56^{a}	1.18^{a}
Sampea 15	23.81^{a}	26^{a}	15^{a}	11^{a}	1.06^{b}	0.82^{b}
Sampea 16	27.30^{a}	30^{a}	18^{a}	11^{a}	1.85^{a}	1.29^{a}
LSD (0.05)	6.03	20.39	5.64	2.99	*	*
Nutrient Management (INM)						
Control	19.09^{b}	46.89^{a}	11^{b}	11^{ab}	0.85^{c}	0.62^{c}
Urea	36.37^{a}	5.89^{b}	13^{b}	12^{ab}	1.19^{bc}	0.87^{bc}
Urea + Micronutrient	26.41^{b}	36.78^{a}	21^{a}	14^{a}	1.90^{a}	1.39^{a}
Bio-fertilizer	21.13^{b}	42.56^{a}	21^{b}	12^{ab}	1.50^{ab}	1.12^{ab}
Urea + Micronutrient + Bio-fertilizer	23.48^{b}	5.00^{c}	16^{ab}	9^{b}	2.02^{a}	1.47^{a}
LSD (0.05)	*	*	*	*	*	*
Interaction						
V * INM	NS	NS	NS	NS	NS	NS

DSW = Dry shoot weight DRW = Dry root weight DNW = Dry nodule weight NNPP = Number of nodule per plant NS = Non significant * significant at P< 0.05

All the yield components were not significantly affected by varietal difference (Table 4). Averagely, Sampea 16 recorded the highest values for the yield components even though values were not significantly different from those of other varieties. Again, this is suggesting that the varieties are marginally different and necessitates the need to verify the breeding of these varieties.

Regardless of varieties, bio-fertilizer alone (inoculation with GW5) or urea + micronutrients produced the highest pod number and pod weight per plant and also the highest seed number and total grain yield per plant. This improvement in yield and yield components by inoculation with GW5 is as a result of the effect of biological nitrogen supply on protein and carbohydrate synthensis and on general assimilate production (Rosenblueth *et al.*, 2018). Improvement in yield and yield components as a result of urea and micronutrient inclusion could be due to better translocation of the assimilates produced by 20kg N ha^{-1} urea as a result of micronutrient inclusion coupled with the role of micronutrients as anti-stress (Wernerman, 2012)

CONCLUSION

This study evaluated the performance of three cowpea varieties receiving various nutrients combinations in Minna. Results show that the Local check and Sampea 16 differed significantly (P<0.05) in their performance in terms of number of leaves, leaf area index, yield and yield components when compared to Sampea 15 that had the lowest values for all parameters assessed. This suggests that Sampea 16 and the local variety are superior to Sampea 15 and should therefore be considered as better choices in this agro-ecological zone of Nigeria. Since several researchers (Dugje *et al.*, 2009 and Okonji *et al.*, 2014) had opined that the choice of any variety suitable for an agro-ecological zone should be based on the maturity period and yield potentials, among other considerations, Sampea 16 is hereby recommended to farmers in Minna, and should be supported with either the application of 30 kg N urea to enhance growth or inoculation with rhizobium GW5 to enhance yield performance.

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