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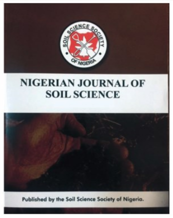

Cowpea (*Vigna unguiculata* [L] Walp) response to the application of NPK fertilizer in a Ferric Luvisol

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ABSTRACT

This study evaluated the response of cowpea to nitrogen (N), phosphorus (P), and potassium (K) fertilizer applications in a ferric luvisol of the Guinea Savanna zone of Ghana, West Africa. The treatments were arranged in a randomized complete block design with 4 replications and carried out in two seasons. Performance of Omondaw cowpea variety was evaluated at different combinations of Nitrogen (0, 10, 20 and 30 kg/ha); Phosphorus (0, 15, 30 and 45 kg/ha) and Potassium (0, 10, 20, 30 kg/ha) fertilizers making 7 treatments based on existing blanket fertilizer recommendations in the region. The fertilizer rate corresponding to 20 – 30 – 20 kg N-P_2O_5- K_2O/ha gave the highest grain yield but not significantly different from the yield obtained from the application of 20 – 45 – 20 and 30 – 45 – 30 kg N-P_2O_5- K_2O/ha. Lower application rates of 10 – 15 – 20 and 10 – 15 – 10 kg N-P_2O_5- K_2O/ha were significantly different ($P < 0.05$) from each other in 2012 cropping season but not different in 2013. The biomass yield was higher in the second year than in the first year and could be due to better rainfall at the season's onset. Fertilizer rate of 30 – 45 - 30 kg N-P_2O_5- K_2O/ha also gave the highest biomass yield while the control gave the lowest yield for the 2 years. The good fertilizer rates selected for optimal cowpea grain yield in the study area are NPK 20 - 30 - 20.

1.0. Introduction

Cowpea is widely produced in Ghana by smallholder farmers under rainfed conditions, especially in the savanna and transitional agro-ecological zones (Agyeman et al. 2014). The yields are very low ranging from 310 to 450 kg/ha (Boddey et al. 2017; Ofosu-Budu et al. 2008). Consequently, efforts have been made to increase cowpea production in Ghana through several means and the use of improved varieties as reported by (Addo-Quaye et al. 2011). These improved varieties, however, on their own cannot reach the potential yield level without appropriate soil amendments. Fosu and Tetteh (Fosu and Tetteh 2008) reported that soils of northern Ghana's savanna zones contain lower soil organic matter and nitrogen (N) than the forest zone soils and therefore need an amendment to obtain a good yield. Farmers in the study area currently use organic manure as a soil amendment; however, it's benefits have not been fully realized due to low nutrient content and the huge quantities required to meet crop nutritional needs (Ewusi-Mensah 2018). Hence, the organic amendments used by smallholder cannot compensate for nutrients removed through crop harvest (Bationo and Kumar 2002). It can also lead to a nutrient imbalance in the soil, potentially affecting crop yield. Farmers are constrained to the use of organic fertilizers due to several reasons. One of the reasons is the fear of health concern that is often associated with inorganic fertilizers and its price that is gradually getting beyond smallholder farmers' reach (Nganchamung et al. 2017; Sharma and Singhvi 2017). Unfortunately, the high cost of inorganic fertilizer fade into oblivion compared to the cost of purchase and handling (including transportation) of the actual volume of organic fertilizer that will be required to meet the nutrient requirement of cowpea in their fields.

Furthermore, the nutrient composition of organic manure will vary based on its source. Therefore, it will be difficult to rely on organic manure for now, until its production is somehow standardized. If handled with care, the health concern and fear of contamination of soil and water by inorganic fertilizer will be minimal. It can also help to increase the productivity of cowpea for smallholder farmers. This will help maintain soil organic matter and soil N by increasing below and above ground biomass due to better plant nutrition. Cowpea, compared with cereals, has received little attention from farmers in terms of fertilizer application partly due to the belief that it will fix its nutrient and the blanket fertilizer recommendation for all crops in Ghana. Food and Agriculture Organization (FAO) in conjunction with the Ghana Ministry of Food and Agriculture (MoFA) and the Council for Scientific and Industrial Research (CSIR) conducted intensive fertilizer use studies throughout Ghana from 1962 to 1969. They recommended 22 kg N, 28 – 67 kg P_2O_5 (phosphorus – P) and 22 – 45 kg K_2O/ha (potassium – K) for cowpea irrespective of location (FAO 1974). These rates were not site-specific and moreover, a lot has changed since then due to climate change. Soil conditions are also no longer the same. Hence, there was a need for site-specific fertilizer recommendation that will enhance production in the region. This could be the reason why the International Fertilizer Development Center (IFDC 2012) used nutrient removal factors to estimate fertilizer requirements for some food crops in the study area but surprisingly, cowpea was omitted from the list. This could also be due to the scarcity of data on cowpea fertilizer use in Ghana.

Cowpea has been known to react differently to fertilizer nutrients. For example, Megani and Kunchinda (Magani and Kuchinda 2009) reported a positive interaction between P fertilizer and cowpea grain yield and suggested that P fertilizer recommendation for cowpea should be location-specific. Although cowpea can fix N symbiotically, depending on fixed N may lead to short-term N deficiency during the seedling development when the cotyledonary reserve has been used up (Abayomi et al. 2008). Fening et al. (Fening et al. 2001) reported cowpea's response to increasing N fertilizer application in 20 soils sampled from 5 ecological zones of Ghana studied. This could be because N fixation was not satisfying N nutrition for optimal growth and yield of cowpea.

Hence, relying on its ability to fix N may not translate into a better yield of cowpea. It has been reported that cowpea scarcely satisfies its N requirement in poor soils. Hence, fertilization was recommended to enhance crop performance (Chiezey et al. 1990). According to (Fosu and Tetteh 2008), savanna soils of Ghana contain a high K level to support legume production. Therefore, omitting K during fertilizer application may not reduce yield immediately. However, continuous removal of K through crop harvest will eventually reduce the inherent supplies to a yield-limiting level. Potassium has been reported to be important for cowpea in dry conditions by encouraging vegetative growth and improving physiological parameters that stimulate grain yield (Abed 2017). There is therefore the need for farmers to ensure appropriate fertilization after nutrient export through crop harvest to reduce a decline in the soil nutrient pool (Hossain 2006). It was hypothesized that cowpea production will be improved using site-specific NPK fertilizer application rate. We, therefore set out to determine the effect of NPK Fertilizer application on the growth, yield, and nutrient uptake of cowpea in the guinea savanna zone of Ghana. This we hope will stimulate similar site-specific studies in other parts of the world.

2.0. Materials and Methods

2.1. Study Sites

The study was carried on a benchmark soil at Nyoli in the Wa West District of the Upper West region of Ghana, West Africa. This area is classified as part of the breadbasket region of Northern Ghana, but the soils are poor. It lies geographically between longitudes 9° 40′ and 9° 46′ N and Latitudes 2° 30′ and 2° 32′ W. The site belongs to Varempere soil series which is classified as Ferric Luvisol according to (Wrb 2014) and experiences a unimodal pattern of rainfall annually, ranging from 840 to 1400 mm.

2.2. Field experiment

Before ploughing, a composite soil sample of the experimental plot was taken and analyzed for its physical and chemical properties (Table 1). The plot size was 4 m x 6 m with a planting distance of 60 cm × 20 cm. Omondaw cowpea variety obtained at the Ministry of Food and Agriculture (MoFA) Wa regional office was used. Weed control was done by applying glyphosate followed by hand weeding with the traditional hoe at the onset of flowering. Insect pests were controlled using Sunhhalothrin 2.5% EC (25 g lambda-cyhalothrin per litre) at the commencement of flowering. Biomass yield was determined at 50% flowering while grain yield was determined at pod maturity. Fertilizer application was made at sowing as spot application using urea, triple superphosphate and muriate of potash. Seven treatments were selected based on FAO (1976) cowpea blanket fertilizer recommendation of 22 kg N, 28 – 67 kg P_2O_5 and 22 – 45 kg K_2O/ha and other studies (Abayomi et al. 2008; Chiezey et al. 1990). The treatments were as follows: N-P_2O_5-K_2O kg/ha corresponding to: T1: 0-0-0, (control), T2: 10 – 15 – 10, T3: 20 – 15 – 20, T4: 20 – 30 – 10, T5: 20 – 30 – 20, T6: 20 – 45 – 20, T7: 30 – 45 – 30.

The experimental design was a fractional factorial experiment laid out in a Randomized Complete Block Design (RCBD) with four replications giving 28 plots. The fractional factorial was used to reduce the number of treatments from all possible combinations. Only treatments of interest were selected.

2.3. Statistical analysis

To test for significant difference among treatment means, all data collected from the field experiment was analyzed with Genstat 11th edition using general linear model (GLM) analysis of variance (ANOVA) with randomized blocks procedure. Means were separated using the Least Significance Difference (LSD) at 5% level of probability. A second analysis of variance was combined for the two cropping seasons with treatments nested into the cropping seasons. The cropping season became a blocking component, while fertilizer rates remained the treatment structure. This enabled a comparison of the yield trend among the 2 cropping seasons.

2.4. Laboratory analysis

Soil pH was determined using glass electrode pH meter in a 1:1 soil to distilled water (soil: water) ratio, available P by the Bray and Kurtz (Bray P-1) method (Bray and Kurtz 1945) while the modified Walkley and Black procedure as described by Nelson and Sommers (Nelson and Sommers 1996) was used to determine organic carbon. Total nitrogen was determined using the macro Kjeldahl method (Miller and Houghton 1945), and 1.0 *N* ammonium acetate (NH_4OAc) extract was used for exchangeable bases. Exchangeable acidity (hydrogen and aluminium) was determined in 1.0 *N* potassium chloride (KCl) extract (Page 1965). Exchangeable bases were extracted using 1.0 N ammonium acetate (NH4OAc) extract. Potassium and sodium in the soil extract were determined by flame photometry while calcium and magnesium were read on Atomic Absorption Spectrophotometer. The sum of exchangeable bases calculated effective cation exchange capacity (Ca, Mg, K, and Na) and exchangeable acidity (Al and H). The Bouyoucos hydrometer method (Bouyoucos 1962) was used for particle size distribution.

3.0. Results

3.1. Physical and Chemical Properties of the experimental sites

The initial physical and chemical properties of the experimental sites are presented in Table 1. The soils were sandy loam in texture with a pH value that is near neutral. The total N value was low (N < 0.10%) while the P-value was moderate (P = 16.80 mg/kg. The values were rated according to the ratings of (Landon 2014).

Table.1 Initial soil physical and chemical properties of the experimental site

Soil parameter	**Value**
Sand (%)	60.00
Silt (%)	38.00
Clay (%)	2.00
pH (1:1 H_2O)	6.52
Organic carbon (%)	0.90
Total nitrogen (%)	0.08
Available P (mg/kg)	16.98
Exchangeable cations (cmol$_+$ /kg)	
Ca^{2+}	9.00
Mg^{2+}	3.60
K^{2+}	0.23
Na^{2+}	0.18
Total exchangeable bases	12.90
Al^{3+}	1.60
H^+	1.20
ECEC	15.70

Ca^{2+}, Mg^{2+}, K^{2+}, Na^{2+}, Al^{3+} and H^+ refer to Calcium, Magnesium, Potassium, Sodium, Aluminium and Hydrogen ions respectively; ECEC is the Effective Cation Exchange Capacity while pH is a scale of acidity from 0 to 14.

3.2. Effect of fertilizer treatments on cowpea grain yield

Effect of fertilizer rates on cowpea grain yield in 2012 and 2013 cropping season and effects of cropping season (2012 and 2013) on the response of cowpea grain yield to all fertilizer rates at Nyoli are presented in Tables 2 and 3, respectively. As expected, the yield response showed a similar trend in the 2 cropping seasons of study as all the treatments gave higher grain yield than the control for both seasons. The highest grain yield was recorded by fertilizer application rate of 20 – 30 – 20 kg N - P_2O_5 - K_2O/ha in both cropping seasons. The grain yield was 112.35% more than the control in the first year and 129.49% in the second year. Lower fertilizer application rates of 10 – 15 – 10 kg N-P_2O_5- K_2O/ha gave a grain yield of 1.05 and 1.27 tons/ha in 2012 and 2013 seasons. There was no significant increase in grain yield with P's increased application from 30 to 45 kg P_2O_5/ha. N - P_2O_5 - K_2O application rate of 20 – 15 – 20 and 20 – 30 – 10 gave grain yields of 1.35 and 1.65 tons/ha in the first year and 1.30 and 1.43 tons/ha respectively in the second year. Increasing N, P and K application in treatment 30 – 45 – 30 kg N-P_2O_5- K_2O/ha gave a rain yield of 1.54 and 1.58 tons/ha in 2012 and

Table 2. Effect of fertilizer rates on cowpea grain yield in 2012 and 2013 cropping season.

Fertilizer rates (N-P_2O_5- K_2O, kg/ha)	**2012 (tons/ha)**	**Increase over control (%)**	**2013 (tons/ha)**	**Increase over control (%)**
0 - 0 - 0	0.81a	-	0.78a	-
10 – 15 – 10	1.05b	29.63	1.27b	62.82
20 – 15 – 20	1.35bc	66.67	1.30b	66.67
20 – 30 – 10	1.65cd	103.70	1.43bc	83.33
20 – 30 – 20	1.72cd	112.35	1.79d	129.49
20 – 45 – 20	1.70cd	80.25	1.76d	125.64
30 – 45 - 30	1.54cd	90.12	1.58cd	102.56
F.pr	<0.001**		0.001**	

Data represent the mean of each of the treatments. Data designated with the same letter(s) are not significantly ($P < 0.05$) different according to Fisher's least significant difference method. F.pr – F probability, **highly significant at 5%.

Table 3. Effects of cropping season (2012 and 2013) on the response of cowpea grain yield to fertilizer rates at Nyoli

Season	**Grain yield**
2012	1.37a
2013	1.33a
Fpr	0.51ns

Data represent the grand mean of all the treatments. Data designated with the same letter(s) are not significantly ($P < 0.05$) different according to Fisher's least significant difference method. F.pr – F probability, ns – not significant at 5%.

2013, respectively.

Comparing the grain yield obtained for both two cropping seasons, there was no significant difference (F.pr = 0.51) on how cowpea responded to fertilizer application rates in 2012 and 2013 (Table 3).

3.3. Effect of fertilizer treatments on cowpea biomass yield

Fertilizer treatments in both cropping seasons increased biomass yield. The biomass yield was higher in the second year than in the first year (Table 4). The highest biomass yield was obtained from 30-45-30 kg N-P_2O_5- K_2O/ha while the control gave the lowest yield for the 2 years. The fertilizer application rate of 20 – 30 – 20 kg N-P_2O_5- K_2O/ha gave a biomass yield of 2.41 tons/ha which was not significantly different from the biomass yield of 2.50 tons/ha obtained from 20 – 45 – 20 kg N-P_2O_5- K_2O/ha in 2012 cropping season. In 2013 cropping season, same treatments gave a biomass yield of 3.89 and 4.06 tons/ha which were comparable. Low fertilizer application in treatment 10 – 15 – 10 kg N-P_2O_5- K_2O/ha gave a biomass yield of 2 tons/ha which compared to 1.62 tons/ha obtained from the control.

Table 4. Effect of fertilizer rates on cowpea biomass yield in 2012 and 2013 cropping season.

Treatment	**2012 (tons/ha)**	**Increase over control (%)**	**2013 (tons/ha)**	**Increase over control (%)**
0 - 0 - 0	1.62a	-	2.55a	-
10 – 15 – 10	2.00ab	23.46	3.52b	38.04
20 – 15 – 20	2.13b	31.48	3.64bc	42.75
20 – 30 – 10	2.24bc	38.27	3.74cd	46.67
20 – 30 – 20	2.41bc	48.76	3.89de	52.55
20 – 45 – 20	2.50bc	54.32	4.06ef	59.22
30 – 45 - 30	2.68c	65.43	4.21f	65.10
Fpr	0.008**		<.001**	

Data represent the mean of each of the treatments. Data designated with the same letter(s) are not significantly ($P < 0.05$) different according to Fisher's least significant difference method. F.pr – F probability, **highly significant at 5%.

However, in 2013, it gave a biomass yield of 3.52 tons/ha, which differed significantly from 2.55 tons/ha obtained from the control. Comparing biomass yield across the 2 cropping seasons (Table 5) showed that cowpea responded differently in both seasons ($P < 0.01$).

Table 5. Effects of cropping season (2012 and 2013) on cowpea biomass response yield to fertilizer rates at Nyoli.

Season	**Biomass yield**
2012	2.23a
2013	3.66b
Fpr	<0.001**

Data represent the grand mean of all the treatments for each season. Data designated with a different letter(s) are significantly ($P < 0.05$) different according to Fisher's least significant difference method. F.pr – F probability, **highly significant at 5%.

3.4. Effect of fertilizer treatments on cowpea grain and biomass nutrient uptake

The N, P and K content dry grain and biomass of cowpea for the 2 cropping seasons are presented in figure 1 - 4. The biomass N, P and k uptake among all the treatments did not differ significantly ($P > 0.05$) across the two cropping seasons. For each of the year, the quantity of grain N and K uptake (Figure 1 and 3) were significantly different among the treatments ($P < 0.05$). Grain N uptake ranged from 3.07 to 6.42 and 2.82 to 6.33 for 2012 and 2013, respectively. The quantity of grain K (Figure 1 and 3) uptake ranged from 1.54 to 3.27 and 1.87 to 4.22 kg/ha for 2012 and 2013, respectively. Across the cropping season, grain P uptake did not differ significantly ($P > 0.05$). The values ranged from 0.39 to 0.71 and 0.22 to 0.60 for both cropping seasons. The lowest grain uptake was obtained from the control while treatment 30 – 45 – 30 (N-P_2O_5- K_2O/ha) gave the highest quantity of nutrient uptake for all the nutrients.

Comparing the two cropping seasons, the biomass N, P and K uptake followed the same trend for all the treatments summarized in Table 6. Hence the seasons had no significant effect on the pattern of nutrient uptake in the

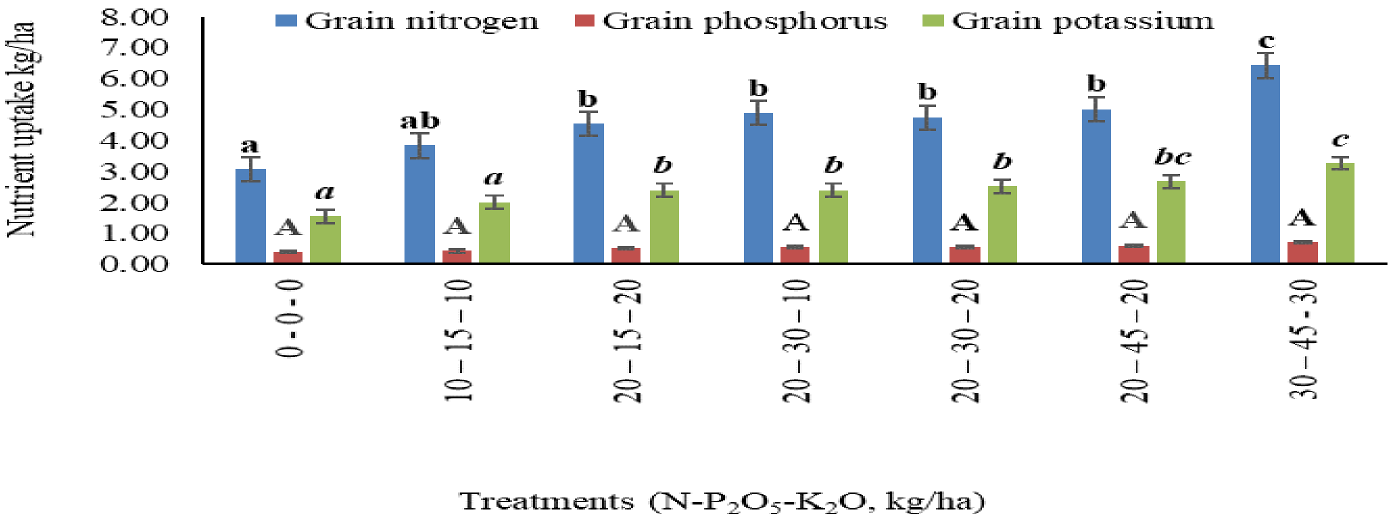

Figure 1. Grain nitrogen, phosphorus and potassium uptake as influenced by fertilizer treatments in 2012 cropping season. Error bars denote the standard error of the mean). Bars designated with the same letter(s) are not significantly ($P < 0.05$) different according to Fisher's least significant difference method.

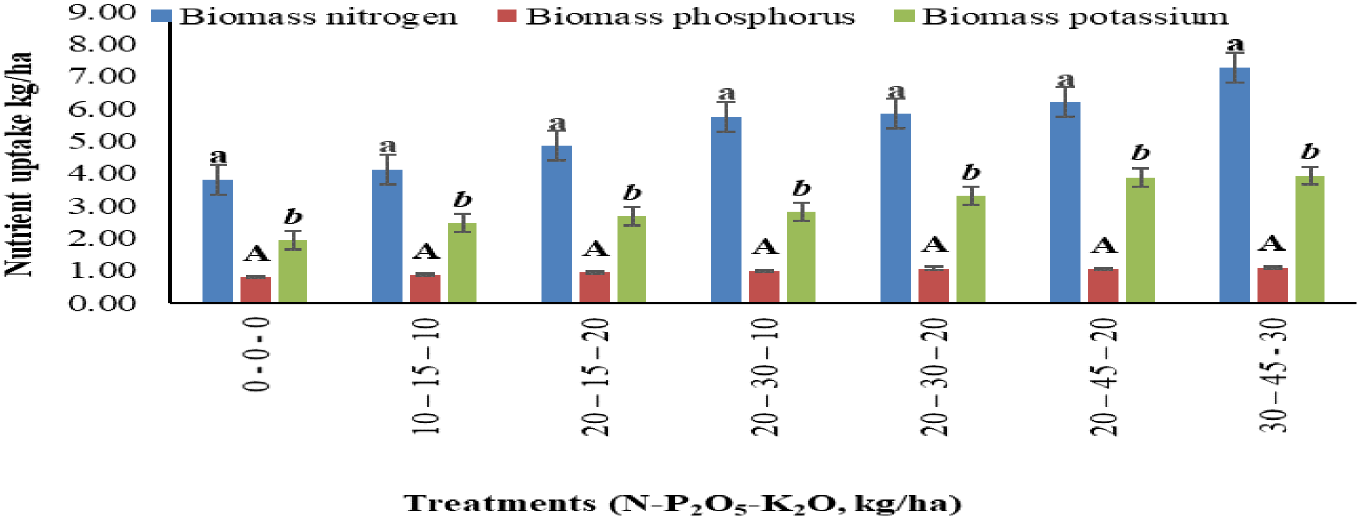

Figure 2. Biomass nitrogen, phosphorus and potassium uptake as influenced by fertilizer treatments in 2012 cropping season. Error bars denote the standard error of the mean). Bars designated with the same letter are not significantly ($P < 0.05$) different according to Fisher's least significant difference method.

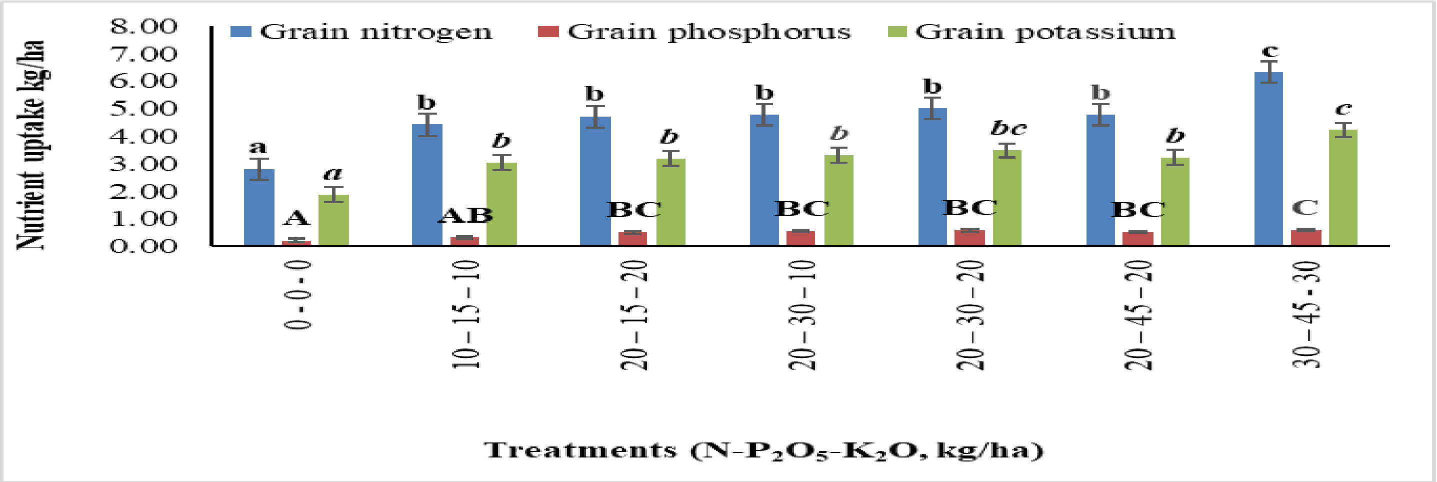

Figure 3. Grain nitrogen, phosphorus and potassium uptake as influenced by fertilizer treatments in 2013 cropping season. Error bars denote the standard error of the mean). Bars designated with the same letter(s) are not significantly ($P < 0.05$) different according to Fisher's least significant difference method.

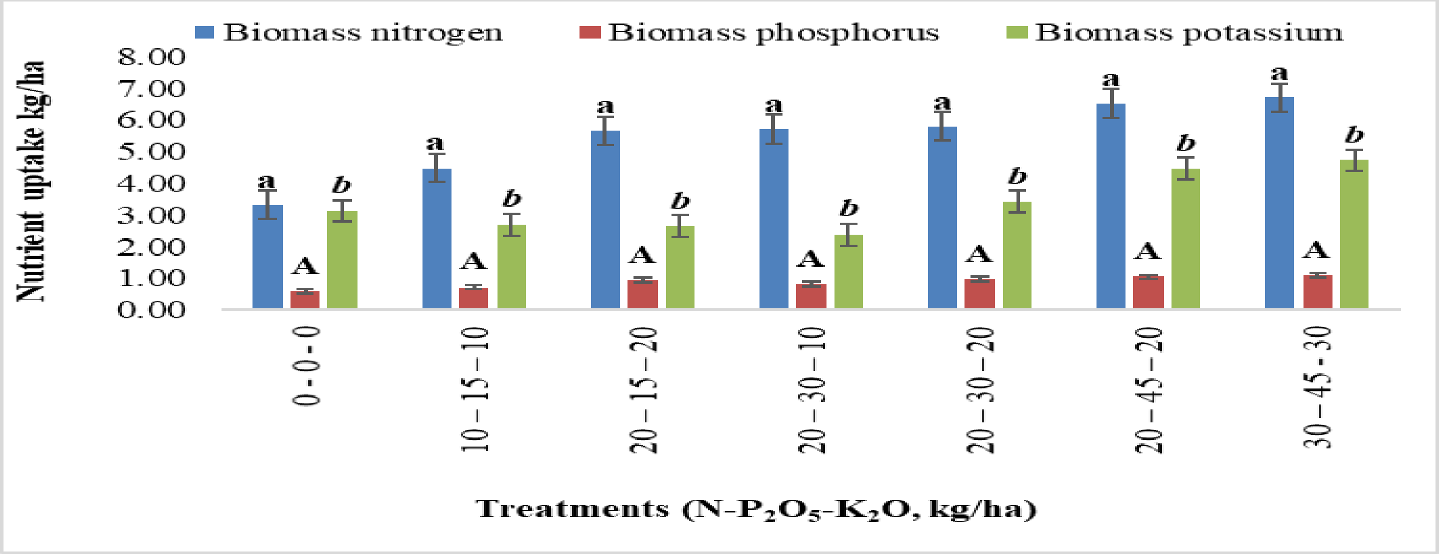

Figure 4. Biomass nitrogen, phosphorus and potassium uptake as influenced by fertilizer treatments in 2013 cropping season. Error bars denote the standard error of the mean. According to Fisher's least significant difference method, bars designated with the same letter are not significantly ($P < 0.05$) different.

Table 6. Effects of cropping season (2012 and 2013) on the nutrient uptake of cowpea biomass and grain to fertilizer rates at Nyoli.

Cropping Season	**Biomass N uptake**	**Biomass P uptake**	**Biomass K uptake**	**Grain N uptake**	**Grain P uptake**	**Grain K uptake**
2012	5.42a	0.98a	3.01a	4.46a	0.52a	2.32a
2013	5.45a	0.98a	3.35a	4.84a	0.51a	3.20b
Fpr	0.95ns	0.96ns	0.44ns	0.845ns	0.28ns	<0.001**

F.pr – F probability, ** - highly significant at 5%, ns – not significant at 5%, data designated with the same letter(s) are not significantly ($P < 0.05$) different according to Fisher's least significant difference method.

biomass. The grain N and P uptake followed the same trend while grain K uptake differed significantly across the two seasons.

Table 7. Selected soil chemical properties as affected by Fertilizer rates after cowpea harvest.

Treatment	**N**	**P**	**K**	**Ca**	**Mg**	**Na**
	%	(mg/kg)		Cmol/kg		
0 - 0 - 0	0.05a	1.21a	0.09a	3.25a	1.35a	0.08b
10 – 15 – 10	0.06a	2.71a	0.21ab	4.00b	1.56ab	0.09b
20 – 15 – 20	0.06a	2.52a	0.17ab	4.15bc	1.35a	0.09b
20 – 30 – 10	0.06a	2.99a	0.21b	4.30bc	1.75bc	0.05b
20 – 30 – 20	0.07a	2.15a	0.39c	4.50bc	1.70bc	0.10b
20 – 45 – 20	0.07a	2.30a	0.20ab	4.20bc	1.70bc	0.07b
30 – 45 - 30	0.06a	3.38a	0.25b	4.60c	1.80c	0.12b
F.pr	0.40ns	0.07ns	0.004**	<0.001**	0.001**	<0.001**

F.pr – F probability, **highly significant at 5%, ns – not significant at 5. Data designated with the same letter(s) are not significantly ($P < 0.05$) different according to Fisher's least significant difference method.

3.5. Soil Chemical Properties

The soil's selected chemical properties at the end of the field study (Table 7) indicated that Total N content ranged from 0.5 to 0.7(%) whilst available P dropped from the initial level of 16.98 mg/kg under all fertilizer application rates. Soil available P contents were higher in all the fertilizer treatments than the control.

However, there were significant differences among the exchangeable cations. Exchangeable K, Ca, Mg and Na ranged 0.09 to 0.39 cmol/kg, 3.25 to 4.60 cmol/kg, 1.35 to 1.8 cmol/kg and 0.08 to 0.12 cmol/kg respectively.

4.0. Discussion

4.1. Effect of fertilizer treatments on cowpea grain yield

Cowpea can obtain its nitrogen requirement by fixing atmospheric nitrogen, but nitrogen fertilizer, especially in deficient soils is vital for growth and grain yield (Abayomi et al. 2008). Under the two cropping seasons (2012 and 2013), fertilizer rates significantly increased cowpea grain yield. The grain yield response to fertilizer application showed a similar trend in both cropping seasons (Table 3) against the report of (Fosu et al. 2012) that crop response to N is rarely the same from year to year because it is dynamic and mobile. Abayomi et al. (Abayomi et al. 2008) reported the same trend in grain yield of cowpea over 3 years (2002, 2003, and 2004) in the report of a study conducted in Southern Guinea Savanna zone of Nigeria. The consistency in yield may be attributed to the fact that cowpea's nutrient requirement was the same for both years. There was no added benefit of applying phosphorus beyond 30 kg/ha. Phosphorus stimulates the formation, growth and function of root nodules (Waluyo and Lie 2016) and rhizobial strains' growth (Abbasi et al. 2010). Our results agree with the report that phosphorus is essential for cowpea production (Daramy et al. 2016; Oladiran et al. 2012). This response to P_2O_5 is similar to the observation of (Giller et al. 1997) that increase in P fertilizer application up to 30 kg P_2O_5/ha increased cowpea grain yield beyond yield reduction. Yakubu(Yakubu et al. 2010) however reported that addition of 40 kg P_2O_5 produced the highest cowpea grain yield in southern Guinea savanna and Sudano - Sahelian zones of Nigeria. Giller (Giller et al. 1997) earlier in 1997 stated that soil P replacement should be accompanied by Soil N replacement to maintain crop production sustainably. Similarly, the increase in grain yield obtained with the increase of K_2O application rate from 10 to 20 kg/ha agreed with the report of (Oliveira 2009) that obtained the best response of cowpea grain yield with the application of 20 and 40 K_2O kg/ha. It has been argued that soils of the savanna zones of Ghana has the capacity of supply sufficient K for plant growth (Buah et al. 2012). However, there have been reported increase in yield of legumes in response to K fertilizer application (Abdul Rahman et al. 2018; Emmanuel et al. 2020; Kanton et al. 2017). Potassium could have contributed to better nutrition of cowpea in the area. Potassium enhances the activity of glutamine synthetase an enzyme found in the nodules that plays a key role in N metabolism (Duke and Collins 2015)

4.2. Effect of fertilizer treatments on cowpea biomass yield

This research underscores the assertion that applying N fertilizer may be required for increased cowpea biomass production. (Bationo and Kumar 2002) reported that the application of fertilizers can triple cowpea biomass production. Also, (Azarpour et al. 2011) emphasized the contribution of applied N to cowpea biomass growth even though it can fix N. Bationo and Ntare (Bationo and Ntare 2000) reported an increase in cowpea biomass with N application up to 45 kg/ha. Even though cowpea biomass forms part of the crop residues that are usually incorporated into the soil the following cropping season, application of N must be at the recommended rate to avoid high biomass production at the expense of grain yield which is of more interest to farmers in the study area. Farmers in this area use blanket fertilizer recommendation mostly urea. This has led to low returns on investment due to the low yield obtained. The low yield could be attributed to the unbalance nutrient supply to cowpea. The increase in biomass due to increasing P application from 15 kg/ha to 45 kg/ha could be linked to the report (Sinclair and Vadez 2002) which stated that phosphorus deficiency resulted in stunted shoot and root growth due to reduced cell division and enlargement. Potassium also enhanced cowpea's biomass accumulation as was observed with an increase from 10 to 20 kg/ha. Ayodele and Oso (Ayodele and Oso 2014) also reported that P fertilizer increased vegetative growth of cowpea when applied with basal N and K_2O than P alone. The higher biomass yield obtained in the second cropping season could be due to better rainfall at the onset of the 2013 season.

4.3. Effect of fertilizer treatments on cowpea nutrient uptake

The plant N concentration in response to increased soil P supply was observed in 20-30-20, 20-45-20 and 30-45-30 kg/ha N, P2O5, and K_2O. This agrees with Sanginga et al. 2000) report where P might have played some roles in increasing the mobility of N-ion in plant tissue. There is, however, the need to confirm this in independent research. Sanginga et al. (Sanginga et al. 2000) also reported a significant increase in total P accumulation by cowpea when 20 kg P/ha was applied. Since N and P accumulations are vital in achieving optimum crop yields, it could be responsible for the inherent ability of crops nutrient uptake systems. This system ensures the effective recovery of available soil N and P through natural selection or breeders selection (Sinclair and Vadez 2002). Optimum yields may not be attained without significant amounts of N and P in the crop. Abdel-Salam and Salem (Abdel-Salam and Salem 2012) reported that uptake of N increased with the increasing potassium rate and concluded that a balanced combination of K and N is a necessary positive response to K application. The uptake of K by the grain should not be a source of worry as it has many beneficial biochemical functions such as for stability, proper folding and functioning of RNA and proteins (Graciano et al. 2006).

4.4. Effect of fertilizer treatments on soil nutrient after the experiment

The fertilizer treatments did not significantly alter soil N and P; hence the fear of soil and water contamination due to nitrogen fertilizer application could be allayed. The initial high-level P (Table 1) value for the soil could be attributed to the spatial variation of soil properties common in smallholder farms. However, the inconsistency in the initial soil P level and final soil P level further confirms the submission of (Mandal et al. 2007) that a long-term experiment is needed to explain soil nutrient dynamics for sustainable production for soil fertility management. Application of fertilizer based on crop need and at recommended rate maintains soil health rather than hurting the soil (Singh 2018).

5.0. Conclusions

Findings from this research work indicated an increase in the grain yield of cowpea following NPK fertilizer application. The fertilizer rate corresponding to 20 – 30 – 20 kg N-P_2O_5- K_2O/ha gave the highest grain yield while fertilizer rate 30 – 45 – 30 kg N-P_2O_5- K_2O/ha gave the highest biomass yield. N's application should be accompanied by applying a commensurate dose of P and K to avoid nutrient deficiency through crop removal in the long run. It will also ensure a balanced uptake of nutrients by the plant. Since high grain yield the principal motivation for cowpea production in this area, the excellent fertilizer rates selected for optimal cowpea yield were 20 – 30 – 20 kg N-P_2O_5-K_2O/ha in the study area. We recommend that the study be replicated on other benchmark soils within the agro-ecological zones to capture variability in the soil. Although this research was conducted in Ghana, West Africa, the results can be applied in other regions with similar weather and soil characteristics.

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