Journal of Experimental Biology and Agricultural Sciences

<http://www.jebas.org>

ISSN No. 2320 – 8694

EFFECT OF NITROGEN AND PHOSPHORUS FERTILIZER APPLICATION ON GROWTH AND YIELD PERFORMANCE OF COWPEA IN GHANA

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Received – November 15, 2016; Revision – December 02, 2016; Accepted – February 24, 2017

Available Online – February 28, 2017

DOI: [http://dx.doi.org/10.18006/2017.5\(1\).038.044](http://dx.doi.org/10.18006/2017.5(1).038.044)

KEYWORDS

Cowpea

Growth

Yield

Nitrogen

Phosphorus

Fertilizer

ABSTRACT

The aim of the study was to evaluate the effect of different rates of nitrogen (0, 10, 20, 30 and 40 kg N/ha) and phosphorus (0, 15, 30 and 45 kg P₂O₅/ha) fertilizers application on growth and yield performance of cowpea (variety Asontem). A factorial experiment was conducted in randomized complete block design with three replicates at the plantation site of Department of Crop and Soil Sciences, Kwame Nkrumah University of Science and Technology, Ghana in the major cropping season of 2014. No significant effect of N and P fertilizer application on cowpea growth and yield was reported in present study. It is thus recommended that there is no need to apply N to cowpea planted in the same fertility status fields as in the present experimental site. Further studies required to be conducted with higher P rates.

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Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

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1 Introduction

Cowpea (*Vigna unguiculata* L. Walp.) is one of the important grain legumes in the world and is playing an important role in the livelihood of millions of people in developing countries (FAO, 2002; El Naim & Jabereldar, 2010). Cowpea has various uses and it is consumed as grain, leaf and forage, with high nutritive value and high palatability (Whitebread & Lawrence, 2006). As a result of its ability to fix atmospheric nitrogen, it is known for improving soil fertility (Abayomi et al., 2008). As per the report of MoFA- SRID, (2012) average yield of cowpea is low about 700 kg/ha in Ghana. According to Haruna et al. (2011) among the factors responsible for the low yields of cowpea in tropical Africa, poor soil fertility and low application of external inputs are the most important once and tropical African soils are low in nitrogen and phosphorus.

Despite low soil fertility, the application of mineral fertilizer to cowpea in tropical Africa is not common due to several socio-economic constraints such as the poor financial status of farmers (Partey & Thevathasan, 2013). Further, since the crop has the ability to fix atmospheric nitrogen with rhizobia, inorganic fertilizer application is considered not much important (Kan` ankuk'a, 1999). Regardless of this N fixing ability, a positive response of cowpea to the application of organic and inorganic fertilizer has been reported by several authors from various cowpea grown areas (Madukwe et al., 2008; Singh et al., 2011a) especially they used nitrogen (Amujoyegbe & Alofe, 2003; Singh et al., 2007; Daramy et al., 2016) and phosphorus (Owolade et al., 2006; Singh et al., 2011a; Nkaa et al., 2014) fertilizers.

In view of this, it is worthwhile to apply mineral fertilizer to cowpea, particularly N and P which are very important nutrients but highly deficient in tropical African soils. However, this requires trials to understand the response of cowpea to the application of N and P fertilizer. Therefore, this study was conducted to evaluate the effect of N and P fertilizers application on the growth and yield of cowpea in the semi- deciduous forest zone of Ghana.

2 Materials and Methods

2.1 Experimental site

A field study was conducted during the major cropping season of 2014 at the Plantation Section of the Crop and Soil Sciences Department, Kwame Nkrumah University of Science and Technology, Kumasi in the semi-deciduous forest vegetation zone (Altitude 356 m, latitude 06° 43'N and longitude 01° 33'W). Rainfall is bimodal (major rainy season from mid-March to July and minor rainy season from September to November) with an average annual rainfall of 1422.4 mm. The weather condition during the experiment is presented in Table 1.

Table 1 Study area weather condition during the study period.

Parameters	Weather conditions
Mean daily maximum temperature (°C)	29.01
Mean daily minimum temperature (°C)	21.32
Rainfall (mm)	466.55
Relative humidity (%)	77.84 (09 hours GMT) - 51.34 (15 hours GMT)

Metrological Department, KNUST, 2014

2.2 Physical and chemical soil analysis

The soil of the experimental area belongs to the Kumasi series - Ferric Acrisol (Asiamah, 1998), with a sandy loam texture (Table 2). For soil analysis, soil samples were taken at 0-15 cm and 15-30 cm depth from the experimental site and analyzed for their physical and chemical properties. Samples were air-dried under laboratory conditions, after drying soil were sieved with a 2 mm mesh sieve before being analyzed. Soil pH were analyzed by using 1:2.5 soil: water suspension using a glass Electrocalomel electrode pH meter (McLean, 1962) while the soil organic carbon were analyzed by using Walkley-Black wet combustion procedure (Nelson & Sommers, 1982) and the estimation of organic matter was carried out by multiplying the organic carbon content with 1.724 (The Van Bemmelen factor). Further, total nitrogen using the Macro Kjeldahl method described by Bremmer & Mulvaney (1982); phosphorus by using the Bray-1 test method with dilute acid fluoride as the extractant (Jackson, 1967); exchangeable base cations which were extracted using ammonium acetate at pH of 7.0, calcium and magnesium- Ethylene Diamine Tetraacetic Acid (EDTA) titration method (Heald, 1965); potassium and sodium by using the flame photometer method and particle size- hydrometer method (Bouyoucos, 1962).

2.3 Experimental setup and management

The land was cleared, ploughed and harrowed with a tractor and leveled manually with a hoe. The experiment was laid out in Randomized Complete Block Design, consisted of 60 plots of size 4.1m × 1.9m in three replications. 1m alley was left between each replication and the plots were separated by a 0.5m alley. Factorial combination of the treatments; (i) 0, 10, 20, 30 and 40 kg N/ha and (ii) 0, 15, 30 and 45 kg P₂O₅/ha was done. On 17 June 2014, three cowpea seeds were sown per hill at a spacing of 60 cm between rows and 20 cm between hills. The plants were thinned to 2 per hill 14 days after planting (DAP) and it was followed by the application of fertilizer by side band placement. Plots were weeded with a hoe at 13 and 35 DAP.

For management of insect pest especially grass hoppers population Lambda master 2.5% E.C (Lambda-Cyhalothrin, 9.8%) was used. This was sprayed by knapsack sprayer (100ml in 15 liters water) at the interval of each 10 days. Further, at flowering stage, aphids were controlled with spraying sunpyrifos 48 % E.C. (Chlorpyrifos-methyl) at a rate of 50ml to 15 liters water at 7 days interval.

2.4 Data collection

2.4.1 Growth data collection

Five consecutive plants per plot were tagged for the collection of growth data related to plant height, number of leaves, number of branches, shoot dry matters and stem girth. Among these numbers related data were collected manually and mean of obtained number were used while in case of stem girth, data was collected by venire calipers at 2cm above the ground. All the above said data were collected at the intervals of 2 weeks and collected up to 6 weeks of fertilizer application.

For the estimation of shoot dry matter data, five plants per plot at 2 and 4 weeks after fertilizer application were uprooted and their root system were removed and placed in labeled envelopes. In the laboratory, they were oven-dried at 80°C for 48 hours and then weighed. The average biomass dry weight was calculated.

2.4.2 Yield data

Various yield related data such as number of pods per plant; number of seeds per pod, weight of Hundred seeds, pod yield per hectare, seed yield per hectare and harvesting index was estimated in present study.

2.4.2.1 Pod number/plant: Pods from five border row plants were harvested, counted and average recorded.

2.4.2.2 Seeds per pod: Five random plants were selected and their pods were threshed, cleaned seeds counted and mean recorded for each plot.

2.4.2.3 Weight of hundred seeds: this was determined by counting 100 seeds for each plot and weighed using an electronic balance.

2.4.2.4 Harvesting index: the harvesting index was estimated by the formula given by Donald (1963) as indicated below.

Harvest index = Economic yield

$$\div \text{Total biological yield (above} \\ - \text{ground parts)} \times 100$$

Here, Economic yield = grain yield; Total biological yield= grain yield+ total above biomass+ pod chaff

2.4.2.5 Pod yield per hectare: Pods from the net plot area of size 1.44m² were harvested, placed in labeled envelopes and oven-dried at 80° C for 48 hours. The weight of the dried pods was extrapolated for Pod yield per hectare (kg/ha).

2.4.2.6 Seed yield per hectare: The weight of oven-dried (80° C for 48 hours) seed from the net plot area of 1.44m² was extrapolated for seed yield per hectare (kg/ha).

2.5 Data Analysis

The data were subjected to Analysis of variance (ANOVA) and least significant difference (LSD) was used to test the significance of differences between means at 5 % probability level using GENSTAT 12th edition.

3 Results

Results of Initial soil analysis have been shown in Table 2; these results revealed that soil of the experimental site have low nitrogen, phosphorus and organic matter and have sandy loam texture along with slightly acidic properties.

Table 2 Physicochemical properties of the study area soil during study period.

Characteristics	Depth (cm)	
	0-15	15-30
pH	5.57	5.50
Total nitrogen (%)	0.15	0.12
Available phosphorus (mg/kg)	5.65	5.22
Organic carbon (%)	0.72	0.50
Organic matter (%)	1.24	0.86
Exchangeable bases (cmol kg ⁻¹)		
Potassium	0.16	0.09
Calcium	2.00	2.80
Sodium	0.38	0.37
Magnesium	1.00	0.80
Sand (%)	84.30	80.90
Silt (%)	3.90	4.07
Clay (%)	11.80	15.03
Soil texture	Sandy loam	Sandy loam

3.1 Growth parameters

Results related to the effect of fertilizers doses on growth parameters have been represented in Table 3. These results clearly indicated that application of N and P did not have any significant ($P > 0.05$) effect on the cowpea growth. However, the 40 kg N/ha mostly shows superiority over all the other tested N doses while the least one was reported from the 10 kg N/ha.

Table 3 Effects of N and P fertilizer application on growth parameters of cowpea.

Treatments	Plant height (cm)			Number of leaves/plant			Number of branches/plant			Stem girth (cm)		
	2 WAFA ¹	4 WAFA	6 WAFA	2 WAFA	4 WAFA	6 WAFA	2 WAFA	4 WAFA	6 WAFA	2 WAFA	4 WAFA	6 WAFA
N rates (kg N/ha)												
0	20.17	151.30	181.90	9.20	23.77	34.73	1.850	3.967	7.920	0.328	0.538	0.823
10	19.97	144.70	183.10	8.80	21.52	35.60	1.870	3.967	7.400	0.313	0.553	0.865
20	19.43	143.90	173.30	9.15	21.22	34.25	1.570	3.900	7.530	0.305	0.563	0.827
30	20.77	157.40	172.60	8.95	24.27	36.83	1.800	4.000	7.730	0.328	0.635	0.885
40	21.35	155.70	184.00	9.15	23.12	36.93	2.080	3.983	7.970	0.335	0.567	0.888
LSD (5%)	NS ²	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SED	1.04	7.19	4.89	0.61	1.96	1.50	0.33	0.26	0.37	0.02	0.05	0.02
P rates (kg P ₂ O ₅ /ha)												
0	20.57	149.80	171.40	8.81	21.79	35.33	1.650	3.960	7.790	0.319	0.549	0.868
15	20.40	148.70	182.40	9.16	22.13	35.41	1.830	3.907	7.330	0.332	0.579	0.871
30	20.52	153.80	182.30	9.29	24.15	34.56	1.960	3.840	7.510	0.321	0.605	0.827
45	19.86	150.10	179.90	8.93	23.04	37.37	1.890	4.147	8.210	0.316	0.552	0.865
LSD (5%)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
SED	0.93	6.43	4.37	0.55	1.75	1.34	0.29	0.23	0.33	0.02	0.04	0.02
N×P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	12.5	11.7	6.7	16.6	21.1	10.3	43.9	16.1	11.6	18.9	19.9	7.1

1. WAFA = weeks after fertilizer application; 2. NS = not significant at $P < 0.05$.

3.2 Shoot Dry Matter

Like growth parameters, application of Nitrogen and phosphorus fertilizers had no significant effect ($p > 0.05$) on shoot dry matter yield (Table 4). Here also highest shoot dry matter was reported from the highest doses of N and P fertilizers while the least was reported from the lowest doses.

Table 4 Effect of N and P fertilizer application of Shoot Dry Matter Yield.

Shoot dry matter		
Treatments	2 WAFA	4 WAFA
N Rates (kg/ha)		
0	2.84	10.75
10	2.43	11.18
20	2.73	10.63
30	2.73	12.87
40	2.88	12.20
LSD (5%)	NS	NS
SED	0.29	1.45
P rates (kg P ₂ O ₅ /ha)		
0	2.77	10.65
15	2.65	11.62
30	2.73	11.70
45	2.73	12.13
LSD (5%)	NS	NS
SED	0.26	1.30
N×P	NS	NS
CV (%)	26.4	30.8

WAFA= Weeks after fertilizer application; NS= not significant at $P < 0.05$

3.3 Yield components and yield

Results presented in Table 5 revealed that application of nitrogen and phosphorus did not have any significant ($P > 0.05$) effect on the grain yield and other yield component of cowpea and it was reported highest in the control which was followed by the highest dose of N and P fertilizers.

4 Discussions

4.1 Effect of N and P fertilizer application on growth and dry matter yield of cowpea

The non significant effect of nitrogen fertilizer application on cowpea growth and dry matter yield suggested that the nitrogen requirement of cowpea for growth can be met by its own nitrogen fixation ability (Singh, 1997); hence cowpea could manage its nitrogen requirement without nitrogen fertilization (Smith et al., 1986). Another possible explanation in this study might be that the initial available N in the soil was sufficient for the growth of cowpea. This result contradicts those of Dart et al. (1997) and Minchin et al. (1981) those who reported significant increase in growth of cowpea on the application of nitrogen fertilizer. Further, this study revealed non-significant effect of phosphorus (P) fertilizer on cowpea growth and this might be due to the slow release of P fertilizer in the soil. Further, the process of P fixation makes P unavailable in the soil for plant use. Plants take up only about 15-30% of applied P, while the 60% is adsorbed to the soil (Olusola, 2009). Our finding corroborates with the reports of FPDD (2002), but contradicts report of Olaleye et al. (2012) those who reported increase in cowpea growth following P application.

Table 5 Effect of N and P fertilizer application rates on Yield and components of cowpea.

Treatments	Harvest index (%)	Pods per plant	Seeds per pod	Weight of 100 seeds	Pod yield (kg/ha)	Seed yield (kg/ha)
N rates (kg/ha)						
0	45.78	9.45	14.61	15.30	2025	1541
10	39.38	7.07	14.78	15.47	1843	1407
20	42.53	8.08	14.71	15.22	1545	1194
30	41.98	9.40	14.57	15.41	2047	1557
40	43.63	9.78	14.45	15.03	1930	1482
LSD (5%)	NS	NS	NS	NS	NS	NS
SED	2.33	1.12	0.44	0.21	212.3	159.7
P rates (kg P₂O₅/ha)						
0	44.28	8.36	14.56	15.30	1848	1409
15	42.19	8.43	14.59	15.10	1862	1416
30	43.69	9.40	14.41	15.51	1863	1436
45	40.48	8.84	14.93	15.24	1939	1484
LSD (5%)	NS	NS	NS	NS	NS	NS
SED	2.09	1.00	0.39	0.19	189.9	142.8
N×P	NS	NS	NS	NS	NS	NS
CV (%)	13.4	31.3	7.3	3.3	27.7	27.2

NS= not significant at P<0.05

4.2 Yield and components of yield as affected by N and P fertilizer application

Result of study suggested a non significant effect of nitrogen fertilizer on cowpea yield and yield components agrees with findings of IITA (1975) who reported that cowpea produced the same grain yield whether fertilized with N fertilizer or depend on biologically fixed N, indicating that the biological nitrogen fixation process can produce the N required by cowpea provided effective symbiosis is established. However these results are contradictory to the findings of Abayomi et al. (2008) those who reported significant increase in grain yield of cowpea following the application of N fertilizer.

Yield components of cowpea (hundred seed weight, number of pods per plant and number of seeds per pods) showed non-significant response to P fertilizer application. Nevertheless, Singh et al. (2011b), Owolade et al. (2006) and Rajput (1994) reported significant effects of P on 100 seed weight, number of pods per plant and number of seeds per pods, but these authors used higher P rates than in the present study.

Harvest index (HI) was not significantly affected by P application, thus confirming the findings of Singh et al. (2011b) that only different varieties can show differences in harvest index because of their genetic differences.

Even though cowpea pod and grain yields were not significantly affected by P rates, they were however increased numerically with each increase in P fertilizer rates- 45 kg P₂O₅ gave the highest pod (1939 kg/ha) and grain (1484 kg/ha) yields and the control gave the lowest pod (1848 kg/ha) and grain (1409 kg/ha) yields. This result corroborates that of

Agboola & Obigbesan (1977) and Osiname (1978) those who reported non-significant effect of cowpea yields with P application but contradicts result of Singh et al. (2011b). The non-significant effect of P rates on both pod and grain yields could probably be explained by the fact that the highest rate of 45 kg P₂O₅/ha used in the present study is not the optimum P rate for the cowpea variety Asontem. Cowpea varieties have been reported to respond differently to P fertilizer (Okeleye & Okelana, 1997). Thus there is a need to determine the P fertilizer requirement of each genotype (Tayo, 1980).

Conclusions and recommendations

This study showed non-significant effect of the application of N and P fertilizers on the growth and grain yield of cowpea. It is therefore, recommended that there is no need to apply N to cowpea planted in fields with the same fertility status as in the experimental site. In addition, further studies should be conducted with higher P rates in order to establish the optimum P rates for cowpea growth and yield in the semi deciduous forest zone of Ghana.

Acknowledgements

The authors are grateful to the West Africa Agricultural Productivity Program of Sierra Leone (WAAPP-IC SL) for financial support, staff of the plantation section at the department of crop and soil sciences, KNUST for assistance with field work, Dr. Olupomi Ajayi (Rice Research Coordinator out-posted by the Africa Rice Center to the Rokupr Agricultural Research Centre) for editing the original manuscript and Dr. Chernor Sullay Kamara (Director, Rokupr Agricultural Research Centre) for his support.

Conflict of interest

Authors would hereby like to declare that there is no conflict of interests that could possibly arise.

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