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Influence of plant growth regulators, varieties and phosphorus levels on the growth and flowering of cowpea (*Vigna unguiculata* (L.) Walp) in Yola, Adamawa State, Nigeria

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Abstract
The experiments were conducted at the Teaching and Research farm of the Department of Crop Production and Horticulture, Faculty of Agriculture, Modibbo Adama University Yola, to investigate the effects of plant growth regulators, varieties and phosphorus levels on the growth and flowering of some varieties of cowpea (*Vigna unguiculata* L) during 2018, 2019 and 2020 rain fed cropping seasons. The treatments consisted of four plant growth regulators (Cytokinins, gibberellins, brassinolite and water sprays), four levels of phosphorus fertilizer (0, 15, 30 and 45 kg P_2O_5 ha^{-1}) and three cowpea varieties (SAMPEA-7, SAMPEA-14 and red "kanannado") which were factorially combined and laid out in a Split-Split Plot Design replicated three times. Data were collected on number of days to first flowering, number of days to 50 % first flowering, crop growth rate, net assimilation rate and grains yield. Data collected were subjected to analysis of variance (ANOVA) and means were separated using Least Significant Difference (LSD) at 5 % probability level. The results show that application of plant growth regulators (PGRs) was not significant on all the parameters measured. Varietal effects were significant on all the parameters measured. All the erect and semi erect varieties (SAMPEA-7 and SAMPEA-14) produced higher growth rate (crop growth and net assimilation rate) over the local cultivar ("kanannado"). SAMPEA-14 recorded least number of days to first and 50 % flowering; and grains yield was also higher on SAMPEA-14. Effect of phosphorus fertilizer application was highly significant on all the parameters measured. Application of 45 kg P_2O_5 ha^{-1} gave the highest crop growth rate and induced early flowering. Higher grains yield was also obtained with the Application of 45 kg P_2O_5 ha^{-1}. There was highly significant interaction between PGRs, varieties and phosphorus levels on crop growth rate per plant, net assimilation rate per plant and number of days to first flowering. For the best yields, application of brassinolite and 45 kg P_2O_5 ha^{-1} on SAMPEA-14 was found to be realistic and is hereby recommended for the farmers to adopt in Yola, Adamawa State Northern Guinea Savannah zone of Nigeria.

Keywords: cowpea varieties, plant growth regulators, phosphorus, growth, flowering and yield.

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) is an annual legume belonging to the family Fabaceae. It is a native of Central Africa grown between 35^0 N to 30^0 S of equator covering Asia, Oceania, Middle East, Southern Europe, Africa, Southern USA, and Central and Southern America. (Magashi *et al.,* 2014; Prafull, 2016). The crop is grown on a wide range of soil conditions and does well with temperature range from 25^oC to 35^oC and can thrive well in low rainfall areas, a heat-loving plant with low fertility requirements, with better growth in warm climates. The crop thrives well in slightly acidic to slightly alkaline (pH 5.5 - 8.3), sandy loam soils. Cowpea can tolerate salinity to some extent (Karunasena, 2001). In Africa, cowpea is an important grain legume found mainly in the savannah regions of Sub-Saharan Africa, where it is grown in intercropping system with cereals such as maize, millet and sorghum due to its shade tolerant (Maishanu *et al.*, 2017). However, some farmers grow it as mono crop at later dates contrast to those grown in mixtures, whose rate of growth is usually affected by the component crops (Kwaga, 2014). Cowpea is cultivated for its immature pods and mature grains and is consumed extensively in Africa and in small amount in Asia (Sreerama *et al.,* 2012). Cowpea is also called vegetable protein because it contains high amount of protein in grain with better biological value on dry weight basis. Beside its use as vegetable, pulse and fodder, cowpea can also be used as green manure, nitrogen fixer, cover crop, leafy vegetable. It forms an excellent forage and it gives a heavy vegetable growth and covers the ground so well that it checks soil erosion. Cowpea is the most versatile legume because of its drought tolerant character, soil restoring properties and multipurpose use with most parts of the plant used as nutritious food, providing protein and vitamins. Immature pods and peas are used as vegetables, snacks and main dishes are prepared from the grains (Duke, 1981) as such it is considered the second most important food grain legume and constitutes a cheap source of protein for humans. Early maturing cowpea varieties can provide the first food from the current harvest sooner than any other crop (in as few as 55 days after sowing), there by shortening the "hungry period" that often occurs just prior to harvest of the current season crop in farming community in the developing world (Bittenbender *et al.*, 1984). Dry grains for human consumption is the most important of the cowpea plant, but fresh or dried leaves (in many parts of Asia and Africa) (Neilson *et al*. 1993). Cowpea has been found to be nutritional and healthy to man, livestock and a major staple in the diets in Africans and Asians (Awe, 2008). The grains make up the largest contributor to the overall protein intake of several rural and urban families hence serves as a poor man's major source of protein (Agbogidi, 2010). Cowpea as a leguminous crop fixes about 70 – 240 kg N ha^{-1} per year (Prafull, 2016). The raw grain contains 343 cal. per 100 g, 22.8 % protein, 1.5 g per 100 g fat, 61.7 g per 100 g carbohydrate, 74 mg per 100 g calcium, 5.8 mg per 100 g Fe and 0.21 mg per 10 g riboflavin (Watt and Merill, 1975; kwaga, 2014). The dry leaves contain phosphorus 3.48 mg per 100 g, Fe 12.0 mg per 100 g and calcium 15.5l mg per 100 g (Imungi and potter 1983; Kwaga, 2014); fat 1.3 %, fiber 3.8 % and mineral 3.2 % (Jakusko, 2017).

In Nigeria, so many local indigenous types such as white *''kanannado''*, Red *''kanannado'', ''Banjiram'', ''kilikili''*, ''*Iron*'' and *''BOSAP''* are commonly grown. Early maturing improved varieties include IT 845-2346-4, IT 84E-124; medium maturity improved varieties (SAMPEA-7, SAMPEA -8, SAMPEA -12, SAMPEA -14 and IAR-48 are common while SAMPEA -6, IAR-1696, IT 81D-994 are among the late maturity improved varieties in Nigeria (Jakusko, 2017). Despite all these available cowpea varieties, the average grain yield of cowpea in the African region including Nigeria is estimated to be about 470 kg ha^{-1} (Ericksen *et al*., 2010) and potential yield are up to 2.3 t ha^{-1}. Nigeria is the highest cowpea producer in the world with an annual production of 3.04 million tons and average yield of 0.69 tons per hectare (Maishanu *et al.,* 2017).

Phosphorus (P) is one of the major nutrients required by plants. It is involved in photosynthesis, glycolysis, respiration and fatty acid synthesis. It stimulates early root development and growth and thus, helps in plant establishment (Prafull, 2016). In legumes, phosphorus induces rhizobia activities, nodule formation and thus Nitrogen (N) fixation (Jakusko, 2016). Phosphorus is a major constituent of plant cell nucleus and growing root tips which helps to absorb more plant nutrients and water from the deeper layer of the soil and ultimately result in better growth of the plants (Prafull, 2016).

Plant growth hormones are known to regulate and modify various physiological processes within the plant, there by influencing both morphological and yield characters. The concept of Plant Growth Regulators (PGRs) are referred to artificially produced substances which in very low quantities normally act at sites other than the place of production and control different physiological processes that modulate plant growth and development. There are five major classes of plant hormones which are auxins, gibberellins, abscisic acid, cytokinins and ethylene but minor ones includes brassinosteroids, tricontanol, naphthalene acetic acid, 2,4-dichlorophenoxyacetic acid, cycocel, planofix among others (Davies, 2010, Prafull, 2016). They affect crop growth rate and growth pattern during the various stage of development from germination through harvesting and post-harvest storages (Hasan *et al.*, 2017). Cytokinins influence cell division and shoot formation, it also helps delay senescence or aging of tissues; Gibberellins acid are important in seed germination, affecting enzyme production that mobilizes food production used for growth of new cells, they promote flowering and cellular division; and Brassinolite (a group of brassinosteroids) help to stimulate cell elongation and division, gravi-tropism, resistance to stress and xylem differentiation (Wikipedia, 2018).

The production of cowpea could not meet up with its demand due to poor yield as a result of non-proper use of phosphorus (P) based fertilizers and plant growth hormones. Phosphorus deficiency is the most limiting soil fertility factor for cowpea production in Nigeria (IITA, 2003). This could be as a result of either inherent low levels of P in the soil or depletion of the nutrient through over cultivation. Many tropical soils are inherently deficient in P (Osodeke, 2005) and Nitrogen (N) (Haruna and Aliyu, 2011). The deficiency can be so acute in some soils of the Savannah zone of Western Africa, including Nigeria resulting in cessation of plant growth as soon as the P stored in the seed is exhausted (Mokwunye and Bationo, 2002).

For sustainable food production to meet the increasing population in developing countries like Nigeria, the production of cowpea need to be increased through proper application of P based fertilizers and plant growth hormones that can give maximum output. Most cowpea growers in Nigeria do not apply P fertilizer and PGRs in their cowpea (Brynes and Bumb, 1998). Information's regarding the use of plant growth regulators and phosphorus fertilizer in the production of numerous varieties of cowpea that can give maximum yield are limited or scarce. There is also limited research on the effects of plant growth hormones, phosphorus fertilizer and varieties on the yield of cowpea in this region.

The objectives of this study therefore are to evaluate the effects of plant growth regulators, varieties and phosphorus levels on the growth and flowering of cowpea and to determine the best interactions of these variables on the growth, flowering and yield of cowpea in the study area.

Materials and Methods

Experimental site: Field experiments were carried out in 2018, 2019 and 2020 under rain fed cropping seasons at the Teaching and Research Farm of the Department of Crop Production and Horticulture, Modibbo Adama University, Yola (Northern Guinea Savannah zone of Nigeria).

Treatments and experimental design: The treatments consisted of four different plant growth regulators (PGRs) (Cytokinins 0.4 %, Gibberellin acid 5 %, Brassinolite 0.01 % SP and Water spray), three cowpea varieties (SAMPEA-7, SAMPEA-14 and Red *''kanannado''* and four levels of phosphorus (0, 15, 30 and 45 kg P_2O_5 ha^{-1}). The experiment was laid out in a Split - split plot design with three replicates. The PGRs was assigned to the main plots, varieties to the sub plots and phosphorus was assigned to sub-sub plots. The gross plot size was 4 m x 3 m and the net plot size was 2 m x 1.8 m. Two (2) meter was left between main plots and replicates while 1 m was left between sub plot and sub-sub plots.

Soil sampling**:** A composite soil sample of the experimental site was collected from three different locations in each replicate at a depth of 0 - 20 and 20 - 40 cm using soil auger for analysis. The soil samples were subjected to laboratory analysis to determine its physical and chemical properties by various standard methods: Organic carbon was determined by the use of modified Walkley and Black wet oxidation method. The percent organic carbon was multiplied by 1.724 (Van Bemmelen factor) to get the percentage organic matter. Soil pH was determined by the use of soil pH meter. The modified Kjeldahl method was used to determine the total nitrogen. Available phosphorus was determined by the Bray-1 test method with dilute acid fluoride as the extractant. The exchangeable base cations were extracted using ammonium acetate at pH 7.0. Calcium and magnesium was determined using Ethylene Diamine Tetra-acetic Acid (EDTA) titration method while potassium and sodium was determined by the flame photometer method as reported by Karikari *et al*. (2015).

Sources of seed and their description**:** The recommended varieties (SAMPEA -7 and SAMPEA - 14) were obtained from Institute of Agricultural Research Samaru Zaria, Kaduna State, Nigeria: SAMPEA -7 is an erect type, medium height and tolerant to drought. It has large, light brown to dark brown seed with rough seed coat texture. It matures in 70 – 80 days, with yield potential of 1,500 – 2,500 kg ha^{-1}. SAMPEA -14 is a semi erect variety, high yielding, tolerant to drought with large, white rough seed coat texture. Matured in 75 – 85 days with yield potential of 1,500 – 2000 kg ha^{-1} while Red *''kanannado''* (local cultivars) a spreading growth habit, medium maturity cultivars, pod curve or coil, seeds are large with brown rough seed coat texture, yield potential of about 2,000 kg ha^{-1}, was obtained from Yola open market which serves as control.

Seed treatment and sowing method: All seeds were treated with apron star at one sachet (10 g) to 3 kg of seed to control the effects of soil pathogens on the germination and early growth of seedlings. The seeds were sown by dibbling with three to four seeds per hill and later thinned to 2 plants per stand at 2 weeks after sowing (WAS). SAMPEA -7 and SAMPEA -14 (erect and semi-erect type) were spaced at 60 cm x 25 cm while Red *''kanannado''* (spreading type) was spaced at 100 cm x 60 cm.

Fertilizer applications: Nitrogen Fertilizer was applied to all experimental plots in the form of Urea at the rate of 30 kg N ha^{-1} as a starter dose, while Phosphorus fertilizer was applied in a form of Single Super Phosphate (20 % P_2O_5). The amount of P_2O_5 needed for each plot was calculated based on treatments of the phosphorus fertilizer. The quantity required per hectare was first calculated using $Q = \frac{R \times 100}{n}$, and later converted to quantity per plot, (Avav and Ayuba, 2006).

Where: Q = amount of fertilizer required,
R = recommended rate of nutrient element
and n = analysis or grade of fertilizer (%)

Potassium was applied to all plots in the form of muriate of potash at the rate of 30 kg K_2O ha^{-1}. All fertilizers were applied during land preparation.

Application of plant growth regulators: All the plant growth regulators were foliage applied at 20, 40, and 60 days after sowing (DAS). Cytokinins 0.4 % was applied at the rate of 300 ml per ha^{-1} (30 ml was diluted per knapsack of clean water), gibberellin acid 5 % was applied at the rate of 600 ml per ha^{-1} (60 ml was diluted per knapsack of clean water), brassinolite 0.01 % was applied at the rate of 80 g per ha^{-1} (8 g was dissolved per knapsack of clean water) while ordinary water used for the dilution and dissolving of the PGRs was sprayed as a control (on plots receiving no PGRs).

Data collection

Days to first flowering: Number of days taken from sowing to the appearance of first flower in a plot were recorded as number of days to first flowering.

Days to 50 % flowering: Days to 50 % flowering were recorded as number of days from sowing to the date when 50 % of plants showed at least one flower fully opened.

***Crop growth rate* (CGR)**: It is the rate of growth of crop per unit area expressed as g/m^2/day. CGR = $\frac{1}{p}\frac{W2-W1}{T2-T1}$ where P is land area (Reddy and Reddi 2010). The rate of growth was calculated and recorded.

***Net assimilation rate* (NAR)**: Net assimilation rate is the plant's rate of increase of dry weight per unit leaf area (Evans, 1974). The NAR was determined using the following formula as suggested by Radford (1967). NAR = $(\frac{W2-W1}{T2-T1} \text{ x } (\frac{\text{Loge L2}-\text{Loge L1}}{L2-L1})$. Where, L_1 and L_2 are total leaf area at time interval T_1 and T_2 (6 and 9 WAS).

Grain yield: Grain yield was determined by harvesting and threshing of pods from the whole net plot of each treatment. First, grain weight per net plot were calculated. The grain weight was then convert to the grains yield per hectare. (Weight of the grains divided by net plot and multiplied by 10,000 m^2) through extrapolation.

Statistical analysis: Analysis of variance (ANOVA) were carried out on each of the observation recorded as described by Gomez and Gomez (1984) for each year of study using SAS version 9.2 (2008). Mean values were subjected to Least Significant Difference (LSD) at 0.05 level of probability.

Results

The result of the effects of plant growth regulators, varieties and phosphorus levels on CGR (g/m^2/day) per plant at 6 and 9 WAS in 2018, 2019 and 2020 (Table 1) indicated that the effect of plant growth regulators on CGR of cowpea per plant was not significant ($p \leq 0.05$) at all the sampled period and in all the years of the experiment. Varietal effect significantly ($p \leq 0.001$) influenced CGR at all the sampled period and in all the years of the study except at 9 WAS in 2020. At 6 WAS in 2018, 2019 and 2020, SAMPEA-14 recorded the highest mean value of 1.472, 1.834 and 2.131g which are statistically the same with SAMPEA-7 which recorded 1.377, 1.652

and 2.131 g. However, at 9 WAS in 2018, SAMPEA-7 recorded the highest CGR of 3.193 g while at 9 WAS in 2019, same SAMPEA-7 recorded the highest value of 4.560g which are also statistically the same with SAMPEA-14 (3.840g). Least values were obtained in "kanannado" with 0.411, 0.403 and 0.432 $g/m^2/d$ at 6 WAS in 2018, 2019 and 2020; and 0.647 and 1.500 $g/m^2/d$ at 9 WAS in 2019 and 2020 respectively. Effect of phosphorus levels was highly significant ($p \leq 0.001$) on CGR at all the sampled period and in all the years of the study except at 6 WAS in 2018. A steady increase was observed with increase in phosphorus levels up to 45 kg ha^{-1} P_2O_5. In 2018, at 9 WAS higher CGR of 3.079g was obtained in the application of 45 kg ha^{-1} P_20_5 while 0 kg ha^{-1} P_2O_5 gave the least mean value of 1.284 $g/m^2/d$. In 2019, application of 45 kg ha^{-1} P_2O_5 gave the highest values of 1.961 and 4.270g at 6 and 9 WAS while 0 kg ha^{-1} P_2O_5 recorded the least mean values of 0.642 and 2.400 $g/m^2/d$ on CGR per plant. Similarly, in 2020, 45 kg ha^{-1} P_2O_5 gave the highest values of 2.631 and 7.230g at 6 and 9 WAS while 0 kg ha^{-1} P_2O_5 gave the least mean values of 0.752 and 2.070 $g/m^2/day$ respectively.

Table 1: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Crop Growth Rate ($g/m^2/d$) $Plant^{-1}$ at Various Growth Stages of Cowpea in Yola During 2018, 2019 and 2020 Rain fed Growing Seasons

Treatment	2018		2019		2020	
	6 WAS	9 WAS	6 WAS	9 WAS	6 WAS	9 WAS
PGRs						
Cytokinins	1.252	1.543	1.251	2.910	1.800	3.090
Gibberellins	0.941	1.503	1.474	3.220	1.494	6.780
Brassinolite	1.030	2.169	1.277	4.000	1.439	3.650
Water (control)	1.124	2.609	1.183	3.040	1.549	3.690
P of F	0.853	0.090	0.583	0.174	0.590	0.515
LSD	0.908	0.985	0.514	1.108	0.663	6.285
Varieties (Var)						
SAMPEA-7	1.377	3.193	1.652	4.560	2.131	4.420
SAMPEA-14	1.472	2.027	1.834	3.840	2.148	7.130
KANANNADO	0.411	0.647	0.403	1.500	0.432	1.350
P of F	<.001	<.001	<.001	<.001	<.001	0.070
LSD	0.284	0.560	0.333	1.067	0.465	4.886
Phosphorus (Phos)						
0 kg P_2O_5 ha^{-1}	0.506	1.284	0.642	2.400	0.752	2.070
15 kg P_2O_5 ha^{-1}	0.827	1.555	1.122	2.840	1.038	2.930
30 kg P_2O_5 ha^{-1}	1.376	1.904	1.460	3.650	1.861	4.980
45 kg P_2O_5 ha^{-1}	1.638	3.079	1.961	4.270	2.631	7.230
P of F	0.518	<.001	<.001	<.001	<.001	<.001
LSD	0.218	0.440	0.325	0.585	0.369	2.115
Interactions						
PGRs X Var.	NS	**	NS	NS	NS	NS
PGRs x Phos.	NS	*	*	**	NS	NS
Var. x Phos	**	**	**	NS	**	NS
PGRs x Var x Phos.	NS	**	NS	NS	NS	NS

WAS = Weeks after sowing, * = Significant ($P \leq 0.05$), ** = Highly Significant ($P \leq 0.01$), NS= Not Significant, PGRs= Plant Growth Regulators

There was highly significant interaction ($p \leq 0.01$) effect between plant growth regulators, varieties and phosphorus levels on CGR of cowpea at 9 WAS in 2018 (Table 2). Combination of 45 kg ha^{-1} P_2O_5 and brassinolite on SAMPEA-7 recorded the highest value of 7.71 g which are statistically the same with the combinations of brassinolite and of 30 kg ha^{-1} P_2O_5 on SAMPEA-7 (6.37 g) and with the combination of 45 kg ha^{-1} P_2O_5 and water on SAMPEA-14 (6.69 g). Combination of 0 kg ha^{-1} P_2O_5 and gibberellins on "kanannado" gave the least mean value of 0.25 g/m^2/day.

Table 2: Interaction Effect between Plant Growth Regulators, Varieties and Phosphorus Levels on Crop Growth Rate (g/m^2/d) Plant^{-1} of Cowpea at 9 WAS in Yola during 2018 Growing Season

PGRs	Varieties	Phosphorus Levels (kg ha^{-1})			
		0	15	30	45
Cytokinins	SAMPEA-7	1.89	1.49	2.32	2.98
	SAMPEA-14	0.68	1.02	1.67	4.41
	KANANNADO	0.43	0.71	0.49	0.42
Gibberellins	SAMPEA-7	2.43	3.11	2.56	2.65
	SAMPEA-14	1.36	0.94	0.63	1.84
	KANANNADO	0.25	0.54	0.69	1.02
Brassinolite	SAMPEA-7	2.54	3.29	6.37	7.71
	SAMPEA-14	0.35	1.12	0.54	2.09
	KANANNADO	0.41	0.41	0.35	0.84
Water	SAMPEA-7	1.98	2.54	2.35	4.88
	SAMPEA-14	2.56	2.81	3.72	6.69
	KANANNADO	0.53	0.67	1.17	1.42
P of F		0.005			
LSD		1.772			

WAS= Weeks After Sowing, PGRs= Plant Growth Regulators

The result of net assimilation rate (g/dm^2) per plant of cowpea at 6 and 9 WAS in 2018, 2019 and 2020 (Table 3) showed that NAR was not significantly ($p \leq 0.05$) affected by plant growth regulators at all the sampled period and in all the three (3) years of the study. Varietal effect was highly significant ($p \leq 0.01$) at 9 WAS in 2018. SAMPEA-7 recorded the highest mean value of 1.952 g while "kanannado" gave the least mean value of 1.235 g/dm^2 on NAR per plant. The effect of phosphorus levels on NAR was highly significant ($p \leq 0.001$) at 9 WAS in 2018, 2019 and at 6 WAS in 2020; and significant ($p \leq 0.001$) at 9 WAS in 2020. In both 2018 and 2019 (9 WAS), 0 kg ha^{-1} P_2O_5 (control) recorded significantly higher NAR of 1.909 and 2.899 g/dm^2 while application of 30 kg ha^{-1} P_2O_5 recorded the least values of 1.247g in 2018 and 45 kg ha^{-1} P_2O_5 recorded the least value of 2.050 g/dm^2 in 2019. In 2020 however, higher dosage of 45 kg ha^{-1} P_2O_5 recorded the highest NAR at both 6 and 9 WAS with 4.44 and 3.30 g/dm^2 while 15 kg ha^{-1} P_2O_5 recorded the least at 6 WAS (2.54g) and 0 kg ha^{-1} P_2O_5 gave the least value at 9 WAS (2.14 g/dm^2).

Table 3: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Net Assimilation Rate (g/dm^2) Plant^{-1} at Various Stages of Cowpea in Yola During 2018, 2019 and 2020 Rain fed Growing Seasons

Treatment	2018		2019		2020	
	6 WAS	9 WAS	6 WAS	9 WAS	6 WAS	9 WAS
PGRs						
Cytokinins	2.98	0.954	3.40	2.199	3.51	1.84
Gibberellins	3.06	1.234	3.34	2.181	3.01	3.47
Brassinolite	2.66	1.388	3.54	3.015	3.32	2.36
Water	4.40	2.403	2.94	2.000	3.40	2.65
P of F	0.514	0.117	0.436	0.061	0.641	0.582
LSD	2.897	1.262	0.864	0.755	0.954	2.796
Varieties (Var)						
SAMPEA-7	3.25	1.954	3.12	2.167	3.32	2.08
SAMPEA-14	3.38	1.296	3.49	2.337	3.64	3.37
KANANNADO	3.19	1.235	3.31	2.543	2.97	2.29
P of F	0.868	0.012	0.535	0.478	0.161	0.478
LSD	0.790	0.491	0.694	0.642	0.705	2.353
Phosphorus (Phos)						
0 kg P_2O_5 ha-^{1}	2.84	1.909	3.31	2.899	2.58	2.14
15 kg P_2O_5 ha-^{1}	3.07	1.364	3.34	2.216	2.54	2.17
30 kg P_2O_5 ha-^{1}	3.76	1.247	3.33	2.231	3.67	2.71
45 kg P_2O_5 ha-^{1}	3.43	1.460	3.25	2.050	4.44	3.30
P of F	0.120	<.001	0.994	<.001	<.001	0.014
LSD	0.807	0.256	0.701	0.420	0.564	0.794
Interactions						
PGRs X Var.	NS	*	NS	NS	NS	NS
PGRs x Phos.	NS	NS	NS	*	NS	NS
Var. x Phos	NS	NS	NS	NS	NS	NS
PGRs x Var x Phos.	NS	*	NS	NS	NS	NS

WAS = Weeks after sowing, * = Significant ($P \leq 0.05$), NS= Not Significant, PGRs= Plant Growth Regulators

Table 4 presented a significant interaction ($p \leq 0.05$) between plant growth regulators, varieties and phosphorus levels at 9 WAS in 2018. Combination of water (control) and 0 kg ha^{-1} P_2O_5 (control) on SAMPEA-14 recorded the highest mean value of 3.83 g which are statistically similar with the applications of brassinolite and 0 kg ha^{-1} P_2O_5 on SAMPEA-7 (2.80 g), gibberellins and 0 kg ha^{-1} P_2O_5 on SAMPEA-7 (2.61 g); and combinations of water and 0 kg ha^{-1} P_2O_5 on SAMPEA-7 and "kanannado" (2.78 and 2.58 g) respectively. Combination of brassinolite and 30 kg ha^{-1} P_2O_5 on SAMPEA-14 recorded the least value of 0.28 g/dm^2.

Table 4: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Number of Days to First Flowering of Cowpea in Yola During 2018, 2019 and 2020 Rain fed Growing Seasons

Treatment	2018	2019	2020
PGRs			
Cytokinins	40.69	41.83	41.61
Gibberellins	40.86	42.00	40.58
Brassinolite	40.08	41.67	40.64
Water	41.61	43.08	41.03
P of F	0.196	0.219	0.444
LSD	1.486	1.574	1.617
Varieties (Var)			
SAMPEA-7	42.60	43.31	41.29
SAMPEA-14	37.23	38.38	37.21
KANANNADO	42.60	44.75	44.40
P of F	<.001	<.001	<.001
LSD	0.700	0.973	0.697
Phosphorus (Phos)			
0 kg P_2O_5 ha-^{1}	42.72	43.86	41.86
15 kg P_2O_5 ha-^{1}	41.36	42.44	40.94
30 kg P_2O_5 ha-^{1}	40.03	41.36	40.81
45 kg P_2O_5 ha-^{1}	39.14	40.92	40.25
P of F	<.001	<.001	<.001
LSD	0.360	0.820	0.674
Interactions			
PGRs X Var.	**	NS	*
PGRs x Phos.	*	NS	NS
Var. x Phos	**	NS	*
PGRs x Var x Phos.	**	NS	NS

* = Significant ($P \leq 0.05$), ** = Highly Significant ($P \leq 0.01$), NS= Not Significant, PGRs= Plant Growth Regulators

The effects of plant growth regulators, varieties and phosphorus levels on number of days to first flowering of cowpea in 2018, 2019 and 2020 is presented on Table 5. Application of plant growth regulators showed no significant ($p \leq 0.05$) effect on numbers of days to first flowering of cowpea in all the years of the trial; where by varietal effect showed a highly significant ($p \leq 0.001$) differences on number of days to first flowering in all the years of the experiment. SAMPEA-14 recorded the minimum number of days to first flowering with 37.23, 38.38 and 37.21 days in 2018, 2019 and 2020 respectively while SAMPEA-7 and ‘‘kanannado’’ gave the maximum number of days to first flowering in 2018 with 42.60 days. In 2019 and 2020, ‘‘kanannado’’ recorded the maximum number of days to first flowering with 44.75 and 44.40 days respectively. Effect of phosphorus levels on number of days to first flowering also was highly significant ($p \leq 0.001$) in all the years of the experiment. Minimum number of days to first flowering of 39.14, 40. 92 and 40.25 was recorded in the application of 45 kg ha^{-1} P_2O_5 while application of 0 kg ha^{-1} P_2O_5 recorded the maximum number of days to first flowering with 42.72, 43.31 and 41.29 in 2018, 2019 and 2020 respectively.

Table 5: Interaction Effect between Plant Growth Regulators, Varieties and Phosphorus Levels on Numbers of Days to First Flowering of Cowpea in Yola during 2018 Growing Season

PGRs	Varieties	Phosphorus Levels (kg ha^{-1})			
		0	15	30	45
Cytokinins	SAMPEA-7	46.33	42.00	41.33	41.67
	SAMPEA-14	38.00	37.00	35.33	34.00
	KANANNADO	44.00	43.33	43.00	42.33
Gibberellins	SAMPEA-7	43.00	42.33	41.33	40.33
	SAMPEA-14	40.33	39.00	38.00	37.00
	KANANNADO	43.67	43.00	41.33	41.00
Brassinolite	SAMPEA-7	44.00	42.67	41.00	40.33
	SAMPEA-14	39.00	38.00	37.00	36.00
	KANANNADO	42.67	41.67	39.33	39.33
Water	SAMPEA-7	45.67	44.67	42.67	42.33
	SAMPEA-14	40.33	38.33	35.67	32.67
	KANANNAD	45.67	44.33	44.33	42.67
P of F				<.001	
LSD				1.990	

PGRs= Plant Growth Regulators

A highly significant interaction ($p \leq 0.01$) effect between plant growth regulators, varieties and phosphorus levels on number of days to first flowering was observed in 2018 growing season (Table 6). Combination of water and 45 kg ha^{-1} P_2O_5 on ‘‘kanannado’’ recorded the minimum number of 32.67 days to first flowering, which are statistically the same with the combination of cytokinins and 45 kg ha^{-1} P_2O_5 on SAMPEA-14 (34.00 days) while combination of cytokinins and 0 kg ha^{-1} P_2O_5 on SAMPEA-7 recorded the highest number of days to first flowering with 46.33 days.

Table 6: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Number of Days to 50 % Flowering of Cowpea in Yola During 2018, 2019 and 2020 Rain fed Growing Seasons

Treatment	2018	2019	2020
PGRs			
Cytokinins	50.06	49.81	50.08
Gibberellins	50.11	49.86	49.42
Brassinolite	49.83	49.67	49.25
Water	50.44	51.31	48.72
P of F	0.348	1.132	0.589
LSD	0.756	1.594	2.334
Varieties (Var)			
SAMPEA-7	52.54	52.23	50.98
SAMPEA-14	47.96	46.98	46.02
KANANNADO	49.83	51.27	51.10
P of F	<.001	<.001	<.001
LSD	0.584	1.383	1.269
Phosphorus (Phos)			
0 kg P_2O_5 ha-^{1}	51.83	52.33	50.47
15 kg P_2O_5 ha-^{1}	50.56	49.72	49.06

30 kg P_2O_5 ha-1	49.42	49.64	49.06
45 kg P_2O_5 ha-1	48.54	48.94	48.89
P of F	<.001	<.001	<.001
LSD	0.348	0.743	0.743
Interactions			
PGRs X Var.	**	NS	NS
PGRs x Phos.	NS	NS	NS
Var. x Phos	NS	NS	**
PGRs x Var x Phos.	NS	NS	NS

** = Highly Significant (P≤0.01), NS= Not Significant, PGRs= Plant Growth Regulators

The effects of plant growth regulators, varieties and phosphorus levels on number of days to 50 % flowering of cowpea in Yola during 2018, 2019 and 2020 rain fed cropping seasons is presented on Table 7. Effect of plant growth regulators was not significant (p≤0.05) on number of days to 50 % flowering in all the years of the studies. Varietal effect shows a highly significant difference (p<0.001) in all the years of the study. SAMPEA-14 recorded the minimum number of days to 50 % flowering with 47.96, 46.98 and 46.02 days in 2018, 2019 and 2020 respectively. SAMPEA-7 recorded the maximum number of days (52.54 and 52.23) to 50 % flowering in 2018 and 2019 growing seasons while "kanannado" gave the maximum number of days to 50 % flowering with 51.10 days in 2020. Phosphorus application also shows a highly significant

Table 7: Interaction Effect between Plant Growth Regulators, Varieties and Phosphorus Levels on Net Assimilation Rate (g/dm^2) $Plant^{-1}$ of Cowpea at 9 WAS in Yola during 2018 Growing Season

PGRs	Varieties	Phosphorus Levels (kg ha^{-1})			
		0	15	30	45
Cytokinins	SAMPEA-7	1.85	0.98	1.13	1.15
	SAMPEA-14	0.74	0.70	0.73	1.39
	KANANNADO	1.16	0.77	0.40	0.44
Gibberellins	SAMPEA-7	2.61	2.01	1.23	0.95
	SAMPEA-14	1.79	0.92	0.41	0.82
	KANANNADO	0.83	1.10	0.97	1.16
Brassinolite	SAMPEA-7	2.80	1.99	2.76	2.99
	SAMPEA-14	0.46	0.79	0.28	0.75
	KANANNADO	1.48	0.49	0.96	0.9
Water	SAMPEA-7	2.78	2.21	1.47	2.34
	SAMPEA-14	3.83	2.56	2.09	2.46
	KANANNADO	2.58	1.84	2.53	2.14
P of F		0.027			
LSD		1.544			

WAS= Weeks After Sowing, PGRs= Plant Growth Regulator

(p<0.001) effect on number of days to 50 % flowering in all the study years. Application of 45 kg ha^{-1} P_2O_5 recorded the minimum number of days to 50 % flowering with 48.54, 48.94 and 49.06 days in 2018, 2019 and 2020 respectively while application of 0 kg ha^{-1} P_2O_5 gave the maximum number of days to 50 % flowering with 51.83, 52.33 and 50.47 days in 2018, 2019 and 2020 respectively.

The result of the effects of plant growth regulators, varieties and phosphorus levels on grains yield of cowpea in 2018, 2019 and 2020 rain fed growing seasons is presented on Table 8. Grains yield was not significantly ($p \leq 0.05$) affected by plant growth regulators in all the study years. Varieties showed a highly significant ($p \leq 0.001$) effect on grain yield in 2018, 2019 and 2020 growing seasons. SAMPES-14 produced a higher grains yield of 1607.57, 1631.20 and 1178.20 kg ha^{-1}, followed by SAMPEA-7 (1395.06, 1366.00 and 714.60 kg ha^{-1}) while, "kanannado" produced the least grains yield (998.92, 914.04 and 482.60 kg ha^{-1}) in 2018, 2019 and 2020 respectively. Grains yield was highly significantly ($p \leq 0.001$) influenced by phosphorus levels. Increased in phosphorus level significantly increased grains yield in all the study years. Application of 45 kg ha^{-1} P_2O_5 recorded the highest grains yield (1674.03, 1685.80 and 983.60 kg ha^{-1}), followed by the application of 30 kg ha^{-1} P_2O_5 (1445.09, 1396.43 and 847.20 kg ha^{-1}) in 2018, 2019 and 2020 respectively. However, least grains yield was that of zero phosphorus in all the study years (1006.22, 979.00 and 603.50 kg ha^{-1}).

Table 8: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Grains Yield (kg ha^{-1}) of Cowpea in Yola During 2018, 2019 and 2020 Rain fed Growing Seasons

Treatment	2018	2019	2020
PGRs			
Cytokinins	1320.55	1352.29	881.50
Gibberellins	1414.23	1431.91	785.40
Brassinolite	1446.77	1348.80	743.60
Water	1153.89	1096.62	756.70
P of F	0.064	0.231	0.237
LSD	222.9	366.1	158.1
Varieties (Var)			
SAMPEA-7	1395.06	1366.00	714.60
SAMPEA-14	1607.57	1631.20	1178.20
KANANNADO	998.92	914.04	482.60
P of F	<.001	<.001	<.001
LSD	122.6	163.4	124.81
Phosphorus (Phos)			
0 kg P_2O_5 ha-^{1}	1006.22	979.00	603.50
15 kg P_2O_5 ha-^{1}	1208.51	1168.50	733.00
30 kg P_2O_5 ha-^{1}	1445.09	1396.43	847.20
45 kg P_2O_5 ha-^{1}	1674.03	1685.80	983.60
P of F	<.001	<.001	<.001
LSD	83.0	95.2	53.59
Interactions			
PGRs X Var.	**	*	NS
PGRs x Phos.	NS	NS	NS
Var. x Phos	**	**	**
PGRs x Var x Phos.	NS	NS	NS

* = Significant ($P \leq 0.05$), ** = Highly Significant ($P \leq 0.01$), NS= Not Significant, PGRs= Plant Growth Regulators

Discussion

Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Growth Parameters of Cowpea

Application of plant growth regulators did not significantly influence crop growth rate (CGR) throughout the period of the study. This confirmed the result of Muhamman *et al*. (2016) who noted that application of plant growth regulators did not significantly influence CGR. However, CGR was highly significantly influenced by varieties throughout the period of the study. There was inconsistence of a particular variety among the improved varieties on CGR. SAMPEA-14 which was statistically the same with SAMPEA-7 which recorded highest CGR in all the years of the study and out yielded the local variety (kanannado). This indicated that the improved varieties produced more dry matter per unit land area than the local variety. This variation could be attributed to genotypic make-up and growing conditions which indicated differences in growth potential. Ankomah *et al*. (1996) also reported similar findings in cowpea. CGR was found to be significantly influenced by P level throughout the period of the study. Increase in CGR was observed with increase in P levels. Application of 45 kg ha^{-1} P_2O_5 gave the highest CGR throughout the years of the study. This indicated that more dry matter accumulation per unit area of land was achieved with increase in phosphorus levels up to 45 kg ha^{-1} P_2O_5.

Net assimilation rate (NAR) was not significantly influenced by plant growth regulators throughout the study period, while varieties significantly influenced NAR at 9 WAS in 2018. SAMPEA-7 recorded the highest NAR when compared with other varieties. It is indirectly indicating that rate of net photosynthesis is higher on SAMPEA-7. Phosphorus fertilization significantly influenced NAR. Zero (0) kg ha^{-1} P_2O_5 recorded the highest NAR per plant in 2018 and 2019 while 45 kg ha^{-1} P_2O_5 gave the highest NAR per plant in 2020.

Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Phenological Parameters of Cowpea

There was no significant influence of plant growth regulators on number of days to first flowering of cowpea in the years of the study. However, the effect of varieties was highly significant in all the three years of the study. SAMPEA-14 started flowering earlier than the rest of the varieties in all the years. This could be due to its genetic make-up. This concurs with findings by Kwaga (2014) who observed that, the erect and semi-erect genotypes came into flowing earlier than "kanannado". Number of days to first flowering was highly and significantly influenced by phosphorus levels. Number of days to first flowering was observed to increase with decrease in phosphorus fertilizer from 45 kg ha^{-1} P_2O_5 down to 0 kg ha^{-1} P_2O_5. This could be attributed to the role of phosphorus in enhancing the development of reproductive parts. This is in line with the report by Jakusko (2016) who confirmed that, phosphorus enhances the development of reproductive parts and also stimulates blooming and fruit setting and seed formation. Prafull (2016) also reported that, phosphorus helped in reaching to the reproductive phase early. He further reported that, the application of 80 kg ha^{-1} recorded the minimum number of days to first flowering in cowpea. This trend was also reported by Philip (1993) and Omokanye *et al*. (2000) in cowpea.

Similarly, application of plant growth regulators has no significant influence on numbers of days to 50 % flowering. On the other hand, varietal effect was highly significant on number of days to 50 % flowering. SAMPEA-14 (a semi-erect) reached 50 % flowered earlier than the rest of the varieties tested. This is in total agreement with the findings by Kwaga (2014) who observed that, erect and semi-erect attained 50 % flowering earlier than "kanannado". Application of phosphorus significantly influenced number of days to 50 % flowering. Similar trend in days to 1st flowering was also observed. Application of phosphorus helped the plants to attain 50 % flowering earlier. Increase in number of days to 50 % flowering was observed with decreased phosphorus level from 45 down to 0 kg ha^{-1} P_2O_5. Prafull (2016) also reported that application of higher dosage of phosphorus help cowpea to attain 50 % flowering earlier. Similar findings were reported by Kwaga (2014) and Karikari *et al*. (2015) who affirmed that phosphorus fertilizer application reduced days to 50 % flowerings in cowpea.

Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Yield of Cowpea

Grains yield was not significantly influenced by plant growth regulators in the three years of the study. This result was in contrast with the findings of Meena *et al*. (2014) who noted that foliar application of plant growth regulators significantly influenced grains yield. Effect of varieties showed a highly significant influence on grains yield. SAMPEA-14 exhibited higher grains yield in all the years of the study, followed by SAMPEA-7. This indicated that the two improved varieties (erect and semi erect) out yielded the local variety in terms of grains yield. This could be attributed to their genetic make-up which indicated that variability existed among species. Magashi *et al.* (2014) also reported similar findings in cowpea. They noted that, improved varieties were discovered to be more productive in grain yield when compared to the local varieties. Kwaga (2014) also reported similar findings in cowpea. Grain yield was also highly influenced by phosphorus fertilization in all the years of the study. Increase in grain yield was observed with increase in phosphorus levels. The highest grains yield was recorded in the application of 45 kg ha^{-1} P_2O_5. Singh *et al*. (2011) reported highest yield in cowpea at 60 kg ha^{-1} P_2O_5. Similar finding was reported by Karikari *et al*. (2015) and Prafull (2016) all in cowpea.

Conclusion

The result indicated that all the parameters measured were not influenced by the application of plant growth regulators. However, application of 45 kg ha^{-1} P_2O_5 was found to be best for its optimum performance. SAMPEA-14 was found to be realistic for its maximum productivity and the combination of brassinolite and 45 kg ha^{-1} P_2O_5 on SAMPEA-14 appears to be promising for farmer's adaptation in the study area for its optimum growth, early flowering and higher yield than any other combinations.

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