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Effects of varieties, plant growth regulators and phosphorus levels on Root, nodulations and yield response 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 varieties, plant growth regulators and phosphorus levels on the growth and yield of cowpea (*Vigna unguiculata* L) during 2018, 2019 and 2020 raining seasons. The treatments consisted of four different 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 root length, number of nodules, number of effective nodules and grains yield. All data collected were subjected to analysis of variance (ANOVA) and means were separated using Least Significant Difference (LSD) at 5% probability level. Results showed that, application of cytokinins recorded significantly higher root length, gibberellins recorded the highest number of nodules per plant while the application of plant growth regulators did not significantly influence number of effective nodules per plant and grains yield. Each variety performed differently in terms of the growth parameters measured. SAMPEA-14 produced higher root length and grains yield than the rest of the varieties while SAMPEA-7 produced the highest number of nodules and number of effective nodules per plant. Significantly higher root length, number of nodules, number of effective nodules and grains yield was obtained in the application of 45 kg P_2O_5 ha^{-1}. There was highly significant interaction ($P \leq 0.01$) between PGRs, varieties and phosphorus levels on root length and number nodules per plant. For the best grains yield, application of 45 kg P_2O_5 ha^{-1} on SAMPEA-14 recorded a promising yield and are hereby recommended for the farmers in Yola, Adamawa State Northern Guinea Savannah zone of Nigeria.

Key words: cowpea, varieties, plant growth regulators, phosphorus levels and yield.

Introduction
Cowpea (*Vigna unguiculata* (L.) Walp) is an annual legume that belongs 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 25ºC to 35ºC 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, millets 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; Bittenbender *et al.*, 1984); 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. Dry grains for human consumption is the most important product 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 improve 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 refered 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. Because most cowpea growers in Nigeria do not apply P fertilizer and PGRs in their cowpea (Brynes and Bumb, 1998). There is paucity of information's regarding the use of plant growth regulators and P fertilizer in the production of numerous varieties of cowpea that can give maximum yield. There is also limited research on the effects of plant growth hormones, phosphorus fertilizer and varieties on the yield of cowpea in this region.

Therefore, the objectives of this study are to determine the effects of these variable (varieties, phosphorus and plant growth regulators) on the root length per plant, number of nodules per plant, number of effective nodules per plant and grains yield of cowpea per hectare.

Materials and Methods

Experimental Site: Field experiments were conducted out in 2018, 2019 and 2020 under rain fed conditions 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 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 sited 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 also 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} (Jakusko, 2017) 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 (%)

And 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

***Root length*:** Destructive sample of two plants was carried out from each plots. The plants were watered up to saturation point, uprooting was carried out with the help of a dibber and the root system washed gently in clean standing water. The roots were then cut with a razor blade at the soil level, length was measured from the tip of main (primary) root to the cut at the soil level and mean recorded.

Number of Nodules per Plant: The nodules from the uprooted plants were separated and counted and their mean recorded.

Number of Effective Nodules per Plant: Nodules from the uprooted plants were cut opened to determine apparent effectiveness, using a razor blade and hand lens. Nodules with pink or reddish color was considered effective and fixing nitrogen, while those with green or colorless was identified as ineffective nodules.

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

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 effects of plant growth regulators, varieties and phosphorus levels on root length of cowpea per plant at 3, 6 and 9 WAS in 2018, 2019 and 2020 is presented on Table 1. Application of plant growth regulators did not significantly ($p \leq 0.05$) influence root length of cowpea except at 6 and 9 WAS in 2018 ($p \leq 0.001$). Cytokinins recorded the longest root at 6 WAS with 18.44 cm, followed by gibberellins (17.69) while brassinolite gave the shortest root length with 15.42 cm. The same pattern was observed at 9 WAS where cytokinins gave the longest root with 22.89 cm which did not differ statistically with gibberellins (21.53 cm) while, brassinolite gave the shortest root length of 19.00 cm which are statistically the same with the control (19.89 cm). Effect of varieties on root length of cowpea shows a highly significant effect ($p \leq 0.01$) at 3 WAS in 2018 and 2020, and significant ($p \leq 0.05$) at 6 WAS in 2020 respectively. At 3 WAS in 2018, SAMPEA-14 produced the longest root of 9.69 cm while SAMPEA-7 recorded the shortest root (8.80 cm). At 3 and 6 WAS in 2020 growing seasons, SAMPEA-14 gave the longest roots of 12.81 and 25.69 cm which are statistically similar with SAMPEA-7 (12.09 and 24.29 cm), while ''kanannado'' produced the shortest root length of 11.25 and 22.95 cm respectively.

Effect of phosphorus levels was highly significant ($p \leq 0.001$) on root length at all the growth stages and in all the years of the study with the exception at 9 WAS in 2019. Steady increase in root length was observed with increase in phosphorus levels up to 45 kg ha^{-1} P_2O_5. In 2018 growing season, application of 45 kg ha^{-1} P_2O_5 gave the highest mean values of 9.61, 17.97 and 21. 97 cm at 3, 6 and 9 WAS which did not differ statistically with 30 kg ha^{-1} P_2O_5. Application of 15 kg ha^{-1} P_2O_5 gave the least mean value of 8.11 cm at 3 WAS and 0 kg ha^{-1} recorded the least mean values of 15.22 and 19.69 cm at 6 and 9 WAS respectively. In 2019, application of 30 kg ha^{-1} P_2O_5 gave the longest roots at 3 and 6 WAS with 8.66 and 20.86 cm which did not differ statistically with 45 kg ha^{-1} P_2O_5 (8.51 and 20.62 cm), while the least roots length was recorded in the application of 0 kg ha^{-1} P_2O_5 (control) with 6.96, 18.42 and 29.44 cm which did not differ statistically with 15 kg ha^{-1} P_2O_5 at 3, 6 and 9 WAS respectively. Similarly, in 2020 application of 45 kg ha^{-1} P_2O_5 recorded the highest mean values of 13.22, 27.31 and 37.53 cm t 3, 6 and 9 WAS which did not differ statistically with 30 kg ha^{-1} P_2O_5 (12.77 and 26.58 cm) at 3 and 6 WAS, while 0 kg ha^{-1} P_2O_5 gave the lowest mean values of 10.79, 19.99 and 25.67 cm at 3, 6 and 9 WAS respectively.

Table 1: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Root Length (cm) $Plant^{-1}$ at Various Growth Stages of Cowpea in Yola During 2018, 2019 and 2020 Rain fed Growing Seasons

Treatment	2018			2019			2020		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS
PGRs									
Cytokinins	8.57	18.44	22.89	8 .39	20.26	29.58	12.00	25.47	33.92
Gibberellins	9.69	17.69	21.53	7.93	19.71	30.19	11.77	25.36	33.86
Brassinolite	9.25	15.42	19.00	7.93	19.04	32.44	12.08	23.26	30.53
Water	8.24	15.47	19.89	7.41	19.56	29.31	12.35	23.14	29.83
P of F	0.224	<.001	<.001	0.582	0.610	0.796	0.708	0.224	0.096
LSD	1.626	0.709	1.136	1.650	2.155	8.423	1.202	3.177	4.078
Varieties (Var)									
SAMPEA-7	8.80	163.3	21.92	7.80	19.75	28.86	12.09	24.29	32.08
SAMPEA-14	9.69	17.19	20.79	8.40	19.96	30.50	12.81	25.69	32.54
KANANNADO	8.83	16.75	19.77	7.55	19.22	31.81	11.25	22.95	31.48
P of F	0.002	0.585	0.085	0.116	0.713	0.114	0.003	0.028	0.453
LSD	0.684	1.719	1.766	0.833	1.941	2.837	0.799	1.938	1.751
Phosphorus (Phos)									
0 kg P_2O_5 ha-^{1}	8.51	15.22	19.69	6.96	18.42	29.44	10.79	19.99	25.67
15 kg P_2O_5 ha-^{1}	8.11	7.22	20.22	7.54	18.68	29.69	11.41	23.36	30.78
30 kg P_2O_5 ha-^{1}	9.54	16.61	21.42	8.66	20.86	31.06	12.77	26.58	34.17
45 kg P_2O_5 ha-^{1}	9.61	17.97	21.97	8.51	20.62	31.33	13.22	27.31	37.53
P of F	<.001	<.001	<.001	0.002	<.001	0.602	<.001	<.001	<.001
LSD	0.519	1.222	1.061	0.968	1.435	3.391	0.902	1.790	2.090
Interactions									
PGRs X Var.	NS	NS	NS	NS	NS	NS	NS	NS	NS
PGRs x Phos.	*	**	**	NS	NS	NS	NS	NS	NS
Var. x Phos	NS	NS	NS	NS	NS	NS	NS	NS	NS
PGRs x Var x Phos.	**	NS	**	NS	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.

Interaction between plant growth regulators, varieties and phosphorus levels was highly significant ($p \leq 0.001$) at 9 WAS in 2018 (Table: 2). Combination of gibberellins and 45 kg ha^{-1} P_2O_5 on SAMPEA-14 recorded the highest root length per plant (25.33 cm), which are statistically similar with the combination of cytokinins and 45 kg ha^{-1} P_2O_5 on “kanannado” (23.67 cm), combination of gibberellins and 45 kg ha^{-1} P_2O_5 on SAMPEA-7 (24.67 cm), combination of brassinolite and 45 kg ha^{-1} P_2O_5 on SAMPEA-7 (24.67 cm). The least mean value of 14.00 cm was recorded in the combination of brassinolite and 0 kg ha^{-1} P_2O_5 on SAMPEA-14.

The mean values of number of nodules per plant of cowpea as affected by plant growth regulators, varieties and phosphorus levels at 3, 6 and 9 WAS in 2018, 2019 and 2020 is presented on Table 3. Application of plant growth regulators was only significant ($p \leq 0.05$) at 9 WAS in 2018 growing season, where gibberellins recorded the highest number of 6.00 nodules per plant, followed by cytokinins 4.89 while the least number of nodules per plant was recorded in the application of water (3.19). Effect of varieties was highly significant ($p \leq 0.001$) on number of nodules per plant at 3 and 9 WAS in 2018; highly significant ($p \leq 0.001$) at 3 WAS in 2019 and 2020; and significant ($p \leq 0.05$) at 6 WAS in 2019 and 2020 respectively. At 3 WAS in 2018, SAMPEA-7 recorded the highest number of nodules per plant with 7.25 and also at 9 WAS, SAMPEA-7 recorded the highest number of nodules per plant with 6.73 which did not differ statistically with "kanannado" (5.15) while SAMPEA-14 gave the lowest number of 3.98 and 2.02 nodules per plant at 3 and 9 WAS respectively. In 2019, ''kanannado'' recorded the highest number of nodules (6.90) at 3 WAS which are statistically similar with SAMPEA-7 (6.46), while SAMPEA-7 produced the highest number of nodules (16.23) at 6 WAS which are also statistically similar with "kanannado" (14.06). The least number of nodules per plant was obtained in SAMPEA-14 with 2.65 and 10.44 at 3 and 6 WAS respectively. In 2020, highest number of 12.92 and 16.98 nodules per plant was obtained from SAMPEA-7 at 3 and 6 WAS which were statistically similar with "kanannado" (12.02 and16.17), while SAMPEA-14 gave the least number of 5.48 and 12.06 nodules per plant at 3 and 6 WAS respectively. Application of phosphorus shows a highly significant ($p \leq 0.001$) difference at all the sample period of the study with the exception of 9 WAS in 2019. There was inconsistence of the effect of phosphorus on number of nodules. At 3 WAS in 2018, application of 45 kg ha^{-1} P_2O_5 produced the highest number of nodules (7.33) which are statistically similar with 30 kg ha^{-1} P_2O_5 (6.47) At 6 WAS, application of 30 kg ha^{-1} P_2O_5 gave the highest mean value of 13.50 nodules which are statistically similar with 45 kg ha^{-1} P_2O_5 (12.03). At 9 WAS however, application of 15 kg ha^{-1} P_2O_5 recorded the highest number of nodule per plant (5.86) which are statistically similar with 30 kg ha^{-1} P_2O_5 and 45 kg ha^{-1} P_2O_5 (5.06). Application of 0 kg ha^{-1} P_2O_5 recorded the least number of nodules (3.53, 6.89 and 2.56 per plant) at 3, 6 and 9 WAS respectively. In 2019, application of 45 kg ha^{-1} P_2O_5 gave the highest number of nodules per plant with 7.22 and 17.19 at 3 and 6 WAS which were statistically similar with 30 kg ha^{-1} P_2O_5 (6.78 and 15.50). And 0 kg ha^{-1} P_2O_5 gave the least number of nodules per plant with 2.08 and 8.44 at 3 and 6 WAS respectively. In 2020 however, application of 45 kg ha^{-1} P_20_5 recorded the highest number of nodules per plant at 3 and 6 WAS with 13.97 and 17.69 which are statistically similar with 30 kg ha^{-1} P_2O_5 (12.50 and 17.06). At 9 WAS however, 45 kg ha^{-1} P_2O_5 recorded the highest (6.78). Application of 0 kg ha^{-1} P_2O_5 recorded the least number of nodules per plant with 5.81, 10.14 and 2.75 at 3, 6 and 9 WAS respectively.

Table 2: Interaction Effect between Plant Growth Regulators, Varieties and Phosphorus Levels on Root Length (cm) 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	23.33	25.33	23.67	21.33
	SAMPEA-14	20.67	24.00	18.33	23.67
	KANANNADO	19.00	22.00	23.67	23.67
Gibberellins	SAMPEA-7	23.00	18.33	24.67	24.67
	SAMPEA-14	19.67	21.33	22.67	25.33
	KANANNADO	20.33	20.00	19.00	19.33
Brassinolite	SAMPEA-7	18.67	18.33	23.67	24.67
	SAMPEA-14	14.00	14.67	16.67	19.00
	KANANNADO	16.67	20.33	21.00	20.33
Water	SAMPEA-7	19.00	19.00	21.67	21.33
	SAMPEA-14	20.00	22.67	24.33	19.67
	KANANNADO	16.00	16.67	17.67	20.67
P of F		<.001			
LSD		4.286			

WAS= Weeks After Sowing, PGRs= Plant Growth Regulators

Table 3: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Number of Nodules Plant^{-1} at Various Growth Stages of Cowpea in Yola During 2018, 2019 and 2020 Rain fed Growing Seasons

Treatment	2018			2019			2020		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS
PGRs									
Cytokinins	5.58	8.06	4.89	7.19	15.72	1.25	11.03	16.08	4.69
Gibberellins	5.31	9.17	6.00	3.50	13.08	2.75	11.93	15.72	4.11
Brassinolite	6.89	11.67	4.44	6.64	15.42	2.00	9.81	13.97	5.08
Water	4.86	12.64	3.19	4.00	10.08	3.75	8.69	14.50	4.19
P of F	0.075	0.252	0.031	0.350	0.372	0.216	0.848	0.751	0.376
LSD	1.536	5.544	1.640	0.845	8.082	2.616	7.532	5.383	1.417
Varieties (Var)									
SAMPEA-7	7.25	11.88	6.73	6.46	16.23	3.13	12.92	16.98	4.94
SAMPEA-14	3.98	9.04	2.02	2.65	10.44	1.52	5.48	12.06	3.73
KANANNADO	5.75	10.23	5.15	6.90	14.06	2.67	12.02	16.17	4.90
P of F	<.001	0.421	<.001	0.008	0.049	0.265	<.001	0.053	0.182
LSD	1.451	4.465	1.857	0.453	4.580	2.063	3.213	4.191	1.491
Phosphorus (Phos)									
0 kg P_2O_5 ha-^{1}	3.53	6.89	2.56	2.08	8.44	1.61	5.81	10.14	2.75
15 kg P_2O_5 ha-^{1}	5.31	9.11	5.86	5.25	13.17	2.61	8.28	15.39	3.67
30 kg P_2O_5 ha-^{1}	6.47	13.50	5.06	6.78	15.50	2.31	12.50	17.06	4.89
45 kg P_2O_5 ha-^{1}	7.33	12.03	5.06	7.22	17.19	3.22	13.97	17.69	6.78
P of F	<.001	<.001	0.005	<.001	<.001	0.283	<.001	<.001	<.001
LSD	1.575	2.821	1.874	0.436	3.784	1.660	3.572	3.398	1.288
Interactions									
PGRs X Var.	NS	NS	NS	NS	NS	NS	NS	NS	NS
PGRs x Phos.	NS	NS	NS	NS	*	NS	NS	NS	**
Var. x Phos	NS	NS	NS	NS	NS	NS	NS	NS	NS
PGRs x Var x Phos.	NS	NS	NS	NS	NS	NS	NS	NS	*

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

There was significant (p≤0.05) interaction between plant growth regulators, varieties and phosphorus levels on number of nodules per plant was recorded at 9 WAS in 2020 (Table 4). Combination of cytokinins and 45 kg ha^{-1} P_2O_5 on SAMPEA-7 produced the highest number of nodules (10.67) which are at par with the combination of water and 45 kg ha^{-1} P_2O_5 on "kanannado" and are statistically the same with the combinations of cytokinins and 45 kg ha^{-1} P_2O_5 on "kanannado" (10.00), gibberellins with 45 kg ha^{-1} P_2O_5 on "kanannado" (8.00); and brassinolite with 45 kg ha^{-1} P_2O_5 on "kanannado" (8.00). Least value was recorded in the combination of brassinolite and 0 kg ha^{-1} P_2O_5 on ''kanannado'' (0.33).

Table 4: Interaction Effect between Plant Growth Regulators, Varieties and Phosphorus Levels on Number of Nodules Plant^{-1} of Cowpea at 9 WAS in Yola during 2020 Growing Season

PGRs	Varieties	Phosphorus Levels (kg ha^{-1})			
		0	15	30	45
Cytokinins	SAMPEA-7	3.67	1.00	5.33	10.67
	SAMPEA-14	4.67	3.67	1.00	5.00
	KANANNADO	2.33	4.33	4.67	10.00
Gibberellins	SAMPEA-7	3.67	8.00	4.67	4.67
	SAMPEA-14	2.67	1.67	2.67	8.00
	KANANNADO	1.00	4.00	4.67	3.67
Brassinolite	SAMPEA-7	3.33	5.67	7.67	7.67
	SAMPEA-14	2.67	5.67	6.67	0.67
	KANANNADO	0.33	3.00	9.67	8.00
Water	SAMPEA-7	1.67	2.67	3.00	5.67
	SAMPEA-14	2.67	2.00	3.33	6.67
	KANANNADO	4.33	2.33	5.33	10.67
P of F		0.037			
LSD		4.620			

WAS= Weeks After Sowing, PGRs= Plant Growth Regulators

The effects of plant growth regulators, varieties and phosphorus levels on number of effective nodules per plant at 3, 6 and 9 WAS in 2018, 2019 and 2020 (Table 5) showed that plant growth regulators was not significant ($p \leq 0.05$) at all the growth stages and in all the years of the study. Varietal effect significantly ($p \leq 0.05$) influenced number of effective nodules at 6 WAS in 2018 and highly significant ($p \leq 0.01$) at 3 and 6 WAS 2019 as well as at 3 WAS 2020. In 2018, at 6 WAS SAMPEA-7 produced the highest number of effective nodules per plant (7.42) which are statistically similar with ‘‘kanannado’’ (6.19) while SAMPEA-14 gave the least number of (3.60) effective nodules per plant. In 2019 however, at 3 WAS ‘‘kanannado’’ produced the highest number of effective nodules (4.73) which are statistically similar with SAMPEA-7 (4.15). At 6 WAS, SAMPEA-7 recorded the highest number of effective nodules with 13.62 which did not differ statistically with “kanannado” (12.83) while SAMPEA-14 recorded the least number of effective nodules of 1.73 and 8.69 per plant at 3 and 6 WAS respectively. In 2020, at 3 WAS SAMPEA-7 recorded the highest number of effective nodules per plant (11.23) which did not differ statistically with “kanannado” (11.06) while SAMPEA-14 gave the least number (5.37) of effective nodules per plant. There was highly significant ($p \leq 0.001$) effect of phosphorus levels on number of effective nodules per plant at all the sampled period and in all the three (3) years of the study except at 9 WAS in 2018 and 2019. In 2018, at 3 WAS, application of 45 kg ha^{-1} P_2O_5 recorded the highest number of effective nodules (4.69) which did not differ statistically with 30 kg ha^{-1} P_2O_5 (3.97) while 30 kg ha^{-1} P_2O_5 recorded more number of effective nodules at 6 WAS (7.61) which did not differ statistically with 45 kg ha^{-1} P_2O_5 (6.61).

Table 5: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Number of Effective Nodules Plant^{-1} at Various Growth Stages of Cowpea in Yola During 2018, 2019 and 2020 Rain fed Growing Seasons

Treatment	2018			2019			2020		
	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS	3 WAS	6 WAS	9 WAS
PGRs									
Cytokinins	3.61	4.31	0.44	5.06	12.19	0.42	10.97	15.00	2.67
Gibberellins	3.91	5.42	1.61	1.36	11.19	1.67	9.65	13.72	1.86
Brassinolite	4.38	7.25	0.97	4.97	14.47	1.22	9.11	12.50	2.33
Water	2.28	5.97	0.50	2.75	9.00	2.03	7.25	13.06	1.69
P of F	0.280	0.375	0.327	0.339	0.273	0.088	0.666	0.461	0.725
LSD	2.366	3.808	1.573	5.319	6.100	1.279	7.165	3.759	2.282
Varieties (Var)									
SAMPEA-7	3.98	7.42	0.90	4.15	13.62	1.96	11.23	15.29	1.90
SAMPEA-14	2.90	3.60	0.62	1.73	8.69	0.52	5.37	11.23	2.10
KANANNADO	3.21	6.19	1.12	4.73	12.83	1.52	11.06	14.19	2.42
P of F	0.153	0.050	0.487	0.014	0.011	0.121	<.001	0.105	0.723
LSD	1.150	3.065	0.864	2.003	3.223	1.422	3.014	3.899	1.367
Phosphorus (Phos)									
0 kg P_2O_5 ha-^{1}	1.75	4.22	0.31	1.11	7.86	1.17	5.50	9.67	1.28
15 kg P_2O_5 ha-^{1}	3.03	4.50	1.33	3.08	11.81	1.75	7.39	13.81	1.11
30 kg P_2O_5 ha-^{1}	3.97	7.61	0.61	5.31	14.14	1.06	11.78	15.39	2.42
45 kg P_2O_5 ha-^{1}	4.69	6.61	1.28	4.64	13.06	1.36	12.22	15.42	3.75
P of F	<.001	<.001	0.090	0.002	0.007	0.509	<.001	<.001	<.001
LSD	0.961	1.804	0.950	2.219	3.686	1.037	3.254	3.057	1.198
Interactions									
PGRs X Var.	*	NS	NS	NS	NS	NS	NS	NS	NS
PGRs x Phos.	NS	NS	NS	NS	NS	NS	NS	NS	*
Var. x Phos	NS	NS	NS	NS	NS	NS	NS	NS	NS
PGRs x Var x Phos.	NS	NS	NS	NS	NS	NS	NS	NS	NS

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

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 6. Grains yield was not significantly (p≤0.05) affected by plant growth regulators in all the study years. Varieties showed a highly significant (p≤0.001) effect on grain yield in 2018, 2019 and 2020 growing seasons. SAMPEA-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≤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 produced 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}).

In 2019, interaction between plant growth regulators and varieties on grains yield was significant (p≤0.05) as presented on Table 7. Brassinolite and SAMPEA-14 produced the highest grains yield (1742.51 kg ha^{-1}) which are statistically the same with cytokinins and SAMPEA-14 (1740.29 kg ha^{-1}); and gibberellins with SAMPEA-14 (1700.83 kg ha^{-1}), and the lowest grains yield was that of water and "kanannado" (830.62 kg ha^{-1}).

Table 6: Effects of Plant Growth Regulators, Varieties and Phosphorus Levels on Grains Yield ($kg\ ha^{-1}$) of Cowpea in Yola During2018, 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≤0.05), ** = Highly Significant (P≤0.01), NS= Not Significant, PGRs= Plant Growth Regulator

Discussion

Root length was found to be significantly influenced by plant growth regulators at 6 and 9 WAS in 2018. Spraying of cytokinins which are statistically similar with gibberellins at 9 WAS recorded the highest root length. This might be due to the role of cytokinins in enhancing the growth of plants. This reconfirmed the findings of Culver *et al*. (2012) in Tomato. Varietal effect significantly influences root length. The improved varieties (SAMPEA-14 and SAMPEA-7) that are statistically similar produced the highest root length over the local varieties ("kanannado"). This is in conformity with the finding of Magashi *et al*. (2014) who reported that significant differences in terms of root parameters existed among varieties in cowpea. Root length was significantly influenced by phosphorus fertilization. Application of 30 and 45 kg ha^{-1} P_2O_5 which are statistically similar recorded the highest root length. This could be attributed to the increase in metabolism which promotes rapid cell division at higher dosage. Philip (1993) noted that application of phosphorus enhanced better root growth and better absorption of nutrients.

Number of nodules per plant was significantly influenced by plant growth regulators at 9 WAS in 2018. Maximum number of nodules was obtained with the application of gibberellins which did not differ statistically with cytokinins and brassinolite. Gibberellins can positively affect enzyme production which mobilizes food production used for the growth of new cells in conformity Emongor (2011) also found that, application of gibberellins significantly increased nodulation in cowpea. Number of nodules per plant was significantly influenced by varieties in the three years of the study. SAMPEA-7 which did not differ statistically with "kanannado" produced the highest number of nodules per plant in all the years of the study. This could be probably due to their genetic make-up that makes it differ from the other variety. Ayodele and Oso (2014) in agreement with their findings also stated that, variation in nodulation in cowpea varieties could be attributed to differences in the genetic make-up of individual varieties. Phosphorus fertilizer significantly influenced number of nodules per plant in all the years of the study. Application of 30 and 45 kg ha^{-1} P_2O_5 which were statistically the same recorded the highest number of nodules per plant. This must be because phosphorus initiate nodules formation as well as rhizobium legume symbiosis. Significant increase in number of nodules per plant as influenced by phosphorus application was also observed by Karikari *et al*. (2015) in cowpea. Nkaa *et al.* (2014) also reported that phosphorus is critical to cowpea yield because it stimulate growth, initiate nodule formation as well as influences the efficiency of the rhizobium legume symbiosis.

Number of effective nodules per plant was not significantly influenced by plant growth regulators in all the years of the study. However, varieties significantly influenced number of effective nodules per plant. Though statistically similar with “kanannado”, SAMPEA-7 produced the highest number of effective nodules per plant in 2018 and 2019; as well as at 3 WAS in 2020. However, “kanannado” which is also statistically similar with SAMPLE-7 produced the highest number of effective nodules per plant in 2020. This proved that, variation among varieties existed. The result collaborates the findings of Ayodele and Oso (2014) and Karikari *et al*. (2015) all in cowpea. Phosphorus fertilizer significantly influenced number of effective nodules per plant in all the study years. Application of 45 kg ha^{-1} P_2O_5 which was statistically the same with 30 kg ha^{-1} P_2O_5 recorded the highest number of effective nodules per plants. Phosphorus initiates nodule formation as well as influenced the efficiency of rhizobium-legume symbiosis there by nitrogen fixation can be enhanced (Nkaa *et al*., 2014). Significant increase in nodulation and effectiveness of nodulation as the applied phosphorus levels increased was also reported by Mokwnuye and Bationo (2002) in cowpea.

Grains yield was not significantly influenced by plant growth regulator 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 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 were reported by Karikari *et al*. (2015) and Prafull (2016) all in cowpea.

Conclusion

The result showed that the root nodulation and yield of cowpea was better with the application of plant growth regulators over the control. Application of 45 kg ha^{-1} P_2O_5 is the best level because of 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 farmers use in the study area for its optimum yield.

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