



Productivity of Cowpea (*Vigna unguiculata* (L) Walp) genotypes under Varying Population Densities

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ABSTRACT

To investigate the influence of three population densities (88,000, 44,000, and 29,000 plants/ha) on the growth and yield of five cowpea varieties (IT97K-461, IT97K-568-18, IT98K-131-2, IT99K-1060 and IT99K-245), a field experiment was conducted at Teaching and Research farm of Landmark University. Growth parameters such as germination count, plant height, and number of trifoliate leaves per plant, number of branches per plant, flower production dynamics and dry matter determination were measured, while harvest index, shelling percentage, number of seeds per pod, seed weight pods per plant and grain yield were measured at harvest as yield components. Data were subjected to statistical analysis of variance (ANOVA) using SAS Institute. Significant means were separated using Duncans Multiple Range Test at 5% probability level. Results revealed that there were no constant trends in growth parameters response to population density. Plant height and flower production decreased with increased population density, while number of leaves per plant and dry matter increased with increasing population density. There was no appreciable effect of population density on branching. All these parameters were significantly ($p \leq 0.05$) affected with variety, while there was no significant ($p \leq 0.05$) interaction effect. Most yield components decreased with increasing population density while grain yield however, slightly increased with increasing population density. All yield parameter and grain yield significantly varied with variety, while there were no appreciable interaction effect. In conclusion, a population density of 88,000 plants /ha gives the highest growth and grain yield. While, variety, IT97-568-18 gives the higher growth and grain yield than other varieties studied.

Keywords: Population density, Shelling percentage, flower production dynamics

Introduction

Cowpea (*Vigna unguiculata* (L) Walp) is one of the increasingly cultivated grain legumes of the tropical and subtropical countries. Cowpea is the most important source of protein for human being and livestock (Ajeigbe *et al.*, 2010). Cowpea can be used as a primary source of protein for Africans who cannot afford animal protein (Brader, 2002).

In most areas they are grown and eat in various ways either alone or mixed with maize, rice, fish or “gaari” which supplies 40% of the daily protein. Flour is made into fried or boiled cakes as ‘akara’ or ‘moinmoin’. Despite the importance of this crop, however, it has been observed that the yield of cowpea in southern guinea savannah of Nigeria has been lower than world average which ranges

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between 200-600kg/ha. A lot of factors may be responsible for this under production. Ajeigbe *et al.* (2006) stated that factors responsible for low yield production include pest infestation, disease and poor management practices. Low yield in cowpea production can also be attributed partly due to inefficient partitioning of dry-matter to the seeds and varietal factors.

A population density of less than 33,000 plants per hectare has been reported from farmers farm (Dugje *et al.*, 2009). At this density, the crop does not cover the ground completely, thus allowing the weeds to grow and reducing the efficiency of land utilization. Experiment has reported that cowpea responded very well to inter row spacing of 60 x 30 cm giving a plant population of 55,000 plant per hectare (Kamara *et al.*, 2014). In Nigeria, Anonymous, (2008 showed that a population of 87,000 plants per hectare was ideal for erect and semi erect type. At low densities, competition may not occur at all and resources are not efficiently used. It is therefore the objectives of this present study is to investigate the influence of inter row spacing on growth and yield of cowpea varieties in southern guinea savannah of Nigeria and also to determine if cowpea response to increasing density is genotype dependent.

Materials and Methods

Field experiment was conducted at the Teaching and Research (T and R) farm of Landmark University Omu Aran, Kwara State (Latitude 8° 28'N, Longitude 4° 34'E and annual rainfall of 1005mm) in the southern Guinea savannah of Nigeria (Afolabi *et al.*, 2020). Composite soil samples were collected randomly from the trial site at the depth of 0-15cm with soil auger prior to planting. The samples were analysed in the Soil, Water and Material Testing Laboratory of Lower Niger River Basin Development Authority, Ilorin, Nigeria for physico-chemical analysis (Table 1). Collected samples were air-dried and passed through 2 mm sieve The sieved samples were analyzed for chemical properties. Soil pH was

determined with a glass electrode pH meter in distilled water using 1:1 soil: water as described by Thomas (1996). Total nitrogen was determined by the macro-Kjeldahl method (Bremner, 1996); Exchangeable cations (Ca^{2+} , Mg^{2+} , K^{+} and Na^{+}) were extracted with neutral 1.0 M NH_4OAc solution of. The K^{+} , Ca^{2+} and Na^{+} concentrations in the extract were determined using the flame photometer while Mg^{2+} was determined using the atomic absorption spectrophotometer (AAS). For the determination of soil organic carbon, the Walkley-Black wet oxidation method (Nelson and Sommers, 1982) was adopted, Available P by the Bray-1 method as described by Kuo (1996)

For soil physical properties, particle size analysis was determined by hydrometer method according to Okalebo *et al.*, (2002). Soils of the sites for the two locations are sandy clay loam, low in nitrogen and other micro elements (Table 1).

The experiment was laid out as a Randomized Complete Block in split plot arrangement with the population consisting of the population density as main block and varieties as subplot. The population density were achieved by planting at inter-row spacing of 30cm, 60 cm and 90 cm equivalent to 88,000, 44,000 and 29,000 plants per hectare respectively. The plot size is 15m² consisting 2 rows of 5m long. The varieties considered were IT97K-461-4, IT97K-568-18, IT98K-131-2, IT99K-1060 and IT99K-1245 which were collected from the International Institute for Tropical Agriculture (IITA) Ibadan. Land preparation was carried mechanically using tractor to plough. Ridging was done at 2 weeks after to allow proper decaying of debris. Direct sowing was done at two seeds per hole in double row on a ridge. Weeds were controlled twice manually with hoe, first at 2 weeks after planting and secondly at 4-5 weeks after planting to ensure a clean field which is the most common method used by farmers in cowpea production. Weeding was at 6 weeks after sowing (WAS), all plot were sprayed with insecticide landacyhalothrine25 EC at a rate of 2ml per litre. The spraying continued at interval until pod

maturity. Data collection started at 2WAS and the following parameters were recorded

Growth parameters

Five plants were tagged randomly in each plot for ease growth parameter collection according to Watson *et al.*, (2002). Growth parameters recorded are: Plant height (measurement was from the soil surface to the last foliage leaf using measuring tape in centimetre); Number of trifoliolate leaves; Number of branches, and Numbers of flowers.

Proximate data taken were; Dry matter determination which were taken at the commencement of flowering using three samples in a plot which were randomly uprooted according to Vogl *et al.*, (2004). The root was cut from stem, packed separately and oven dried at 100^oc for 48 hours.

Yield Parameters taken at harvest, harvesting was done at 11 WAP when all pods had been dried; data were taken on;

$$\text{Number of pod per plant} = \frac{\text{Total number of pods}}{\text{Number of tagged plants}}$$

Number of seeds per pod, Seed weight, Pod weight determination, Grain weight, Stoffer weight, Shelling percentage: The shelling percentage from each plot was recorded using the expression below:

$$\text{Shelling percentage (SP)} = \frac{\text{Grain weight} \times 100}{\text{Pod weight}}$$

Harvest index: the ration of economic yield to that of total biomass is harvest index. Biomass is stoffer weight plus pod weight

$$\text{Harvest index} = \frac{\text{Economic yield}}{\text{Total biomass}}$$

Data analysis

All data collected data were subjected to statistical analysis of variance (ANOVA) using SAS 9.4 (2013). Significant means were separated using Duncans Multiple Range Test at 5% probability level.

Results

Effects of plant growth parameters

The result of the analysis of variance for germination shows that both the main effect of population density and variety as well as their interaction were significant (Table 2). The table also show that the effect of population density, variety and the population x variety interaction were generally significant for plant height throughout the measuring periods except at 2 and 3 WAP for population density. Table 3 showed that germination was significantly higher at density of 44,000 plants per hectare, while 88,000 plants per hectare and 29,000 plants per hectare showed similar germination. IT97K-461-4 has significantly lower germination than other varieties. IT98K-131-2, IT99K-1060 and IT99K-1245 have similar germination which was significantly higher in germination than IT97K-568-18. However, significant interaction effect revealed that while population density had no effect in germination of varieties IT97K-568-18, IT99K-1060 and IT99K-1245.

Germination in variety IT97K-461-4 and IT98K-131-2 was significantly reduced by the lowest population density (Table 4). Plant height decreased with increased population density with the plant at the highest population density showing significantly lower height than in the other two population densities. Plant height was highest at population density of 29,000, the values however, were not significantly taller than in plans at 44,000 plants per hectare. Plant height was significantly highest with variety IT97K-568-18 and significantly lowest with variety IT97K-461-4 throughout the measurement period (Table 3). Analysis of variance for number of trifoliolate leaves show that the effects of population density were significant from 4 WAS to 7 WAS, while the effects of variety were significant throughout the measurement period except at 2 WAS. Population density x variety effect were also significant

throughout the period except at 2 WAS and 5 WAS (Table 5).

Table 6 shows that number of leaves increases with increase in days of planting. Number of trifoliolate leaves increased with increasing population density throughout the measurement period with leaves production at population density 88,000 plants/ha significantly higher than at both 44,000 and 29,000 plants/ha which showed similar leave production. IT97K-568-18 and IT99K-1245 gave significantly ($p \leq 0.05$) higher number of leaves more than in the other varieties throughout the measurement period. The result of analysis of variance for branches (Table 7) shows that both the effects of population density and variety as well as their interaction were not significant ($p \leq 0.05$) throughout the period of data collection with the exception of 4 WAP for variety and interaction. Table 8 show that branches initially increase with increase in days of planting until a constant number is recorded at 4WAP till 7 WAP. Numbers of branches were neither affected by population density nor by variety. There was also no significant effect.

Effect on dry matter production

Dry matter was not significantly ($p \leq 0.05$) affected by both density and density by variety interaction, while it is significantly ($p \leq 0.05$) influenced by the variety (Table 9)

Table 10 show that dry matter was higher with population density of 88,000 plants/ha and least with 44,000 plants /ha. However, the differences were not significant. IT97K-568-18 has the highest dry matter which was significantly ($p \leq 0.05$) higher from those of other varieties. IT98K-131-2 was significantly lower from other varieties.

Effects of flower production dynamics

Analysis of variance for flower production show that that effect of population density were generally not significant throughout the period of flower counting with the exception of days 3 and 4. However, the effects of variety were generally

significant with the exception of days 3 and 4. However, the effect of variety was generally significant with the exception of days 7,8,9 and 15. Density x variety effect was only significant on few occasions during measurement (Table 11). Flower production increased with decrease in population density with production at the highest population density significantly lower than in the two lower densities which showed similar flower production from day 1 to day 7. Thereafter flower production was similar for all the three varieties. IT97K-461-4 and significantly lowest with variety IT98K131-2 throughout the measurement period (Table 12).

Effect on yield components

Analysis of variance for yield and yield component shows that the effect of population except seeds per pod. Similarly, the effects of variety were only significant ($p \leq 0.05$) for number of seeds per pod and seed weight, (Table 13), while the interaction effect of density x variety were only significant for shelling percentage and number of pods per plant. Table 14, showed that harvest index was highest at 29,000 plants/ha and least at 44,000 plants/ha, even though the IT98K-131-2 and IT99K-1245 had similar harvest index which was significantly ($p \leq 0.05$) higher than those of IT97K-461_4 and IT99K-1060.

Shelling percentage was not significantly different with all density even though it increased with increasing density. IT99K-125 showed significantly ($p \leq 0.05$) higher shelling percentage than other varieties.

Number of seeds was highest at 29,000 plants/ha although this was not significantly ($p \leq 0.05$) higher than 44,000 plants /ha. Number of seeds per pod decreased with increasing density. IT97K-568-18 has significantly higher number of seeds per pod than the other varieties. Number of seeds per pod

was significantly ($p \leq 0.05$) lowest in IT97K-461, although the value was not significantly lower than in IT99K-1245.

Pod per plant decrease with increased population with significant ($p \leq 0.05$) difference between 88,000 plants/ha and 29,000 plants/ha. Number of seeds per plant at 44,000 plants/ha was neither significantly lower than in 29,000 plants/ha higher than 88,000 plants/ha. IT97K-461 and IT99K-1060 was not significantly different but significantly higher than other varieties.

Seed weight shows no significant ($p \leq 0.05$) difference. IT97K-461-4 has the highest seed

weight and value was significantly higher than in other varieties which showed similar seed weight.

Grain yield slightly increased with increasing density even though the differences were significant. IT97K-568-18, IT98K-131-2, IT99K-1245 and IT99K-1060 had significantly ($p \leq 0.05$) higher grain yield which was however not significantly lower in IT99K-1060.

Table 1: Physical and Chemical Properties of Soil in the Experimental Sites

Properties	Value
Sand %	73.00
Clay %	6.00
Silt %	21.00
Textural class	Sandy clay loam
pH (H ₂ O)	5.70
Organic matter %	1.70
Nitrogen %	0.07
Phosphorus (mg/kg)	8.80
Ca ²⁺ (cmol/kg)	1.72

Table 2: Mean square from the analysis of variance for germination and plant height

SV	Df	Germ	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS
Density	2	424.09*	0.34ns	2.06ns	13.36**	436.99*	1692.57**	3158.77*
Error (a)	4	49.62	1.61	1.64	0.59	34.32	95.67	49.62
Variety	4	477.37***	6.48	7.79	9.93***	531.10***	1171.16***	477.37**
Density variety	x 8	198.70**	2.01**	1.34	3.07***	130.30***	204.30**	198.70**
Error (b)	24	61.71	0.46	0.54	0.5151	24.18	57.20	61.71

*, **, *** Significant F test at 0.05, 0.01 and 0.001 levels of probability respectively, “ns” not significant

Table 3: Effect of population density and variety in germination and plant height

Treatment	Germination	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS
88,000	77.9 ^b	9.65 ^a	10.90 ^b	12.99 ^b	21.37 ^b	24.40 ^b	26.45 ^c
44,000	84.4 ^a	9.95 ^a	11.68 ^a	14.43 ^a	31.31 ^a	39.10 ^a	50.15 ^b
29,000	73.9 ^b	9.79 ^a	11.39 ^{ab}	14.77 ^a	30.00 ^a	45.00 ^a	52.80 ^a
Sed	2.57	0.46	0.47	0.28	2.14	3.57	0.73
Variety							
IT97K-461-4	57.1 ^c	9.68 ^b	11.36 ^b	14.44 ^b	21.32 ^c	25.30 ^c	28.00 ^c
IT97-568-18	76.9 ^b	10.27 ^a	11.56 ^b	14.16 ^b	29.60 ^a	51.70 ^a	28.57 ^a
IT98K-131-2	85.1 ^a	9.76 ^b	11.56 ^b	14.28 ^b	30.68 ^b	44.50 ^b	50.36 ^b
IT99K-1060	86.6 ^a	8.5 ^c	9.77 ^c	12.31 ^c	21.94 ^c	27.70 ^c	32.19 ^d
IT99K-1245	87.9 ^a	10.78 ^a	12.29 ^a	15.13 ^a	24.26 ^c	31.60 ^c	36.56 ^c
Sed	3.70	0.32	0.35	0.33	2.32	3.57	1.39

*Mean values with the same letter along the same row are not significantly different, $p \leq 0.05$

Table 4: Interactive effects of population and variety on germination

Variety	88,000	44,000	29,000	Variety means
IT97K-461-4	61.7	72.0	37.7	57.1
IT97-568-18	69.7	80.7	80.3	76.9
IT98K-131-2	86.0	88.3	81.0	85.1
IT99K-1060	87.0	83.7	87.0	86.6
IT99K-1245	85.0	95.3	83.3	87.9
Population means	77.9	84.4	73.9	

s.e.d. for population = 2.57; s.e.d. for variety = 3.7; s.e.d. for population x variety = 6.29

Table 5: Means square from the analyses of variance for number of trifoliolate leaf per plant

SV	df	Plant height (weeks after planting (WAS))					
		2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS
Density	2	0.022ns	7.27ns	37.96*	90.82***	190.16**	224.47***
Error (a)	4	0.01	2.37	4.49	0.79	6.92	2.56
Variety	4	0.08ns	23.61	17.80***	34.03	55.19***	61.42***
Density x variety	8	0.08ns	3.04***	5.90**	3.52	15.91**	19.19*
Error (b)	24	0.10	0.5	1.75	3.24	4.86	7.00

*, **, *** Significant F test at 0.05, 0.01 and 0.001 levels of probability respectively, "ns" not significant

Table 6: Effect of population density and variety on number of trifoliolate leaves per plant

Treatment	Plant height (weeks after planting (WAS))					
	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS
88,000	2.07 ^a	6.47 ^a	13.53 ^a	23.47 ^a	29.80 ^a	30.67 ^a
44,000	2.13 ^a	5.33 ^b	11.27 ^b	20.40 ^b	23.67 ^b	24.73 ^b
29,000	2.07 ^a	5.20 ^b	10.47 ^b	18.60 ^c	23.60 ^b	23.40 ^b
Sed	0.11	0.56	0.78	0.32	0.96	0.59
Variety						
IT97K-461-4	2.11 ^a	8.56 ^a	13.56 ^a	22.67 ^a	27.33 ^a	28.11 ^a
IT97-568-18	2.00 ^a	5.11 ^b	11.67 ^{bc}	21.33 ^a	25.22 ^b	5.78 ^b
IT98K-131-2	2.22 ^a	4.89 ^b	10.00 ^d	22.56 ^a	26.89 ^a	26.56 ^a
IT99K-1060	2.11 ^a	5.00 ^b	12.67 ^{ab}	19.00 ^b	21.56 ^c	22.11 ^c
IT99K-1245	2.00 ^a	4.78 ^b	10.89 ^{cd}	18.56 ^b	27.44 ^a	28.78 ^a
Sed	0.14	0.32	0.62	0.85	1.08	1.25

*Mean values with the same letter along the same row are not significantly different, $p \leq 0.05$

Table 7: Mean square from the analyses of variance for branch per plant

SV	Df	Plant height (weeks after planting (WAS))					
		2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS
Density	2	0.56ns		0.09ns	0ns	0ns	0ns
Error (a)	4	0.29	0.73	0.02	0	0	0
Variety	4	0.14ns	0.37ns	0.09**	0ns	0ns	0ns
Density x variety	8	0.19ns	0.97ns	0.09**	0ns	0ns	0ns
Error (b)	24	0.33	0.88	0.02	0	0	0

*, **,*** Significant F test at 0.05, 0.01 and 0.001 levels of probability respectively, "ns" not significant

Table 8: Effect of population density and variety on number of branches per plant

Treatment	2 WAS	3 WAS	4 WAS	5 WAS	6 WAS	7 WAS
88,000	0.60 ^a	2.20 ^b	4.00 ^a	4.00 ^a	4.00 ^a	4.00 ^a
44,000	0.27 ^a	2.87 ^a	3.87 ^b	4.00 ^a	4.00 ^a	4.00 ^a
29,000	0.27 ^a	2.13 ^b	4.00 ^a	4.00 ^a	4.00 ^a	4.00 ^a
Sed	0.20	0.31	0.05	0.00	0.00	0.00
Variety						
IT97K-461-4	0.56 ^a	2.44 ^a	3.78 ^b	4.00 ^a	4.00 ^a	4.00 ^a
IT97-568-18	0.33 ^a	2.33 ^a	4.00 ^a	4.00 ^a	4.00 ^a	4.00 ^a
IT98K-131-2	0.22 ^a	2.44 ^a	4.00 ^a	4.00 ^a	4.00 ^a	4.00 ^a
IT99K-1060	0.33 ^a	2.67 ^a	4.00 ^a	4.00 ^a	4.00 ^a	4.00 ^a
IT99K-1245	0.44 ^a	2.11 ^a	4.00 ^a	4.00 ^a	4.00 ^a	4.00 ^a
Sed	0.27	0.43	0.07	0.00	0.00	0.00

*Mean values with the same letter along the same row are not significantly different, $p \leq 0.05$

Table 9: means square from the analyses of variance for dry matter per plant

SV	Df	DM
Density	2	10.64ns
Error (a)	4	4.40
Variety	4	399.84***
Density x variety	8	2.01ns
Error (b)	24	0.92

*, **,*** Significant F test at 0.05, 0.01 and 0.001 levels of probability respectively, “ns” not significant

Table 10: Effects of population density and variety on dry matter per plant

Treatment	DM
88,000	25.13 ^a
44,000	23.60 ^a
29,000	23.75 ^a
Sed	0.766
Variety	
IT97K-461-4	23.52 ^c
IT97-568-18	33.60 ^a
IT98K-131-2	15.33 ^d
IT99K-1060	23.33 ^c
IT99K-1245	25.00 ^b
Sed	0.46

*Mean values with the same letter along the same row are not significantly different, $p \leq 0.05$
Means having the same letter in a column are not significantly different by DMRT ($p < 0.05$)

Table 11: Mean square from the analyses of variance for flower production

SV	d f	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Density	2	11.82 ns	15.26 ns	20.69 **	26.6* *	4.95n s	4.42 **	6.82 ns	0.42n s	0.96 ns	0.36 ns	0.00 ns	1.42 ns	5.07 ns	2.49 ns	0.87 ns
Error (a)	4	1.92	2.57	1.32	1.87	0.86	0.55	2.29	1.16	1.39	1.79	0.40	1.06	1.97	0.75	1.43
Variety	4	60.33 ***	59.86 ***	63.61 ***	34.37 ***	16.91 ***	4.03 **	0.81 ns	0.86n s	2.37 ns	9.86 ns	5.57 **	3.81 **	3.26 **	2.36 ns	0.24 ns
Density x variety	8	7.93* **	1.49n s	3.07* *	3.43n s	3.51* *	1.28 ns	2.46 ns	3.172 ***	2.57 **	3.44 ***	2.52 ns	1.97 **	1.37 ns	1.74 **	1.06 ns
Error (b)	24	0.71	1.56	0.94	1.61	1.18	0.73	1.11	0.51	0.60	0.89	1.09	0.80	0.83	0.54	0.66

*, **,*** Significant F test at 0.05, 0.01 and 0.001 levels of probability respectively, “ns” not significant

Table 12: Effects of population density and variety on flower production

Treatment	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
88,000	6.27 ^b	6.67 ^b	6.87 ^b	7.40 ^b	6.13 ^b	5.47 ^b	5.20 ^b	5.40 ^a	4.67 ^a	4.40 ^a	3.53 ^a	2.27 ^a	1.40 ^b	1.20 ^b	0.53 ^a
44,000	7.47 ^a	8.13 ^a	8.93 ^a	9.60 ^a	7.27 ^a	6.47 ^b	6.40 ^a	5.60 ^a	5.13 ^a	4.40 ^a	3.53 ^a	2.80 ^a	2.33 ^b	2.00 ^a	1.00 ^a
29,000	8.00 ^a	9.60 ^a	8.87 ^a	7.20 ^b	6.53 ^{ba}	5.60 ^b	5.27 ^b	5.73 ^a	5.07 ^a	4.14 ^a	3.53 ^a	2.80 ^a	2.47 ^a	1.73 ^{ab}	0.87 ^a
Sed	0.51	0.59	0.42	0.50	0.34	0.27	0.55	0.40	0.43	0.49	0.23	0.38	0.51	0.32	0.43
Variety															
IT97K-461-4	9.56 ^a	10.78 ^a	11.78 ^a	10.11 ^a	8.00 ^a	6.22 ^{ab}	5.67 ^a	5.67 ^{ab}	5.22 ^{ab}	5.56 ^a	4.67 ^a	2.89 ^a	2.33 ^a	2.33 ^a	0.89 ^a
IT97-568-18	7.44 ^b	5.78 ^c	6.67 ^c	6.78 ^b	6.67 ^b	6.56 ^a	5.44 ^a	5.11 ^b	4.67 ^c	4.56 ^b	3.78 ^{ab}	3.00 ^a	2.33 ^a	1.67 ^{ab}	0.78 ^a
IT98K-131-2	2.89 ^c	4.56 ^d	4.78 ^d	5.33 ^c	4.44 ^c	4.89 ^c	5.22 ^a	5.78 ^{ab}	4.33 ^c	2.89 ^c	2.56 ^c	1.11 ^b	1.00 ^b	1.00 ^b	0.56 ^a
IT99K-1060	8.78 ^a	9.44 ^b	9.33 ^b	9.11 ^a	7.56 ^{ab}	6.11 ^{ab}	6.00 ^a	5.89 ^a	5.67 ^c	4.89 ^{ab}	3.56 ^b	3.33 ^a	2.44 ^a	1.89 ^a	1.00 ^a
IT99K-1245	7.56 ^b	8.44 ^b	8.56 ^b	9.00 ^a	6.56 ^b	5.44 ^{bc}	5.78 ^a	5.44 ^{ab}	4.89 ^c	3.67 ^{bc}	3.11 ^{bc}	2.78 ^a	2.22 ^a	1.33 ^b	0.78 ^a
Sed	0.40	0.50	0.46	0.60	0.51	0.4	0.50	0.33	0.37	0.44	0.49	0.43	0.43	0.34	0.38

*Mean values with the same letter along the same row are not significantly different, $p \leq 0.05$

Table 13: Mean square from the analyses of variance for flower production

SV	df	HI	SP	Seed pod	Pods	Seed weight	Yield (Kg/ha)
Density	2	0.01ns	42.68ns	6.00***	47.76ns	0.01ns	170336ns
Error (a)	4	0.01	45.53	0.49	13.29	0.01	119326
Variety	4	0.02ns	97.42ns	6.70***	24.58ns	4.01***	76916ns
Density x variety	8	0.01ns	125.30a	1.23ns	40.06**	0.01ns	27656ns
Error (b)	24	0.01	47.89	0.84	10.97	10.97	43037

*, **,*** Significant F test at 0.05, 0.01 and 0.001 levels of probability respectively, "ns" not significant

Discussion

Population density of 29,000 plants/ha resulted in taller plant from other plant population densities. This agrees with Kamara *et al.* (2003) who stated that increase in number of plant per hectare was associated with increase in plant height. This short plant height to increase in population density can be attributed to increase in moisture stress (Sing 2007) and competition for limited available nutrient. This means that the greater the plant density the lower the plant highest. The leaf production increased with increased in plant population density especially at 4WAP-7WAP with 88,000 plants/ha having the highest lead production. This observation agrees with Xiaolei and Zhifeng (2002) who stated that widely spread plants at low density, never completely cover the ground with their leaves and radiation interception is less efficient that at high population. The reason is that the increased competition at high density result in excessive leaf growth at the expense of the roots. The response on dry matter production in this study agreed with the observation of Purcell *et al* (2002) that dense sowing increased dry matter weight. The result from this research work showed that 88,000 plants/aha gives the highest dry matter weight which in turn gives the highest yield as compared to other densities.

Flower production was positively affected by population density with 88,000 plants/ha gave the highest flower production. This showed that dense sowing gave more flower production. This statement disagrees with (Xiaolei and Zhifeng, 2002) who stated that higher plant density decreased flower formation and increased abortion of reproductive structure due to plant competition for space, light and other growth factors. Results of this study with a significant decrease in pod formation with increased population density disagree with Purcell *et al.* (2002) who stated that with decreasing plant population density, there were increase in the number of pods per stem and number of seed per

meter square (m²). This is because the resources needed for the pod formation are less competed for at low densities.

In this study, number of seeds per pod increased with decreasing population density. This is in agreement with Chiezey (1990) who reported that higher density plant lead to decreased yield of individual plants. This is attributed to lesser competition for light, moisture and nutrient. The result of rain yield response to the effect of population densities showed that as population level increases, grain yield increases. This agrees with the results of Ismail and Hall (2000) who stated that higher density planting resulted in increased yield per unit area. Also it agrees with Kamara *et al.*, 2014 who reported that yield increased with increasing number of plant per stand although individual plants yield was reduced because the lower half of the stem produced fewer pod. The best spatial distribution and density and plant population are those which maximize yield hence a population of 88,000 plants/ha was revealed to be the best for the selected specie of cowpea in this study.

Conclusion

From the experiment, it could be observed that population of 88,000 plants/ha gave the highest yield and this can be recommended for farmers' usage. Any farmer that is interested in any of cowpea varieties in Southern Guinea Savannah should go for IT97K-568-18 because it gives highest seed per pod and yield.

Competing interests

The authors declare no conflict of interest.

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