DISCOVERY

Understanding options for improving cowpea production under changing climatic and variability in rain-forest agro-ecology of Nigeria

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ABSTRACT

Options for improving cowpea production under influence of climate change and variability impacts such as delayed onset, early cessation and shortened length of growing season in rain forest agro-ecological zone of Nigeria was investigated in this study. In order to achieve a sustainable improvement in cowpea production using selection of planting dates option for good growth and yield of cowpea, three planting dates were selected at two weeks interval starting from the onset of rain. This research was conducted during the growing season of 2021 and 2022 at the Laboratory for Geoecology and sustainable food systems (GeoLab), Federal University of Technology Akure, Nigeria (7°15′N, 5°15′E) and project farm of the Institute of Agricultural Research and Training (I.A.R&T.) Ibadan, Nigeria (7°22′N; 3°.30′E). Both locations are within the rain-forest agro-ecological zone of Nigeria. The varieties of cowpea used are, FUAMPEA 2(V1), Ife Brown (V2) and 573-1-1(V3). The planting spacing of 25cm x 75cm crop was followed. Variables measured are plant height, number of leaves, leaf area, days to 50% flowering, number of peduncles per plant, number of pods per peduncle, number of seeds per pod, pod length, 100 seed weight and yield per hectare. Cultivar differences were noticed among the three varieties of cowpea which indicated their generic differences. Ife Brown and 573-1-1 matured earlier than FUAMPEA 2. Ife Brown had more pods per plant, shorter pod length, fewer numbers of seeds per pod and smaller seeds than FUAMPEA 2 and 573-1-1 varieties of cowpea. Generally, the plant growth and yield parameters decreased with delayed planting irrespective of location and variety of cowpea planted. Maximum yield for FUAMPEA 2, Ife Brown and 573-1-1 planted in Akure are 1.48tons/ha, 1.47tons/ha and 1.22 ton/ha respectively while the maximum yield of cowpea planted in Ibadan for V1, V2 and V3 are 1.36 tons/ha, 1.38 tons/ha and 1.12 ton/ha respectively. Planting of cowpea for good grain yield is best done at the onset of rains in rain-forest of Nigeria. Through this adaptation strategy, the negative effects of climate change on cowpea production are reduced and positive influences enhanced.

Keywords: Climate change, Adaptation strategies, planting dates, agronomic characteristics, improved crop production.

1. INTRODUCTION

The inter-governmental panel on climate change IPCC, (2007) defined climate change as statistically significant variations in climate that persist for an extended period, typically decades or longer. Omotosho et al., (2000) defined climate as the characteristic condition of the atmosphere deduced from repeated observations over a long period. It includes considerations of departures from average (i.e., variability) extreme conditions and the probabilities of frequencies of occurrences of given weather conditions. Omotosho et al., (2000) also defined climate variability as the way climate fluctuates yearly above or below a long-term average value. Climate variability is of much importance to agriculture as it allows us to interpret information on weather and climate and to make sense out of our environment.

However, agricultural production activities are generally more vulnerable to climate change and variability than other sectors (IPCC, 2007; Hassen et al., 2011; Ezeh et al., 2016). Nigeria like all the countries of sub-sahara Africa is highly vulnerable to the impact of climate change, (IPCC, 2007; Bannanvan and Hooganboom, 2015). Reasons for this can be attributed to the fact that agricultural production in most sub-saharan African countries (Nigeria inclusive) is dependent on weather and climate (Ifeanyi, 2016). Agriculture is responsible for over a quarter of total global greenhouse gas emissions. Climate variability affects agriculture in various ways. The effect could be on quantity and quality of produce which has become more threatening to the totality of human existence.

Climate change induces unfavorable trends in agricultural production which intensify food insecurity. The issue of climate change has become a menace not only to the sustainable development of any nation's socio-economic activities (including agriculture) but to the totality of human existence. Various studies by inter-governmental panel on climate change (IPCC) have identified Africa as one of the most exposed continents to suffer the devastating effects of climate change because of inadequate adaptive capacity (IPCC, 2007). The Nigeria rain-fed agriculture is viewed by many observers to be the most vulnerable sector to climate variability. Climate change has been a topical issue in the sustainability of environment as crop yield and production becomes very important to economy and human livelihood. There is the need to study the impact of climate variability on crop production and to proffer suggestion to improve yield because variability in climate is a major reason for crop yield variability (Shanogo et al., 2015).

The climate of an area is highly correlated to the vegetation and by extension the type of crop that can be cultivated. Cowpea (*Vigna unguiculata*) is of major importance to the livelihoods of the majority of relatively poor people in the developing countries in the tropics. In Nigeria, the crop is cherished for its grains, which can be made into varieties of dishes, while the mature above ground plant parts, except pods are harvested for fodder. After harvest, the root residues decay in sites, contributing some organic matter to the soil. Cowpea can be regarded as the fulcrum of sustainable farming in semi-arid lands. When cowpea is being cultivated, the spreading and the bushy growth provides ground cover, thereby suppressing weed and serves as protective cover against soil erosion. After harvest, the root residue decay in-situ, contributing organic matter and associated nutrients to the soil (Asio et al., 2015).

Cowpea has the ability to fix atmospheric nitrogen by the means of rhizobia bacteria living in symbiosis in its root nodules. A contribution of 40 – 80 N ha-1 is the commonly obtained range, while the total amount of nitrogen fixation is 70 – 350 kg ha-1 (Akande et al., 2012). One of the factors affecting cowpea production is wrong timing of the planting regime due to rainfall variability as a result of global warming effects, particularly, the inability to adequately and accurately synchronize rainfall incidences with agricultural calendar of cowpea. Savannah agro-ecology accounted for over 75% of cowpea production in Nigeria while its major consumption is in the rain-forest agro-ecology, one major factor responsible for the high price of cowpea in the region (Dugie et al., 2019). Therefore, carefully synchronizing the growing period of crops to suitable period of rainfall availability, we can possibly increase the cropland available for cultivation in rain-forest agro-ecology.

With the rising human population, resulting in higher demand for food, it becomes imperative to sustainably increase food production in forest agro-ecological zone of Nigeria. Such crop production management should involve adequate knowledge of rainfall regime vis-à-vis scheduling the agricultural calendar of crops for optimum yield. By carefully synchronizing the growing period of crops to suitable period of rainfall synchronization should be such that different phonological stages of plants obtained adequate moisture and heat throughout the developmental stages. Therefore, the objective of this study is to investigate planting date as an adaptation strategy to the impact of climate change and variability on crop production in the rain-forest agro-ecology of Nigeria.

2. MATERIALS AND METHODS

Experimental site

This research was conducted during the growing season of 2021 and 2022 at this research was conducted during the growing season of 2021 at the Laboratory for Geoecology and sustainable food systems (GeoLab), Federal University of Technology Akure, Nigeria (70-15'N, 5015'E) and project farm of the Institute of Agricultural Research and Training (I.A.R&T.) Ibadan, Nigeria (7022'N; 3030'E). Both stations are within the rain forest agro-ecological zone of Nigeria. The forest-Savannah eco-climatic zone of Nigeria covers a total land area of about 115,000 sq. km. Rainfall in the zone can be described as humid to sub-humid tropical with distinct dry and wet season.

There are two rainfall peaks in June and September with dry spell in August (August break) which produces the bimodal rainfall pattern. It is characterized by minimal fluctuations, usually less than 5oC throughout the year. The mean monthly maximum temperature ranges between 28oCand 35oC for the period of 10 years, while the mean monthly minimum temperature ranged between 22.6oC and 26.7oC. It is characterized by minimal fluctuations, usually less than 5oC throughout the year. It is referred to as iso-hyperthermic temperature regime. The highest mean monthly maximum temperature is recorded in the months of February and March (35oC) for the period of 10 years, while the least monthly maximum temperature is about 28oC in the month of August for the same period.

The highest mean monthly minimum temperature is about 26.7oC in March/April, while the lowest mean monthly minimum temperature is between 22.6oC and 22.9oC in August/September for the same period. February and March have the highest evaporation rate, and it is as high as 6.9 mm. The least evaporation rate (1.6 mm) is recorded in June/July. The relative humidity ranges from 64.5% in February to 91% in June. February and March have the highest evaporation rate, and it is as high as 6.9 mm. The least evapotranspiration rate (1.6 mm) is recorded in June/July. This pattern is directly related to the pattern of rainfall/cloud cover and atmospheric temperature. The relative humidity is relatively high throughout the year. It ranges from 64.5% in February to 91% in June. Thus, the highest values are recorded at the height of rainy season, while the lowest values occur during the dry months (Wilhite, 2016).

The geomorphology and physiography of the area show that the area is part of the Western Nigeria low land area described as being relatively flat to very gently undulating plain developed on sedimentary rocks and Littoral deposits. The site was characterized by the presence of rills created by water erosion. The soil is deep, well drained with red (2.5YR 4/8) to brownish-red (5YR 5/4) in colour. It has a sandy loam texture at the surface (0 – 15 cm depth) and belongs to Ultisol, classified as Rhodic Kanhaplustult.

Field Experiments

Soil sampling was carried out before land preparation to quantify the baseline nutrient status of the soil before the trial. The result of the pre-planting soil analysis indicates soil pH of 4.76 and 5.12 for Akure and Ibadan respectively. The percentage organic matter and organic carbon of the soils in Akure and Ibadan are 13.2%, 1.28% and 8.9%, 1.04% respectively. The exchangeable bases Ca (1.50 cmol kg-1) and cation exchange capacity (3.26 cmol kg-1) was found in Akure soil, while Ca (1.52 cmol kg-1) and cation exchange capacity (4.02 cmol kg-1). The textural class of the soil in both sites is sandy-loam

Three experiments were conducted between 2021 and 2022 growing seasons. The treatments consist of 3 varieties of cowpea. The experiment was laid out in split plot design with varieties of crops as the main plot and dates of planting as subplot treatment. The treatment combinations were replicated 3 times in each location. The varieties of cowpea to be used are, FUAMPEA 2(V1), Ife Brown (V2) and 573-1-1(V3). The recommended planting space (20cm x 75cm) of the crop was followed. The three planting dates selected for are 28th April (D1), 12th of May (D2) and 26th of May (D3) in 2021 and 16th April (D1), 30th of April (D2) and 14th of May (D3) in 2022 in both locations. Three seeds per hole were planted which was later be thinned to two per stand at one week after planting. Weeding was carried out manually using hoe two weeks after planting and subsequently at two weeks interval. Spraying with insecticides at the rate of 4ml per liter of water was carried out at flowering and on weekly basis.

Data Collection and Analysis

Five plants were randomly selected and tagged from each plot for data collection. The growth and yield data collected include plant height, number of leaves, leaf area, number of peduncle per plant, number of pods per peduncle, number of seeds per pod, pod length, weight of 100 seeds and yield per hectare. Descriptive statistics including the mean standard error and the variance for each of the sites, years, weeks after planting, planting date and for each of the variety were computed. General linear model (glm) was adopted to describe the relationship between two variables (sources of variation and crop growth and yield) and to determine whether such relationship is statistically significant. Analysis of Covariance (ANCOVA) and regression analysis have been adopted to test the effect of these main sources of variation. Means of significantly different sources of variation were infographically analyzed using line and bar chart.

3. RESULTS

Short Term Rainfall Characteristics of Akure and Ibadan

Total rainfall obtained for Akure in 2021 ranged between 438mm for planting date 3 to 679.5mm for planting date 1 with corresponding variance of 178.973 – 386.188 (Table 1). The mean and the variance of 2021 rainfall for Akure agree with each other. Mean 2022 rainfall for Akure falls between 500.7mm for planting date 1 and 585.6mm for planting date 2 while the variance ranged from 235.015 for planting date 3 to 284.607 for planting date 1. Mean 2021 rainfall for Ibadan followed a regularly increasing trend from 304.5mm for planting date 1 to 365.5mm for planting date 3 with variance of 139.211 for planting date to 153.655 for planting date 3 (Table 1). Mean 2022 rainfall pattern inverse that of 2021 and it falls between 188.5mm for planting date 3 and 288.9mm for planting date 1. The variance decreases with increasing planting date from 122.328 for planting date 1 to 67.248 for planting date 3 (Table 1).

Table 1 Descriptive Statistics of Short-term Weather of the Study areas**.**

Years	Sites	Planting Date (PD)	Mean Periodic Rainfall	Variance
2021	Akure	PD1	679.5	386.188
		PD2	484.2	209.7411
		PD3	438	178.9732
2022		PD1	500.7	284.6066
		PD2	585.6	275.3041
		PD3	546.6	235.0148
2021	Ibadan	PD1	304.5	139.2114
		PD2	330	147.2108
		PD3	365.5	153.655
2022		PD1	288.9	122.3284
		PD2	211.3	79.51664
		PD3	188.5	67.24823

The results of the infographic analysis of the consecutive Days Without Rainfall (DWR) and Consecutive Rainfall Days (DCR) indicated that none of the planting date returned zero consecutive days without rainfall (DWR) and consecutive rainfall days (DCR) for Akure (Figure 1). Frequencies of the DWR as well as DCR vary with number of with number of days involved in each. DWR and GCR for 3 days returned the highest frequencies while DWR and GCR for 10 days returned the least or zero frequencies. All the planting dates have no 10 consecutive days with rainfall (DCR) while 10 consecutive days without rainfall were obtained for planting date 3 (for 2021 and 2022) and for 2021 of planting date 2 of Akure (Figure 1). For Ibadan, none of the planting date returned zero consecutive days without rainfall (DWR) and DCR.

Three DCR for all the planting date remained the most frequently encountered for Ibadan while DCR was the least frequently encountered for Ibadan. The trend of the consecutive rainfall days (DCR) was such that DCR (Planting date 1) is greater than DCR (Planting date 2) and greater than DCR (Planting date 3). All the planting date for Ibadan returned zero 10consecutive rainfall days for both 2021 and 2022. Similarly, consecutive days without rainfall (DWR) followed a decreasing trend form 3DWR to 10DWR for Ibadan (Figure 1). The trend of the DWR is however inverse of the DCR such that DWR (Planting date 1) is less than DWR (Planting date 2) and less than DWR (Planting date 3). Ten consecutive days without rainfall (DWR) were however obtained for both planting date 2 and planting date 3 in both 2021 and 2022 (Figure 1).

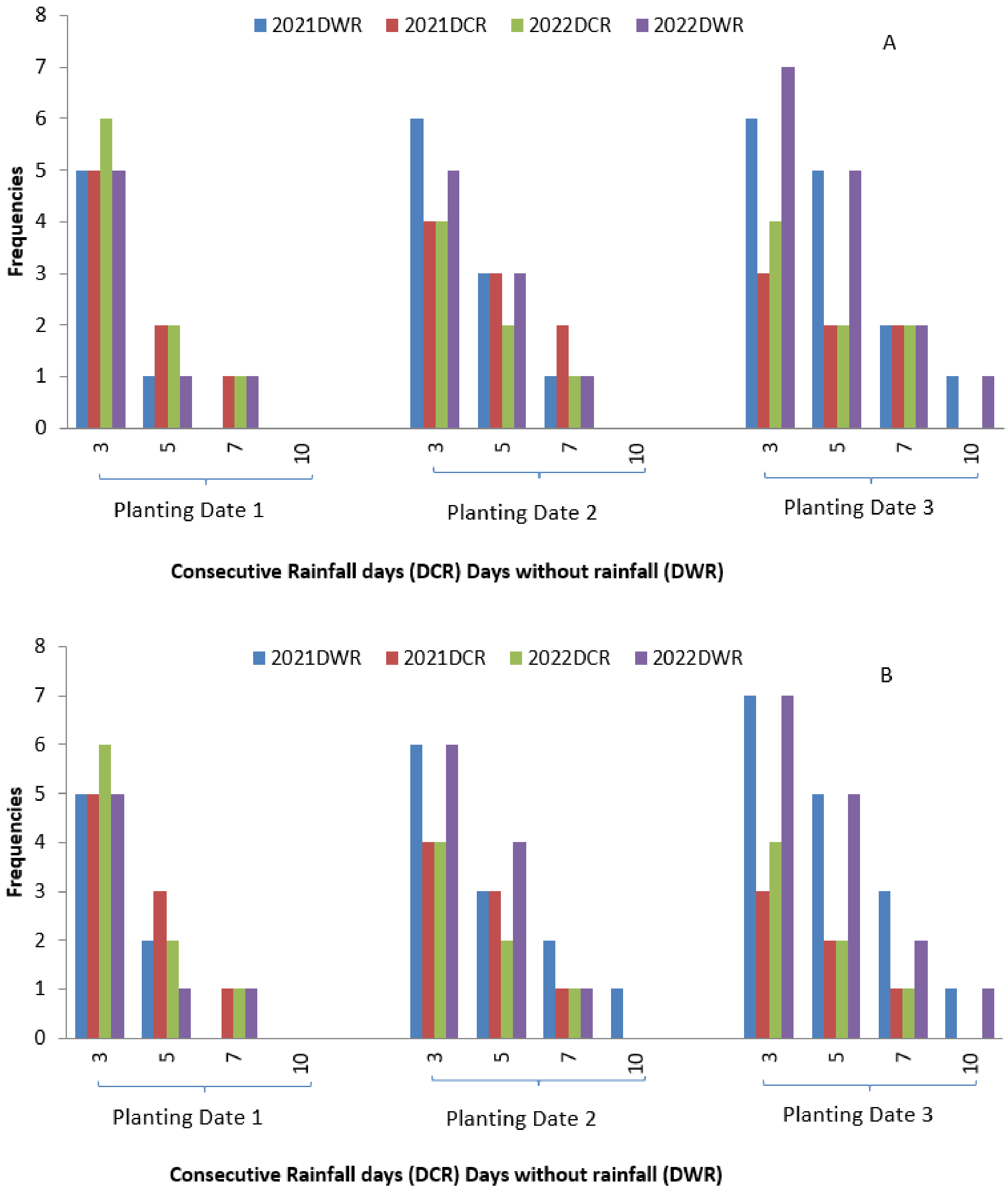


Figure 1 Dry and Wet spell by Planting dates for Akure - A & Ibadan – B (Using consecutive rainfall and dry days).

Descriptive Statistics of the Growth and Yield variables of the Cowpea.

Table 2 shows the descriptive statistics of the cowpea growth parameters. The result of the descriptive analysis statistics of the growth parameters of cowpea shows that mean plant height (29.591), number of leaves (26.413) and leaf area (236.5970) obtained for Ibadan were higher than those of Akure. Similarly, the variability of these variables (plant height and number of leaves) shows that the variances of the parameters at Ibadan were greater than those of Akure. The variance for the leaf area at Ibadan (13866.16) was however lower than that of Akure (14771.28). Years 2021 returned higher mean plant height (29.089) and higher mean leaf area (239.944) than year 2022 irrespective of the location of trials, while higher number of leave of 26.358 was obtained for year 2022. The variance followed the same pattern of the mean of the higher mean returning the higher variance. The descriptive statistics analysis result also showed that variety 3 produced the highest vegetative growth with plant height, number of leaves and leaf area of 31.608cm, 28.198 and 261.980cm2 respectively.

Table 2 Descriptive Statistics of the Cowpea growth variables.

		Plant height		Number of leaves		Leaf areas	
		Mean±SE	Variance	Mean±SE	Variance	Mean±SE	Variance
Site	Akure	28.329±0.919	319.463	25.69±1.007	383.265	226.381±6.251	14771.28
	Ibadan	9.591±0.946	338.372	26.413±1.03	400.772	236.597±6.057	13866.16
Years	2021	28.851±0.932	328.371	26.358±1.046	413.379	223.034±5.703	12294.62
	2022	29.069± 0.935	330.239	25.745±0.990	370.731	239.944±6.557	16251.78
Variety	V1	28.316±1.190	356.711	26.361±1.320	438.868	236.733±7.782	15262.42
	V2	26.956±1.04	272.442	23.595±1.006	255.079	195.754±5.55	7761.01
	V3	31.608±1.176	348.625	28.198±1.37	473.283	261.980± 8.41	17825.25

V1- FUAMPEA 2; V2- Ife Brown; V3- 573-1-1

The descriptive statistics analysis of the cowpea yield indicated that mean number of peduncle per plant (20.074), 100 seed weight (13.37g) and total yield (2293.07kgha-1) obtained for Ibadan were higher than those of Akure. Mean pod per peduncle (3.5) pod length (10.825cm), number of seeds per pod (8.204) obtained for Akure were higher than those of Ibadan (Table 3). The descriptive statistics of the annual yield parameters of cowpea indicated that mean number of peduncle per plant (19.704), mean pod length (10.315cm), number of seeds per pod (8.093) obtained for 2021 were higher than those of 2022. Mean seed yield for 2022 (2307.30kgha-1) was however higher than the total yield obtained for 2021 (2189.6kgha-1). Variety 2 (Ife Brown) of the cowpea returned the highest number of peduncle per plant (22.194) and pods per peduncle (3.972) while variety 3(573-1-1) had the highest pod length (13.972), number of seed per pod (10.972) and highest 100 seed weight of 14.833g (Table 3).

The results of the descriptive statistics analysis of the cowpea yield by the planting date showed that planting date 1 favoured highest number of peduncle per plant (21.667), highest pods per peduncle (4), highest pod length (11.639mm) and highest number of seed per pod (8.944). Highest 100 seed weight (2513.80g) and highest total yield of 2513.8kgha-1 were obtained for the planting date 1. Planting date 3 on the other hand returned the least of all these yield variables (Table 3). The variance of these variables does not follow the same pattern as the mean. Highest variance was obtained for variety 1 for both number of peduncle per plant (8.571) and pod length (10.809). Planting date 3 returned the highest variance for both pods per peduncle (0.673) and number of seeds per pod (7.933) while planting date 2 returned highest variability for both 100 seed weight (2.883) and total yield (38232.56).

Table 3 Descriptive Statistics of the Cowpea Yield variables.

		NPPP		PodsPP		PodL		NSPP		100sd		Yldkgha	
		Mean±SE	Variance	Mean±SE	Variance	Mean±SE	Variance	Mean±SE	Variance	Mean±SE	Variance	Mean±SE	Variance
Site	Akure	19.204±0.267	3.863	3.500±0.111	0.67	10.852±0.491	13.034	8.204±0.362	7.071	13.333±0.254	3.472	2203.83 38.086	78328.31
	Ibadan	20.074±0.458	11.315	3.333±0.118	0.755	9.741±0.411	9.101	7.889±0.339	6.214	13.37±0.184	1.823	2293.07 35.259	67131.5
Years	2021	19.704±0.389	8.175	3.352±0.116	0.723	10.315±0.498	13.39	8.093±0.388	8.123	13.352±0.221	2.647	2189.60 38.903	81725.36
	2022	19.574±0.37	7.381	3.481±0.114	0.707	10.278±0.417	9.374	8.00± 0.311	5.208	13.352±0.221	2.647	2307.30 33.536	60732.64
Variety	V1	19.00±0.319	3.657	3.389±0.1	0.359	10.00± 0.239	2.057	7.556±0.171	1.054	13.778±0.106	0.406	2365.06 50.815	92959.04
	V2	22.194±0.431	6.675	3.972±0.146	0.771	6.917± 0.230	1.907	5.611±0.161	0.93	11.444 0.162	0.94	2286.78 38.934	54569.75
	V3	17.722±0.254	2.321	2.889±0.111	0.444	13.972±0.364	4.771	10.972±0.291	3.056	14.833 0.116	0.486	2093.51 32.784	38691.88
Planting Date	PD1	21.667±0.488	8.571	4.00± 0.12	0.514	11.639±0.548	10.809	8.944± 0.380	5.197	13.778 0.243	2.121	2513.80 28.148	28523.42
	PD2	19.444±0.317	3.625	3.361±0.099	0.352	10.278±0.529	10.092	7.889± 0.396	5.644	13.444 0.283	2.883	2230.08 32.589	38232.56
	PD3	17.806±0.318	3.647	2.889±0.137	0.673	8.972±0.525	9.913	7.306± 0.469	7.933	12.833 0.266	2.543	2001.48 25.899	24148.18

V1-FUAMPEA2; V2-IfeBrown; V3-573-1-1; PD-PlantingDate

General Linear Model (glm) and Mean Separation of the Effects of Climatic variables on Growth and Yield of Cowpea

General linear model analysis of the growth of cowpea indicated that there exists significant difference in the mean plant height obtained for the planting date, variety, weeks after planting and sites. These were based on $F (2, 604; 0.05) = 84.13$ (planting date) and 325.07 (variety) as well as $F (1, 604; 0.05) = 2.02$ (Year), 67.85 (site) and $F (6, 604; 0.05) = 8819.05$ (weeks after planting) at $P < 0.05$ (Table 4). Mean plant height obtained for site was not significant because $F (1, 604; 0.05) = 2.02$ was not significant ($P > 0.05$) while all other interactive effects were all significant. These include, variety*planting date ($F (4, 604; 0.05) =34.97$), weeks after planting*planting date (F (12, 604; 0.05) =7.51), year*planting date (F (2, 604; 0.05) = 32.75), site*planting date (F (2, 604; 0.05) = 27.06) at (P < 0.05). Similarly, the results of the glm analysis of the number of leaves indicated that means for the planting date, variety, weeks after planting, year and site interactive effects were significant (Table 4).

Table 4 General Linear Model (glm) analysis of the growth parameters of Cowpea.

Sources of variation	Df	Plant height	Number of leaves	Leaf Area
PD	2	84.13**	126.13**	33.80**
Variety	2	325.07**	339.13**	171.45**
WAP	6	8819.05**	11684.6**	828.74**
Year	1	2.02	17.84**	32.92**
Site	1	67.85**	24.82**	12.01**
Variety*Pdate	4	34.97**	7.14**	1.87
WAP*Pdate	12	7.51**	10.41**	3.61**
Year*Pdate	2	32.75**	36.93**	9.92**
Site*Pdate	2	27.06**	13.74**	10.34**
WAP*Variety	12	67.85**	122.79**	21.56**
Year*Variety	2	10.97**	12.67**	10.42**
Site*variety	2	7.66**	16.26**	6.31**
Year*WAP	6	4.02**	12.33**	1.05
Site*WAP	6	4.69**	3.12**	3.05**
Site*Year	1	13.22	5.86*	1.64
WAP*Var*Pdate	24	5.55**	13.99**	1.36
Year*Var*Pdate	4	3.72**	3.97**	4.05**
Site*Var*Pdate	4	5.55**	4.35**	1
Year*WAP*PD	12	3.05**	2.69**	2.53
Site*WAP*Pdate	12	2.64**	2.59**	0.84
Site*Year*Pdate	2	7.98**	1.82	1.73
Year*WAP*Var	12	2.20**	2.55*	1.34
Site*WAP*Var	12	1.37	2.44**	1.58
Site*Year*Var	2	13.41**	3.85*	3.55*
Site*Year*WAP	6	0.73	6.21**	1.54

The F (2, 604; 0.05) = 126.13 and 339.13 obtained for both planting date and variety, F (1, 604; 0.05) = 17.84 and 24.82 obtained for both year and site as well as F (6, 604; 0.05) = 11684.6 returned for weeks after planting were all significant at P < 0.05 (Table 5). The results of the glm analysis of the leaf area returned significant results for all the main effects including planting date, variety, weeks after planting, year and site. The F (2, 604;0.05) = 33.80 for planting date and 171.45 for variety of cowpea.

The general linear model analysis of the yield of cowpea portends significantly different mean planting date, site, and variety for the number of peduncle per plant (Table 5). The F (2, 76, 0.05) = 150.16 obtained for planting date and 212.17 obtained variety, F (2, 76, 0.05) = 22.72 returned for site were significant at P < 0.05. Similarly, site by variety, variety by planting date and site by planting date interaction were significant. Mean pods per plant obtained for planting date, variety and site by planting date were all significant at P < 0.05. The F (2, 76, 0.05) = 38.41 (planting date), 36.32 (variety) and 4.67 (site*planting date) were also significant at P < 0.05. The glm analysis results for pod length indicated that mean pod length returned for planting date, site and variety as well as mean pod length for site by planting date, site by variety, year by variety and site*variety*year were all significant at P < 0.05. The F (2, 76, 0.05) = 110.19 (planting date), 775.35 (variety), 4.35 (site*planting date), 47.48 (site*variety), 9.39 (year*variety), 9.39 (site*year*variety) and F (4, 76; 0.05) = 4.78 were significant. Other main effect (year) and interaction effects returned not significant.

Majority of the main and interaction effects of the 100 seed weight were also not significant and some of the statistical parameters were zero. Mean 100 seed weight obtained for planting date and variety as well as site by variety were however significant. The F (2, 76; 0.05) = 18.85 (planting date), 246.83 (variety) and 11.23 (site*variety) were significant (P < 0.05). Mean total yield realized for planting date, site variety and year were significant. Similarly, mean interaction effects for variety by planting date, site by year and year by variety were significant. The F (2, 76; 0.05) = 299.994 (planting date), 88.96 (variety), 8.97 (site*variety), 5.4 (year*variety) F (1, 76; 0.05) = 27.19 (site), 47.32 (year), 8.08 (year*site) and 4.28 (variety*planting date) were significant at $P < 0.05$ (Table 5).

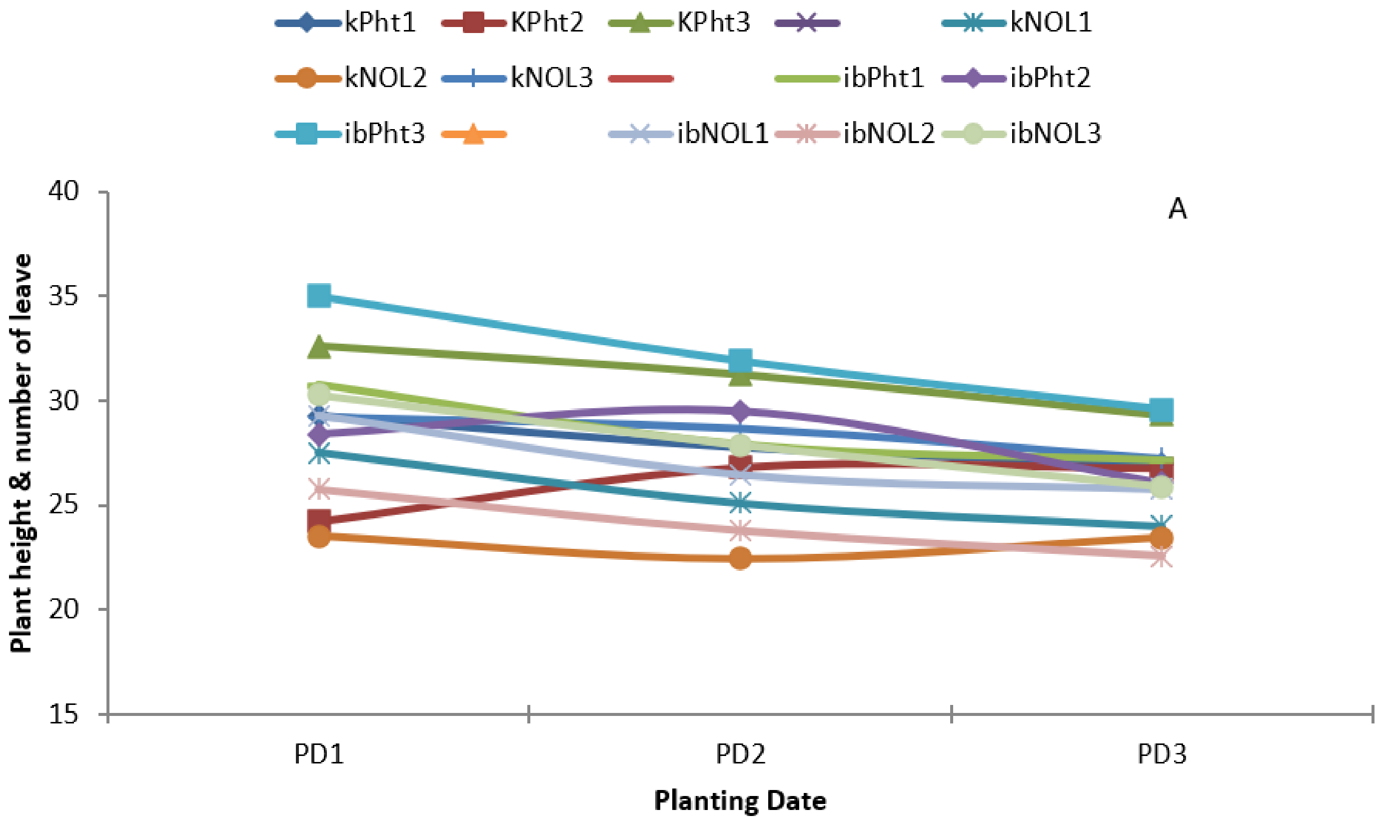
Table 5 General linear model Analysis of the Yield Variables of Cowpea.

Sources of variation	Df	NPPP	PPP	Podlenght	NSPP	100sdwt	Yieldkg/ha
Planting date	2	150.16**	38.41**	110.19**	20.02**	18.83**	299.994**
Site	1	22.72**	2.57	57.38**	2.16	0.08	27.19**
Variety	2	212.17**	36.32**	775.35**	213.68**	246.83**	88.96**
Year	1	0.5	1.56	0.06	0.19	0	47.32**
Site*PD	2	20.19**	4.67**	4.35*	1.48	0.08	2.83
Variety*PD	4	4.18**	0.95	2.17	0.2	1.48	4.28**
Year*PD	2	0.5	2.51	0.78	1.66	0	1.14
Site*Variety	2	14.57**	1.24	47.48**	0.14	11.23**	8.97**
Site*Year	1	0.26	0.03	0.06	0.19	0	8.08**
Year*Variety	2	0.2	0.98	9.39**	2.25	0	5.4**
site*Variety*PD	4	0.52	0.76	4.78**	0.65	0.97	0.68
site*Year*PD	2	0.32	1.56	0.78	1.65	0	0.56
Year*Variety*PD	4	0.24	0.51	0.06	0.33	0	0.92
site*Year*Variety	2	0.38	0.6	9.39**	2.25	0	2.3

Effects of Planting date, variety and Sites on the growth and yield of cowpea

Generally, growth variable decreased as the planting dates are delayed. Planting date 1 and variety 3 was the most favorable planting date and suitable variety for cowpea in the study areas (Figure 2A). The number of leaves obtained for Akure and for variety 2 presented the least trend. The plant height trends for variety 2 and for Akure also conflict with others by its increasing trend from planting date 1 to planting date 3 (Figure 2A). The leaf area for Akure and variety 1 and variety 2 presented a negative parabolic trend (Figure 2B). Generally, the weekly growth of cowpea irrespective of planting date, variety or site presented three types of trends; the increasing linear trend, the sigmoidal trend and the negative parabolic increment (Figure 2). Weekly leaf area growth is an increasing linear trend, plant height is an increasing sigmoidal trend while number of leaves is an increasing negative parabola.

The infographic analysis of the least significant mean of the effects of year by variety and planting date indicated that no regular trend was obtained for plant height and number of leave of cowpea for variety 1 and variety 2 in 2021 (Figure 3A). For variety 3 of 2021 and all the varieties of 2022 however, significant decreasing trends were visible. Plant height as well as number of leave and variety 3 of 2022 have the highest trend while variety 2 of 2022 of both plant height and number of leave have the least trends. For leaf areas, 3 trends are obtainable and are increasing linear trend, decreasing linear and irregular trend. Generally variable 3 returned the highest trend in each of the year (Figure 3B). Leaf areas of variety 1 planted in both years presented an irregular negative parabola while variety 2 of 2021 has an increasing trend. For variety 2 planted 2022 as well as variety 3 of both years, decreasing trends were obtained.



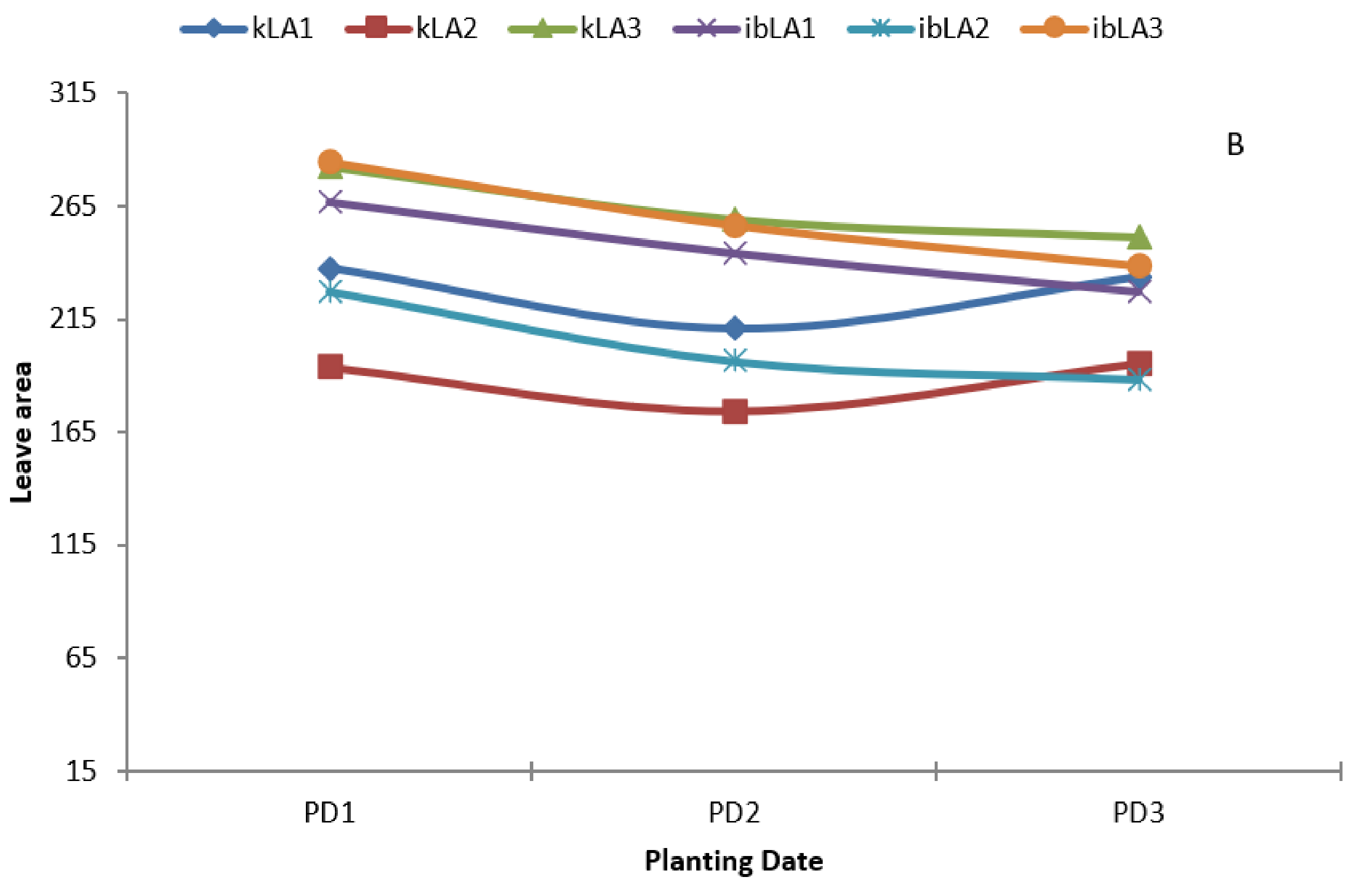


Figure 2 Effects of variety and planting date on number of leaves and plant height (A) and leaf area (B) of cowpea at different weeks after planting. (KPht- plant height for plantind date in Akure; KNOL- Number of leaves in Akure; KLA- Leaf Area in Akure; IbPht- plant height for plantind date in Ibadan; IbNOL- Number of leaves in Ibadan; IbLA- Leaf Area in Ibadan)

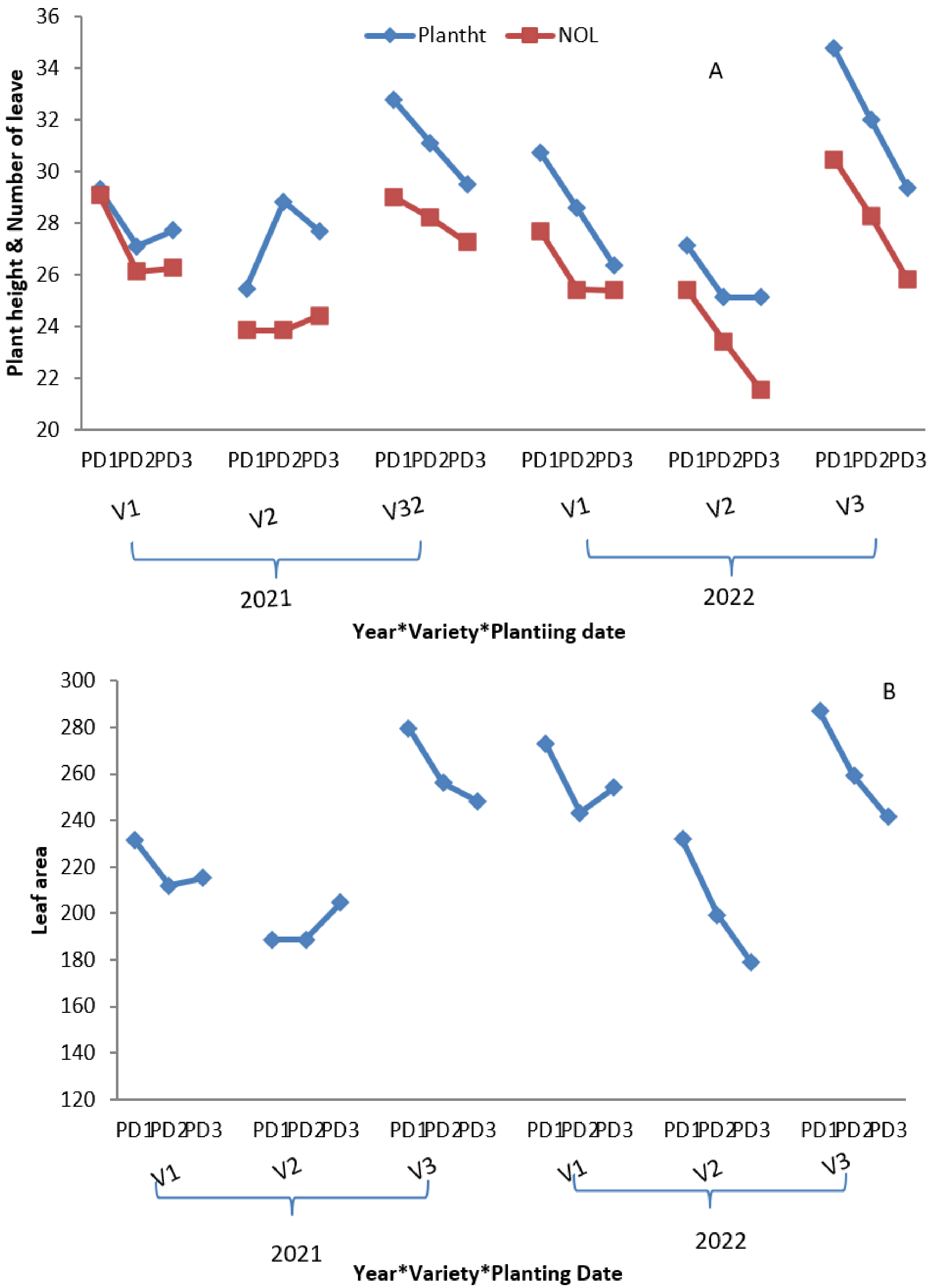
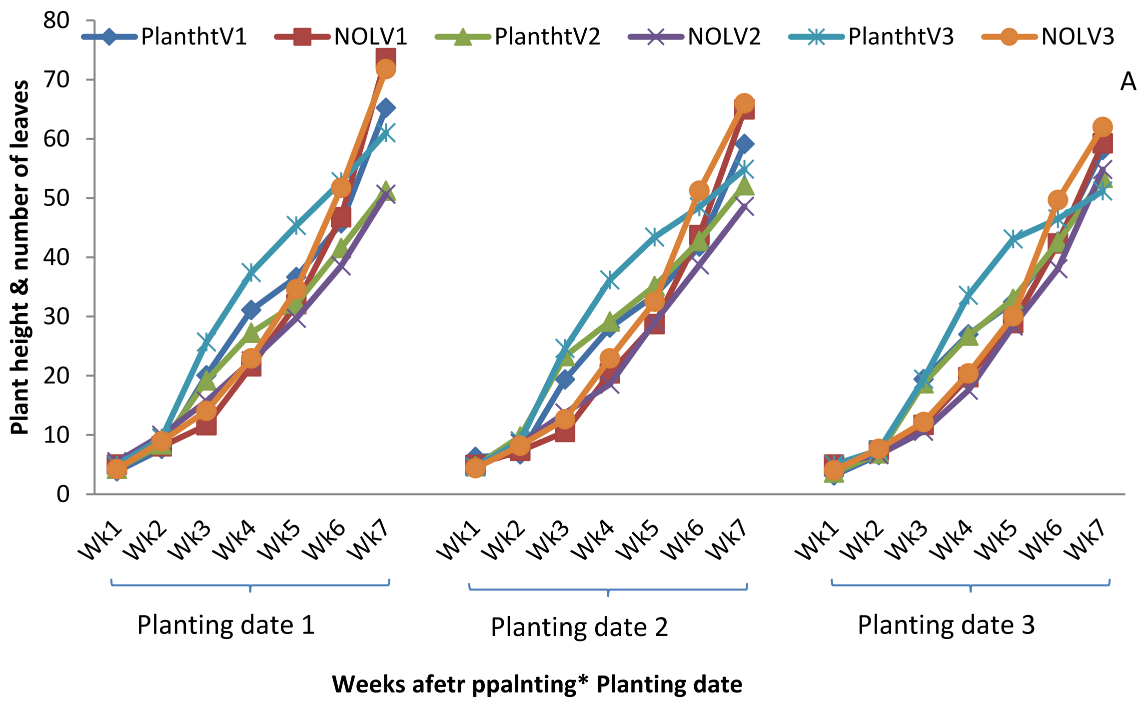


Figure 3 Effects of year by variety and planting date on number of leaf and plant height (A) and leaf area (B) of cowpea

Effects of Planting Date, Variety and Sites on the Growth of Cowpea

The infographic analysis of the effects of planting date on weekly growth of cowpea indicated that planting date on weekly growth of cowpea. It was shown that planting date 1 and variety 3 has the highest are with trend while variety 3 has the least trend for the planting date 1 over the week. Similarly, number of leave for planting date 1 of variety 3 returned the highest trend while number of leave for variety 2 was the least trend (Figure 4A). The analysis of the effects of planting date by variety on weekly growth of leaf area of cowpea showed that the leaf area increases as the week progresses. Leaf area of the variety 3 for planting date1 returned the highest trend while planting date 3 returned the least (Figure 4B).

Plant height obtained for planting date 1 at Ibadan presented the highest trend over the period. Some of the plant height and number of leaf returned increasing sigmoidal trends while others returned an increasing parabola (Figure 5A). Plant height for planting date 2 at Ibadan, plant height for planting date 3 at Ibadan, plant height for planting date 2 at Akure and plant height for planting date 3 at Akure presented an increasing sigmoidal trend. The number of leaves for all the planting dates and at both Akure and Ibadan followed a parabolic trend (Figure 5A). The infographic analysis of the leaf area for all the planting dates and at both Akure and Ibadan returned an increasing linear trend over the weeks (Figure 5B). The leaf area obtained for Ibadan and for planting date 1 had the highest increasing trend while the leaf area for Akure planting date 2 was the least.



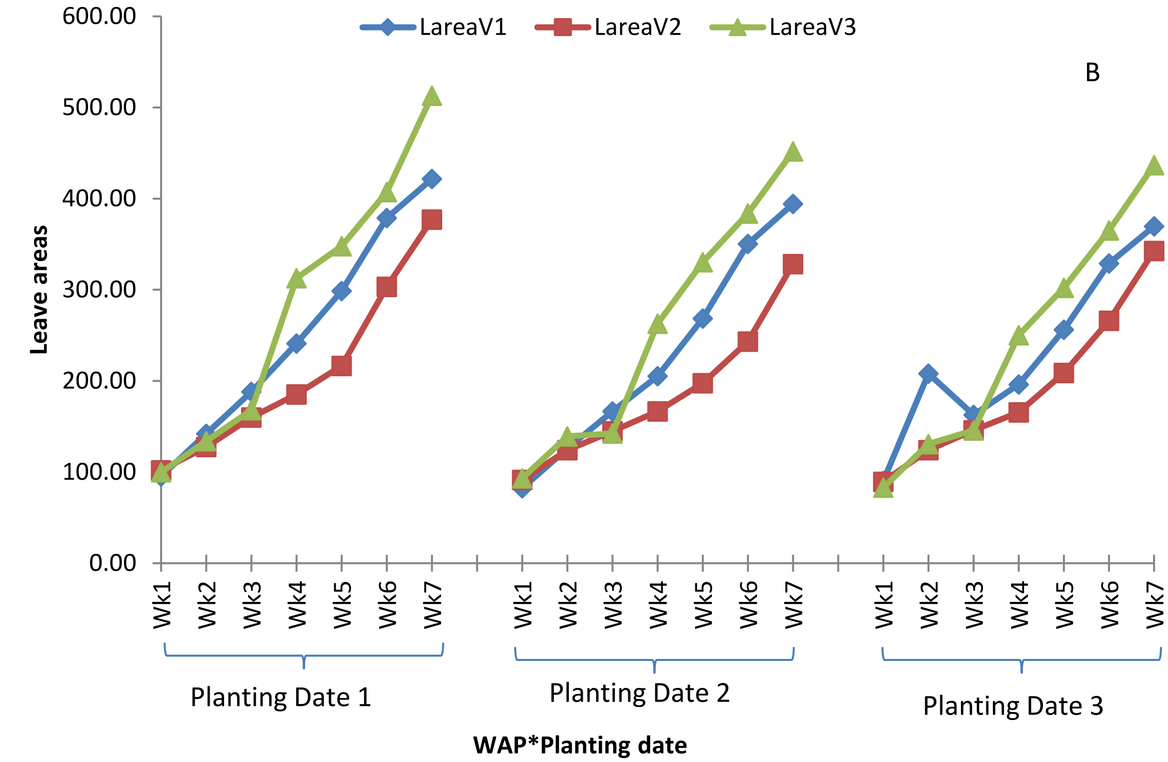
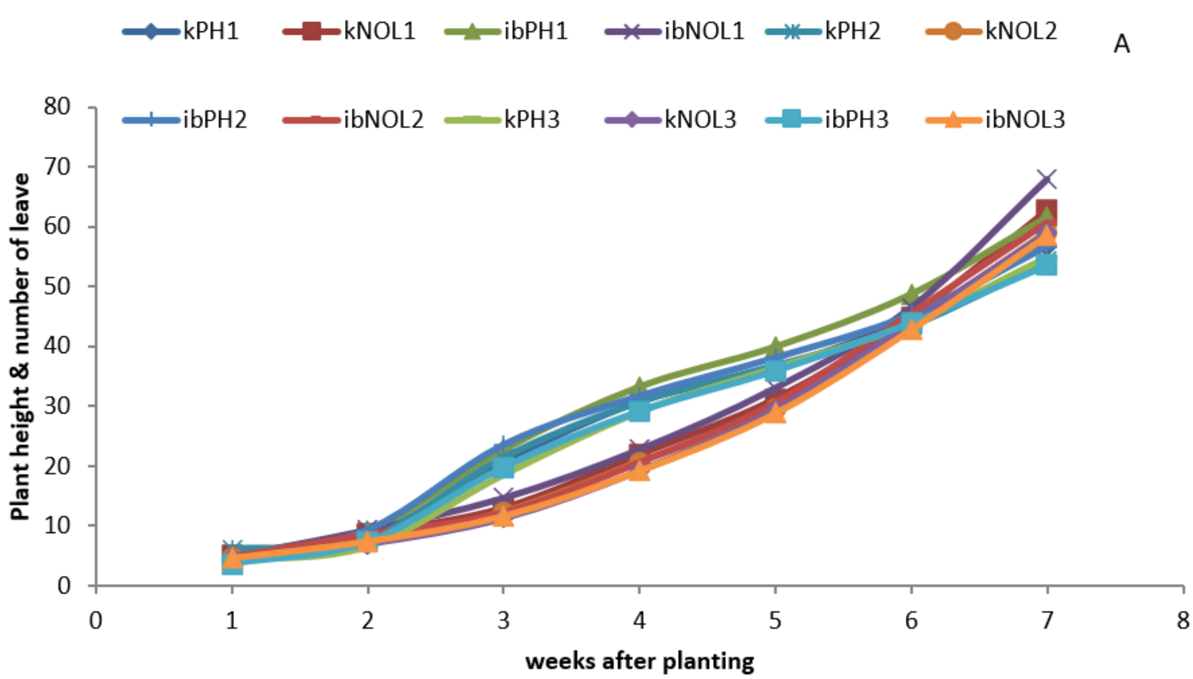


Figure 4 Effects of planting date by variety on number of leaf and plant height (A) and leaf area (B) of cowpea at different weeks after planting



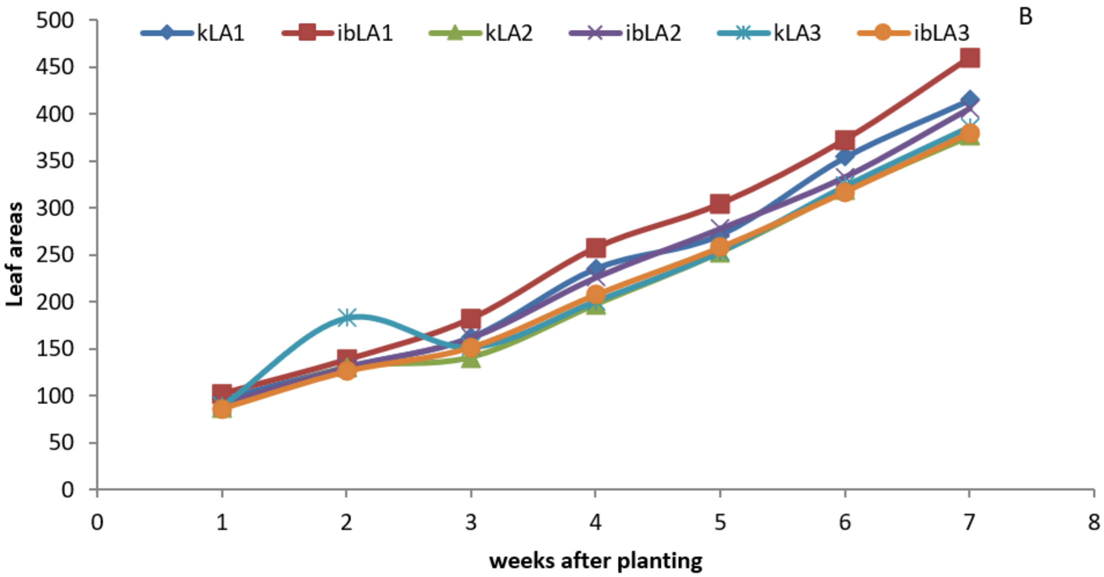


Figure 5 Effects of planting date on plant height and number of Leaf (A) and leaf area (B) of cowpea in Akure and Ibadan.

Effects of Planting Date, Site and Varieties on the yield of Cowpea

Generally, the number of peduncle per plant maintained that the highest yield variable trends for all the variables while pods per plant maintained the least yield variable trend for the variables (Figure 6A). The infographic analysis of the yield variables indicated that variety 2 of both Akure and Ibadan produced the highest number of peduncle per plant while variety 3 of both sites produced the least. The number of peduncle per plant for Ibadan were however higher than those of the Akure. Variety 3 of Akure could thus be adjudged the least number of peduncle per plant and the variety 3 of the Ibadan was adjudged the highest (Figure 6). Variety 2 of the Ibadan returned the highest trend of pods per plant while variety 3 of Akure maintained the least. The trend obtained for 100seed weight for variety 3 of the Ibadan was the highest while variety 2 of the Akure had the least.

Similarly, variety 3 of both Ibadan and Akure were significantly the highest in terms of pod length with Ibadan planting date returning higher pod length trend than Akure pod length (Figure 6). This is similar with the results of the infographic analysis of the number of seeds per plant. Variety 3 of the Ibadan had significantly the highest number of seeds per plant while variety 2 of Akure had the least. The infographic analysis of the effects of site by variety by planting date of the total yield of cowpea indicated that planting date 1 of Ibadan returned the highest yield (kgha-1) of cowpea while the least was obtained for variety 3 of planting date 3 (Figure 6).

The infographic analysis of the effects of year by site by planting date on yield variables of cowpea indicated that yield trends in both locations are contradictory. For Akure, number of peduncle per plant obtained for planting date 1of 2021 was lesser than that of planting date 1 of 2022. Conversely, peduncle per plant obtained for planting date 1of 2021 of Ibadan was greater than that of planting date 1 of 2022. Pods per plant for both year and site were significantly similar in values and trend. This result was obtained for number of seeds per pod and 100seeds weight. The infographic analysis of the effects of year by site by planting date on the total yield of cowpea showed that mean total yield for planting date 1 is greater than planting date 2 and the planting date 3 is the least. Total yield for planting of 2022 were greater than 2021 for both sites. Total yield of cowpea for Ibadan were greater than those of Akure (Figure 7).

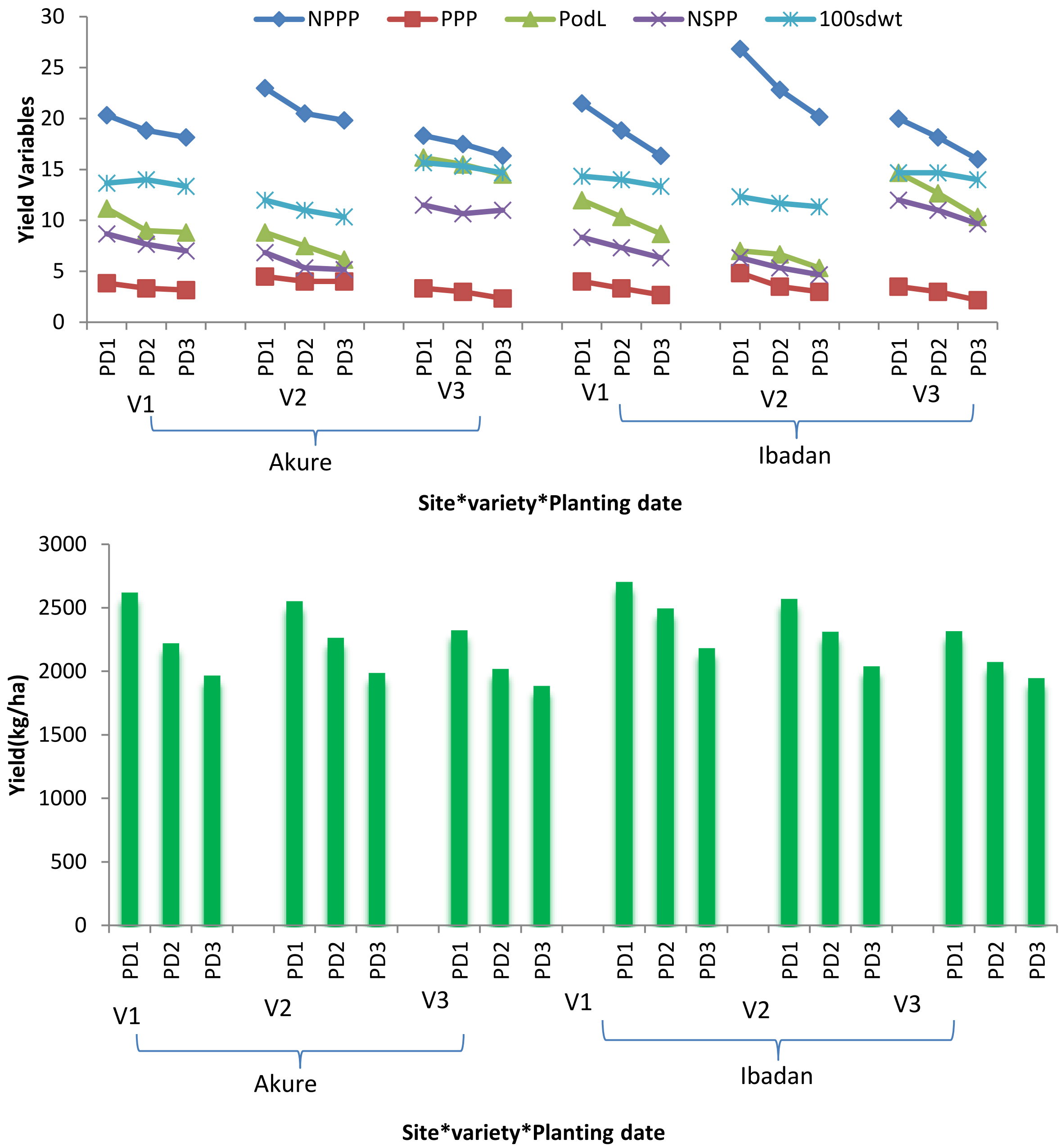
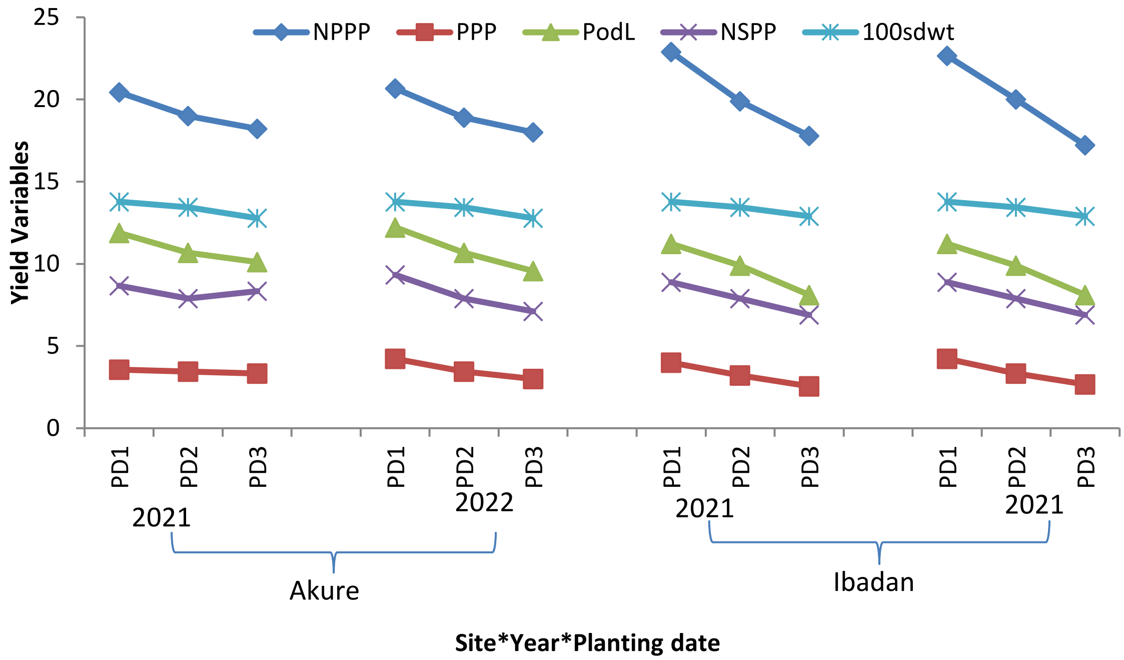


Figure 6 Effects of Planting date, variety and Sites on some yield variables (A) & yield kgha-1 (B) of Cowpea.



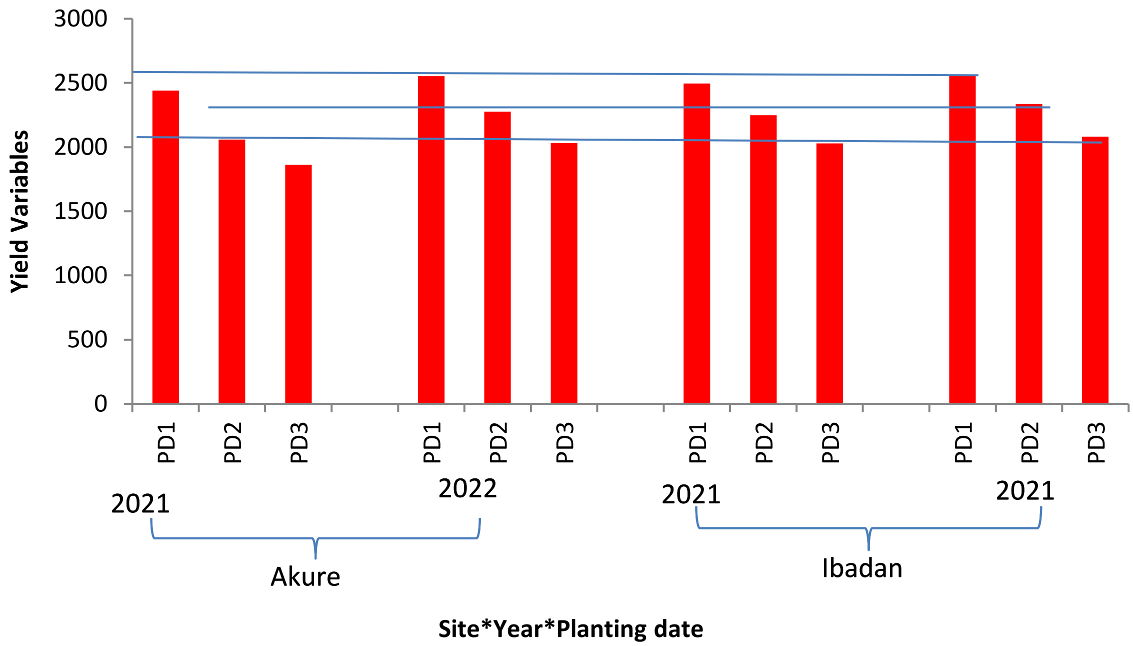


Figure 7 Effects of Planting date, year and Sites on some yield variables of Cowpea.

4. DISCUSSION

Planting dates were utilized to evaluate some selected varieties of cowpea across two locations in the rain-forest agro-ecology of Nigeria. According to Javaid et al., (2015), changing planting dates could influence cowpea's growth and yield processes. There are many interactive effects among year, planting dates and cultivars. The growth parameters differ among cultivars because of their generic make ups and growth habits. This is in line with Nwofia and Okocha, (2016), who reported that differences in plant growth characteristics due to genetic make-up and adaptation to weather conditions. Significantly higher growth parameters were noticed in cowpea planted early. This significant increase in the growth parameters of cowpea planted early might be due to the favourable pattern of rainfall received during the growth stages of the crop. Also, variations were noticed on the growth characteristics among the different varieties of cowpea. This was justified by Ray and Shipe, (2018), who found that variations in growth parameters among cowpea varieties could be explained by the variations in their genetic make-ups.

There is a positive correlation between the growth and yield parameters of cowpea. This corroborates with the findings of Kamara et al., (2001) and Shegro et al., (2020), who found out that growth and yield attributes of cowpea performed the same way. This study shows that delayed planting of cowpea consistently leads to reduction in the yield attributes of the crop in the study area irrespective of the varieties of the crop. This may be due to the more favourable environmental conditions received during the developmental stages of the earlier planting of the crop. The observation agrees with the findings of Akande et al., (2012) who reported that environmental stress could reduce the yield of cowpea thus leading to lower yield.

5. CONCLUSION

With the prevailing climate change scenarios which have no doubt impacted crop production in recent past, this study established that planting date selection is an important strategy in adapting to the impacts caused by the menace. Results from this study indicated that the optimum planting date for cowpea production in forest agro-ecology of Nigeria is at the onset of rains. Therefore, to reduce the impact of climate change and variability in rain forest agro-ecology of Nigeria, it is recommended that farmers should plant early maturing varieties of cowpea at the onset of rains.

Informed consent

Not applicable.

Ethical approval

Not applicable.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Funding

The study has not received any external funding.

Data and materials availability

All data associated with this study are present in the paper.

REFERENCES AND NOTES

1. Akande SR, Olakojo SA, Ajayi SA, Owolade OF, Adetunbi JA, Adeniyan NO. Planting date effects on cowpea seed yield and quality in Southern Guinea Savanna of Nigeria. Proofs 2012; 3 4:79-88.
2. Asio MT, Osiro DSO, Adipada E. Multilocational evaluation of selected local and improved cowpea lines in Uganda. Afr Crop Sc 2015; 13:239-247.
3. Bannanvan M, Hooganboom G. Quauntification of agricultural drought occurrences as an estimate for insurance program. Theor App Climatol 2015; 122:799-808.
4. Dugie LO, Omogui LO, Ajeigbe D. Farmers' guide to cowpea production in West Africa. IITA, Ibadan, Nigeria 2019; 75-86.
5. Ezeh CU, Obeta MC, Anyadike R. Variations in the sequence of rainfall across Nigeria. Arab J Geosc 2016; 9:681.
6. Hassen JW, Morhead MC, Thomson JW. Review of seasonal climate forecasting for ariculture in Sub-Saharan Africa. Exp Agric 2011; 47:205-240.
7. Ifeanyi-Obi C. Analysis of climate change adaptation measures used by raral dwellers in Southeast and Southsouth of Nigeria. Implementing Climate Change Adaptation in Cities and Communities. Springer 2016; 367-390.
8. IPCC. Contribution of working group 1 to the fourth assessment report of the Inter- governmental Panel of Climate Change 2007; 30.
9. Javaid J, Dadson RB, Authur LA. Effects of insecticides spray application, sowing dates and cultivar resistances on insect pest of cowpea in Delmarva region of USA. J Sustain Agric 2015; 26:57-68.
10. Kamara CS. Effects of planting dates and mulching on cowpea in Sierra Leone. Expl Agric 2001; 47:25-31.
11. Nwofia GE, Okocha PI. Genotypic and Phenotypic variability in cowpea grown in a humid environment in Nigeria. Trop Sc 2016; 56:82-86.
12. Omotosho JB, Balogun A, Ogunjobi S. Predicting monthly and seasonal rainfall onset and cessation of the rainy season in West Africa using only surface data. Int J Climatol 2000; 20:86 5-880.

13. Ray EL, Shipe RE. Planting dates influence on cowpea agronomic traits and seed composition in modified fatty acids breeding lines. Crop Sci 2018; 48:181-188.
14. Shanogo S, Fink AH, Omotosho JA, Ermert V. Spatiotemporal characteristics of the recent rainfall recovery in West Africa. Int J Climatol 2015; 35:4589-4605.
15. Shegro A, Atilaw A, Geleta N. Influence of variety and planting dates on growth and development of cowpea in Metekel zone, Northwestern Ethiopia. J Agron 2020; 9(3):148-156.
16. Wilhite DA. Managing drought in changing climate. Clim Res 2016; 70:90-102.