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Rainfall instability differences on the effect of planting date on growth and yield of three cowpea (*Vigna unguiculata*) varieties in the forest-savanna eco-climatic region of Nigeria

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Abstract The effects of climate change on growth and yield of cowpea were investigated in this study using three cowpea varieties (IT960-610, AGRIBVI and IT98K205-8) during the late and early rains of the years 2017 and 2018 respectively. Three planting dates at two weeks interval between July 8 and August 15 2017 (late rain planting) and April 7 and May 5, 2018 (early rain planting) were followed. At the vegetative stage, cowpea planted during early rains had more leaves and higher plant height than those planted during the late rains. The yield characteristics of cowpea planted during the late season were significantly ($P \leq 0.05$) higher than those planted during the early rains; in addition, the yield characteristics decreased with delayed planting during the two seasons. The relatively lower yield observed during the early rains could be attributed to higher rainfall received during flowering stage, which led to absorption of flowers. The timing of planting cowpea in the study area should be done such that flowering stage and pod filling stage do not coincide with the period of high rainfall.

Key words

Planting dates, climate change, varieties of cowpea, optimum yield

The long term fluctuations in weather parameters around the world have been linked to the effects of global warming (Shackel, 1993; Bello, 1996). Most if not all of farming activities like planting, weeding, harvesting, etc depend on the weather parameters which are greatly dominated by these instabilities. Instability according to Summerfield *et al*., (1993) is the lack of determination of fixedness, that is, the quality of being fixed in a place as by some firm attachment, while fixedness as defined by Shackle (1993) refers to object phenomenon that is not subjected to change or variation. Weather and climate act as both resource and constraints to agricultural production and need to be studied to alleviate the consequences of global warming. Crops adapt to diverse environments through considerable plasticity of phenology and morphology, with rainfall as the main determinant (Udungwu and Summerfield, 1985). One of the ways of manipulating climatic factors is the adequate knowledge of optimal planting dates so as to accurately synchronize rainfall incidences with the calendar of crops. Rainfall records monitored by the meteorological unit of the University of Agriculture Abeokuta, Ogun State, Nigeria, showed that its pattern in the forest-savanna eco-climatic region have been characterized by instability with resultant impact on the growth and yield patterns of agricultural crops most of which are rainfall dependent. Most of these crops are usually planted when rainfall have been established (that is, effective rainfall). Effective rainfall is the fraction of the total amount of rain water useful for meeting the water needs of crops; while instability difference referred to the differences between variance of differently related data; which according to Tofani (2008) might be of the same type, but different periods. Hence, rainfall instability difference refer to the variability differences in the rainfall pattern of the different growth and development period of the different planting dates (Ng, 2007); that is, μ_i (where i = 1st, 2nd and 3rd planting dates) be the rainfall variability differences of different planting dates.

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 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}. 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. With rising human population resulting into higher demand for cowpea, it becomes imperative to intensify the effects at increasing the production of cowpea in forest-savanna eco-climatic zones of Nigeria. Hence, this study was designed to investigate the instability differences on the effect of variations in planting dates on the growth and yield of cowpea in forest-savanna eco-climatic zone of Nigeria.

Materials and Method

This study was conducted during the late and early seasons of 2017 and 2018 respectively at the research farm of the University of Agriculture, Abeokuta ($7^0$15`N; $30^0$25`E), Nigeria. The soil of the experimental site was a well-drained tropical ferruginous soil classified as sandy-loam (Bello, 1996). The land was ploughed twice and harrowed once during the planting seasons. The experiment was laid out as a spilt plot design (Figure 1) with three replications. The main plot treatments were three semi-upright cowpea varieties (IT960-610, brown small sized seeds; AGRIBVI, brown medium sized seeds; and IT98K205-8, white medium sized seeds) while the sub-plot treatments were three planting dates (late raining season - 8^{th} and 22^{d} of July and 9^{th} of August, 2017; early raining season - 7^{th} and 21 of April and 5^{th} of May, 2017). The recommended planting spacing of cowpea (30cm between rows and 25cm between plant stands) were followed on a 4x5 m plot resulting in a plant population of 294 stands per plot.

IT960-610	d_1L / d_1E	d_2L / d_2E	d_3L / d_3E
	d_2L / d_3E	d_3L / d_3E	d_1L / d_1E
	d_3L / d_3E	d_1L / d_1E	d_2L / d_2E
AGRIB VI	d_1L / d_1E	d_2L / d_2E	d_2L / d_2E
	d_2L / d_2E	d_3L / d_3E	d_3L / d_3E
	d_3L / d_3E	d_1L / d_1E	d_1L / d_1E
IT98K205-8	d_1L / d_1E	d_2L / d_2E	d_3L / d_3E
	d_2L / d_2E	d_3L / d_3E	d_1L / d_1E
	d_3L / d_3E	d_1L / d_1E	d_2L / d_2E

Key

d_1L = July 8, 2017 d_2L = July 22, 2017 d_3L = August 5, 2017

d_1E = April 7, 2018 d_2E = April 21, 2018 d_3E = May 5, 2018

Figure 1: Experimental Lay-out

Three seeds per hole were planted, and was later thinned to two per stand at one week after planting (WAP). Weeding was carried out manually with hoe two WAP and subsequently at two weeks interval. The plants were sprayed with Cymbush 10 EC at the rate of 4ml per liter of water 30 days after planting, and were repeated weekly until 50% flowering was observed. Two types of data were utilized in this study: the climatic and the growth and yield data. The growth and yield data were plant height, number of leaves, leaf area and yield per hectare, while the climatic data was rainfall. The plant height was determined using tape rule, while the leaf area was determined according to the method of Wanki *et al*. (1980).

Leaf area/plant – No. of terminal leaflets x 2.7 x 1 ________(cm^2)

0.37

Climatic data were obtained from the meteorological station of the Department of Water Resources and Agrometeorology, University of Agriculture, Abeokuta. The data sets were subjected to description statistics as well as analysis of variance irrespective of the year. Means of the different treatment were separated using Duncan Multiple Range Test (DMTR).

Results and Discussions

The results of the preliminary soil survey indicated that the experimental sites were sufficient in terms of nutrient requirements. The soil was slightly acidic pH= 6.7, while organic matter and organic carbon were 1.17% and 0.68% respectively. The exchangeable bases were Ca (1.36 cmol kg^{-1}), Mg (1.92 cmol kg^{-1}), K (0.14 cmol kg^{-1}), Na (90.36 cmol kg^{-1}) with cation exchangeable capacity of 3.75 cmol kg^{-1}. The soil was sandy-loam in texture with 78% sand, 14% silt and 8% clay.

Figure 2 shows the mean decadal rainfall pattern at different growth stages of the three cowpea varieties for the three planting dates during the late season of 2017. There was an increase in mean decadal rainfall from 45.3 – 55.4mm during the establishment period, which dropped to 45m at the vegetative period during the first planting. The second planting showed a sharp increase in the mean decadal rainfall from 40.5mm at establishment to 60.1mm at vegetative period. The third showed a mean decadal rainfall of 35.4mm at vegetative period and 64.5mm at the flowering period.

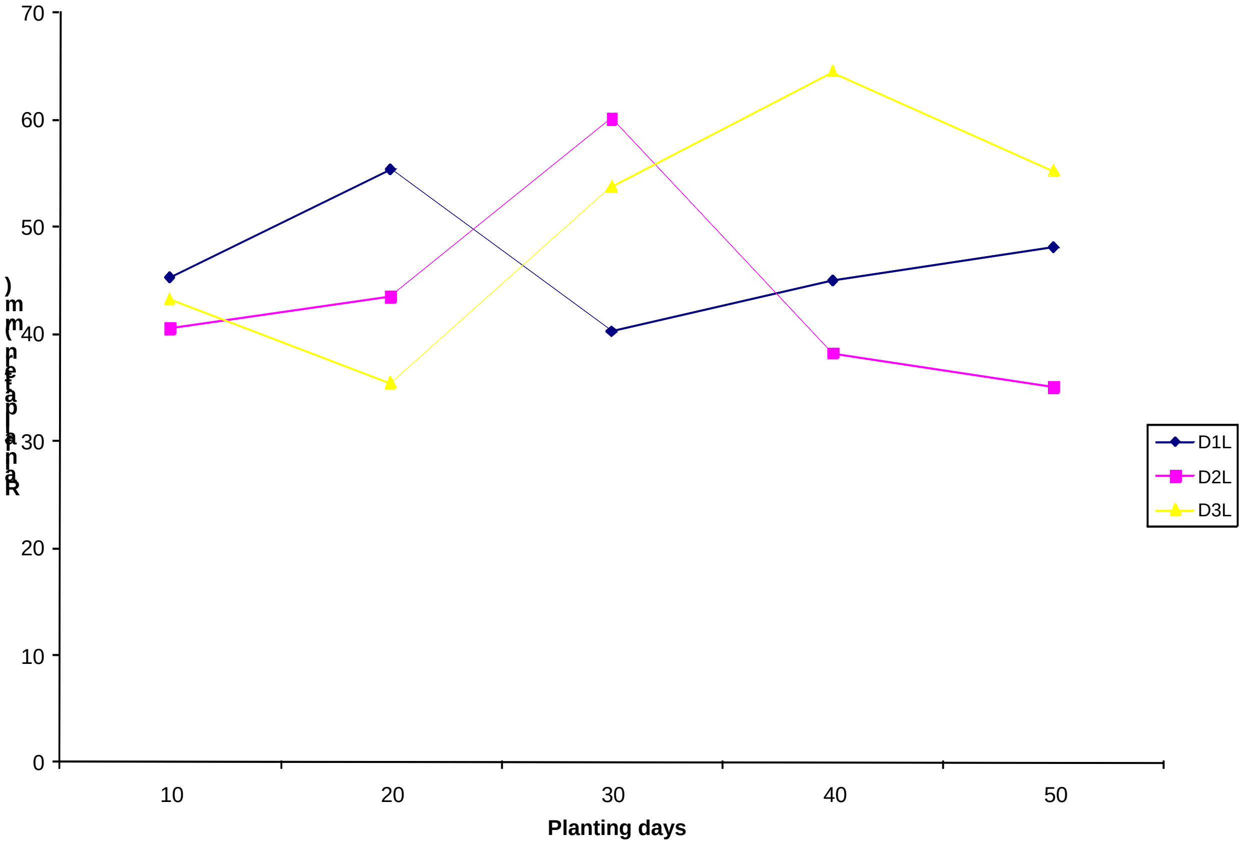

Fig 2: Mean dacadal rainfall pattern during late rains of 2017

The mean decadal rainfall pattern at different growth stages of the three cowpea varieties for the three planting dates during the early season of 2018 are shown in Figure 3. The data showed that different rainfalls received during the early rains were significantly heavier than those received during late rains. The lowest rainfall was 46.7mm, while the highest was 120.3mm.

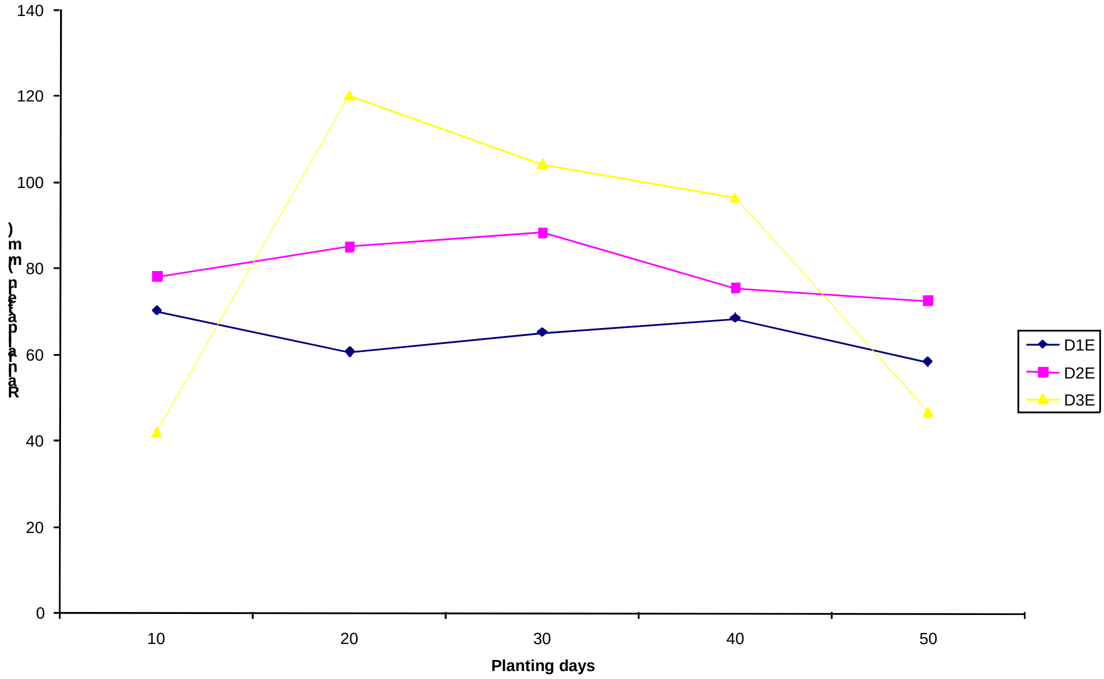

Fig. 3: Mean decadal rainfall pattern during early rains of 2018

Table 1 shows the growth patterns of the three cowpea varieties planted during the late rains of 2017 and early rains of 2018. At the establishment stage, there was no significant difference in the growth characteristics of all the varieties at different dates of planting; there were variations during the vegetative stage. During the late rains, IT960-610 planted on day 1 (July 8, 2017) had the highest number of leaves (91), while AGRIBVI planted on day 3 (August 15, 2017) had the least of 87. The variety that had the highest number of leaves during the early rains was IT960-610 (90), while IT98K205-8 had the least of 60 leaves. At 10 days after planting, IT98K205-8 planted on day 1 during the late rains had the highest among the three varieties, while IT960-610 planted on day 1 (April 7, 2018) during the late rains had the least irrespective of the season or date of planting. Conversely, IT960-610 planted on day 1 during the late rains was the tallest (80cm), while AGRIBVI planted on day 3 was the shortest at pod filling stage. This trend did not vary as IT960-610 planted in day 1 had the highest leaf area out of the three varieties irrespective of time and season of planting. Again, irrespective of the varieties, cowpea planted on July 8 2017 had the highest number of pods per peduncle, pods per plant, seeds per pod and highest grain yield (Table 2). The yield components (numbers of peduncle per plant, pods per peduncle, pods per plant, seeds per pod and grain yield per hectare) decreased with delayed planting irrespective of the variety. Cowpea planted during the late rains produced higher number of peduncle per plant, pods per peduncle, pods per plant, seeds per pod and consequently higher grain yields than those planted during the early rains; AGRIBVI had the highest grain yield followed by IT960-610 and lastly IT98K205-8. All these variations in the growth and yield performance were in accordance with the findings of Roger (2000) from his data that planting dates brought about variation in the performance of the cowpea. Most of these variations were not unconnected with the rainfall instability differences recorded at these planting dates. The results factor showed that it is likely the third planting suffered from water stress especially during pod filling.

Table 1

Growth performance of three selected varieties of cowpea at different dates during the late rains of 2017 and early rains of 2018

Var. * Day and Season	No. of leaves DAP					Plant height (cm) DAP					Leaf area (cm^2) DAP				
	10	20	30	40	50	10	20	30	40	50	10	20	30	40	50
V_1*D_1L	5	9	14	46	91	9	20	32	42	80	101	138	323	536	1098
V_1*D_2L	5	11	21	50	88	11	21	30	43	73	115	214	286	356	386
V_1*D_3L	5	11	21	56	83	10	25	36	41	48	188	191	292	365	410
V_1*D_1E	5	11	25	49	90	12	30	42	58	78	164	186	313	437	464
V_1*D_2E	5	11	17	37	64	12	33	36	41	48	173	264	298	338	364
V_1*D_3E	5	11	24	57	85	12	21	38	49	73	128	142	236	298	367
V_2*D_1L	5	17	22	40	60	10	18	29	36	41	49	94	224	339	390
V_2*D_2L	5	11	27	55	87	13	24	41	63	78	99	136	254	372	465
V_2*D_3L	5	11	17	28	48	12	15	19	25	36	39	57	114	230	320
V_2*D_1E	7	11	28	53	89	12	20	36	52	72	117	220	284	345	418
V_2*D_2E	5	11	26	51	63	11	21	28	33	38	50	100	247	271	338
V_2*D_3E	5	11	19	45	66	10	19	32	49	72	97	121	192	351	440
V_3*D_1L	5	11	20	54	77	19	26	32	36	38	40	99	221	266	320
V_3*D_2L	5	11	24	50	78	12	20	32	38	43	81	113	190	301	397
V_3*D_3L	5	11	23	46	88	15	20	29	37	40	49	102	190	275	380
V_3*D_1E	5	11	21	50	85	12	26	34	50	83	87	133	201	293	437
V_3*D_2E	5	11	19	40	69	12	19	27	33	48	40	89	210	245	301
V_3*D_3E	5	11	26	56	79	12	18	36	42	51	84	168	238	331	492
LSD		0.03	3.48	7.11	6.52	1.14	2.24	2.10	3.225	6.04	16.78	36.46	107.8	122.2	118.5
SEM		0.11	1.13	2.30	2.11	0.37	0.73	0.68	1.047	1.90	5.44	11.83	34.99	39.96	38.4

Table 2

Yield performance of three varieties selected of cowpea at different dates during the late rains of 2017 and early rains of 2018

Var.	Season	Planting date	No. of peduncle/plant	No. of pods/peduncle	No. of pod/plant	No. of seeds/pod	Grain yield (kg ha^{-1})
IT960-610	Late rains	July 8, 2017	20.60	0.96	19.80	11.80	2144.50
		July 22, 2017	19.90	0.92	19.60	11.40	2007.60
		Aug. 5, 2017	11.80	0.78	19.20	10.10	1494.40
	Early rains	April 7, 2018	20.30	0.86	19.80	9.80	1091.90
		April 21, 2018	13.50	0.58	6.70	9.40	949.40
		May 5, 2018	12.20	0.55	5.10	9.20	856.20
AGRIB VI	Late rains	July 8, 2017	24.20	1.15	20.60	12.90	2619.30
		July 22, 2017	20.20	1.04	19.60	12.40	2503.80
		Aug. 5, 20117	17.50	0.80	10.20	10.20	2209.10
	Early rains	April 7, 2018	18.80	0.80	15.04	10.50	1436.60
		April 21, 2018	17.20	0.69	11.86	9.80	981.70
		May 5, 2018	17.40	0.69	12.00	9.80	714.60
IT98K205-8	Late rains	July 8, 2017	22.00	1.04	20.10	11.80	1947.50
		July 22, 2017	21.20	0.95	19.50	10.80	1861.00
		Aug. 5, 2017	17.40	0.64	10.40	10.50	1275.30
	Early rains	April 7, 2018	18.90	1.55	18.10	10.20	858.20
		April 21, 2018	17.20	1.15	7.50	10.10	825.20
		May 5, 2018	13.80	1.10	7.50	7.50	800.30
CV (%)			5.79	12.21	6.22	6.02	16.40
LSD ($P \leq 0.05$)			1.58	0.15	1.08	1.09	85.70
SEM			0.52	0.48	0.35	0.37	2.35

Conclusions

Rainfalls received during the planting seasons on the experimental site were higher than the amount required for the growth and development of cowpea; thus, the seedlings stood no risk of water stress. This suggests that for the planting periods, rainfall amount was able to sustain the growth and development of cowpea seedlings. Cultivar differences were obtained for most of the parameters measured reflecting the genetic differences between the three cowpea varieties used in this study. Generally, the growth and yield characteristics decreased with delayed planting irrespective of the variety of cowpea and planting season. This implies that planting of cowpea should not be delayed beyond the middle of July for late rains and mid April for early rains in the agro-ecological zone. The grain yield of cowpea planted during the late rains was higher than those planted during early rains. The potential yield was reduced possibly by higher rainfall received during early rains than those received during late rains. Relatively low amount of rainfall is required for podding, while occasional showers with high temperature are required for ripening and drying for good quality seeds. The possibility of growing cowpea in the dry season by irrigation and amount in forest-savanna agro-ecological zone of Nigeria needs to be investigated.

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