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VARIATION IN THE PERFORMANCE OF CONTRASTING MATURITY CLASS OF COWPEA CULTIVARS (*Vigna unguiculata* L. WALP) IN THE DERIVED SAVANNA

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ABSTRACT

Three field trials (2009, 2010 and 2011) were established at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta (7°38'N, 3°88'E; 450 m asl). The trials aimed to evaluate the performance of cowpea cultivars of contrasting maturity class in the derived savanna. Four short and seven medium duration (local check inclusive) cowpea cultivars were sown in a randomised complete block design, replicated three times. Across the years cowpea cv. IT98K-573-2-1 (short duration) had the significantly ($p < 0.05$) highest seed yield (2486 kg ha^{-1}), an observation that could be attributed to its pod yield (3651 kg ha^{-1}), stand count (73.1) and earliness (49.22 days). Cowpea cv. IFE-98-12 (medium duration) produced significantly low pod weight (1826 kg ha^{-1}), with the least shelling weight (613 kg ha^{-1}) and stand count (44.87) across the years. Three clusters of cowpea cultivars were identified in Principal Component Analysis biplot. They were identified based on their superior performance on seed yield, duration of development and dry fodder weight for short duration, medium duration and local check, respectively. It is concluded that these attributes could form the basis of their use and crop improvement programme in the derived savanna.

Key words: Earliness, medium duration, shelling weight, short duration

INTRODUCTION

Cowpea is widely grown in the West Africa sub-region. As a legume, it is a major component of the cropping system for its ability to biologically fix atmospheric nitrogen (Quin, 1997). Compared to cereals, its grain yield is low, probably due to the construction cost of the major nutrient component which is predominantly protein (Munier-Jolain and Salon, 2005). The average grain yield of most of the cultivated varieties of cowpea across Nigeria in 2015 was reported to be 577.6 kg ha^{-1} (FAO, 2015). However, higher grain yield between 0.8-2.0 t ha^{-1} had been reported by Dugje *et al.* (2009). Different classification had been proposed concerning cowpea (Ehlers and Hall, 1996), but the most popular is based on their photothermal response. In most parts of West Africa, farmers prefer short duration cowpea or those that are insensitive to photothermal effect (El-Madina and Hall, 1986; Lawn, 1989). Such genotypes are more productive due to their higher harvest index and earliness than photo-sensitive genotypes (Lawn, 1989). Roberts and Summerfield (1987) reported that duration of flowering was affected by temperature and photoperiod. The response to temperature below the optimum is linear, but at supra-optimum temperature there is a decline in the rate of development in most cultivated crops (Craufurd *et al*., 1997). There is the need to evaluate other maturity classes of cowpea especially in the derived savanna because of the differences in its utilisation at different locations in the country (human consumption, fodder for livestock and green manure source). This agroecology is characterised by unstable climatic conditions under the prevailing climate change. Tree crops and vegetables are usually cultivated in this agroecology in Nigeria. Sowing of cowpea in this agroecology is done mostly in the late wet season when the photoperiod would have shortened (Wien *et al.*, 1980). Another reason for the late sowing is the complex pest attack on cowpea that is most severe in the early wet season (Timko *et al*., 2007). There is dearth of information on the performance of some recently released improved cowpea cultivars of contrasting maturity class in the derived savanna. Results from this investigation would allow farmers to cultivate the most suitable cowpea cultivar for this ecology, just as the data on yield (fodder or a grain legume or both) would guide them on the utilisation of the cowpea. Information obtained from this trial would further guide breeders in cowpea improvement programme in the country. This trial was carried out to investigate the performance of cowpea cultivars of different maturity class in the derived savanna.

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MATERIALS AND METHODS

Characterisation of experimental location and site

Three field trials were conducted during 2009-2011 at the Teaching and Research Farm, Federal University of Agriculture, Abeokuta (7˚38'N, 3˚88'E; 450 m asl). Abeokuta, Nigeria lies in the derived savanna agroecology. This ecology is characterised by a bimodal rainfall pattern. The highest precipitation of 322.9 mm and 349.5 mm were observed in July of 2010 and 2011 respectively, except 2009 where it was observed at October (180.1 mm). The least amount of rainfall was observed in December and January of the years the trials were established. In 2009 similar temperature pattern was observed throughout the year. In 2010 the highest temperature (30.7°C) was observed in February, while the least temperature (25.3°C) was recorded in July. In 2011 temperature was in the range 29.2-25.3°C (Table 1). The textural class of the experimental site was loamy sand and the soil was characterised as Arenic Plinthic Kandiudalf (Busari and Salako, 2015).

Experimental treatments and design

Eleven genotypes of cowpea that consisted of seven medium duration: IAR-00-1006, IAR-06-1060, IFE-98-12, IFOB/01/94/B, IT04K-227-4, LDP10-OBR1and a local check (Oloyin) and four short duration: IT04K-333-2, IT98K-573-1-1, IT98K-573-2-1, IT99K-1060 cowpea cultivars were evaluated on the field. These cowpea genotypes were sourced from the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria. The categorisation into different maturity class was based on duration to maturity as proposed by Singh *et al*. (1997). The experiments were in randomised complete block design, replicated three times.

Cultural operations

The experimental site was ploughed twice and harrowed once. The gross plot size was 2.25 × 3 m. Cowpea plant was established on the 17th, 2nd and 11th of September 2009, 2010 and 2011 respectively at a spacing of 0.75 × 0.25 m. Three seeds were sown, which was later thinned to two seeds per stand at 10 days after sowing (DAS). This consisted of four rows of plant with ten plants per row and a total of 80 plants per plot. The plant density was 106666 plants ha^{-1}. Insect pest were controlled with the application of Karate 2.5 EC insecticide at the rate of 80 ml/15 l of water. This was applied at two weeks interval. Weeding was done as at when due manually.

Sampling and measurement

Five samples were chosen randomly from the middle two rows to determine growth, development, yield and its attributes. Yield attributes were determined at physiological maturity, while grain yield was determined at harvest maturity when the grain moisture content was assumed to have attained 14%. This was determined visually when the pods turned yellowish in colour. Yield attributes determined included number of pods per plant, pod yield per hectare, 100 seed weight, shelling weight, shelling percentage and harvest index. Shelling weight was determined as the difference between pod yield and seed yield. Shelling percentage was ratio of shelling weight to pod yield expressed in percentage. Days to 50% flowering and days to 95% harvest maturity were determined as the duration in days from sowing to when 50% and 95% of cowpea genotypes attained flowering and harvest maturity, respectively.

Statistical analysis

Data obtained were subjected to combined analysis of variance (ANOVA) using Genstat 12th (Payne *et al*., 2009). The treatment structure consisted of genotype and year, while the random structure consisted of the replicate. Table of interaction was presented. Significant means were separated using Fishers Protected Least Significant difference (LSD). Data were subjected to multivariate analysis (Cluster analysis and Principal component analysis). Hierarchical Cluster analysis was conducted to classify the cowpea cultivars based on their grain yield. Principal Component Analysis was conducted to identify the contributions of the investigated parameters on linear component axis.

Table 1: Agro meteorological data of the experimental site in 2009-2011

Months	Mean temperature (ºC)			Rainfall (mm)			Relative humidity (%)			Sunshine duration (hours)		
	2009	2010	2011	2009	2010	2011	2009	2010	2011	2009	2010	2011
January	26.3	28.1	27.2	0.0	4.4	0.0	59.9	80.9	65.9	3.8	5.3	6.2
February	26.0	30.7	28.9	0.0	41.2	139.8	67.1	78.3	78.7	3.9	6.4	6.2
March	26.7	29.4	29.2	96.0	58.9	23.9	64.0	78.8	80.0	4.0	3.9	6.5
April	26.3	28.5	29.2	101.0	112.7	74.5	53.0	78.8	76.4	3.9	7.0	6.5
May	26.1	28.0	28.0	124.0	169.6	73.7	73.0	80.5	78.9	3.2	7.2	6.6
June	26.3	27.4	26.9	140.0	98.3	84.5	72.0	85.4	82.2	3.1	7.1	5.7
July	26.7	25.9	24.5	160.0	322.9	349.5	77.2	87.7	84.6	3.6	5.5	3.8
August	26.5	26.1	25.3	162.1	266.6	88.7	80.7	85.9	84.7	3.3	4.5	3.1
September	29.5	26.7	26.6	151.6	257.6	204.1	78.1	85.9	84.1	3.7	5.3	5.5
October	26.7	27.3	26.9	180.1	172.3	288.1	74.7	81.7	79.5	3.1	6.2	5.0
November	26.0	27.1	27.9	64.6	94.7	3.6	68.0	86.0	82.0	3.2	6.4	6.4
December	26.1	27.2	27.1	10.4	0.0	0.0	63.7	81.1	67.7	3.7	7.2	6.4

Source: Department of Water Resources and Agro meteorology, Federal University of Agriculture, Abeokuta

RESULTS

Significant varietal variability was observed on stand count across and within the years of cultivation of cowpea. Across the years stand, count of cowpea was in the range of 44.87-73.1. Cowpea cv. IFE-98-12 had the lowest stand count while cowpea cv. IT98K-573-2-1 had the highest significant stand count. Increase in stand count across the years was in the order 2010 > 2009 > 2011(Table 2).

Significant varietal differences on development parameters were observed on days to 50% flowering and days to 95% harvest maturity Cowpea cv. IAR-00-1006 attained 50% flowering later (57 days) than other cowpea cultivars. Cultivar IT99K-1060 flowered (47.89 days) earlier than other varieties. It was observed that across the years days to attain 50% flowering was in the order 2011 < 2009 < 2010. The cowpea varieties investigated had their days to 95% harvest maturity between 71.22 days (IT99K-1060) and 79.33 days (local check). Across the years all the cowpea varieties attained 95% harvest maturity in decrease order of 2009 > 2011 > 2010 (Table 2).

Cowpea cultivar IT98K-573-2-1 had the highest shelling weight (1165 kg ha^{-1}), while cowpea cv. IFE-98-12 recorded the least shelling weight (613 kg ha^{-1}) in the years under investigation. Shelling weight was in decreasing order of 2010 > 2009 > 2011. Similar order was observed on shelling percentage across the years. In those years the local cowpea cultivar had the highest shelling percentage (48.17%), while the least was recorded in IT98K-572-1-1(28.59%). Conversely, the highest harvest index (60.69%) was observed in the cowpea cultivar IT98K-573-1-1, while the least harvest index (35.32%) in the years under investigation was observed in the local check. The decrease in harvest index was in the order 2009 > 2011 > 2010 (Table 3).

Cowpea cultivar LDP10-OBR1 had the highest number of pods per plant (19.00) while the least (11.78) was observed in cowpea cultivar IT98K-573-1-1 in the years under investigation. Year 2010 recorded the highest number of pods per plant, while the least was observed in 2009. Across the years the highest pod and seed yield was observed in cowpea cultivar IT98K-573-2-1. The least pod and seed yield in those years was observed in cowpea cultivars IFE-98-12 and IAR-00-1006 respectively. Pod and seed yields were observed to be more in 2010 than other years. The least amount of pod and seed yields was observed in the year 2011. However, a converse pattern was observed on 100 seed weight, where heavier seeds were observed in 2011 than other years. Cowpea cultivar IAR-06-1060 had the highest mean weight across the years with the lowest observed in the cultivar IT99K-1060 (Table 4).

Tabe 2: Interaction of cowpea variety × year on stand count, days to 50% flowering and days to 95% harvest

Maturity class/	Stand count				Days to 50 % flowering				Days to 95 % maturity			
Variety	2009	2010	2011	$\bar{Y}$	2009	2010	2011	$\bar{Y}$	2009	2010	2011	$\bar{Y}$
IAR-00-1006	62.7^{d-k}	58.3^{e-l}	29.7^{l-o}	50.23	55.00^{c-e}	57.00^{a-c}	59.00^{a}	57.00	85.00^{ab}	72.33^{j-m}	80.33^{c-e}	79.22
IAR-06-1060	51.7^{f-o}	89.0^{a-d}	24.7^{o}	55.13	55.00^{c-e}	53.00^{d-g}	58.00^{a}	55.33	84.67^{ab}	70.67^{k-n}	80.33^{c-e}	78.56
IFE-98-12	43.0^{i-o}	46.3^{g-o}	45.3^{h-o}	44.87	50.67^{gh}	51.67^{f-h}	56.67^{a-c}	53.00	83.00^{bc}	69.67^{m-o}	79.33^{e-g}	77.33
IFOB/01/94/B	53.7^{f-o}	63.7^{c-k}	28.0^{m-o}	48.47	51.33^{gh}	51.33^{gh}	57.67^{ab}	53.44	82.67^{b-d}	70.33^{l-n}	80.33^{c-e}	77.78
IT04K-227-4	31.7^{l-o}	92.3^{a-c}	31.3^{l-o}	51.77	52.00^{f-h}	50.00^{h}	55.00^{c-e}	52.33	82.33^{b-e}	67.00^{o}	76.67^{f-i}	75.33
IT04K-333-2	75.0 $^{b-g}$	85.7^{b-e}	39.7^{j-o}	66.8	47.00^{i}	46.00^{ij}	57.00^{a-c}	50.00	75.00^{h-j}	68.67^{no}	73.67^{i-k}	72.45
IT98K-573-1-1	67.7^{c-j}	79.3^{b-f}	54.7^{f-n}	67.23	47.00^{i}	45.33^{ij}	55.33^{b-d}	49.22	77.00^{f-h}	69.00^{no}	73.00^{j-l}	73.00
IT98K-573-2-1	70.3^{b-i}	99.0^{ab}	50.0^{g-o}	73.1	44.67^{ij}	46.00^{ij}	57.00^{a-c}	49.89	76.33^{g-i}	70.00^{l-o}	75.00^{h-j}	73.78
IT99K-1060	66.7^{c-k}	74.3^{b-h}	58.0^{e-l}	66.33	44.00^{j}	45.67^{ij}	54.00^{d-f}	47.89	71.67^{k-n}	67.00^{o}	75.00^{h-j}	71.22
LDP10-OBR1	41.3^{i-o}	70.0^{b-i}	26.3^{no}	45.87	52.67^{e-g}	50.67^{gh}	56.67^{a-c}	53.34	85.00^{ab}	70.33^{l-n}	79.67^{d-f}	78.33
Local Check	56.3^{f-m}	115.0^{a}	38.3^{k-o}	69.87	58.33^{a}	52.00^{f-h}	58.00^{a}	56.11	87.00^{a}	70.00^{l-o}	81.00^{c-e}	79.33
	56.37	79.36	38.73		50.70	49.88	56.76		80.88	69.55	77.67	
SED±:Variety (V)		8.43				0.73				0.94		
Year (Y)		4.40				0.38				0.49		
V × Y		14.61				1.26				1.62		

$\bar{Y}$ - mean, SED - standard error of differences of means, means in a row or column followed by the same letter are not significantly different from each other

Table 3: Interaction of cowpea variety × year on shelling weight, shelling percent and harvest index

	Shelling weight (kg ha^{-1})				Shelling %				Harvest index (%)			
Variety	2009	2010	2011	$\bar{Y}$	2009	2010	2011	$\bar{Y}$	2009	2010	2011	$\bar{Y}$
IAR-00-1006	1005^{c-f}	664^{e-h}	274^{h}	639	38.04^{b-i}	35.60^{b-j}	23.04^{j-l}	32.23	49.96^{a-i}	36.40^{h-j}	40.85^{f-j}	42.40
IAR-06-1060	579^{e-h}	1280^{a-d}	283^{h}	714	37.99^{b-i}	38.70^{b-h}	26.43^{h-l}	34.37	40.98^{f-j}	51.71^{a-h}	56.55^{a-f}	49.75
IFE-98-12	522^{f-h}	505^{f-h}	811^{d-h}	613	23.46^{j-l}	46.31^{b}	39.08^{b-h}	36.28	54.11^{a-g}	36.42^{h-j}	49.69^{a-i}	46.74
IFOB/01/94/B	504^{f-h}	1782^{ab}	571^{f-h}	952	28.32^{f-l}	43.84^{b-e}	33.03 $^{c-l}$	35.06	54.56^{a-f}	46.91^{b-i}	42.03^{e-j}	47.83
IT04K-227-4	335^{gh}	1583^{a-c}	704^{d-h}	874	31.08^{e-l}	38.91^{b-h}	26.64^{g-l}	32.21	33.95^{ij}	53.07^{a-g}	60.15^{a-c}	49.06
IT04K-333-2	856^{d-h}	1791^{a}	560^{f-h}	1069	21.21^{l}	39.45^{b-g}	29.27^{f-l}	29.98	65.54^{a}	53.74^{a-g}	52.67^{a-g}	57.32
IT98K-573-1-1	519^{f-h}	1589^{a-c}	763^{d-h}	957	22.49^{kl}	32.21^{d-l}	31.06^{e-l}	28.59	61.77^{ab}	61.46^{ab}	58.83^{a-d}	60.69
IT98K-573-2-1	1005^{c-f}	1835^{a}	656^{e-h}	1165	26.60^{g-l}	40.60^{b-f}	29.46^{f-l}	32.22	63.53^{a}	51.05^{a-h}	43.26^{d-i}	52.61
IT99K-1060	1057^{c-f}	765^{d-h}	1083^{c-f}	968	25.52^{i-l}	34.50^{b-k}	30.89^{f-l}	30.30	64.83^{a}	54.99^{a-f}	57.25^{a-e}	59.02
LDP10-OBR1	830^{d-h}	914^{d-g}	669^{e-h}	804	30.89^{f-l}	45.38^{bc}	29.24^{f-l}	35.17	45.07^{c-i}	41.13^{e-j}	50.19^{a-h}	45.46
Local Check	1183^{b-e}	1306^{a-d}	986^{c-f}	1158	59.55^{a}	44.87^{b-d}	40.10^{b-f}	48.17	26.03^{j}	41.76^{e-j}	38.18^{g-j}	35.32
	763	1274	669		31.38	40.03	30.75		50.94	48.06	49.97	
SED±:Variety (V)		175.2				3.71				4.66		
Year (Y)		91.5				1.94				2.43		
V × Y		303.4				6.43				8.07		

$\bar{Y}$ - mean, SED - standard error of differences of means, means in a row or column followed by the same letter are not significantly different from each other

Table 4: Interaction of cowpea variety × year on number of pod plant^{-1}, pod yield, seed yield and 100 seed weight

	Number of pod plant^{-}				Pod yield (kg ha^{-1})				Seed yield (kg ha^{-1})				100 seed weight (g)			
Variety	2009	2010	2011	Ȳ	2009	2010	2011	Ȳ	2009	2010	2011	Ȳ	2009	2010	2011	Ȳ
IAR-00-1006	12.33^{i-n}	14.33^{f-l}	17.00^{d-i}	14.55	2684^{c-j}	1509^{ij}	1375^{ij}	1856	1679^{d-j}	845^{ij}	1101^{h-j}	1208	16.05^{i}	13.85^{l-n}	16.65^{gh}	15.52
IAR-06-1060	20.00^{b-e}	14.67^{e-k}	14.00^{g-m}	16.22	1515^{ij}	3304^{a-h}	1243^{ij}	2021	937^{h-j}	2023^{a-i}	960^{h-j}	1307	22.16^{b}	14.05^{lm}	22.36^{ab}	19.52
IFE-98-12	8.67^{mn}	18.00^{b-h}	22.67^{bc}	16.45	2240^{d-j}	1164^{j}	2075^{f-j}	1826	1717^{d-j}	659^{j}	1264^{g-j}	1213	16.37^{hi}	14.11^{klm}	16.19^{hi}	15.56
IFOB/01/94/B	10.33^{k-n}	16.33^{d-j}	15.00^{e-k}	13.89	1791^{h-j}	3916^{a-d}	1882^{g-j}	2530	1287^{g-j}	2134^{a-h}	1311^{g-j}	1577	11.58^{o}	14.09^{k-m}	16.12^{i}	13.93
IT04K-227-4	13.33^{g-n}	23.00^{ab}	10.00^{k-n}	15.44	1110^{j}	4184^{a-c}	2570^{c-j}	2621	775^{ij}	2602^{a-f}	1865^{c-j}	1747	16.22^{hi}	14.29^{j-l}	16.68^{gh}	15.73
IT04K-333-2	13.00^{g-n}	17.67^{b-i}	11.00^{j-n}	13.89	3904^{a-e}	4534^{ab}	1986^{g-j}	3475	3048^{a-c}	2743^{a-d}	1427^{f-j}	2406	19.19^{d}	14.27^{j-l}	17.93^{f}	17.13
IT98K-573-1-1	13.33^{g-n}	14.00^{g-m}	8.00^{n}	11.78	2475^{d-j}	4833^{a}	2455^{d-j}	3254	1956^{b-i}	3243^{a}	1692^{d-j}	2297	18.45^{e}	14.70^{j}	20.26^{c}	17.80
IT98K-573-2-1	11.00^{j-n}	12.67^{h-n}	15.33^{e-k}	13.00	3691^{a-f}	4920^{a}	2342^{d-j}	3651	2686^{a-e}	3085^{a-c}	1686^{d-j}	2486	18.24^{ef}	14.57^{jk}	18.18^{ef}	17.00
IT99K-1060	18.33^{b-g}	21.67^{b-d}	17.33^{c-i}	19.11	4189^{a-c}	2210^{e-j}	3511^{a-g}	3303	3132^{ab}	1445^{e-j}	2428^{a-g}	2335	13.517	13.99^{l-n}	16.54^{g-i}	14.68
LDP10-OBR1	9.00^{l-n}	19.67^{b-f}	28.33^{a}	19.00	2516^{c-j}	2051^{f-j}	2289^{d-j}	2285	1686^{d-j}	1136^{h-j}	1620^{d-j}	1481	16.93^{g}	14.12^{k-m}	16.45^{g-i}	15.83
Local Check	17.00^{d-i}	17.33^{c-i}	18.33^{b-g}	17.55	1958^{g-j}	2934^{b-i}	2540^{c-j}	2477	775^{ij}	1628^{d-j}	1554^{d-j}	1319	22.780^{a}	13.69^{mn}	18.63^{e}	18.37
Ȳ	13.30	17.21	16.09		2552	3233	2206		1789	1959	1537		17.41	14.16	17.82	
SED±:Variety (V)		1.63				492.1				361.9				0.15		
Year (Y)		0.85				257.0				189.0				0.08		
V × Y		2.81				852.4				626.8				0.26		

Ȳ mean, SED – standard error of differences of means, means in a row or column followed by the same letter are not significantly different from each other

Table 5: Latent vector loadings of the two principal components (PC1 and PC2) axes for contrasting maturity classes of cowpea cultivars evaluated for performance in the derived savanna

	PC	
	1	2
100 seed weight	0.00	0.00
Days to 50 % flowering	-0.00	0.00
Days to 95 % harvest maturity	-0.00	0.00
Dry fodder weight	-0.07	0.54
Fresh fodder weight	-0.19	0.74
Harvest index	0.01	-0.01
Pod yield	0.76	0.23
Number of pods per plant	-0.00	0.00
Seed yield	0.60	-0.08
Seed per pod	-0.00	-0.00
Shelling percentage	-0.00	0.01
Shelling weight	0.16	0.31
Stand count	0.01	0.31
%age of variance accounted for	81.17	17.16
Cumulative percentage of variance accounted for by PCs	81.17	98.33

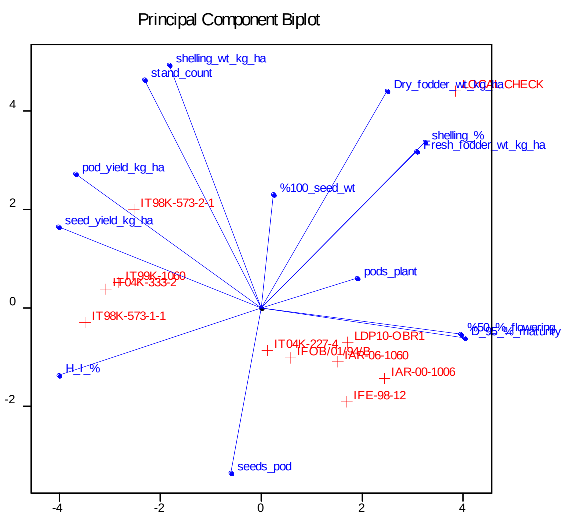

Figure 1: PC1 and PC2 axis of principal component analysis biplot of contrasting maturity class of cowpea cultivars and variates evaluated during 2009-2011 in the derived savanna

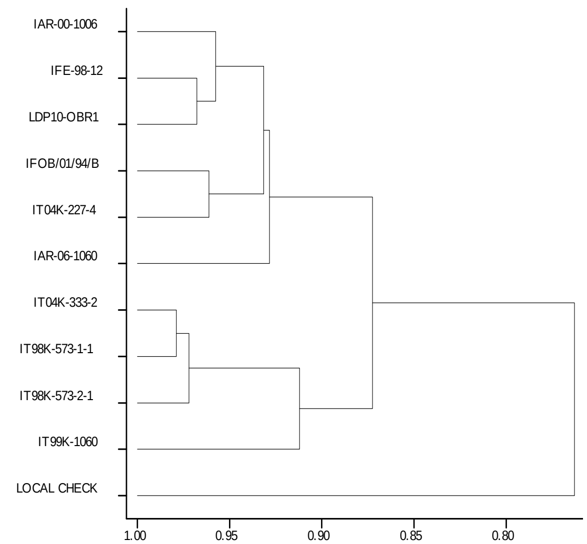

Figure 2: Dendrogram from single link cluster analysis showing the three clusters formed at the normalised distance of 0.9 of contrasting maturity class of cowpea cultivars evaluated during 2009-2011 in the derived savanna

Principal component analysis was conducted on growth, development, grain yield and its attributes to determine the contribution of these parameters on the principal components (PC) of contrasting maturity class of cowpea. The first two principal component (PC 1 and PC 2) axes explained the total variation observed. PC 1 and PC 2 contributed 81.17% and 17.16% respectively to the total variation on the performance of cowpea investigated. Cumulatively they both accounted for 98.33% variation observed. In PC 1 axis, at a cut-off point equal or greater 0.33 pod yield and seed yield accounted majorly for the variations observed. In PC 2 fresh and dry fodder weights contributed majorly to the variation in cowpea performance observed (Table 5).

PCA biplot provides a visual representation of the distribution of the cowpea cultivars based on the grouping of the variates. Cowpea cultivars were clustered into three groupings on the positive axis of PC 1 and PC 2. The first cluster was on the positive axis of PC 1 with superior performance on seed yield and pod yield. It consisted of cultivars IT98K-573-1-1, IT04K-333-2, IT99K-1060 and IT98K-573-2-1. On the positive axis of PC 2 one cowpea cultivar (local check) formed the second cluster with superior performance on dry fodder weight. The third cluster exhibited superior performance on days to 50 % flowering and days to 95 % harvest maturity. This cluster consisted of cultivars LDP 10-OBR1, IT04-227-4, IFOB/01/94/B, IAR-06-1060, IAR-00-1006 and IFE-98-12. On the positive axis of PC 1 there was a positive correlation between shelling weight and stand count; seed yield and pod yield. On the positive axis of PC2 there was a positive correlation between fresh fodder weight and shelling percentage based on the angle between the two varieties. Positive correlation was also observed between days to 50 % flowering and days to 95 % harvest maturity (Fig. 1). At 90 % similarity axis three clusters were also identified based on single link method of establishing similarity. These clusters were similar to the ones indicated on the PCA biplot (Fig.2).

DISCUSSION

Significant varietal differences were observed on growth, development, seed yield and its attributes across the years. Across the years cowpea cv. IT98K-573-2-1 (short duration) had the highest seed yield (2486 kg ha^{-1}) which could be attributed to its pod yield (3651 kg ha^{-1}), stand count (73.1) and comparative earliness (49.22 days). Cowpea cv. IFE-98-12 (Medium duration) had significantly the least pod weight (1826 kg ha^{-1}), with the least shelling weight (613 kg ha^{-1}) and stand count (44.87) across the years. The reduced shelling weight observed in cowpea cv. IFE-98-12 could have been explained by its stand count. Principal Component Analysis showed the clustering of these cowpea cultivars based on their agronomic characteristics. It was observed that on the positive axis of the PC 1 cowpea cultivars IT98K-573-1-1, IT04K-333-2, IT99K-1060 and IT98K-573-2-1 formed a cluster based on their superior performance on seed and pod yield per hectare. These cowpea cultivars belong to the short duration maturity class. This finding corroborated earlier report by Lawn, (1989) where he indicated that most farmers favoured cowpea with short maturity duration. It was opined that those cowpea with short maturity would be able to partition more assimilates to the reproductive structures consequently resulting in higher harvest index (Lawn, 1989). This observation was realisable in those Studies provided the cowpea cultivars were insensitive to photothermal effect. The harvest index observed in this study was within the range observed for most grain crops (40-60 %) (Hay, 1995). This parameter had been reported to show little variation under management practises except under drought (Hay, 1995). However, this study indicated that on the PC 1 axis a negative correlation exists between harvest index and pod and seed yield. This could have suggested that other environmental factors could have been involved in the response of harvest index of these short duration cowpea cultivars. The possibility of thermal effect creating saturation deficit could not be precluded since there was an increased temperature towards the end of the cropping season. The observed seed and pod yield could have been achievable through the contributions of other yield components apart from harvest index. All the medium duration cultivars of cowpea attained days to 50 % flowering and days to 90 % harvest maturity longer than the short duration class of cowpea. They formed another cluster on the positive axis of PC 2. This attribute was negatively correlated with number seeds per pod on the negative axis of PC 2. This observation could have suggested that these medium duration cultivars could have had longer period of vegetative growth at the expense of reproductive development. It could also be opined that they could have exhibited different reproductive strategies as reflected in the length of critical period of pod set, reproductive plasticity, morphology and the presence of apical dominance for the competition of available assimilates. Though fruit set is comparatively low in pulses (Sinha, 1974), it is affected by genetic, environmental and management factors. Ehlers and Hall, (1996) had earlier posited that the genetic effect on fruit set observed in cowpea is reflected in juvenility, floral bud suppression and pod setting ability. In Nigeria the sowing of cowpea is conventionally conducted at the end of raining season or shortly after to reduce the incidence of pest and diseases and the negative effect of water deficit on cowpea growth (Wien *et al*., 1980). This practise it was observed would better foster timely flowering of cowpea. Wien *et al*. (1980) reported that photoperiod also shortens toward the end of raining season in West Africa. Reduced sunshine hours were mostly pronounced during cropping season especially in the year 2009 compared to others. The prolonged duration to flowering and harvest maturity observed in the medium duration cowpea cultivars could have been affected by these environmental factors (shorter photoperiod, reduced relative humidity and high temperature). High relative humidity with increased temperature except in 2009 during the cropping season could have created vapour pressure deficit thus favouring increased evaporative demand. However, it could not be substantiated if it was the presence of vapour deficit that could have affected the reproductive output of these medium duration cowpea cultivars. Earlier reports had indicated that saturation deficit is more pronounced at sub-optimal temperature for the growth and development of cowpea (Craufurd *et al*., 1996). High temperature observed towards the end of the cropping season could have affected the reproductive output of medium duration cowpea through reduced floral bud development, reduced pollen viability and increased anther dehiscence (Ehlers and Hall, 1996).

While longer sunshine period could facilitate carbon assimilatory process in a non-water limiting condition through increased assimilate availability, increased seed weight and prolonged duration of seed fill (Munier-Jolain and Salon, 2005). Conversely longer duration to the attainment of 50% flowering and 95% harvest maturity observed in both 2009 and 2011 cropping seasons could be attributed to reduced sunshine hours in 2009 and increased temperature in 2011. This development response could be attributed to photothermal effect. Lower temperature below the optimum is capable of reducing rate of development in most crops. Craufurd *et al*. (1997) reported that the optimum temperature for flowering observed in cowpea is around 28˚C.

Favourable growth, shorter duration towards the attainment of flowering and harvest maturity, better yield attributes except 100 seed weight (year 2011) and seed yield observed in the year 2010 than other years during the cropping season could be attributed to more stable temperature, evenly distributed rainfall, higher and stable relative humidity and longer sunshine period. Reduced vapour pressure deficit through stable temperature and relative humidity and evenly distributed rainfall could reduce evaporative demand from the assimilatory surface of cowpea cultivars. Presence of vapour pressure deficit might have compromised aforementioned performance attributes of cowpea. Cowpea had been reported to exhibit little leaf osmotic adjustment in the presence of water deficit (Shackel and Hall, 1983). Though cowpea had been reported to be relatively tolerant to drought at vegetative growth stage (Watanabe *et al*., 1997), its grain yield is very sensitive to terminal drought (Ziska and Hall, 1983). Earliness exhibited by cowpea cultivars in 2010 would have conferred on them an advantage in the presence of water deficit.

CONCLUSION

Significant varietal differences were observed on growth, development, seed yield and its attributes. Variation in the performance of cowpea cultivars of contrasting maturity class was explained by PC 1 (81.17%) and PC 2 (17.16%). In PC 1 most of the variation was observed on seed and pod yield, while in PC 2, most variation was observed on fresh and dry fodder weight. On the positive axis of PC 1 all the short duration cowpea cultivars were superior on seed and pod yield. This class of cowpea cultivar could be used as grain legumes. On the positive axis of PC 2 all the medium duration cowpea cultivars were superior on days to 50 % flowering and days to 95% harvest maturity. This maturity class of cowpea could be used as dual purpose legume. Superior performance of local check was on the dry fodder weight. The local check could be used as a source of feed for livestock. Significant variation on the performance of cowpea cultivars were observed across the years. Better performance was observed in 2010 than other years. This was premised on the prevailing environmental factors across the years.

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