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Planting date and cultivar effects on growth and yield performance of cowpea (*Vigna unguiculata* (L.) Walp)

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Genotype by environment interaction results in significant differences in the performance of cultivars when tested in diverse environments. Nine improved cowpea (*Vigna unguiculata* (L.) Walp) cultivars obtained from International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria and a local check were evaluated for growth, reproductive and grain yield components in a non-traditional cowpea growing region of south eastern Nigeria with the aim of identifying high yielding genotypes and optimum planting date. The study was conducted in two locations namely Mgbakwu (06°17'N, 07°04'E; 83 masl) and Ishiagu (05°58'N, 07°34'E; 197 masl) across two years and two seasons in each year. A split-plot design was used with three replications. The results indicated that early planting date gave significantly higher yield and yield components than late planting date in both years and locations. IT 98K-131-2 produced mean grain yield of 1220 kg ha^{-1} in early planting date and 732 kg ha^{-1} in late season planting in Ishiagu, while in Mgbakwu, it produced 921 and 326 kg ha^{-1} in early and late planting dates, respectively. IT 97K-556-4 on the other hand produced mean grain yield of 1154 and 424 kg ha^{-1} in early and late planting dates, respectively in Ishiagu; while in Mgbakwu, the mean grain yield were 1594 and 251 kg ha^{-1} for early and late planting dates, respectively. IT 98K-131-2 exhibited the highest mean grain yield attributes in all the environments, indicating broad adaptation; while IT 97K-556-4 was the next highest grain yielder with specific adaptation to early season in Mgbakwu. The two cultivars are therefore recommended to farmers for multiplication and general cultivation in south eastern Nigeria.

Key words: Cowpea, growth and yield components, planting date.

INTRODUCTION

Cowpea is cultivated on at least 12.5 million hectares, with an annual production of over 3 million tonnes. Cowpea is widely distributed throughout the tropics, but Central and West Africa accounts for over 64% of the area (Singh et al., 1997). Cowpea is mostly grown in the drier northern parts of the country; however, advances in crop development have opened up opportunities for its production in wetter agro-ecologies (Nwofia et al., 2006).

Cowpea is an important component of the food intake of the less developed countries of the world because of its high protein content (Jaritz, 1991). It is consumed by humans in many forms; the young leaves, green pods

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and green seeds which are used as vegetables; dry seeds are used in various food preparations; and the haulms including pod walls are fed to livestock as nutritious supplement to cereal fodder (Barrett, 1987). Nigeria is the largest consumer of cowpea in the world (Nnanyelugo et al., 1985; McWatters et al., 1990). The bulk of the diet of rural and urban poor African people consists of starchy food made from cassava, yam, cocoyam, millet, sorghum and maize. The addition of even a small amount of cowpea ensures the nutritional balance of the diet and enhances the protein quality by the synergistic effect of high protein and high lysine from cowpea and high methionine and high energy from the cereals. The nutritious and balanced diet ensures good health and enables the body to resist infectious diseases and slow down their development (Nielsen et al., 1993). Similarly, Carper (1988) pointed out that a cup of cooked dry beans every day should lower the low-density lipid cholesterol, regulate blood sugar and insulin, lower blood pressure, regulate the bowels, and prevent gastrointestinal troubles, even hemorrhoids and cancer of the gut. It is estimated that cowpea supplies about 40% of the daily protein requirements to most of the people in Nigeria (Muleba et al., 1997). Cowpea improves soil fertility fixing atmospheric nitrogen and some varieties fix 46 to 103 $kgNh^{-1}$ annually (Sanginga et al., 2003). This can reduce the need for application of nitrogenous fertilizers that are detrimental to the environment. Biological nitrogen fixation is environmentally friendly and ideal for sustainable agriculture (Cheng, 2008).

Cowpea is usually grown under rain fed conditions. Both quality and quantity of cowpea seed are affected by the amount and distribution of rainfall, which is affected by the period of planting (Morakinyo and Ajibade, 1998). Identification of the appropriate timing of sowing of a crop in any particular location is an important agronomic requirement needed for high and sustained productivity (Akande et al., 2012).Year, location, planting dates and climatic factors of a place often affect crop production by interacting with cultivar and its traits (Akande, 2007). Multi-environment trials are evaluated to identify superior and stable cowpea genotypes and to understand the effects of genotypes and environments on cowpea performance. The interaction between genotype and environment results in significant differences in performance of genotypes when tested in various environments (Gauch and Zobel, 1997). The genotype by environment (GE) interactions plays a major role in the performance of any genotype and in identification of adaptable genotypes to varying environments. Interactions between genotype and environment affect both quantitative and qualitative traits. Due to varying effects of climate change and divers ecological conditions in Nigeria, it is important to select suitable cultivars for adaptability to specific as well as across environments.

Use of improved cultivars and alteration of crop planting dates have been reported by many researchers as effective strategies for reducing pest damage and improvement of crop productivity (Ekesi et al., 1996; Karungi et al., 2000). Studies conducted in Kano (Northern Guinea Savanna of Nigeria) showed that elite cowpea lines performed better in terms of grain yield when planted between mid-June and mid-July without insecticide protection, whereas a local variety included in the study produced higher grain yield when planted between late July and early August (Asante et al., 2001). The value of manipulating the planting date as a package for optimizing cowpea productivity have been confirmed, thus giving scientific credence to the traditional practice of planting early in the season than late planting (Jackai et al., 1985). Experiment conducted in monomodal climates had shown that early planting, as soon as rains become well established in mid to late June, to be associated with high grain yield (IITA-SAFGRAD, 1983). Kamara (1981) reported that plant height, pod number and seed yield of cowpea planted in September were significantly greater than those from other planting dates in Sierra Leone. Late season planting was recommended as the most appropriate planting period in southern Nigeria based on distinct variations observed in the growth and reproduction of cowpea planted at different times (Morakinyo and Ajibade, 1998). Asio et al. (2005) observed higher grain yield of the best yielding variety when planted in the late season in Uganda as compared to early season planting, and this was attributed to different weather conditions that prevailed in the two seasons. The first season was associated with heavy rains which promoted excessive vegetative growth, fewer pods and thus lower grain yields.

Climate change has caused significant modification of the cropping seasons in different regions, and the effect of this alteration is variation in performance of crop species grown in different environments. The objectives of this study were to determine the effects of planting season on cowpea cultivars and to identify cultivars with high agronomic values. The study was also meant to identify optimum sowing date so that farmers could be advised on the appropriate planting date that will stimulate higher cowpea production.

MATERIALS AND METHODS

Experimental sites

The study was conducted across two locations and over two years within derived savanna agro-ecology of southeastern Nigeria, considered as non-traditional cowpea growing region. In each year, early and late season sowing dates were utilized to assess the agronomic potentials of the cultivars. The two locations experiences bimodal rainfall pattern and they include Mgbakwu (06° 17'N, 07° 04'E; 83 m asl) and Ishiagu (05° 58'N, 07° 34'E; 197 m asl). Mgbakwu location experienced an average daily temperature and relative humidity of 31°C and 74, respectively with a total annual precipitation of 1571 mm in 2007 and 1638.1 mm in 2008. Ishiagu witnessed an average daily temperature and relative humidity of 31.5°C and 81, respectively with a total annual precipitation of

1677.5 mm in 2007 and 1954.1 mm in 2008. The soils of Mgbakwu are predominantly sandy and acidic (pH 4.6) while that of Ishiagu are sandy loam soils with alkaline pH of 6.0.

Cultivars

Nine improved cowpea cultivars collected from IITA, and a local cultivar (check) were used in this study. The improved cultivars consisted of extra early (IT 93K-452-1), early (IT 84S-2246-4, IT 90K-82-2, IT 97K-558-18) and medium maturing cultivars (IT 90K-277-2, IT 97K-499-35, IT 97K-556-4, IT 98K-131-2, IT 98K-205-8) (Dugje et al., 2009) while local check falls within long duration category.

Experimental procedures

The experimental plot was ploughed, harrowed and manually ridged. Prior to ridging, a basal dose of 100 kg NPK 15-15-15 per hectare plus 1000 kg per hectare of well cured cow dung was broadcasted uniformly and later incorporated into the soil before ridging. Seed was dressed with fungicide (seed-plus) at the rate of one sachet (10 g) to 2 kg of seed. Inter-row spacing was 75 cm while intra row spacing was 25 cm; 2-3 whole-seeds per hill were sown at 3-5 cm depth. Plants were thinned down to two stands per hill two weeks after crop emergence. Weeds were manually controlled as regularly as they appeared while other agronomic practices were carried out as recommended. Early and late season sowing dates were observed for the two years and in the two locations. In 2007, the experiments were established on July 23 for early season sowing and September 4 for late season sowing in Mgbakwu while in Ishiagu location, sowing was done on July 31 and September 12 for early and late season sowing, respectively. In 2008, the experiment was established in Mgbakwu on July 21 and September 15 while sowing in Ishiagu was carried out on July 24 and September 12 for early and late season sowing, respectively. Planting done before the month of August was considered early planting date while planting done after August was regarded as late planting date. The experiment was a split-plot arranged in a randomized complete block design (RCBD), replicated three times on a four row plots of 2 m long. Insect pests were managed with the application of full dose of 100 ml of insecticide, cypermethrin and dimethoate mixture containing 30 and 250 g active ingredients respectively, using 15 L knapsack sprayer.

Data collection

The data were collected from the inner two rows in each replicate. Observation were recorded on growth components (dry fodder weight, number of internodes, number of leaves, number of nodules, number of plant stand, peduncle length, taproot length and vine length) and reproductive and grain yield components (bloom, duration of grain filling period, 100 seed weight, number of pods per plant, number of seed per pod, pod length, grain yield, threshing percentage and harvest index). Days to 50% flowering/bloom was sampled when there was at least one flower in 50% of all plants in the plot. Duration of grain filling period was determined as days from 50% bloom to when the pods have reached physiological maturity (when the pods had reached their mature pod color). At the end of vegetative growth, the rest of the growth components were determined on five randomly selected plants while at maturity, the yield and yield components were sampled from five randomly selected plants. Dry fodder weight was determined from the net plot after harvest and sun drying while the weight of 100 seeds was recorded by weighing a random sample of 100 seeds.

Data analysis

The data collected were subjected to analysis of variance (ANOVA) using GENSTAT Discovery Edition 2 (GENSTAT, 2005) procedures as outlined for RCBD. Means of cultivars were separated using fishers least significant difference (F-LSD) (P = 0.05).

RESULTS

Results indicated that early planting date in Ishiagu location significantly increased growth components such as internode length, number of nodules, number of plant stand and vine length than in late planting date (Table 1). Response of cultivars to both planting dates differed for dry fodder weight, number of leaves, peduncle length and root length with local cultivar expressing significantly higher dry fodder weight, internode length, number of leaves, number of nodules and vine length. Conversely, local cultivar produced the least plant stands in both planting dates indicating poor plant establishment while IT 845-2246-4 produced significantly higher plant stand in both planting dates showing that the cultivar had good crop establishment probably due to its viability.

Table 2 shows that early season plating resulted in significantly higher reproductive and grain yield components except number of nodes per plant and pod length which differed among all the cultivars and across the two planting dates. In early season, local cultivar did not flower as expected and therefore could not produce any yield components, on the contrary it flowered and produced grains in late planting. IT 93K-452-1 was the earliest to bloom in both planting dates. The cultivar IT 98K-131-2 produced significantly higher grain yield per hectare of 1220 and 732 kg in both early and late planting dates, respectively. Similarly, IT 98K-131-2 produced significantly higher number of pods per plant, number of seed per pod, threshing percentage and harvest index in both planting dates. It also took relatively longer days to fill its pods. Local cultivar however expressed significantly lower 100 seed weight, number of pods per plant, number of seeds per pod, pod length, grain yield, threshing percentage and harvest index.

Response of cultivars to the growth parameters in Table 3 revealed similar trend to that shown in Table 1 with early planting dates expressing significantly higher dry fodder weight, internode length, number of nodules, number of plant stands and vine length. Local cultivar again produced significantly higher growth components for most traits except number of plant standand peduncle length. In both locations and planting dates, IT 93K-452-1 was the earliest to bloom making it an extra early flowering cultivar.

Early planting date in Mgbakwu location supported significantly higher reproductive and grain yield components across all the cultivars except 100 seed weight and planting dates Table 4). IT 97K-556-4 produced significantly higher grain yield per hectare (1394 kg) in early

Table 1. Effect of early and late planting dates on growth components of cowpea cultivars combined across 2007 and 2008 in Ishiagu.

Cultivar	DFWT (g)		Inter node		NLEAF		NNODULE		NSTAND		PEDLT(CM)		RTLENGTH (CM)		VINELTH (CM)	
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
IT 84S-2246-4	554	625	6	5.58	24.1	21.58	1.17	5.58	39.5	39.17	29.29	30.67	22.75	22.12	43.7	35.1
IT 90K-277-2	952	842	12.O8	9.17	28.8	39.08	16.67	14.5	34.33	31.83	30.83	33.08	22.5	22.5	111.2	89.9
IT 90K-82-2	742	608	10.08	7.25	30	27.5	6.17	4.17	38.42	36.5	29.71	27.25	19.67	20.25	72.7	41
IT 93K-452-1	298	400	8.5	7.42	22.2	20.42	15.5	8.92	35.17	29.83	25.92	25.08	17.92	19.17	65.7	45.7
IT 97K-499-35	640	450	9	8	21.8	23.25	8.25	5.75	37	36.67	29.33	25.5	20.75	22.21	62	44.9
IT97K-556-4	771	875	7.42	4.92	27.8	23.75	17.5	10.58	38.17	34.42	27.58	26.33	20.08	19.58	72.4	31.8
IT97K-55568-8	696	600	9.92	8.83	29.3	32.33	14.67	4.33	30.75	26	29.75	29.67	20.5	21.42	97.2	75.6
IT98K-131-2	625	550	9.58	9.08	32.5	32.83	9.92	4.58	29.83	27.17	30.75	31.08	21.75	23.33	89.2	77.3
IT98K-205-8	642	458	9.25	7.75	26	20.5	10.83	4.92	34.58	32.5	30.75	31.08	21.75	23.33	83.3	54.7
LOCAL	853	569	20.42	15.75	83.5	68.25	17.25	9.5	14.08	20.33	0	22.75	18.08	16.42	185.7	168
MEAN	677.3	598	10.22	8.38	32.6	30.95	12.69	7.28	33.18	31.44	26.58	27.77	20.7	20.81	88.3	66.4
F-LSD(0.05)	191.9	136.8	2.459	2.448	18.72	7.175	5.467	3.218	3.362	4.087	5.1	4.32	3.922	3.398	34.06	24.69

P_1 =early planting date; P_2 = late planting date; DFWT (g) = Dry fodder weight; Internode = Number of internodes; NLEAF = Number of leaves; NNODULE = Number of nodules; NSTAND = Number of Plant Stands; PEDLT = Peduncle length; RTLENGTH = Roof length; VINELTH = Vine length.

Table 2. Effect of early and late planting dates on reproductive and grain yield components of cowpea cultivars combined across 2007 and 2008 in Ishiagu.

Cultivar	Bloom (days)		Podfill (days)		100 SWT (g)		NPOD/PLT		NSEED/POD		PODLT (cm)		GYD/ HA		Thresh (%)		HI	
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
IT845-2246-4	51.67	43.25	16.67	14.17	11.92	7.5	17.08	19.08	10.25	8.25	14.58	14.08	892	455	58.94	32.2	52.9	20.1
IT90K-277-2	50.25	43.42	21.58	16.58	17.77	10.58	16.92	15.42	13	9.67	14.62	15	1072	581	54.61	36.4	31.07	26.3
IT90K-82-2	51.25	45.25	19.17	14	11.63	9.45	19.75	16.75	12.08	10	14.75	14.92	978	401	58.09	41	45.5	30.2
IT93K-452-1	40.25	38.92	20.25	14.33	16.33	12.41	14.5	14.08	11.75	9.83	13.38	13.73	807	492	63.09	47	70	39.2
IT97K-499-35	44	41.08	21	15.83	14.71	9.48	13.33	13	11.5	8.5	13.67	14.08	1114	341	65.02	37.6	50.4	38
IT97K-556-4	50.58	41.67	19.83	17.42	17.24	10.88	14.92	17.33	11.58	9.83	16.93	17.17	1154	424	62.94	32.5	50.9	15.6
IT97K-568-18	47	41.75	20.83	18.83	15.19	12.58	16.67	17.33	12	9.33	14.38	14.38	943	566	54.7	42.4	39.2	24.7
IT98K-131-2	50	41.58	21.67	18.67	15.43	11.5	17.58	20	12.58	10.08	14.88	14.84	1220	732	68.55	47.5	74.2	43.8
IT98K-205-8	43.33	40.33	2075	18.75	15.48	11.84	15.5	16.25	11.67	9.08	13.96	13.67	1023	408	64.18	44.8	59.9	33.8
LOCAL	0	49.08	0	27.42	0	8.33	0	6.33	0	4.92	0	7.83	0	145	0	28.4	0	8.8
MEAN	43.48	42.63	18.18	17.6	13.57	10.46	14.62	15.56	10.64	8.95	13.11	13.97	920	455	55.09	39	52.74	29.05
F-LSD(0.05)	5.857	4.645	2.494	4.259	0.515	3.466	5.183	4.907	1.729	2.325	0.841	2.316	230.7	191.3	6.458	14.52	24.1	15.8

P_1 =early planting date; P_2 = late planting date; Bloom = Days to 50% flowering; PODFILL = Days to pod filling; 100 SWT = 100 Seed Weight; NPOD/PLT = Number of pods per plant; NSED/POD = Number of Seeds per pod; PODLT = Pod length; GYD/HA = Grain Yield per hectare; Thresh % = Threshing percentage; HI = Harvest Index.

Table 3. Effect of early and late planting dates on growth components of cowpea cultivars combined across 2007 and 2008 in Mgbakwu.

Cultivar	DFWT (g)		Inter node		NLEAF		NNODULE		NSTAND		PEDLT(CM)		RTLENGTH (CM)		VINELTH (CM)	
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
IT845-2246-4	608	284	8.17	6.5	18.5	14.5	8.83	3.88	43.33	36.67	33.58	31.36	30.38	30.58	47	26.7
IT90K-277-2	592	338	14.92	9.67	31.6	32.92	14.33	5.33	31.25	17.58	26.78	25.91	37.25	29.29	143.7	66.1
IT90K-82-2	331	321	10.5	8.25	24.4	20.42	8.08	4.08	37.75	33.5	24.1	28.38	32.25	28.54	40.7	37.5
IT93K-452-1	288	252	9.08	10	20.3	25.75	17.5	5.33	32.25	23.58	22.83	25.25	27.25	28.83	98.4	59.4
IT97K-499-35	250	252	10.17	7.17	17.2	21.42	7.5	4.29	36.33	33.75	25.77	22.23	29.58	30.38	68.9	29.9
IT97K-556-4	962	538	9.5	6.83	26.5	26.83	20.58	10.85	38.58	32.08	26.18	26.95	33.67	27.25	57.4	31.9
IT97K-568-18	312	226	14.75	9.92	22.6	21.29	14.25	5.54	28.5	22.92	26.44	25.18	31.46	27.54	117.4	67.5
IT98K-131-2	296	276	14.25	8.42	26.5	24.04	10.67	5.5	25.5	23.58	26.33	26.15	27.33	25.68	113	50.9
IT98K-205-8	588	247	10.67	9.25	21.9	19.67	7.08	4.54	34.58	28.75	28.76	22.96	29	25.62	86.9	43.1
LOCAL	1171	382	22.42	14.25	81	39.42	29.08	9.04	26.17	22.5	16.69	17.48	33.58	30.46	218.9	109.1
MEAN	550	312	12.44	9.03	29.1	24.62	13.79	5.84	33.42	27.49	25.75	25.19	31.18	28.42	99.2	52.2
F-LSD (0.05)	327.7	121.4	2.485	1.442	17.16	5.97	8.95	2.751	3.617	5.46	4.029	5.098	5.375	5.607	34.57	18.76

P_1 =early planting date; P_2 = late planting date; DFWT (g) = Dry fodder weight; Internode = Number of internodes; NLEAF = Number of leaves; NNODULE = Number of nodules; NSTAND = Number of Plant Stands; PEDLT = Peduncle length; RTLENGTH = Roof length; VINELTH = Vine length.

Table 4. Effect of early and late planting dates on reproductive and grain yield components of cowpea cultivars combined across 2007 and 2008 in Mgbakwu.

Cultivar	Bloom (Days)		PODFILL (days)		100 SWT (g)		NPOD/ PLT		NSEED/ POD		PODLT (cm)		GYD/ HA		THRESH %		HI	
	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2	P_1	P_2
IT84S-2246-4	49.42	46.67	23.83	16.5	11.5	10.58	16.42	6	11.79	7.96	16.42	13.42	848	184	64.61	51.5	43.4	41.8
IT90K-277-2	50.5	45.58	24.92	20.92	18.12	15.52	15.25	10.92	11.29	8.29	16.61	14.18	750	149	58.64	51.3	60.3	18.9
IT90K-82-2	53.5	46.83	20.75	17.17	12.29	12.31	12.5	6.08	14.08	9.92	15.17	14.83	815	160	67.44	52.7	89	55.1
IT93K-452-1	41.58	41.33	22.25	19.5	16.3	16.68	17.83	12.5	11	7	14.42	14.87	864	216	66.65	50.3	95	30.6
IT97K-499-35	45.67	41	22.5	19.58	15.02	13.17	11.54	6.92	11.83	6.29	15.19	14.49	638	195	64.39	49.5	63.1	51.3
IT97K-556-4	49	42	22.33	24.33	18.67	12.03	13.04	9	11.79	6.79	19.02	15.63	1394	251	68.36	40.2	57.9	17.5
IT97K-568-18	49	44.33	23.83	21.75	16.3	14.35	20	11.42	12.46	8.92	15.38	14.72	792	216	67.93	53.6	81.4	83.4
IT98K-131-2	49.83	43.75	22.5	23	16.24	15.34	17.21	13.92	12.42	9	16.52	14.64	921	326	72.05	62.4	97.5	55.7
IT98K-205-8	44.75	41.58	23.17	21.5	15.78	13.48	14.33	6.5	11.75	6.54	15.19	13.63	758	134	66.37	47	51.5	60.1
LOCAL	0	61.17	0	23	0	11.15	0	3.33	0	3.87	0	7.17	0	64	0	32.7	0	6.3
MEAN	48.14	45.42	22.9	20.73	14.03	13.46	13.97	8.66	11.24	7.46	16	13.74	778	190	59.65	49.1	71	42.1
F.LSD (0.05)	2.186	1.583	4.826	3.667	0.918	3.473	4.741	3.491	1.637	2.345	1.433	1.81	446.1	93.7	4.271	15.54	28.91	48.19

P_1 =early planting date; P_2 = late planting date; Bloom = Days to 50% flowering; PODFILL = Days to pod filling; 100 SWT = 100 Seed Weight; NPOD/PLT = Number of pods per plant; NSED/POD = Number of Seeds per pod; PODLT = Pod length; GYD/HA = Grain yield per hectare; Thresh % = Threshing percentage; HI = Harvest Index.

Table 5. Interaction effect of cultivar and year on reproductive and grain yield components in early season, Ishiagu.

Cultivar	PODFILL (days)		100 SWT (g)		NPOD/PLT		NSEED/pod		PODLT (cm)		GYD/ HA		THRESH (%)		HI	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
IT 845-2246-4	16.5	16.83	12.17	11.67	14.2	20	10	10.5	14.08	15.08	482	1303	49.79	68.09	46.7	59.2
IT 90K-277-2	22.17	21	17.37	18.17	13.7	20.17	13.67	12.33	13.75	15.5	462	1682	39.99	69.24	26.3	37.2
IT 90K-82-2	18.33	20	11.1	12.17	15.7	23.83	12.83	11.33	14.83	14.67	624	1332	44.04	72.15	53	38
IT 93K-452-1	18.67	21.83	15.82	16.83	12.2	16.83	11.83	11.67	13	13.75	366	1249	49.76	78.03	68.6	95.6
IT 97K-499-35	18.67	23.33	14.42	15	10	16.67	12.67	10.33	13.67	13.67	494	1733	54.02	76.03	35.6	65.3
IT 97K-556- 4	18.67	21.5	17.32	17.17	11	18.83	11.5	11.67	16.7	17.17	689	1618	51.33	74.55	55.6	46.1
IT 97K-568-18	20.67	21	14.05	16.33	15.5	17.83	12.17	11.83	13.83	14.92	480	1406	37.35	72.04	39.2	39.3
IT 98K-131-2	21.17	22.17	14.52	16.33	14.2	21	13	12.17	14.5	15.25	799	1640	60.13	76.96	67.6	80.9
IT 98K-205-8	18.33	23.17	15.28	15.67	12.3	18.67	11.5	11.83	13.17	14.75	574	1473	54.41	73.95	49.1	70.8
LOCAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEAN	17.27	19.08	13.2	13.93	11.9	17.38	10.92	10.37	12.75	13.48	497	1343	44.08	66.1	44.2	59.16
F-LSD (0.05)	3.409	3.409	0.737	0.737	6.85	6.846	2.539	2.539	1.442	1.442	297.2	297.2	8.453	8.453	33.53	33.53

Y_1 = Year 1; Y_2 = Year 2; PODFILL = days to pod filling; 100 SWT = 100 Seed Weight; NPOD/PLT = number of pods per plant; NSED/POD = number of Seeds per pod; PODLT = pod length; GYD/HA = Grain yield per hectare; Thresh % = Threshing percentage; HI = harvest Index.

planting while it gave the second highest grain yield in late planting date. The reverse is the case with IT 98K-131-2 which produced significantly higher grain yield per hectare (326 kg) in late planting date while it was the second highest grain yielder per hectare (921 kg) in early planting date.

The interaction effects of cultivar and year on reproductive and grain yield components in early (Table 5) and in late season (Table 6) in Ishiagu location are shown. The results revealed that in both early and late seasons, year two (2008) expressed significantly higher reproductive and grain yield traits. Cultivar IT 98K-131-2 again produced significantly higher grain yield per hectare in both year and season indicating that the cultivar is an ideotype cultivar possessing superior grain yielding ability with broad adaptation endowment.

The interaction effects of cultivar and year on reproductive and grain yield components in early (Table 7) and late season (Table 8) in Mgbakwu location are presented. In both early and late seasons, year one (2007) expressed significantly higher reproductive and grain yield components for most traits sampled. IT 97K-556-4 produced significantly higher grain yield in year one (1428kg) and year two (1360 kg) in early season while in late season, IT 98K-131-2 produced significantly higher grain yield in year one (488 kg) and year two (164 kg) revealing that IT 97K-556-4 was more adapted to early season than late season, while IT 98K-131-2 possess broad adaptation to both early and late seasons. Late season in Mgbakwu location supported the lowest expression of grain yield per hectare with grain yield range (136 and 488 kg) in year one while it ranged between 49 and 164 kg in year two. Pod length was minimally influenced by year effect in most cases. In both planting dates and locations, IT90K-277-2, IT 93K-452-1 and IT97K-556-4 produced significantly higher 100 seed weight. A similar trend was observed where IT97K-556-4 produced the longest pod in both planting dates and locations.

DISCUSSION

Early and late planting dates were utilized to evaluate some selected cowpea genotypes across two locations and over years. Results obtained indicated that yield and yield components were best expressed in early planting date but decreased in late planting date in all the environments. Ray et al. (2008) and Shegro et al. (2010) working on soybean reported that early planting date produced a higher seed yield than late planting. Javaid et al. (2005) and Akande et al. (2012) also obtained similar result on cowpea and attributed the yield differences to higher solar

Table 6. Interaction effect of cultivar and year on reproductive and grain yield components in late season, Ishiagu.

Cultivar	PODFILL (days)		100 SWT (g)		NPOD/ PLT		NSEED/ POD		PODLT (cm)		GYD/ HA		THRESH %		HI	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
IT 845-2246-4	10.5	17.83	5.67	9.33	11.5	26.67	6.5	10	13.92	14.25	111	799	18	46.4	9	31.2
IT90K-277-2	15.17	18	8.67	12.5	9	21.83	8	11.33	15	15	184	978	22.1	50.6	7.9	44.7
IT 90K-82-2	9.67	18.33	5.9	13	8.83	24.67	7.67	12.33	15	14.83	193	609	21.7	60.4	14.5	45.8
IT 90K-452-1	15.67	13	9.48	15.33	10.5	17.67	8.83	10.83	13.62	13.83	187	797	27.5	66.5	14.8	93.6
IT 97K-499-35	16.5	15.17	7.13	11.83	8.17	17.83	6.67	10.33	14.17	14	196	485	26.8	48.4	10.4	65.6
IT 97K-556-4	15.17	19.67	10.43	11.33	12.5	22.17	7.83	11.83	17.17	17.17	211	637	25.6	39.4	8.8	22.4
IT 97K-568-16	16.5	21.17	8.33	16.83	9.17	25.5	7.83	10.83	13.92	14.83	225	908	23.8	61.1	14.8	34.6
IT98K-131-2	17.83	19.5	7	16	13.17	26.83	9.5	10.67	14.85	14.83	333	1131	25.8	69.1	17	70.7
IT 98K-205-8	20.17	17.33	10.18	13.5	12.5	20	7.83	10.33	13.58	13.75	203	612	33.8	55.8	11.1	56.5
LOCAL	33.33	21.5	7	9.67	2.17	10.5	1.67	8.17	5.83	9.83	88	203	27.1	29.6	3.2	14.3
MEAN	17.05	18.15	7.98	12.93	9.75	21.37	7.23	10.67	13.71	14.23	193	716	25.2	52.7	11.1	47.9
F-LSD (8.05)	6.5	6.5	4.389	4.389	6.389	6.389	3.079	3.079	2.532	2.532	272.5	272.5	18.35	18.35	21.84	21.84

Y_1 = Year 1; Y_2 = Year 2; PODFILL = Days to pod filling; 100 SWT = 100 Seed Weight; NPOD/PLT = Number of pods per plant; NSED/POD = Number of Seeds per pod; PODLT = Pod length; GYD/HA = Grain yield per hectare; Thresh % = Threshing percentage; HI = Harvest Index.

Table 7. Interaction effect of cultivar and year on reproductive and grain yield components in early season, Mgbakwu.

Cultivar	PODFILL (days)		100 SWT (g)		NPOD/ PLT		NSEED/ POD		PODLT (cm)		GYD/ HA		THRESH (%)		HI	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
IT845-2246-4	25.33	22.33	11.5	11.5	21.17	11.67	13.83	9.75	16.08	16.75	1023	673	60.09	69.14	53.9	33
IT90K-277-2	27.83	22	18.52	17.83	15.33	15.17	12.83	9.75	17.42	15.8	618	882	46.54	70.73	61.6	59
IT 90K-82-2	21.83	19.67	12.25	12.33	13.67	11.33	14.33	13.83	15.42	14.92	827	803	62.51	72.36	66.4	79.2
IT 93K-452-1	22.67	21.83	16.27	16.33	21.17	14.5	12.17	9.83	14.25	14.6	746	981	63.01	70.29	96	83.4
IT97K-499-35	22	23	15.03	15	14.17	8.92	12	11.67	16.08	14.3	686	589	59.8	68.98	62.6	63.6
IT97K-556-4	23.83	20.83	18.67	18.67	14.83	11.25	12.67	10.92	19.92	18.13	1428	1360	67.61	69.12	65.2	50.6
IT97K-568-18	25.67	22	15.43	17.17	21.83	18.17	13	11.92	16.33	14.43	1002	581	63.95	71.92	73.7	89.1
IT 98K-131-2	23.17	21.83	15.65	16.83	20.33	14.08	12.5	12.33	16.42	16.63	999	843	69.76	74.34	95.67	91.2
IT98K-205-8	22.33	24	15.72	15.83	17.17	11.5	13	10.5	15.42	14.97	781	734	63.57	69.17	67.2	35.8
LOCAL	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
MEAN	21.47	21.83	13.9	14.15	16.13	11.81	11.97	10.51	16.37	15.61	811	745	55.68	63.61	71.36	64.99
F-LSD (0.05)	6.629	6.629	0.918	0.918	6.472	6.472	2.19	2.19	2.107	2.107	390.8	390.8	6.884	6.884	44.62	44.62

Y_1 = Year 1; Y_2 = Year 2; PODFILL = Days to pod filling; 100 SWT = 100 Seed Weight; NPOD/PLT = Number of pods per plant; NSED/POD = Number of Seeds per pod; PODLT = Pod length; GYD/HA = Grain yield per hectare; Thresh % = Threshing percentage; HI = Harvest Index.

Table 8. Interaction effect of cultivar and year on reproductive and grain yield components in late season, Mgbakwu.

CULTIVAR	PODFILL (days)		100 SWT (g)		NPOD/PLT		NSEED/POD		PODLT (cm)		GYD/HA		THRESH (%)		HI	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
IT845-2246-4	14.67	18.33	8.45	12.67	8.33	3.67	9.67	6.25	15.33	11.52	234	134	42.7	60.2	11.4	72.3
IT90K-277-2	19.5	22.33	13.2	17.83	15	6.83	11.33	5.25	14.67	13.7	216	82	37.3	65.3	13.1	24.8
IT90K- 82-2	13.67	20.67	10.78	13.83	8.33	3.83	13.17	6.67	16.25	13.42	240	81	35.6	69.9	19.7	90.5
IT93K-452-1	17.67	21.33	15.7	17.67	19	6	9	5	15.67	13.68	282	151	44.4	56.1	22.4	38.7
IT97K-499-35	17	22.17	10.17	16.17	9.5	4.33	7	5.58	15.92	13.07	262	128	38.6	60.4	20	82.7
IT 97-556-4	22.33	26.33	11.73	12.33	14	4	10	3.58	18	13.27	418	84	42.3	38.1	22.3	12.7
IT97K-568-18	19.33	24.17	13.03	15.67	16.67	6.17	11.5	6.33	15.75	13.68	328	104	40.6	66.7	32.9	94.5
IT 98K-131-2	25.5	20.5	12.85	17.83	23.67	4.17	12.17	5.83	15.5	13.78	488	164	58.1	66.7	34.8	76.5
IT 98K-205-8	20	23	9.97	17	8.5	4.5	7.5	5.58	14.25	13.02	136	131	30.1	63.9	11.9	73.65
LOCAL	32.67	13.33	11.13	11.17	4.33	2.33	4.83	2.92	7.83	6.5	79	49	26.7	38.7	4.9	7.7
MEAN	20.23	21.22	11.7	15.22	12.73	4.58	9.62	5.3	14.92	12.56	268	111	39.7	58.6	19.3	57.41
F-LSD (0.05)	6.569	6.569	4.525	4.525	4.777	4.777	3.151	3.151	2.564	2.564	133.5	133.5	18.85	18.85	69.64	69.64

Y_1 = Year 1; Y_2 = Year 2; PODFILL = Days to pod filling; 100 SWT = 100 Seed Weight; NPOD/PLT = Number of pods per plant; NSED/POD = Number of Seeds per pod; PODLT = Pod length; GYD/HA = Grain yield per hectare; Thresh % = Threshing percentage; HI = Harvest Index.

radiation and leaf area index as well as lower pest pressure in early season. This result confirmed those findings except that differences in yield between the two seasons could also be attributed to rainfall, since the reproductive period was longer in the early season than late season owing to adequate moisture. This view was supported by Hall (1992), Ismaila and Hall (1998) who noted that early sowing enabled cowpea to escape high temperatures during the flowering stages when the crop was sensitive to heat and the crop would mature before the rains ceased. Higher grain yield in early season could therefore be attributed to longer duration of pod filling which was observed in early season in this study. This result was in line with that of Evans (1993) who reported that the longer the duration of growth period, the higher the potential photosynthates production and consequently the better the crop performance.

The result further showed that plant population was higher in early season than late season, indicating that lower soil temperatures at the time of late planting affected seed germination, and consequently resulted in lowered plant population. Lower cowpea grain yield as observed in this study in late season could be attributed to this phenomenon. Ismail et al. (1997) reported that warm season annual crop such as cowpea exhibited slow and incomplete emergence when subjected to cool soils.

The threshold soil temperature where cowpea exhibits incomplete emergence is about 19°C. Soil temperatures below 19°C often occur at the peak of rainy season. Craufurd et al. (1997) reported that with optimum soil moisture, the rate of seed germination increased linearly as temperature increased. Hall (1992) recommended that farmers should adopt early sowing at high soil temperature because such practice would result in higher plant population and better crop yield. The differences in yield pattern across these locations as observed in this study are as expected, and justified the evaluation of crop species in environments with distinct biotic and abiotic resources. A complete evaluation of crop genotypes cannot take place in one environment as use of the results of the evaluation would be limited only to that environment. However, even in one environment, evaluation should be carried out at least for two or more years and in different seasons (Baiyeri, 1998; Perrino and Monti, 1991).

In this study, season was found to exhibit significant effect on cowpea flowering. The non-photosensitive genotypes flowered and produced components of grain yields as expected in both seasons, while the local variety failed to flower and produced no yield in the first season owing to its sensitivity to photoperiod. This result is in conformity with Nangju et al. (1979), Singh et al. (2002)

and Kamara et al. (2009). The shortened days to flowering as observed in this study is in agreement with Summerfield and Roberts (1985) who noted that warmer temperature hasten the appearance of flower in both photoperiod sensitive and insensitive genotypes.

The result also showed that pod length, number of seeds per pod, number of branches and number of internodes were least influenced by seasonal changes. This result confirmed the observation made by Uguru and Uzo (1991) and Singh et al. (2002) that these traits are moderately to highly heritable.

Threshing percentage and harvest index were affected by season in a similar way it affected grain yield with early season favouring higher expression of both traits. Harvest index was directly related with some yield components. This finding is supported by Kwapata and Hall (1990) who noted that harvest index was positively correlated with yield and yield components in cowpea. This indicated that the yield potential of cowpea could be raised by selecting for high harvest index.

Local cultivar recorded significantly lower yield and yield components than improved cultivars. The higher yield of improved cowpea over local variety was supported by Singh et al. (2002) who showed that the use of improved varieties led to the realization of 4 tonnes per hectare. Local cultivars were found to be poor in resource capture and utilization. The local variety although had lower plant population, it nevertheless produced the highest fresh and dry fodder yield as well as other growth components especially in early season. This observation is supported by Singh et al. (1997) and Blade et al. (1992) who reported that while the traditional varieties do not yield as much grain, they do give large fodder yield. IT90K-227-2 and IT97K-556-4 exhibited dual-purpose characteristics in both seasons having produced high yield of both grain and fodder, while the rest of the genotypes were purely grain type. Earlier reports by Ajeigbe et al. (2005), Singh et al. (1997) and Kamara et al. (2010) were confirmed in this study as they also identified these cultivars as dual-purpose cowpea. IT98K-131-2 gave significantly higher yield and yield components. Its superior performance cut across seasons, locations and years indicating that the cultivar had broad and stable adaptation. Kamara et al. (2010) working in northern Nigeria also identified this cultivar as high yielding.

Most of the cultivars expressed similar I00 seed weight across different environments. For instance, the cultivars IT90K-277-2, IT98K-556-4, local and IT93K-452-1, produced significantly higher and more stable 100 seed weight while IT84S-2246-4 and IT 90K-82-2 consistently produced smaller seed size across all the environments. This result is corroborated by Karkannavar et al. (1991) who pointed out that seed size in cowpea is highly heritable and is less affected by environment. Drabo et al. (1984) concluded that the gene action controlling seed size is predominantly additive but they also noted that it could be modified by environment. This is in conformity with the findings in this study. IT90K-277-2, IT98K-556-4 and IT93K-452-1 were earlier identified by IITA (1995) as possessing large seed size.

The cultivar IT97K-556-4 expressed significantly higher grain and fodder yield attributes in early season, particularly in Mgbakwu location while its yield and yield components were significantly depressed in late season making it a cultivar with narrow adaptation to early season.

Conflict of Interest

The authors have not declared any conflict of interest.

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