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Seasonal and Genotypic Influence on Insect Pests, Growth and Yield of Cowpea (*Vigna unguiculata* L. Walp)

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Authors' contributions

This work was carried out in collaboration between all authors. Author IEE conceived the work, designed the experiment, produced the protocol, collected data, managed literature search and participated in drafting the manuscript. Author BCE wrote the first draft, effected corrections on the manuscript and provided technical backstopping. Authors KPB and BNM managed the statistical analysis of the data and final editing of the work. All the authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Cowpea (*Vigna unguiculata* L. Walp) is rich in dietary protein and a relish in most West African countries. Four elite genotypes (IT 97K-499-35, IT 97K-568-18, IT 98K-131- 2 and IT 93K-452-2) emanating from the breeding programme of International Institute of Tropical Agriculture (11TA), Ibadan were therefore evaluated for their relative adaptations to a rainy season environment. A local variety was added as a check. The accessions were laid out in a randomized complete block design (RCBD) in two seasons (early and late) for two years (2009 and 2010) at DEMACCO Integrated Farms Ltd., AKO, Enugu state, Nigeria. The result revealed the presence of genotype x season interaction. Reproductive grain yield and insect damage on the crop differed significantly ($p<0.05$) between genotypes and/or season. Pod weight, 100-seed weight, grain weight, threshing percentage and harvest index of the late crop increased by 31%, 25%, 72%, 71% and 41% respectively over that of the early. Late season grain yields of IT 93K-131-2 (1177.0 kg ha^{-l}) and IT 93K-452-1 (1121.0kg ha^{-1}) were outstanding compared to other genotypes and seasons and were more tolerant to pre-and post flowering insect pest. The early season grain yields of IT 93K-452-1 (1000.02 kg ha^{-1}) and IT 97K-499-35 (987.00kg ha^{-1}) were comparable to their respective late season yields (1121.00kg ha^{-1} and 898.22kg ha^{-1}

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respectively). Prevalence of pod sucking bugs and thrips were more evident on the late crops than on the early, while the reverse was the case for aphid, *Maruca* and *Ootheca* counts. Bruchid populations were not affected by seasonal variation.

Keywords: Adaptation; genotype x season; harvest index; insect damage; threshing percentage.

1. INTRODUCTION

Cowpea, *Vigna unguiculata* (L.) Walp is an important protein rich source. It is cultivated on at least 12.5 million hectares with an annual production of over 3 million tonnes world wide [1]. The plant is widely distributed throughout the tropics, but Central and West Africa accounts for over 64% of the area. In West Africa, a substantial part of the cowpea production comes from the drier regions of northern Nigeria [1]. In spite of the importance of this crop in southern Nigeria, it is not a dominant crop and where it is grown its production is very low. This low production is attributed to lack of improved varieties, high incidence of insect pests, poor crop management and high humidity [2]. Although the crop is little cultivated in this region advances made in crop improvement and management can enhance its expansion to longer season wetter agro-ecologies.

To tackle the menace of insect pest problem, one of the strategies is to spray with insecticides, which does not bring good results due to harm it does to the environment. Thus, the most reliable alternative is to identify cultivar (s) that produce reasonable yield without insecticidal protection. This can constitute a low input approach to solving the problem of yield constraint occasioned by high population of insect pests and also enhance sound, ecologically and economically viable cowpea production options. Furthermore, the integration of low input genotypes with seasonal variations will even result in more sustainable cowpea production system through better Integrated Pest Management (IPM) strategy lending credence to G X E (Genotype x Environment Interaction) impact.

The presence of G X E interaction indicates that the genotype might be superior to another genotype in one environment but inferior in a different environment [3]. Crop yield and performance fluctuates due to suitability of varieties to different growing seasons and conditions brought about by environmental stresses such as insect pests. Knowledge of the G X E interaction is therefore important in selecting new varieties that will catalyze the commercialization of the variety production enterprise by medium and large scale farmers.

This study was aimed at selecting cowpea genotype (s) that could be adaptable in areas of rainfall without significant devastation by insect pests. The general objective of this study is to assess the productivity of some newly bred accessions of cowpea from International Institute of Tropical Agriculture (IITA) under varying seasons in a moist derived savanna area of southeastern Nigeria.

2.1 The Specific Objectives

i. To assess the effect of cropping seasons on the growth and yield of different cowpea genotype.
ii. To assess the effect of seasonal variation on major insect pest of cowpea in the field.

2. MATERIALS AND METHODS

The experiment was carried out at the DEMACCO Integrated Farms Ltd., Ako, Nike Enugu (06^0 34' N; 07^0 35' E; 154 m asl) in Enugu state; Nigeria from June 2009 to September 2010. The soil of the experimental sites had low percentage sand (28% in 2009 and 23% in 2010) and moderately high silt content (13% in 2009; 39% in 2010) and therefore of moderately high moisture retention (Table 1). The cation exchange capacity (12meq/100g soil in 2009; 20 meq/100g soil in 2010), organic carbon and organic matter contents were 0.19% and 0.33% respectively in 2009 and 2.57% and 4.42% respectively in 2010. Also the total nitrogen, phosphorus, base saturation and exchangeable calcium contents were 0.042%, 10.26ppm, 23.58% and 1.8 meq/100g soil respectively in 2009 and 0.154%, 13.06ppm, 33.35% and 4.2 meq/100g soil respectively in 2010. The rainy season which varies between May and October of each year is bi-modal with highest monthly rainfall occurring between the months of June and September (Table 2). Temperature ranged from 28ºC to 34ºC in both years. The lowest temperature was experienced from July to September and rises steadily from October to March. Conversely, the relative humidity followed a reverse order with temperature and highest relative humidity occurring from July to September and decreasing gradually from October to May with the lowest being experienced between January and March.

Table 1. Soil Physical and chemical properties of the experiment sites

Soil Properties	**Ako**	
	2009	**2010**
Clay (per cent)	12	18
Silt (per cent)	13	39
Fine sand (per cent)	47	20
Coarse sand (per cent)	28	23
Texture class	Sandy loam	Loamy
Chemical properties		
pH in water	6.0	5.6
pH in KCL	5.1	4.9
Organic carbon (per cent)	0.19	2.57
Organic matter (per cent)	0.33	4.42
Total nitrogen (per cent)	0.042	0.154
Total phosphorus (per cent)	10.26	13.06
Base saturation (per cent)	23.58	33.35
Exchangeable bases in meq/100g soil		
Sodium	0.38	0.51
Potassium	0.05	0.16
Calcium	1.8	4.2
Magnesium	0.6	1.8
CEC	12.0	20.0

Prior to ridging, a basal dose of 100kg NPK 15-15-15 per hectare plus 1000kg per hectare of well cured cow dung was broadcast uniformly and later incorporated into the soil before ridging. Two sowing dates (early and late seasons) were observed for 2009 and 2010 with early sowing date in June 18, while late sowing was in August 30. In each of the two planting seasons (early and late), the experiment was laid out in a randomized complete block design (RCBD) with three replications. Four elite genotypes (IT 97K-499-35, IT 97K-568-18, IT 98K-

131-2 and IT 93K-452-2) emanating from the breeding programme of IITA were used. A local variety was added to serve as a control. The characteristics of the accessions used are as shown in Table 3.

Seeds were dressed with fungicide, “seed plus”(R) (Imidacloprid 10% + Metalaxyl 10% + Carbendazim 10%) at the rate of 10g to 2kg cowpea seed as recommended by the manufacturers. Each plot consisted of 4 rows of cowpea of 2-m long. Inter-row spacing was 75-cm with an intra-row spacing of 25-cm. Three seeds were planted per hole at 3-5-cm depth but later thinned down to two stands per hill 14 days after planting (DAP). Weeds were manually controlled as regularly as they appear, while other agronomic practices were duly observed. Data were collected from the two inner rows in each plot on days to 50% flowering, days to maturity, number of pods per plant, pod weight, fresh and dry fodder weight, 100-seed weight, pod length, number of seeds per pod, grain yield per hectare, threshing percentage and harvest index. The threshing percentage was calculated as:

$$\left(\frac{\text{Grain weight}}{\text{pod weight}}\ x\ 100\right)$$

While the harvest index (HI) was estimated as:

$$\left(\frac{\text{Economic Yield (grain yield)}}{\text{Biological yield (fodder yield)}}\ x\ 100\right)$$

For the entomological data, five flowers were picked 100 days after planting (DAP) from each plot during the morning hours (6.00 hrs-9.00 hrs) and put in vials containing 30% alcohol. The flower samples were later dissected and the number of flower thrips adults (*Megalurothrips sjostedti* Trybom) and *Maruca* larvae (*Maruca vitrata* Geyer) determined. Pod sucking bugs (*Clavigralla tomentoscicollis* Stal. and *C*. *shadabi* Dolling) were counted in the two middle rows when the insects were observed in the field. *Ootheca mutabilis* Schonher and cowpea aphids (*Aphis craccivora* Koch) were scored on a scale of 1-5, where 1= no sign of damage, 2 = 25% damage, 3=50% damage, 4 = 75% damage and 5 = 100% damage [4]. Bruchids (*Callosobruchus maculatus* Fabricius) damage was determined three months after harvest. For the bruchid assessment, 100 grains were randomly sampled from each plot lot and enclosed in a paper bag of similar material type and kept under room temperature. The bruchid damage was determined by counting the number of bruchid holes on 50 randomly selected grains from each lot.

2.2 Statistical Analysis

Data collected for the two years (2009 and 2010) were later pooled as there was no significant year effect before subjecting them to analysis of variance (ANOVA) using GENSTAT Discovery Edition 2 [5] as outlined for RCBD. Insect counts and damage percentages were normalized using square root transformation procedure [6] before analysis of variance was carried out on them. Means were compared using Fisher’s least significant difference (F-LSD) at 5%.

3. RESULTS

The soil of the experimental sites had low percentage sand (28% in 2009 and 23% in 2010) and moderately high silt content (13% in 2009; 39% in 2010) and therefore of moderately high moisture retention (Table 1). The cation exchange capacity (12 meq/100g soil in 2009; 20 meq/100g soil in 2010), organic carbon and organic matter contents were 0.19% and 0.33% respectively in 2009 and 2.57% and 4.42% respectively in 2010. Also the total nitrogen, phosphorus, base saturation and exchangeable calcium contents were 0.042%, 10.26%, 23.58% and 1.8meq/100g soil respectively in 2009 and 0.154%, 13.06ppm, 33.35% and 4.2meq/100g soil respectively in 2010. The rainy seasons which vary between May and October of each year is bi-modal with highest monthly rainfall occurring between the months of June and September (Table 2). Temperature ranged from 28ºC to 34ºC in both years. The lowest temperature was experienced from July to September and rises steadily from October to March. Conversely, the relative humidity followed a reverse order with temperature and highest relative humidity occurring from July to September and decreasing gradually from October to May with the lowest being experienced between January and March.

Seasonal effects were obtained on the reproductive and grain yield components of the cowpea genotypes (Table 4). Respective genotypes sown during the late season significantly ($p<0.05$) flowered earlier and took longer days to fill their pods compared with those sown during early in the season. Late season sown genotypes also resulted in 25% higher mean 100-seed weight, 31% higher mean pod weight, 71% higher mean seed weight, 72% higher mean grain yield, 25% higher mean threshing percentage and 41% higher mean harvest index relative to early season grown genotypes. On the other hand, early season genotypes produced 23% higher mean pod length than late season genotypes.

With respect to the grain yield, genotypes IT 93K-452-1 and IT 97K-499-35 significantly ($p<0.05$) produced higher grain yield compared to other early season planted genotypes, while genotypes IT 98K-131-2 and IT 93K-452 -1 in the late season significantly ($p<0.05$) outperformed other genotypes irrespective of season. Meanwhile, seasonal variations depressed 100-seed weight in genotype IT 93K-452-1 from 15.46 g in early season to 14.19 g in the late season and the number of pods per plant from 31.67 in early season to 23.54 in late season. On the other hand, IT 97K-499-35, IT 97K-568-18 and IT 98K-131-2 exhibited similar performance for 100-seed weight in both seasons. Local being photo-sensitive could not flower during the early season as expected while it produced significantly ($p<0.05$) lower grain yield than other genotypes in the late season. Local varieties however, expressed significantly higher 100-seed weight (17.73g) over the rest of the genotypes in the late season. Mean pod length was affected by season as late season drastically reduced pod length in all the genotypes but worse on IT 97K-499-35.

Seasonal changes also affected most genotypes with respect to threshing percentage and harvest index. This is such that early season depressed the threshing percentage and harvest index in genotype IT 97K-568-18 by 22.9% and 47.1% respectively, relative to the genotypes during the late season. Genotypes IT 97K-568-18 and IT 98K-131-2 were mostly affected as their harvest indices were significantly ($p<0.05$) reduced in early season.

Table 2. Rainfall (mm), temperature (ºC) and relative humidity (percent) of the study sites

Year	Variable	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept	Oct.	Nov	Dec.	Total	Mean
2009	Rainfall	53.6	2.2	0.0	180.6	283.7	152.4	248.2	260.3	175.8	387.1	103.2	0.0	1847.1	153.9
	Temperature	32.0	33.0	34.0	32.0	30.0	29.0	29.0	28.0	28.0	28.0	30.0	33.0	_-	31
	Rel. humidity	71.0	73.0	73.0	76.0	74.0	75.0	75.0	75.0	75.0	75.0	64.0	65.0	_-	73
2010	Rainfall	0.0	0.0	43.9	161.8	212.3	247.4	158.5	404.2	204.0	183.6	19.3	0.0	1635	136.3
	Temperature	33.0	34.0	34.0	33.0	30.0	29.0	28.0	28.0	28.0	29.0	30.0	32.0	_	31
	Rel. Humidity	67.0	72.0	71.0	73.0	74.0	76.0	77.0	77.0	77.0	76.0	74.0	61.0	_	73

Table 3. The origin and description of genotypes used in this study

Genotype	Origin	Photo-sensitivity	Maturity	Growth habit	100 seed weight (g)	Seed coat colour	Seed texture
IT 98k-131-2	IITA	NPS	Medium	Prostrate, indeterminate	16	Brown	Rough
IT 97k-568-18	IITA	NPS	Medium	Prostrate, indeterminate	16	Brown	Rough
IT 97k-499-35	IITA	NPS	Early	Semi-Prostrate, determinate	16	white	Rough
IT 93k-452-2	IITA	NPS	Early	Semi-prostrate, determinate	17	white	Rough
Local Check	Landrace	PS	Late	Prostrate, indeterminate	17	White	Rough

NPS-Non-Photosensitive; PS-Photosensitive

Table 4. Effect of season and genotypes on reproductive and grain yield components of 5 cowpea genotypes combined over 2009 and 2010

Season	Genotype	DFWT (g)	FFWT (g)	Bloom (days)	Maturity (days)	Pod fill (days)	100SWT (g)	NPOD/PLT	NSEED/POD	PODLT (cm)	PODWT (kg)	SEED WT (kg)	GYLD/Ha (kg)	THRESH (%)	HI (%)
Early	IT 97K-499-35	1117.0	7850.0	43.73	63.88	20.00	14.77	24.98	11.46	19.21	418.66	296.10	987.00	69.88	50.75
	IT 97K-568-18	1692.0	11615.0	47.54	71.08	24.03	13.98	21.23	11.29	16.00	95.40	54.92	183.12	54.42	5.51
	Local	1383.0	10092.0	_	_	_	_	_	_	_	_	_	_	_	_
	IT 98K-131-1	1617.0	10625.0	47.46	69.63	23.00	14.06	25.08	13.57	15.53	185.33	123.22	411.00	69.07	11.66
	IT 93K-452-1	858.0	5692.0	39.65	62.33	23.09	15.46	31.67	10.71	13.98	416.70	300.00	1000.02	70.30	65.18
	Mean	1333	9175.0	44.60	66.73	23.00	11.78	20.82	9.47	16.00	223.20	154.90	516.00	52.73	26.62
Late	IT 97K-499-35	846.0	3154.0	39.23	61.75	23.24	14.04	20.10	11.96	14.33	364.73	269.43	898.22	73.30	34.41
	IT 97K-568-18	493.0	1772.0	43.96	65.69	28.16	14.60	29.56	11.92	14.00	299.00	226.67	754.64	69.78	39.25
	LOCAL	783.0	2741.0	50.56	76.00	30.00	17.73	33.62	9.42	11.01	233.70	141.30	470.90	74.55	15.10
	IT 98K-131-2	708.0	2308.0	43.31	66.10	26.00	14.92	25.19	12.27	13.75	468.70	353.20	1177.00	73.55	54.46
	IT 93k-452-1	758.0	2733.0	34.23	60.00	26.00	14.19	23.54	10.58	12.00	458.20	336.40	1121.09	73.90	48.07
	Mean	718.0	2542.0	42.26	65.91	27.00	15.10	26.40	11.23	13.00	364.90	265.40	885.00	65.46	38.26
	F-LSD (0.05)	169.3	1079.4	2.47	3.26	3.17	1.29	4.62	0.95	2.25	51.37	39.49	131.60	3.16	7.94

DFWT= Dry fruit weight; FFWT= Fresh fruit weight; Bloom Days to 50 percent flowering; MATURITY = Days of maturity; PODFILL; 100SWT=100 seed weight; NPOD/PLT = number of pods per plant; NSEED/POD = Number of seeds per pod; PLENGHT = Pod length; PODWT = pod weight; SEEDWT = seed weight; GYLD/HA = Grain yield per hectare; THRESH percent = Thressing percentage; HI = Harvest index

Table 5. Effect of season and genotypes on insect damage of 5 cowpea genotypes combined over 2009 and 2010 in Ako

SEASON	Genotype	Aphisc	Bruchidct	Marct	Oothesc	Psbsc	Thripct
Early	IT 97K-499-35	2.65	45.60	5.54	1.25	1.00	6.29
	IT 97K-568-18	2.25	15.20	3.68	1.63	1.10	6.42
	Local	1.06	-	-	1.92	-	-
	IT 98K-131-2	2.69	15.30	3.94	1.58	1.00	6.87
	IT 93K-452-1	3.49	50.20	7.52	1.33	0.98	7.27
	Mean	2.51	31.58	4.13	1.54	0.95	5.37
Late	IT 97K-499-35	0.94	43.40	1.50	1.06	1.29	8.62
	IT 97K-568-18	1.23	18.30	1.48	1.04	1.33	10.56
	Local	1.10	40.30	1.12	1.10	1.63	14.23
	IT 98K-131-2	0.96	14.90	1.73	1.06	1.33	9.73
	IT 93K-452-1	1.44	40.60	1.46	10.00	1.44	11.67
	Mean	1.13	31.50	1.46	1.05	1.40	10.96
	F-LSD $_{(0.05)}$	1.94	8.82	2.74	0.20	0.23	3.22

APHIDSC = Aphid score; BRUCHICT = Bruchid count; MARUCT = Maruca count; OOTHESC = Ootheca score; PSBSC = Pod Sucking Bug score; THRIPCT = Thrips count

Counts of aphids, *Maruca* and *Ootheca* sampled from the respective genotypes in the early season were higher than their corresponding late season genotypes (Table 5). On the average, mean populations of aphids, *Maruca* and *Ootheca* were 113%, 182% and 47% respectively higher in early than in the late season. Conversely, the corresponding scores and counts of the pod sucking bugs and thrips sampled from the genotypes in the late season were significantly ($p<0.05$) higher than their corresponding early season genotypes. On the average, the presence of the bugs and thrips were respectively higher by 43% and 60% in the late season over those of the early season. Population difference of the bruchids between early and late season did not differ appreciably. However, early season local variety harboured no bruchid, *Maruca* pod sucking bug or thrips during the season.

4. DISCUSSION

Seasonal variations (early and late) were utilized to evaluate some selected cowpea genotypes. Yield and yield components were found to be higher in the late than in the early season planted cowpea. The better performance of the crops in the late season was seen to be due to better solar radiation, higher leaf area index and lower aphid and *Maruca* pressures on the crops within the season. Similar results were obtained by [7,8], which they attributed to higher solar radiation and leaf area index as well as lower pest pressures. In our study, rainfall, temperature and relative humidity differed slightly in the two seasons. The late season cropping experienced relatively remarkable reductions in rainfall and increase in temperature during the pod maturation stages. This slightly higher rainfall in the early over the late season could have contributed to the increased pest (aphids and *Maruca*) population during early relative to the late season.

Seasonal variation basically had significant effects on cowpea flowering. The non-photosensitive genotypes flowered and produced grain yields and yield components as expected in both seasons, while local failed to flower or produce grain yield in the early season planting owing to its sensitivity to photoperiods. This result is in conformity with the findings of [2,9]. The photoperiodic response of the genotypes consequently explains the shorter days to flowering observed in the late season crops. This is in agreement with [10] thesis which reported that warmer temperatures hasten the appearance of flowers irrespective of their photoperiodic responses. Most of the local cowpea cultivars in Nigerian savanna belt are photoperiod sensitive and have indeterminate growth habits. They are late maturing and very susceptible to pests and disease [11]. As photoperiod shortens towards the end of the rainy season (September-October) in West Africa, these adaptive features ensure timely flowering of land race germplasms [12].

The local variety recorded significantly lower yield and yield components in late season. This is supported by [13] who revealed that the actual grain yield obtainable in farmers farm in West Africa sub-region are very low (25-300 kg ha^{-1}) due to severe attacks from extensive pest complex and use of unimproved varieties.

The population of aphids was found to be generally low but higher in early than late season. Our finding is similar to that of [14] who also observed lower aphid populations in southern Nigeria. They reported that aphids occurred throughout the year because groundnut, cowpea and other leguminous hosts were always available. This result is further supported by [15], who observed that aphids are present all the year round but predominates during the early season in the south and dry season in the North. The high population of aphids in late season in Northern Nigeria as reported by researchers was attributed to the fact that cowpea is grown along with other susceptible host crops such as groundnut. High humidity also promotes the inversion of aphids especially under irrigation and high plant population.

Seasonal variation did not affect bruchid infestation in our study; however, accessions IT 97K-499-35 and IT 98K-452-1 significantly harboured higher pest loads in all the seasons. Although IITA claimed that some of the genotypes used in this study are bruchid resistance, our finding did not confirm their claim in all cases except IT 90K-277-2 that was stable for this trait in all seasons. It was also found that *Maruca* pest was considerably lower in late season in all the genotypes than in the early season. This result is similar to the finding of [16], who reported very low infestation levels of *Maruca* in the season. *Maruca* is a migratory pest which moves from south to North over a period of several months or generations following pattern of leguminous crops and rainfall [15]. This movement of legume cultivation from south to north following the northward programme of rainfall also could account for the lower infestation of this pest recorded during the late season.

It was also found that pod sucking bugs were prevalent in the location used for this study with higher population in the late than early season. Local and IT 93K-452-1 were more infested by pod sucking bugs than the rest of the improved genotypes. The findings of [8] and [17] are in support of our result that pod sucking bugs attacked cowpea more in late than early season but at variance with [18], who reported that pod sucking bug infestations were always higher in early than late season. The two varieties (Local and IT 97K-452-1) found to habour more pod sucking bugs in our study are posses large seed size. [18] Also reported that several of the newly identified resistant germplasm that are resistant to pod sucking bugs have small seed size. They concluded that seed size was directly related to damage by the bugs. *Ootheca* population was found to be low in this study. Also genotypic variation was not prominent with respect to *Ootheca* count. The population of thrips was found to be higher than other post-flowering pests implicating thrips as one of the most important pest of cowpea in West Africa savanna. This result is in agreement with [19] who reported thrips as the most prevalent insect pests of cowpea in southern Guinea and Sudan savanna agro-ecological zone in Nigeria. [11] Identified thrips as the most limiting insect pest in terms of grain yield loss.

Generally, the late season grown cowpea performed better than the early season grown crops. However, performance of accessions IT 97K-499-35 and IT 93K-452-1 grown in the early season compared favorably with such crops grown during the late season. There was no appreciable difference in the harvest indices and threshing percentages of the crops in the both seasons. Again, damage on the two accessions (IT 97K-499-35 and IT 93K-452-1) by the bugs and thrips were lower during the early than the late season, which was the reverse with aphid, bruchids and *Maruca*.

5. CONCLUSION

There were genotypic and seasonal variation for yield, yield components and insect infestation on cowpea in southeastern Nigeria. Cowpea genotype IT 93K-452-1 and IT 97K-499-35 produced significantly higher grain yield than other genotypes in early season while IT 98K-131-2 and IT 93K-452-1 were the highest grain yielders in late season. In order words IT 93K-452-1 exhibited wide adaptations to both seasons an indication that it is possible to develop genotypes with specific adaptation to either low or high rainfall conditions as well as genotypes with broad adaptation to both seasons. Late season grown cowpea performed better than early season. Thrips was identified as the most yield limiting insect pests in the study areas.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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