Genetic evaluation of some cowpea (*Vigna unguiculata*) genotypes to address food insecurity in Mubi Northern Guinea Savannah, Nigeria

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Abstract: Field experiments were conducted during the rainy seasons of 2022 and 2023 at the Research Farm; Department of Crop Science, Adamawa State University, Mubi. The experiment studied the genetic evaluation of some cowpea genotypes to address food insecurity in Mubi, with the following objectives: to determine the amount of diversity among 26 cowpea genotypes; evaluate and select early maturing genotypes; including high yielding genotypes. The 26 genotypes were evaluated in Randomized Complete Block Design replicated three times. Data were collected on 16 agronomic traits. Results revealed highly significant differences ($P < 0.01$) among genotypes for most agronomic traits studied. These indicated the presence of sufficient variation among the 26 genotypes. From the mean performance, Loko genotype and UAM 14-122-17-7 produced the highest cowpea grain yields with 636.33 kg/ha and 605.84 kg/ha respectively. IT 14-1683-2 (42 and 45 days), IT99K-573-1-1 (42 and 47 days) and IT07K-292-10 (42 and 47 days) showed earliness with respect to days to first and 50% flowering. Mubi-3 and IT97K-449-35 genotypes recorded the highest estimates of fresh pod vegetables. Furthermore, the highest Genotypic Coefficient of Variation and Phenotypic Coefficient of Variation were recorded for kernel yield (30.57 and 35.53) and grain yield (30.18 and 34.47), high heritability coupled with genetic advance were recorded for days to 50% flowering (95.92 and 23.40), 100 seed weight (90.56 and 10.37), fresh pod weight (78.71 and 14.19) and grain yield (76.63 and 230.75).

Keywords: Genetic advance, heritability, genotype, genotypic and phenotypic coefficient variation, earliness and grain yield.

1.0 INTRODUCTION

Cowpea (*Vigna unguiculata* (L.) Walp) is one of the most ancient crop known to man and a highly valued crop (Kaloo and Bergh, 2012; Adewale *et al.,* 2021). The crop is a versatile annual and warm season legume belonging to the family, *Fabaceae;* subtribe *Phaeseolinae*; genus, *Vigna* and section catjang (Padulosi and Ng 1997; Pasquet *et al*., 2001 and Vegetables, 2023). The name was most likely acquired due to their use as a fodder crop for cowpea. Cowpea is a crop with wide global distribution, especially in tropical regions. It is an important grain legume crop in sub Saharan Africa with significant production in Nigeria, Burkina faso, Niger, Cameroon and United Republic of Tanzania (Fatokun *et al*., 2012; FAOSTAT, 2017; Odireleng *et al*. 2020).

Studies suggest that most southern region of Africa could be the center of origin for *V. unguiculata* while domestication might have occurred in West Africa (Padulosi and Ng, 1997). Cowpea is produced throughout the world including Europe, Asia, United States of America and many parts of Africa, which accounts for about 60% of global production (IITA, 2015). The crop is cultivated on about 14.5 million hectares on the world arable land, with an annual production of 6.2 million metric tons and out of this, Africa accounts for 83.4% (Boukar *et al*., 2018; Kebede, 2020). West Africa produces over 80% of the quantity produced in Africa.

Furthermore, according to FAOSTAT (2017), cowpea was grown on an estimated 11 million ha in Africa in 2017, with most production confined to West Africa (10.6 million ha) especially in Niger, Nigeria, Burkina faso, Mali and Senegal. More than 7.4 million tons of cowpea are produced worldwide with Africa producing nearly 5.2 million tons. FAOSTAT (2017) also reported that over 87% of cowpea are produced in Africa. However, in South America, Brazil, increased cowpea cultivation and the country is now in third place in terms of global production.

Nigeria is the largest producer and consumer of cowpea and accounts for 61% of the production and in Africa 58% worldwide (Bayash, 2013). Nigerian states that are significantly participating in cowpea production includes: Adamawa, Benue, Bauchi, Borno, Gombe, Kaduna, Yobe, Niger, Katsina, Taraba and Zamfara with quantum production from the drier areas of these states, (FAOSTAT, 2017).

Cowpea is a principal and multipurpose food legume in many African countries where tender leaves, fresh pods and grain are consumed (Alemu *et al.,* 2016 and Owade *et al.,* 2020). It is also a genuine African crop for hay and forage. Chimma *et al.* (2008), Noma (2019) and Maletsema *et al.* (2020) further buttressed that several plant parts including its grains, green pod and leaves are consumed as leafy vegetables, whereas the vines and haulms are used as animal feeds. There are a lot of variability within cowpea species in Nigeria which guarantees reliable improvements as earlier reported by Ariyo (1993); but unfortunately, this variability has not been exploited in plant breeding to develop high yielding cowpea varieties which have largely resulted to the low yield of the cowpea varieties. As a means of increasing and ensuring reasonable high yield, the available genotypes need to be evaluated to identify high yielding genotypes for genetic improvement of the crop.

Statement of the Problem

The major challenges affecting cowpea cultivation in North Eastern part of Nigeria, apart from the humanitarian crises are the problems of food insecurity and scarcity of livestock feed resources. Furthermore, the problem of climatic change has aggravated the challenge due to early ceasation of rains coupled with the late maturing cowpea varieties that has led to poor yield harvest. This problem can be mitigated by intensifying research on evaluation and selection of early maturing and high yielding cowpea grains and haulms in Mubi. At the moment, the performance of diverse germplasm response among genotypes of cowpea has not been determined adequately in Mubi environs of Adamawa State. Also information on agronomic performance with respect to grain yield and yield component traits, along with indices of variatability such as genotypic and phenotypic coefficients of variation, broad sense heritability including genetic advance in cowpea is scanty in the study area. In view of the foregoing, this research is informed to evaluate some cowpea genotypes in order to address food insecurity in the study area.

Therefore, the specific objectives of the study are to:

i. evaluate and select genotypes with high grain yield and yield related attributes
ii. select early maturing genotype
iii. evaluate and select genotype with high vegetable potentials

MATERIALS AND METHODS

Experimental site, experimental design and treatment

The two years (2022 and 2023) field trials were conducted on genetic evaluation of some cowpea genotypes (*Vigna unguculata* L Walp) to address food insecurity and livestock scarcity in Mubi – North, Northern Guinea Savannah, Adamawa State, Nigeria. The research was conducted at Food and Agricultural organization/Tree Crops Plantation (FAO/TCP); Department of Crop Science, Faculty of Agriculture, Adamawa State University Mubi. Geographically, Mubi is located on latitude (10° 06' – 10° 29' N) longitude (13° 07' – 10° 30' E) and also found on alatitude 696 m above sea level, with annual rainfall between 700 mm - 1050 mm (Adebayo *et al.,* 2021).

Treatment and Experimental Design

The experimental trial field measured 32 m by 21.5 m (688 m²) and the twenty-six genotypes were sown in a Randomized Completely Block Design (RCBD) with three replications. For each genotype of cowpea, two to three seeds were sown on a plot size of 3 m x 2 m (i.e. 6 m²) with inter row spacing of 0.60 m and intra row spacing of 0.40 m. The gross plot size was 6 m² and net plot size of 1.2 m (0.60 m x 2 m) was also used. At two weeks after sowing (WAS), thinning was done to one plant per stand to obtain 16 plants population per plot.

Germplasm Source

Twenty-six genotypes of cowpea were sourced: Three from Institute for Agriculture Research Zaria, eleven from International Institute of Tropical Agriculture Ibadan, four genotypes from University of Agriculture Makurdi and seven genotype each from Adamawa State and one from Samaru Market respectively.

Land Preparation

The site for the trial was cleared of shrubs, stubbles and volunteer crops. Thereafter, a disc plough tractor will be used to plough the soil and later the soil was harrowed to enable the easy germination of cowpea seeds and seedlings emergence. Hand hoe was used to level the soil properly to reduce pockets of water on the field; that could cause seed rot and seedling growth stagnation.

Seed Treatment and Sowing

Healthy and robust cowpea seeds without holes and damages were selected for sowing. The selected cowpea seeds was dressed prior to sowing using Apron plus (fungicide) Momtaz 45 WS. This provided protection from fungal and other diseases related organisms; thereby enhancing good seedling emergence. The cowpea genotypes for the research was sown on 30th July 2022 and 2023 respectively. For each genotype of cowpea, two to three seeds were sown. At two weeks after sowing (WAS), thinning will be done to one plant per stand.

Cultural Practices

Weed Control

Hand hoe was used to control weeds on the plots. The first weeding was done at 2 WAS after sowing and second weeding at 6 WAS. The weeding helped to minimize weed competition for space and nutrients with the cowpea plants.

Pest and Diseases Control

Pesticides such as cypermethrine 12 EC was applied to control pests and diseases, particularly prior to and during flowering stages.

Data Collection

Quantitative Parameters collected are as follows:

Growth Parameter: Primary vein length (cm), Number of branches/plants, Number of clusters/plants, Fresh pod weight and Dry pod weight (gm).

Phenological Parameter: Days to first and 50% flowering**.**

Yield Attributing Parameter: Pods/plant, Pod length (cm), seeds/pod and 100 seed weight (g).

Yield Parameter: Fresh plant weight (cm), Haulm yield, Kernel yield/plant and Grain yield (kg/ha).

Statistical Analysis

The data obtained was subjected to analysis of variance (ANOVA) using software package 9.0 of SAS (2002). Differences between the means were partitioned using Duncan Multiple Range Test (DMRT).

Estimation of Generic Parameters

The genetic parameters were calculated by applying Burton and Davane (1953), Singh and Chaudhry (1985) method.

Genetic variance $\delta^2_g = \frac{MSg - MSe}{r}$
Phenotypic Variance $\delta\,^2{}_p = \sigma^2{}_g + \sigma^2{}_e$
Variance due to error = MS_e

Where

MS_g and MS_e are genotype and error mean square and r = number of replications
The phenotypic coefficient of variation PCV

$$(PCV) = \frac{\sqrt{\sigma^2 p}}{\bar{X}} \times 100 \text{ and the}$$

$\bar{X}$ = Mean
Genotypic Coefficient of Variance (GCV)

$$GCV = \frac{\sqrt{\sigma^2 g}}{\bar{X}} \times 100$$

Heritability

Broad sense heritability ($h^2{}_B$) is the ratio of genotypic variance to the phenotypic variance ($h^2 = \delta^2_g/\delta^2_g$. Heritability was computed as described by Singh and Chaudhary (1985) as

$$h^2_B = \frac{\delta^2 g}{\delta^2 p + \delta^2 e\,(\delta^2 p)} \quad \text{for individual analysis}$$

$$h^2_B = \frac{\delta^2 g}{\delta^2 p + \delta^2 yl + \delta^2 gy + \delta^2 e} \quad \text{for combined analysis}$$

The genetic Advance (GA) was calculated using percentage of the grand mean

$$GA = \frac{h^{2 \text{ x } k\sigma^2_p}}{x} \times 100$$

Where:

H = heritability
K = selection differential = 2.06, h^2 = heritability and
σ^2_p = standard deviation of phenotypic variance.

RESULTS

Analysis of Variance

Table 2 showed the mean squares values of cowpea genotypes evaluated during 2022 and 2023 cropping seasons at Mubi, combined. The results further revealed highly significant differences among the genotypes for days to first and 50% flowering, fresh and dry weight of roots, primary vein length, number of branches, pods/plant and clusters/plant. Other traits include: fresh pod weight, pod length, seeds/pod, 100 seeds weight, kernel yield and grain yield of cowpea. Although fresh weight of shoot and haulm yield/plant showed a non-significant difference among the genotypes studied.

The results also shows highly significant differences among years for all studied traits except dry weight of roots, which showed a non significant differences. Furthermore, the results showed that all the traits were significantly different for year x genotypes interaction except for fresh weight of shoots and roots which had a non significant difference.

Mean Performance among Traits of 26 Cowpea Genotypes during 2022 and 2023 Cropping Season at Mubi, Combined

Table 3 shows the mean performance of 16 traits of cowpea genotypes evaluated at Mubi in 2022 and 2023 (combined) years. There were significant differences in all the traits among all the genotypes. Highest days to flowering was recorded by Iron beans for days to first and 50% flowering (69.17 and 80.83 days respectively). This was followed by Samira, which recorded 68.83 days for days to first flowering and black berry with 76.83 days for days to 50% flowering. IT14-1683-2 had the lowest days to first and 50% flowering (41.50 and 45.33). For fresh weight of shoots trait, Iron beans recorded the highest estimate (133.43 g), followed by IT13K-1201-5 (130.62g) and the least was Mubi-3 (60.95 g). On the other hand, the highest fresh weight of roots was recorded by UAM14-122-17-7 (9.45 g), followed by Iron beans (9.12 g), while the least was Mubi-3 (5.15 g). Iron beans had the highest dry weight of roots (19.10 g) and IT99K-573-2-1 (16.38 g) folloed, while Samaru cowpea was the least (5.74 g). Furthermore, Iron beans had the longest primary vein length (192.15 cm) followed by IT97K-499-35 (183.67 cm) and the shortest vein length was recorded by IT13K-1322-4 (69.98 cm). For branches/plant, Madaran Banjaram (10.63) had the highest number and then followed by black berry (10.48). Number of pods/plants was highest for Samaru cowpea (24.38), followed by IT10K-863-11 (23.43), while Iron bean was the least. Genotype UAM09-1051-1 had the highest number of clusters/plant (18.83), followed by Samaru cowpea (18.00), while UAM14-127-20-1-1 was the least with 7.17 clusters. Mubi-3 recorded the highest fresh weight of pods (62.33 g), followed by IT97K-499-35 (59.17 g) and the least estimate was recorded by IAR-001-1074 (30.67 g). The longest pod length of cowpea was recorded by IT97K-499-35 (20.48 cm), followed by IT13K-1201-5 (19.78 cm), with Samaru cowpea recording the least (14.22 cm).

UAM14-127-20-1-1 recorded the highest seed number/plant (16.67), followed by Loko cowpea (15.00) and IT13K-1201-5 was the least (8.50). The result for 100 seed weight shows that Madaran Banjaram had the highest seeds mass (33.58 g), Samira and Iron beans followed each with 31.17 g. The highest haulm yield estimate was recorded by Iron beans (1,288.80 kg/ha) and was followed by IT97-499-35 (993.1 kg/ha). Kernel yield/plant and grain yield (kg/ha) were highest for seeds mass for genotypes UAM14-122-17-7 (45.45 and 605.84 kg/ha respectively) and Loko cowpea (43.25 g and 36.33 kg/ha respectively). Although from beans had the lowest kernel yield/plant (60.05 g) and grain yield of cowpea (80.56 kg/ha).

Genetic Parameters of 16 Agronomic Traits in Cowpea during 2022 and 2023 Cropping seasons at Mubi; combined

Estimates of genetic parameters for traits of cowpea during 2022 and 2023 (combined results) is presented in Table 4.9. Highest estimates of genotypic and phenotypic variances were obtained by grain yield (16,374.25 and 21,367.62 respectively) and haulm yield 13,677.32 and 10,892.68), while the lowest estimates of genotypic and phenotypic variance was recorded by fresh weight of roots (0.87 and 2.37 respectively). Generally, PCV estimates were higher than their corresponding GCV for all the traits evaluated. High estimates of GCV and PCV was recorded by kernel yield (30.57 and 35.53 respectively) and grain yield (30.18 and 34.47 respectively). GCV ranged from 7.91 to 30.57 for fresh weight of shoots and kernel yield/plant respectively. Similarly, PCV ranged from 10.42 to 46.96 for pod length and haulm yield/plant. The lowest estimates of GCV and PCV was recorded by pod length of cowpea with 9.13 and 10.42. High broad sense heritability estimates were recorded for days to 50% flowering (95.92), days to first flowering (93.77), 100 seed weight (90.56), fresh pod weight (78.71). Other traits with high heritability estimates include: pod length of cowpea (76.77), grain yield of cowpea (76.63), kernel yield/plant (74.04) and primary vein length (73.60).

DISCUSSION

Analysis of Variance

Combined analysis of variance for most traits studied among the genotypes of cowpea were significantly different ($P \leq 0.01$) for all traits except for fresh weight of shoots and haulm yield/plant. The highly significant differences observed among the genotypes with respect to the traits studied implies that there is clear evidence of inherent genetic variability among the cowpea genotypes as earlier reported by the following researchers (Khan *et al*., 2015; Hermes *et al*., 2021; Gaiwal *et al*., 2022; Shrikant *et al*., 2022 and Dipankar *et al*., 2023).

The highly significant differences for genotype x year interaction effect for all these traits with exception of fresh weight of shoots and roots revealed the diversity of the genotypes and their differences in environmental responses across the two years of evaluation as reported by (Bello *et al*., 2012; and Jonah *et al*., 2019) in maize and okra trials respectively.

Mean Performance among Traits of Cowpea Genotypes

From the combined mean performance Table, wide range of significant variations were observed in flowering traits and also in most of the characters studied. The mean value for days to first and 50 % flowering, ranged from 41.50 to 69.17 and 45.33 to 80.83 respectively. This coroborate with the findings of the following researchers (Ishiyaku and Singh 2003; Egbe *et al*., 2010; Idahosa *et al*., 2010; Magashi *et al*., 2019; Jonah and Fakuta 2021 and Emmanuel *et al*., 2021) in cowpea trials. The differences in time to flower as observed in the study reflected the differences in inherent earliness. Mak and Yap (1980) reported that early maturity may provide an opportunity for selection for earliness and that early maturity is dominant over late maturity in different genotypes of cowpea. The earlier a genotype flowers, the earlier the physiological maturity is reached (Shegro *et al*., 2010).

Furthermore, earliness traits facilitate escape from drought-stressed environment conditions, which may enable selection for adaptation to drought prone areas of Northeastern Nigeria. The mean of Madaran Banjiram (10.63) and Black Berry (10.48) revealed the highest values of number of branches and this was followed by IAR-001-1074 (10.12). Similar results were earlier reported by Abe *et al.* (2015b). IT97K-499-35 and IT13K-1201-5 produced the longest pod length as reported by Jonah and Fakuta (2021) in cowpea. Egbe *et al.* (2010) reported pod lengths of 8.95 cm and 20.17 cm and Idahosa *et al.* (2010) reported pod lengths of 10.57 cm to 18.85 cm. The variation in pod lengths might be due to genotypes, environment and interaction of genotypes and environment as reported by Abe *et al.* (2015b). Samaru cowpea had the highest number of pods/plants, followed by IT10K-863-11 which were statistically at Par. The values obtained for number of pods/plants were similar with the findings of Abe *et al.* (2015b); Jonah and Fakuta (2021) and Emmanuel *et al.* (2021). UAM 09-1051-1 had the highest number clusters/plant, followed by Samaru cowpea. This result corroborates with the findings of Jonah and Fakuta, (2021) in some cowpea genotypes. The result revealed that Mubi – 3 and IT97K-449-35 which had the highest green pods of cowpea agreed with the findings of Saidaiah *et al.* (2021). Variation in green pod weight (vegetable cowpea) might be due to the variation in pod length among the different variety studied. Peksen (2004) also reported that there is a significant and positive correlation between pod length and fresh pod weight.

Genotype UAM14-122-20-1-1 and Loko cowpea gave the highest number of seeds/pods. Egbe *et al.* (2015) revealed significant difference between cowpea varieties for seeds/pod and their findings agreed with Ajayi *et al.* (2014); Emmanuel *et al.* (2021); Jonah and Fakuta (2021).

Iron beans and IT97K-499-35 showed the highest estimates for primary vein length as also reported by Magashi *et al.* (2019). Emmanuel *et al.* (2021), further revealed highest primary vein length in seventeen genotypes of cowpea they studied. Madaran Banjiram, Samira and Iron beans recorded the highest 100 seed weight, while IT10K-863-11 was the lowest. This agrees with the findings of Egbe *et al.* (2010); Magashi *et al.* (2019); Gondwe *et al.* (2019); Jonah and Fakuta (2021) and Emmanuel *et al.* (2021).

Grain yield is the most farmer important trait; hence the ultimate goal of the current study (Gondwe *et al*., 2019). Loko cowpea, UAM 14-122-17-7 including IT13K-1322-4 and IT07K-292-10; had the highest cowpea grain yield. Similar reports on high yielding cowpeas were reported by Egbe *et al.* (2010); Gondwe *et al.* (2019) including Jonah and Fakuta (2021).

Estimates of Coefficient of Variation and Genetic Parameters in Traits of Cowpea

High genotypic and phenotypic variances were found in the individual and the combined years for primary vein length, haulm and grain yields. This result is agreements with the findings of Abiola and Alaba (2020) in primary vein length (plant height) and seed yields. Furthermore, high estimates of genotypic and phenotypic variances for plant height and grain yield were obtained by Chaudhary *et al.* (2020) and Tekle *et al.* (2022) in Cowpea trials. Noma (2019) also had high variances in haulm and grain yields of cowpea. High estimates in genotypic and phenotypic coefficient of variations were obtained in year 2022 for dry weight of roots and kernel yield. For the year 2023 haulm and grain yields were highest; while the combined analysis (2022 and 2023 combined), kernel and grain yields were the highest. This result corroborates with the findings of the following researchers (Noma 2019; Emmanuel *et al*., 2021; Hermes *et al*., 2021 and Jonah and Fakuta 2021) in cowpea trials.

Heritability indicates the scope of genetics improvement of any character through selection and the knowledge of heritability enables the plant breeder to decide the course of selection procedure to be followed under a given situation (Li and Yang 1985). For the individual years (2022, 2023) and the combined years (2022 and 2023); high heritability were recorded in 100 seed weight, days to first and 50% flowering, fresh pod weight and grain yield. For the year 2022 and the combined years (2022 and 2023); pod length, primary vein length and kernal yield recorded high estimates of heritability. High heritability estimates provides greater effectiveness for selection and improvement to be expected for these traits. Furthermore, high heritability estimates indicate that the variability observed are mainly under genetic control. High heritability values are used to predict the expected progress to be achieved through the process of selection (Tekle *et al*., 2022) with less environmental influence on the traits. Similar high heritability estimates for: primary vein length, days to 50% flowering, pod length, 100 seed weight and grain yield were reportedly by the following researchers (Ajayi *et al*., 2014; Noma 2019; Abiola and Alaba 2020 and Sudhamani *et al*., 2022) in cowpea trials

The high heritability and high genetic advance observed for primary vein length, 100 seed weight, grain yield and days to 50% flowering in the combined analysis agreed with the findings of the following cowpea researchers (Ajayi *et al*., 2014; Abiola and Alaba 2020; Hermes *et al*., 2021; Gaiwal *et al*., 2022; and Sudhamani *et al*., 2022). The high heritability and high genetic advance obtained for these traits indicated the preponderance of additive gene action governing or controlling the inheritance of these traits and it offers the best possibility of improvement of these traits through simple selection procedure.

Conclusion

In conclusion this study revealed that sufficient genetic variability existed among the agronomic traits of cowpea evaluated. The results revealed clearly that Loko cowpea and UAM 14 – 122 – 17 – 7 are high yielders that can be useful in cowpea for hybridization in order to improved low grain yielders that have other promising traits. For drought prone environments genotypes IT14-1683-2 and IT99K-573-2-1 showed earliness. Mubi-3 and IT97K-449-35 genotypes had high vegetable potentials than the other genotypes studied. The highest genotypic coefficient of variation and phenotypic coefficient of variation estimates were recorded for kernel yield, grain yield and dry weight of roots. Furthermore, high heritability estimates coupled with a high genetic advance were obtained for days to 50% flowering, primary vein length, fresh pod weight and grain yield.

Recommendations

1. The genotypes Loko cowpea and UAM 14 – 122 – 17- 7 can be cultivated by farmers who desire high yielding cowpea genotypes in Mubi environs.
2. In drought prone environments, genotypes: IT14 – 1683 -2 and IT99k - 573 – 2 -1 that showed earliness is recommended to cowpea farmers.
3. Genotypes (Mubi – 3 and IT97k-449-35) are best selected as vegetable cowpeas.

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Table 1: Origin and description of cowpea genotypes use for this study

S/N	Genotype	Origin	Seed Size	Seed Coat Colour
1	IT98KD – 391	IITA	Small	Brown
2	Kananado	Mubi – 4, Adamawa	Medium	White
3	Mubi – 3	Mubi – 6, Adamawa	Medium	Light brown with stripes
4	IAR –001 – 1074	IAR	Small	Brown
5	Sampea – 7	IAR	Small	Dark brown
6	IT97K – 131 – 2	IITA	Small	Brown
7	IT97K – 499 – 35	IITA	Small	White
8	Samira (White eye)	Mubi – 1, Adamawa	Medium	White
9	Iron Bean (Farin Hanchi)	Mubi – 2, Adamawa	Large	White
10	Madaran Banjiram	Mubi – 5, Adamawa	Large	Milk
11	IAR – 07 – 1050	IAR	Small	Brown
12	IT10K – 863 – 11	IITA	Small	White
13	ITI3K – 1201 – 5	IITA	Small	White
14	ITI3K – 1322 – 4	IITA	Small	White
15	IT99K – 573 – 2 – 1	IITA	Small	White
16	IT08K – 150 – 12	IITA	Small	White
17	IT07K – 292 – 10	IITA	Small	White
18	IT99K – 573 – 1 – 1	IITA	Medium	White
19	IT14 – 1683 – 2	IITA	Small	White
20	UAM09 – 1055 – 6	UAM	Small	White
21	UAM 14 – 127 - 20 – 1 –1	UAM	Medium	Dark brown
22	UAM14 – 122 – 17 – 7	UAM	Large	Brown
23	UAM 09 – 1051 – 1	UAM	Small	Light brown
24	Loko Cowpea	Song, Adamawa	Large	Brown
25	Black Berry	Mubi – 3, Adamawa	Large	Black and White
26	Samaru Cowpea	Samaru Market, Zaria	Small	Brown

IITA: International Institute of Tropical Agriculture, Ibadan
IAR: Institute for Agricultural Rseearch, Samaru, Zaria
UAM: University of Agriculture, Makurdi, Benue State.

Table 2: Mean Squares Values for 16 Agronomic Traits of Cowpea Evaluated during 2022 and 2023 Cropping Seasons at Mubi

Source of variation	DF	DFF	D50F	FWS	FWR	DWR	PVL	NOB	NOP	NOC	FPW	PLC	NOS	100SW	HYP	KYP	GYC
Replication (Year)	4	14.64^{NS}	18.01^{NS}	6703.80**	2.30^{NS}	27.61^{NS}	1218.68^{NS}	1.12^{NS}	142.97**	19.36^{NS}	90.06**	0.69^{NS}	28.16**	1.52^{NS}	940998.67**	1.52^{NS}	209.97^{NS}
Year (Y)	1	76.16**	236.31**	17472.03**	91.52**	25.31^{NS}	58717.59**	77.14**	1510.96**	710.83**	14003.10**	178.13**	166.16**	55.68**	633073.66**	2608.44**	489288.80**
Genotype(G)	25	530.67**	818.72**	1487.69^{NS}	8.21**	64.11**	5245.62**	16.83**	91.43**	50.19**	394.34**	16.28**	21.75**	173.69**	272540.66^{NS}	618.06**	108232.25**
Y x G	25	50.08**	23.53**	1693.26^{NS}	5.22^{NS}	58.86*	1208.43**	8.41**	53.12**	21.87**	236.82**	5.20**	20.79**	14.53**	4400.69**	149.69**	28687.41**
Error	10	12.11**	9.70**	1111.83**	3.53**	19.97**	611.76**	3.04**	11.26**	8.39**	33.20**	1.40**	9.70**	7.94**	199136.09**	63.19**	10061.72**

* and ** = significant values at P = 0.05 and P = 0.01 respectively, DFF = days to first flowering, D50F = days to 50% flowering, FWS = Fresh weight of shoots, FWR = Fresh weight of roots, DWR = Dry weight without root, PVL = Primary vein length, NOB = Number of branches, NOP = Number of pods, NOC = Number of clusters, FPW = Fresh pod weight, PLC = Pod length of cowpea, NOS = Number of seeds, 100SW = Hundred seed weight, HYP = Haulm yield of plant, KYP = Kernel yield/plant and GYC = Grain yield.

Table 3: Mean Squares Values for 16 Agronomic Traits of Cowpea during 2022 and 2023 Cropping Seasons at Mubi, combined

Acc	Genotypes code	DFF	D50F	5FWS	5FWR	DWR	PVL	NOB	NOP	NOC	5FPW	PLC	NOS	100SW	HYP	KYP	GYC
1	IT98KD-391	43.67^{e-I}	49.33^{h-j}	113.88^{a}	6.91^{a-d}	9.57^{de}	114.00^{c-g}	6.45^{d-g}	17.18^{d-g}	10.50^{c-f}	42.67^{g-i}	16.60^{f-h}	13.50^{a-c}	26.25^{c-e}	495.50^{bc}	28.07^{ef}	394.44^{ef}
2	Kananado	62.83^{bc}	72.50^{cd}	92.08^{ab}	5.64^{d}	8.39^{de}	106.85^{d-g}	8.92^{a-d}	13.38^{g-i}	10.00^{d-f}	45.33^{e-h}	16.07^{f-h}	13.33^{a-c}	19.58^{g-k}	623.30^{bc}	25.57^{fg}	340.75^{fg}
3	Mubi-3	63.00^{bc}	69.33^{d}	60.95^{b}	5.15^{d}	8.40^{de}	116.13^{c-g}	7.97^{b-f}	14.43^{g-i}	10.00^{d-f}	62.33^{a}	18.63^{bc}	14.00^{a-c}	20.50^{bc}	644.10^{bc}	39.70^{a-d}	528.89^{a-e}
4	IAR-001-1074	48.17^{de}	59.00^{e}	102.92^{ab}	5.22^{d}	10.27^{c-e}	115.13^{c-g}	10.12^{ab}	16.42^{e-h}	11.83^{c-e}	30.67^{j}	15.45^{f-h}	14.83^{ab}	22.00^{f-h}	892.60^{a-c}	30.68^{d-f}	409.17^{ef}
5	Sampea-7	50.17^{d}	55.83^{ef}	109.00^{a}	7.25^{a-d}	12.06^{b-d}	129.58^{b-e}	7.58^{c-g}	13.12^{g-j}	9.83^{d-f}	42.33^{g-i}	15.92^{f-h}	15.00^{ab}	21.83^{f-i}	921.80^{a-c}	39.90^{a-d}	531.94^{a-e}
6	IT97K-131-2	47.17^{d-g}	52.00^{f-h}	91.28^{ab}	5.78^{d}	7.63^{de}	135.27^{b-e}	5.23^{g}	19.43^{b-f}	11.83^{c-e}	36.67^{ij}	16.85^{e-f}	13.50^{a-c}	18.42^{h-k}	490.20^{bc}	38.02^{a-e}	506.67^{a-e}
7	IT97K-499-35	46.67^{d-h}	49.50^{h-j}	126.05^{a}	7.64^{a-d}	16.37^{ab}	183.67^{a}	5.70^{fg}	20.23^{a-e}	10.83^{c-f}	59.17^{ab}	20.48^{a}	13.50^{a-c}	16.75^{kl}	993.1^{ab}	42.98^{ab}	573.45^{a-c}
8	Samira	68.83^{a}	75.17^{bc}	112.98^{a}	7.78^{a-d}	13.73^{a-d}	143.00^{bc}	9.50^{a-c}	11.08^{ij}	8.33^{ef}	44.33^{f-i}	16.32^{f-h}	11.67^{b-d}	31.17^{ab}	763.40^{a-c}	10.83^{hi}	144.31^{hi}
9	Iron Bean	69.17^{a}	80.83^{a}	133.43^{a}	9.12^{ab}	19.10^{a}	192.15^{a}	7.97^{b-f}	8.93^{j}	8.00^{ef}	57.00^{a-c}	15.83^{f-h}	9.67^{cd}	31.17^{ab}	1288.80^{a}	6.05^{i}	80.56^{i}
10	Madaran Banjiram	63.83^{b}	75.50^{bc}	119.73^{a}	6.90^{a-d}	7.76^{de}	91.22^{f-i}	10.63^{a}	14.60^{g-i}	9.67^{d-f}	42.17^{g-i}	16.43^{f-h}	8.83^{d}	33.58^{a}	637.60^{bc}	18.48^{gh}	246.14^{gh}
11	IAR-07-1050	45.00^{e-i}	50.00^{g-i}	95.26^{ab}	7.48^{a-d}	8.24^{de}	130.30^{b-e}	7.05^{d-g}	15.55^{f-i}	14.17^{bc}	32.33^{j}	15.15^{hi}	11.50^{b-d}	19.17^{h-k}	659.70^{bc}	30.82^{d-f}	442.78^{c-f}
12	IT10K-863-11	44.00^{e-i}	47.17^{ij}	86.53^{ab}	5.83^{d}	9.16^{de}	89.67^{f-i}	5.25^{g}	23.48^{ab}	12.67^{cd}	42.67^{g-i}	18.45^{b-d}	14.33^{ab}	14.58^{l}	307.80^{c}	30.52^{d-f}	406.67^{ef}
13	IT13K-1201-5	42.17^{hi}	48.00^{h-j}	130.62^{a}	8.73^{a-c}	13.76^{a-d}	90.58^{f-i}	6.30^{e-g}	17.35^{c-g}	11.33^{c-e}	53.33^{b-d}	19.78^{ab}	8.50^{d}	23.00^{e-g}	764.70^{a-c}	33.10^{b-f}	441.11^{c-f}
14	IT13K-1322-4	43.83^{e-i}	48.17^{h-j}	104.16^{ab}	7.02^{a-d}	8.11^{de}	69.98^{i}	5.53^{fg}	21.68^{a-c}	14.67^{bc}	44.33^{f-i}	16.12^{f-h}	11.50^{b-d}	18.33^{h-k}	571.70^{bc}	42.02^{a-c}	559.45^{a-d}
15	IT99K-573-2-1	43.67^{e-i}	45.67^{j}	103.05^{ab}	6.19^{cd}	16.38^{ab}	134.63^{b-e}	5.97^{e-g}	14.80^{g-i}	11.33^{c-e}	54.17^{b-d}	19.50^{ab}	12.00^{b-d}	18.50^{g-k}	748.60^{a-c}	30.22^{d-f}	402.78^{ef}
16	IT08K-150-12	43.17^{f-i}	47.50^{ij}	106.59^{ab}	6.55^{b-d}	11.88^{b-e}	107.53^{d-g}	5.93^{c-g}	16.25^{e-h}	12.50^{cd}	41.50^{g-i}	16.73^{f-h}	13.67^{a-c}	16.50^{kl}	532.60^{bc}	32.47^{b-f}	432.78^{d-f}
17	IT07K-292-10	42.50^{gh}	47.17^{ij}	122.50^{a}	9.05^{ab}	15.87^{a-c}	72.06^{hi}	5.52^{fg}	21.43^{a-d}	9.83^{d-f}	52.50^{b-e}	18.27^{b-e}	13.67^{a-c}	18.00^{i-l}	441.00^{bc}	39.95^{a-d}	532.50^{a-e}
18	IT99K-573-1-1	42.17^{hi}	47.50^{ij}	115.36^{a}	7.43^{a-d}	9.79^{de}	153.05^{b}	6.03^{e-g}	13.05^{g-j}	10.00^{d-f}	49.00^{d-g}	19.73^{ab}	11.67^{b-d}	21.08^{g-j}	770.00^{g-c}	30.83^{d-f}	410.83^{ef}
19	IT14-1683-2	41.50^{i}	45.33^{j}	120.06^{a}	7.68^{a-d}	8.91^{de}	101.08^{e-i}	5.62^{fg}	15.32^{f-i}	10.33^{c-f}	56.83^{a-c}	19.10^{ab}	12.33^{a-d}	18.42^{h-k}	463.00^{bc}	38.00^{a-e}	484.17^{b-e}
20	UAM09-1055-6	43.33^{f-i}	46.50^{ij}	96.15^{ab}	7.79^{b-d}	10.32^{c-e}	137.03^{b-d}	5.78^{e-g}	20.05^{a-e}	10.67^{d-f}	52.67^{b-e}	18.50^{b-d}	13.83^{a-c}	17.75^{j-l}	758.00^{a-c}	33.88^{b-f}	451.39^{c-f}
21	UAM14-127-20-1-1	45.67^{d-i}	50.50^{g-i}	115.21^{a}	7.19^{a-d}	9.74^{de}	86.33^{g-i}	7.40^{c-g}	14.47^{g-i}	7.17^{f}	41.33^{g-i}	16.18^{f-h}	16.67^{a}	21.58^{g-i}	490.80^{bc}	30.95^{d-f}	412.50^{ef}
22	UAM14-122-17-7	46.33^{d-h}	53.83^{fg}	96.15^{ab}	9.45^{a}	12.35^{b-d}	95.37^{f-i}	6.08^{e-g}	21.30^{a-d}	17.00^{ab}	50.50^{c-f}	17.10^{d-f}	14.33^{ab}	28.50^{b-d}	640.80^{bc}	45.45^{a}	605.84^{ab}
23	UAM09-1051-1	47.67^{e-d}	53.67^{fg}	118.70^{a}	6.01^{d}	10.42^{b-e}	112.37^{c-g}	5.88^{e-g}	14.13^{g-i}	18.83^{a}	41.17^{g-i}	16.87^{e-g}	13.17^{a-c}	20.33^{g-k}	659.70^{bc}	31.57^{c-f}	420.83^{ef}
24	Loko Cowpea	59.33^{c}	69.50^{d}	101.88^{ab}	7.28^{a-d}	8.13^{de}	118.02^{c-g}	8.15^{a-e}	15.93^{e-h}	11.50^{c-e}	45.50^{e-g}	17.27^{c-f}	15.00^{ab}	31.08^{ab}	913.00^{a-c}	43.25^{ab}	636.33^{a}
25	Black Berry	66.67^{ab}	76.83^{b}	112.31^{a}	6.55^{b-d}	9.59^{de}	104.72^{d-h}	10.48^{a}	12.42^{h-j}	9.33^{d-f}	51.67^{b-f}	15.40^{g-i}	13.67^{a-c}	25.38^{d-f}	925.40^{a-c}	11.47^{hi}	202.92^{h}
26	Samaru Cowpea	45.67^{d-i}	48.33^{h-i}	94.04^{ab}	5.98^{d}	5.74^{e}	122.58^{b-f}	7.02^{d-g}	24.38^{a}	18.00^{a}	37.50^{h-j}	14.22^{i}	12.50^{a-d}	22.00^{f-h}	876.40^{a-c}	31.92^{c-f}	425.28^{d-f}
	Mean	50.24	56.33	106.95	7.02	10.85	117.13	7.08	16.55	11.51	46.53	17.19	12.93	22.48	702.82	31.41	424.02
	CV	6.93	5.53	31.18	26.76	41.17	21.07	24.64	20.27	25.18	12.39	6.87	24.09	12.54	63.49	25.31	23.66

DFF = days to first flowering, D50F = days to 50% flowering, 5FWS = 5 Fresh weight of shoots, 5FWR = 5 Fresh weight of roots, DWR = Dry weight without root, PVL = Primary vein length, NOB = Number of branches, NOP = Number of pods, NOC = Number of clusters, 5FPW = 5 Fresh pod weight, PLC = Pod length of cowpea, NOS = Number of seeds, 100SW = Hundred seed weight, HYP = Haulm yield of plant, KYP = Kernel yield/plant, GYC = Grain yield (kg/ha) and Acc = Accession

Table 4: Estimates of Genetic Parameters for 16 Traits of Cowpea during 2022 and 2023 Cropping Seasons at Mubi.

	δ_g^2	δ_p^2	GCV	PCV	h^2	GA
DFF	86.53	92.28	18.52	19.12	93.77	18.56
D50F	134.55	140.27	20.59	21.02	95.92	23.40
FWS	71.64	600.57	7.91	22.91	11.93	6.02
FWR	0.87	2.37	13.25	21.94	36.47	1.16
DWR	7.22	17.61	24.76	38.66	41.01	3.55
PVL	780.89	1,061.03	23.80	27.75	73.60	49.39
NOB	2.33	3.76	21.56	27.40	61.91	2.47
NOP	13.05	19.61	21.82	26.75	66.54	6.07
NOC	7.10	10.89	23.16	28.68	65.25	4.44
FPW	60.29	76.59	16.69	18.81	78.71	14.19
PLC	2.46	3.21	9.13	10.42	76.77	2.83
NOS	1.79	7.30	10.35	20.89	24.53	1.37
100SW	27.98	30.89	23.53	24.73	90.56	10.37
HYP	13,677.32	10,892.68	16.64	46.96	12.56	85.37
KYP	92.23	124.57	30.57	35.53	74.04	17.02
GYC	16,374.25	21,367.62	30.18	34.47	76.63	230.75

δ_g^2 = Genotypic variance, δ_p^2 = Phenotypic variance, DFF = days to first flowering, D50F = days to 50% flowering, FWS = Fresh weight of shoots, FWR = Fresh weight of roots, DWR = Dry weight without root, PVL = Primary vein length, NOB = Number of branches, NOP = Number of pods, NOC = Number of clusters, FPW = Fresh pod weight, PLC = Pod length of cowpea, NOS = Number of seeds, 100SW = Hundred seed weight, HYP = Haulm yield of plant, KYP = Kernel yield/plant and GYC = Grain yield of cowpea.