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Research Article

Evaluating the Performance of Cowpea (*Vigna unguiculata* L. Walp) Genotypes for Yield and Yield Attributes in Sudan Savannah Conditions

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ABSTRACT

Cowpea (*Vigna unguiculata* L. Walp) is a crucial pulse crop cultivated globally and is well-adapted to diverse cropping systems. Key breeding objectives for this crop include enhancing yield and associated traits while reducing growth duration. A study was conducted during the 2023 rainy season to evaluate and characterize cowpea genotypes for growth, yield, and quality parameters in the Sudan Savannah Agro-climatic region. The objective was to identify the most promising genotype for improved productivity. Thirteen cowpea genotypes *ALOKA LOCAL, DAN ILA, TVU7778, IT99K-573-1-1, IT07K-292-10, IT00K-901-5, IT07K-284-12, IT08K-150-12, IT07K-297-13, IT87K-876-11, SAMPEA-7, SAMPEA-11,* and *SAMPEA-12* were evaluated based on seed yield attributes and field performance. The assessment included field emergence, days to 50% flowering, days to maturity, plant height, number of pods per plant, number of seeds per pod, number of nodules per plant, nodule fresh weight, seed yield per plant, seed yield per plot, biological yield, and harvest index. Additionally, various seed quality parameters were examined, including germination percentage, root length, shoot length, seedling length, fresh weight, seedling dry weight, seedling vigour index, and 100-seed weight. The results revealed significant differences among the genotypes. Genotype *IT99K-573-1-1* recorded the lowest values for most traits, while *TVU7778* exhibited the highest seedling length, seedling fresh weight, seedling dry weight, vigor indices, and yield-related traits. Moreover, genotypes *SAMPEA-7, TVU7778*, and *IT08K-150-12* demonstrated the highest germination rates. This study provides valuable insights into the performance of different cowpea genotypes, supporting the selection of superior varieties for enhanced productivity in the Sudan Savannah region.

Keywords: Cowpea; Evaluation; Genotypes; Growth; Vigna *unguiculata*

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INTRODUCTION

Cowpea or black-eyed pea (Vigna unguiculata L.) is among the food legumes that provide food and fodder, as well as improve soil fertility and contribute to the sustainability of food production in marginal areas of the dry tropics (Singh, 1997; Varshney *et al*., 2019). It is one of the preferred food crops in Nigeria, in terms of land area and production. For instance, land areas of cowpeas were estimated at 0.117 million ha in 1981 and rose to 3.2 million ha and 4.3 million ha in 2012 and 2019, respectively (Manda *et al*., 2019). The North West and North East regions of Nigeria are the most productive, including Borno, Bauchi, Gombe, Jigawa, Kaduna, Kano, Katsina, Kebbi, Sokoto, and Zamfara States, which represent 75% of the total cowpea production in Nigeria (Manda *et al*., 2019). Likewise, the national output of cowpeas has increased by 165% from 1980 to 1990 and 50% from 2009 to 2019 (Ogundapo *et al*., 2020). The crop's popularity is in part related to the successful development and adoption of improved cowpea varieties (Kouakou, Ogundapo, *et al*., 2022). Cowpea has outstanding features that have made it an important component of subsistence agriculture, such as drought tolerance, shade tolerance, quick growth, and rapid provision of ground cover (Singh, 2005; Boukar, Belko, *et al*., 2019). The grain contains about 22% protein and constitutes a major source of protein for resource-poor rural and urban people (Ogundapo *et al*., 2020). In recent years, several studies have evaluated the performance of cowpea genotypes in several ecological zones of Nigeria (Singh, 1997). In selecting appropriate genotypes for different agroecological environments, it is important to know how various soils and climatic factors affect the growth and development of the varieties to interpret the observed yields under these environments (Manda *et al*., 2019; Kouakou *et al*., 2022). Appropriate agronomic practices to improve the performance of new varieties of improved and dual-purpose cowpeas under different agroecological zones are generally important for breeding and production purposes (Boukar *et al*., 2019). Yield and growth performance could be increased through the evaluation of all these varieties under different agroecological zones for a better understanding of their morphological, physiological, and biochemical response to the environment (Kouakou, Ogundapo, *et al*., 2022). Although hundreds of superior cowpea varieties were released by IITA and other research institutes, very little research has been carried out concerning the suitability of specific cowpea varieties for certain regions (Boukar *et al*., 2019; Varshney *et al*., 2019). Therefore, there is an urgent need to evaluate the cowpea varieties. A certain recommendation has been released to generate research evidence of different varieties concerning their suitability under certain conditions to benefit the cowpea growers of Jigawa. This underscores the importance of evaluating the agronomic performance of cowpea varieties as a food security crop under the current and foreseeable future scenarios. The study evaluated key yield-related parameters among 10 cowpea genotypes in Jigawa State.

MATERIAL AND METHODS

Experimental Site

The study was conducted at the Screen House of Teaching and Research Farm, Faculty of Agriculture, Federal University Dutse, Jigawa State. Dutse is located in the north-western part of Nigeria. It has a latitude of 11.7562^{o}N and a longitude of 9.3390^{o}E.

Experimental Materials

Thirteen (13) cowpea genotypes were sourced from the International Institute of Agriculture Kano sub-station. Table 1.

Table 1. List of genotypes and their source for the study

S/N	Cowpea Genotypes	Source
1	ALOKA LOCAL	SOURCE
2	DAN ILA	IITA
3	TVU7778	IITA
4	IT99K-573-1-1	IITA
5	IT07K-292-10	IITA
6	IT00K-901-5	IITA
7	IT07K-284-12	IITA
8	IT08K-150-12	IITA
9	IT07K-297-13	IITA
10	IT87K-876-11	IITA
11	SAMPEA-7	IITA
12	SAMPEA-11	IITA
13	SAMPEA-12	IITA

Experimental Design

The experiment comprised 13 cowpea genotypes, that were laid in a Randomized Complete Block Design with three replications. Each genotype had two rows per plot with an intra-row spacing of 15cm and an inter-row spacing of 20 cm. Weed control was done when needed, and insect control was done at the seedling stage and during pod formation to avoid insect damage. Three middle plants per genotype were used to collect data for growth and yield components. The experimental plot layout

Experimental Parameters

Germination Percentage and Field Emergence

Germination percentage was carried out using blotting paper (BP method). The first count was recorded on the 4thday and the final count was recorded on the 7th day using the formula

Germination percentage (%) =
Total Number of seed sown × 100
Total no. of seeds germinate

Field emergence (%)

One hundred seeds from each treatment were selected for the field emergence studies. The seeds were sown in well-prepared at 3m deep. The field emergence count will be taken on the 4th, 7^{th,} and 10th day after sowing and the emergence percentage was measured based on the number of seedlings that emerged three centimeters above the soil surface.

Field emergence (%) =
Total Number of seedlings emerged × 100
Total no. of seeds sown

Seedling vigor index length:
The seedling vigor index was calculated by adopting the method suggested by Abdul Baki and Anderson (1973). Seedling vigor index length = Germination (%) x Total seedling length (cm.)
Seedling vigor index mass:
The vigor index in terms of mass is determined by the multiplication of germination percentage with seedling dry weight on the day of the final count. Seedling vigor index mass= germination (%) X seedling dry weight
Plant height (cm)
was measured from ground level to the base tip fully opened leaf at the harvesting stage. The average height of five plants was recorded.
Number of pods per plant
The total numbers of pods from five randomly selected plants were counted manually from each genotype.
Number of seeds per pod
The total number of seeds from five randomly selected plant pods was counted manually from each genotype.
Number of nodules per plant
Five plants from each genotype plot were uprooted 30 days after seedling (DAS), and the extent of nodulation was estimated by carefully washing the roots and detaching the nodules before counting according to (Khan, 2006)
Nodules fresh weight (g)
After washing the root nodules from the field, the nodules were detached from the plant roots and weighed using an electronic weighing balance for fresh weight of root nodules expressed in grams (g).
Days to 50% flowering
The numbers of days were counted till the days of 50% flower initiation from the date of sowing.
Days to maturity
The number of days from sowing to plant harvest (physiological maturity) was count manually for each genotype.
Seed yield per plant (g)
The seed weights of five randomly selected genotypes were recorded on each plot.
Seed yield per plot (g)
The seed weight of the total plants in a plot was recorded.
Biological yield
The biological yield refers to the total dry matter accumulation of a plant system. The biological yield of five randomly select plants was recorded of each plot.
Harvest index
harvest index (HI) is the ratio of harvested grain to total shoot dry matter, and this can be used as a measure of reproductive efficiency. The HI of five randomly selected plants were recorded for each plot.

Grain yield

$$\text{Harvest index (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Data Analysis
Data collected were subjected to the analysis of variance (ANOVA) using SAS (2003) and treatment means were separated using the Duncan multiple range test at a 5% level of probability.

RESULTS AND DISCUSSION

All growth and yield attributes studied such as., field emergence, days to 50% flowering, days to maturity, plant height (cm), no. of pods per plant, no. of seeds per pod, no. of nodules per plant, nodules fresh weight (g), seed yield per plant (g), seed yield per plot (g), biological yield (g) and harvest index (%) were observed
Seedling traits
Germination Percentage
SAMPEA-7 recorded the highest germination percentage (89%), followed by *TVU7778* and *SAMPEA-12* (87% each). The lowest germination percentage was observed in *IT07K-297-13* (81%). These findings align with Agbogidi and Egho (2011) and Teame *et al*. (2017), who reported significant genotypic variability in germination rates. (Table 2)
Root and Shoot Lengths
IT00k-901-5 exhibited the longest root length (62.66.00 cm), followed by *IT87k-876-11* with (61.66 cm) while I*T08K-150-12 and SAMPEA 11* had the lowest value of (32.66) respectively. On the other hand, the longest shoot length (84.66 cm) was found on IT87K-876-11 followed by IT80k-901-3. While the shortest root lengths were recorded in *TVU7778* with (72.00 cm) As seen in (Table 2). Previous studies (e.g., Oladiran *et al*., 2012) support the association of longer roots with improved nutrient uptake and drought tolerance.
Seedling Vigor and Biomass
SAMPEA-7 had the highest seedling vigor index based on length (46.66 followed by *IT08K-150-12* and *TVU7778* with (44.60 and 43.36 respectively, while *SAMPEA-7* recorded the highest index based on mass (0.852) followed by *TVU7778* and *IT08K-150-12* with (0.650 and 0.513) respectively (Table 2). These genotypes also had superior seedling fresh and dry weights, corroborating the findings of Adewale and Dumet (2011).
100-Seed Weight
TVU7778, *SAMPEA-7,* and *IT08K-150-12* had the highest 100-seed weight (18.55g 16.29g, and 13.49g, respectively), highlighting their superior

seed quality. Whereas *IT99k-573-1-1* recorded the lowest value of 9.09g. This agrees with Singh *et al*. (2019), who demonstrated a positive correlation between seed weight and complete plant vigor.

Yield Parameters

Field emergence percentage was highest in *SAMPEA-7* (92%), followed by *TVU7778* (91%), and *IT87K-876-11* (89%) with the lowest observed in *IT99K-573-1-1* (83%). Days to 50% flowering ranged from 16.42 *SAMPEA-7 15.40 TVU7778* to 14.45 (*IT08K-150-12* while *IT99k-573-1-1* recorded the lowest value of *10.10*, as seen in (Tab 3) reflecting genotypic variability. Days to maturity ranged from 21.01 in TVU7778 and 15.09 in *Danila local*. Plant height was highest in *TVU7778* (36.42 cm) and lowest in *IT99k-573-1-1* (24.07 cm). (Table 3). The tall plants of TVU7778 (95.4 cm) align with the findings of Ehlers and Hall (1997), who reported that taller genotypes often show better adaptability to varying environments but may face lodging issues. Flowering and Maturity

The Days to Flowering (DTF) and Days to Maturity (DMT) results align with the work of Adetiloye *et al*. (2015), who reported similar flowering and maturity periods in cowpea varieties evaluated under tropical conditions. Contrasting findings were reported by Aremu *et al*. (2020), who found that some genotypes with a high Number of Pods per Plant (NPP) did not necessarily produce high Number of Seeds per Pod (NSP), indicating a trade-off between pod production and seed size. However, in this study, genotypes like SAMPEA-7 managed to excel in both traits. Genotypes like SAMPEA-7, which exhibited early Days to Flowering (DTF) and shorter Days to Maturity (DMT), align with the findings of Adetiloye *et al*. (2015), emphasizing the importance of early-maturing varieties in regions prone to drought or short growing seasons. However, late-flowering genotypes such as TVU7778 demonstrated higher yields due to extended vegetative growth, supporting results from Ehlers and Hall (1997), who argued that prolonged growth stages often improve biomass and pod production.

Number of pods per plant and Seed Yield per plant *TVU7778*, *SAMPEA-7,* and *SAMPEA-12* consistently performed well in yield-related traits. *TVU7778* had the highest number of pods per plant (5.87) and seeds per pod (0.674). Seed yield per plant was highest in *TVU7778* (12.40g), while the lowest was recorded in *IT99K-573-1-1* (8.17g). (Table 3) These results align with Babiker *et al*. (2016), who reported significant variability in cowpea yield traits. The strong performance of *SAMPEA-7* and *TVU7778* indicates their suitability for high-yield breeding programs. Number of pods per plant NPP and seed yield per plot SYPP. The high number of Pods per Plant (NPP) and Seed Yield per Plant (SYPP) observed in SAMPEA-7 and TVU7778 are consistent with findings by Singh *et al*. (2019), who reported a strong positive correlation between NPP and SYPP in high-yielding cowpea genotypes. In contrast to the relatively low CV (1.22%) for SYPP in this study, Mohammed *et al*. (2018) reported greater variability in seed yield across multiple environments, highlighting the importance of environmental factors in genotype performance. The observed positive relationship between the Number of Pods per Plant (NPP), Number of Seeds per Pod (NSP), and Seed Yield per Plant (SYPP) is well-documented in legume studies. Similar results were reported by Singh *et al*. (2019), where high NPP directly contributed to increased yield. However, the efficiency of photosynthate translocation into seeds (reflected in NSP) was crucial for achieving high SYPP, as seen in genotypes like SAMPEA-7 and TVU7778.

Harvest Index and Biological Yield

For the biological yield, *IT08K-150-12* had the highest with (18.56) followed by *SAMPEA 7* at (16.42) and *TVU7778* at (15.42). the lowest was recorded in *IT99K-573-1-1* (13.97) As seen in (Tab 3) while for the harvest index. *IT08K-150-12, TVU7778,* and *SAMPEA 7* recorded the highest value of (33.01, 21.02, and 19.42) while *IT99K-573-1-1* had the lowest value of (13.97) *(*Tab 3*).* Similar trends were observed by Ogunniyi *et al*. (2016), who reported high Harvest Index (HI) and Biological Yield (BY) in improved cowpea varieties under controlled conditions. Their results also emphasized the role of efficient photosynthate partitioning in increasing yield. In contrast to our results, The moderate Harvest Index (HI) for most genotypes contrasts with findings by Taiwo *et al*. (2013), who observed higher HI values in drought-tolerant genotypes, signifying the need to evaluate water use efficiency alongside productivity traits. The superior Harvest Index (HI) of *IT08K-150-12* (33.01) indicates efficient partitioning of biomass towards economic yield. This corroborates the findings of Ogunniyi *et al*. (2016), who noted that genotypes with higher HI are more resource-use efficient, particularly under optimal growing conditions.

Table 2 Mean performance of 13 cowpea genotypes for 9 seedlings attributes

S/N	GNP	Germination %	Root length (cm)	Shoot length(cm)	Seedling length (cm)	Seedling fresh weight(gm)	Seedling dry weight(gm)	Vigour Index length	Vigour Index mass	100 seed weight
1	ALOKA L.	79	35.00	76.00	88.40	11.23	11.73	29.93	0.300	10.94
2	DAN ILA	83	35.33	74.66	67.50	10.83	10.46	32.66	0.373	10.19
3	TVU7778	87	33.33	72.00	95.40	13.46	16.13	43.36	0.650	18.55
4	IT99K-573-1-	78	35.66	77.66	78.93	5.80	9.85	28.53	0.213	9.09
5	IT07K-292-10	84	35.33	75.33	83.70	6.13	10.90	34.86	0.483	11.89
6	IT00K-901-5	82	62.66	83.33	94.83	9.66	12.75	29.73	0.280	11.29
7	IT07K-284-12	80	36.33	77.66	77.40	7.86	11.36	23.43	0.203	12.74
8	IT08K-150-12	86	32.66	73.66	89.26	12.16	13.93	44.60	0.513	13.49
9	IT07K-297-13	81	34.00	76.33	117.46	10.46	12.01	24.13	0.240	11.62
10	IT87K-876-11	84	61.66	84.66	80.50	11.66	14.60	32.80	0.386	12.08
11	SAMPEA-7	89	33.00	72.33	103.13	13.33	14.21	46.66	0.852	16.29
12	SAMPEA-11	83	32.66	74.00	79.60	8.33	13.53	33.40	0.413	9.86
13	SAMPEA-12	85	36.33	76.33	74.80	9.00	11.62	32.13	0.320	11.32
	Grand Mean	83.15	38.77	76.46	87.00	10.00	12.55	33.56	0.402	12.26
	C.D. (5%)	2.92	1.30	1.82	8.64	1.76	1.44	3.67	0.05	1.55
	SE(m)	1.00	0.44	0.62	2.96	0.60	0.49	1.26	0.02	0.53
	SE(d)	1.42	0.63	0.88	4.19	0.85	0.70	1.78	0.03	0.75
	C.V.	2.09	1.98	1.41	5.89	10.46	6.83	6.49	7.69	7.51

Table 3. Mean performance of 13 cowpea genotypes for 12 growth and yield characters

S/N	GNP	F.E %	DTF 50%	DMT	PH (cm)	NPP	NSP	NNP	FW(g)	SYPP(g)	SYPP(g)	BY(g)	HI
1	ALOKA L.	84	10.50	16.34	25.59	4.58	0.434	2149.62	36.44	9.10	87	10.50	16.34
2	DAN ILA	87	11.85	15.09	28.19	3.69	0.481	2452.62	41.87	11.12	84	11.85	15.09
3	TVU7778	91	15.40	21.02	36.42	5.87	0.674	3313.70	61.35	12.40	91	15.40	21.02
4	IT99K-573-1-1	83	10.10	13.97	24.07	3.35	0.416	1998.32	34.43	8.17	83	10.10	13.97
5	IT07K-292-10	88	12.75	16.02	28.77	4.45	0.502	2533.80	44.19	9.81	86	12.75	16.10
6	IT00K-901-5	86	11.84	15.62	27.46	3.51	0.466	2363.97	40.07	10.53	88	11.84	15.62
7	IT07K-284-12	84	10.95	14.36	25.31	3.95	0.441	2125.22	36.99	9.61	84	10.95	14.36
8	IT08K-150-12	84	14.45	18.56	33.01	4.94	0.570	2939.47	50.71	11.70	14.45	18.56	33.01
9	IT07K-297-13	85	11.17	16.10	27.27	4.68	0.508	2319.25	43.26	10.21	89	11.17	16.02
10	IT87K-876-11	89	13.42	17.03	30.45	3.12	0.460	2709.49	47.83	11.39	85	13.42	31.75
11	SAMPEA-7	92	16.42	19.42	35.84	5.42	0.610	3297.95	56.16	12.16	92	16.42	19.42
12	SAMPEA 11	86	11.52	15.37	26.89	4.15	0.537	2314.20	39.62	10.80	86	11.52	15.37
13	SAMPEA-12	90	14.10	17.60	31.70	5.07	0.547	2852.07	49.27	12.03	90	14.10	17.60
	Grand Mean	87.23	12.65	16.65	29.30	4.36	0.511	2566.89	44.78	10.69	87.23	12.65	16.65
	C.D. (5%)	2.69	0.93	1.63	2.02	0.53	0.07	195.05	5.92	0.40	2.69	0.93	1.63
	SE (m)	0.94	0.32	0.57	0.70	0.18	0.02	68.34	2.07	0.14	0.94	0.32	0.57
	C.V	2.15	5.16	6.85	4.82	8.53	9.71	5.32	9.24	2.67	2.15	5.16	6.85

GNP Genotypes, F.E % Field emergence %, DTF50% Days to 50 % flowering, DMT Days to Maturity, PH Plant height, NPP Number of pods per plant NSP Number of seed per plant, NNP Number of nodules per plant, FW Fresh weight, SYPP Seed yield per plant, SYPP Seed yield per plot, BY Biological yield, HI Harvest index

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