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ASSESSMENT OF SOME COWPEA (*Vigna unguiculata* L.) GENOTYPES FOR QUANTITATIVE AND QUALITATIVE TRAITS

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Abstract
The qualitative and quantitative traits, as well as nutritional composition of six cowpea genotypes were assessed to determine their worth for improvement purposes. The experiment was conducted at the research site of the Institute of Agricultural Research and Training (IAR&T) Ibadan in 2018 and 2020. The genotypes comprised of three improved varieties and three landraces. The experiment was laid out in a randomized complete block design in three replicates. Combined analysis of variance, means, coefficient of variation, and correlation analysis were conducted on the data collected. Mean squares for year and genotype were significant for most of the traits. Virus incidence and severity were significantly higher in ART/98-12 and least in Cotonou. Number of pods per peduncle was highest in Ife BPC (5) and least in Cotonou (2). Number of days to 50% flowering was least in Cotonou and ART/98-12 (46 days). Seed weight per plot was highest in Cotonou (0.35kg/m^2) and least in Oloyin (0.003kg/m^2). Crude protein was significantly higher in Oloyin (23.92%) and least in ART/98-12 (21.15%). Calcium, magnesium and potassium were highest in Cotonou. Cotonou, a landrace, is a promising genotype for improvement for yield and earliness.

Keywords: Cowpea (Vigna unguiculata), crop improvement, improved varieties, landrace, mineral composition

Introduction

Cowpea is a major legume crop consumed in Nigeria. It is mostly grown in the north and drier part of southwest Nigeria. Cowpea thrives under low fertile soil and dry-land, making it one of the most resilient leguminous crops suitable for the low input and water-limited production systems in Sub-Saharan Africa (Nkhoma *et al*., 2020). While some cowpea genotypes are improved varieties, some are landraces which have been existing in the farmers' locality but no improvement has been done on them. Landraces are generally defined as populations of cultivated plants with historical background and are adapted to local environments, but without any breeding improvement (Camacho-Villa *et al*., 2005). They are also called 'farmer-developed accessions' or 'traditional varieties'. (Iseghohi *et al.*, 2019). They represent valuable resources that can be explored for introgression of new genes in varietal improvement (Hedge and Mishra, 2009; Xu *et al*., 2010). Cowpea landraces have been reported to have lower yield (Breseghello and Coelho, 2013), but other reports have shown that some landraces may be more productive than improved cultivars (Peksen, 2004; Makoi *et al*., 2009). Thus, studies of traditional cultivars enable the identification of cultivars that can be used directly by farmers or used in breeding programs (Boukar and Fatokun, 2009). The low palatability and prolonged cooking time of cowpea landraces as observed by Nkhoma *et al.* (2020), have reduced their use for human consumption. However, Mamiro *et al*. (2011) in Tanzania reported that in comparison with improved varieties, traditional cowpeas had comparable levels of dry matter, crude protein and nitrogen free extracts (NFE). They also reported that local cowpea grains had the highest calcium, zinc and iron contents. In order to be able to exploit the good quality attributes inherent in landraces, there is need for the critical assessment of quantitative and qualitative traits, including nutritional composition of individual genotype to identify the best cowpea genotype under the production environment for breeding, production and processing uses.

Materials and Methods

Six cowpea genotypes (three landraces and three improved varieties) were used for the study. The list of the cowpea genotypes and their attributes is presented in Table 1. Genotypes Campala and Cotonou are traditional varieties got from farmers in Oke-Ogun area of Oyo state. Oloyin is well-adapted and commonly grown in the northern part of Nigeria. It is widely accepted for its sweet taste. The other three are improved varieties from the Institute of Agricultural Research and Training (IAR&T), Ibadan. The experiment was conducted at the research site of IAR&T, Ibadan in September, 2018 and 2020. Each trial was set up in a randomized complete block design with three replications. Plot size was 3m x 3m, while the plant spacing was 60cm x 60cm, at two plants per hill giving 50 stands per plot. Pre-emergence herbicide (Metaforce) was applied a day after planting at the rate of 3 liters per hectare. Plots were sprayed at intervals using Lambda cyhalothrin to control insect pests. Insect data were taken before spraying. No fertilizer was applied throughout the trial. Hand weeding was done once at 4 weeks after planting. Harvesting started at about 55 days after planting, and continued as the pods get dried. Data were collected on quantitative and qualitative traits using IBPGR Cowpea Descriptor (1983). Proximate analysis was conducted for crude protein, fat and fibre, total ash, and nitrogen free extract (NFE) using the method described by AOAC (1990), Chang (2003), and James (1995). The mineral composition such as calcium, magnesium sodium and potassium were also assayed. Data collected were subjected to analysis of variance using SAS software, version 9.2 (SAS Institute, 2009). Viral incidence in percentage was first transformed using arcsine before analysis. Means and coefficient of variation (CV) were estimated. Means were separated using Least Significant Difference (LSD). Correlation analysis was also conducted among the qualitative and quantitative traits using Pearson correlation model.

Quantitative traits studied

Days to first flowering and days to 50% flowering were determined from the day of planting to when the first flower was noticed, and when 50% of the plants had flowered, respectively. Plant height (cm) was measured at flowering from the base of the stem to the tip of the main stem using tape rule on average of five plants per plot. Number of leaves was determined at 2, 4 and 6 weeks after planting on average of five plants per plot. Number of main branches per plant and number of pods per peduncle were also taken on average of five plants per plot. Seed weight per plot (kg/m^2) was taken by threshing all the pods per plot, and the seeds weighed using measuring scale. Number of bugs was counted per plot. Virus incidence (%) was taken by counting the number of plants infected by virus, and the number expressed as percentage of plant stands per plot. Pod wall thickness (mm) was measured by picking 10 pods randomly per plot, the pods threshed and thickness of each half of the shaft measured using vernier caliper. The average of the ten shafts was taken.

Qualitative traits

Flower colour was taken through visual observation at flowering on a scale of 1-5 (1 for white, 2 for violet, 3 for mauve-pink, 4 for yellow and 5 for light blue). Plant hairiness was taken by feeling the leaves with hand and rated on a scale of 0-1 (1 for hairy and 0 for non-hairy). Pod shape was taken after harvesting on a scale of 1-4 (1for curved, 2 for slightly curve, 3 for straight and 4 for coiled). Seed shape was rated on scale 1-5 (1 for kidney shape, 2 for ovoid, 3 for crowder, 4 for globuse, and 5 for rhomboid shape). V-shape marking was observed on the leaves per plot and rated on a scale of 1 for presence and 0 for absence. Virus severity was rated on a scale of 1-5 (1 for clean and no infection, 5 for severe viral infection). Leaf damage was rated on scale of 1-9 with 1 for no infestation and 9 for severe infestation. Thrips (*Megalorothrips sjostedti* Trybom), Aphids (*Aphis craccivora* Koch) and Maruca (*Maruca vitrata* Fab) were also rated on scale of 1-5 based on the population of the insects with 1 for no insect and 5 for very high insect population.

Results and Discussion

Mean squares for the quantitative and qualitative traits studied

Analysis of variance of the quantitative traits for the cowpea genotypes is presented in Table 2. Mean square of year was significant ($P< 0.05$) for almost all the traits. This could be due to variation in climate in each of the year under which the study was conducted. Mean square of genotype was significant for number of leaves, virus incidence, days to 50% flowering and pods per peduncle, suggesting that variation observed was due to variation among the genotypes. Similar observation was reported by Nkhoma *et al*. (2020) and Kalambe *et al*. (2019). Mean square of year by genotype interaction was not significant for almost all the quantitative traits except for number of pods per peduncle indicating that the response of the genotypes was not influenced by the environment. Mean squares of the qualitative traits are presented in Table 3. Mean squares of year was significant for most of the traits except for number of branches, bug count and seed weight per plot, while mean square of genotype was significant for all the traits except seed shape, flower colour and aphids rating. Mean square of year by genotype interaction was also significant for plant hairiness, V-shape marking, flower colour, thrips and maruca rating. The significant mean square of genotype for most of the traits indicated wide variation among the genotypes, and that the observed variations are more as a result of the variations among the genotypes rather than the flux due to year differential. Similar results were observed by Belay *et al*. (2017). The genotypes evaluated are of wide background, hence this variation is expected. The significant mean squares of year by genotype interaction for some qualitative traits show that the genotypes responded differently to the test years. Differential response of genotypes to different environments is attributable to the differences in genetic constitution among test genotypes and micro-environmental conditions (Akter *et al*., 2015).

Mean performance of the cowpea genotypes

Mean performance of the significant qualitative and quantitative traits is presented in Table 4. Virus (Cowpea

Aphid-borne mosaic virus, CABMV) incidence and severity were significantly high in ART/98-12 (22.2% and 2.43 respectively) and least in Cotonou (2.21% and 1.33), followed by Ife BPC (2.28% and 1.33 respectively) This is an indication of some level of resistance to viral infection in Cotonou and Ife BPC. Cotonou is a landrace, while ART/98-12 is an improved variety. Ife BPC (16.09cm) and Oloyin (16.17cm) were the tallest genotype and were significantly ($p<0.05$) taller than Campala and Ife brown. Ife BPC and Oloyin also had highest number of leaves at 6 weeks after planting (63.67 and 55.97, respectively), while Campala was not the leafy type (28.50). Ife BPC and Oloyin are late-maturing genotypes adapted to the savanna ecology where the solar radiation is high. In the forest zone, they grow vegetatively and flowers much later when the weather condition is favourable. This accounts for their height and larger number of leaves. Number of days to 50% flowering was least in Cotonou (46 days) and ART/98-12 (46 days). Cotonou flowering earlier than the early-maturing Ife brown is an indication that Cotonou is an extra-early genotype. This is a good trait to explore in breeding for drought tolerance as early maturity has been noted as a drought escape mechanism for many crops (Shavrukov *et al*., 2017). Hall (2012) reported that cowpea cultivars with a determinate growth type were more drought tolerant compared to the indeterminate types. Cotonou has a determinate growth habit. V-shape marking was absent in the leaves of most of the varieties (Table 4). Thrips rating was least in Campala (2) and Ife Brown (2.17), and highest in Ife BPC (3.5). The rating in Cotonou and Oloyin was moderate (2.8), an indication of inherent tolerance of these landraces to thrips infestation. This is contrary to a report that landraces are susceptible to pests and diseases (Iseghohi, 2015). Maruca damage was moderate among all the cowpea genotypes. It was however highest in Cotonou (2.67). Number of pods per peduncle is an important yield component in cowpea (Almeida *et al*., 2014, Santos *et al*., 2014, Freitas *et al*., 2019). It was highest in Ife BPC (4.58) and least in Cotonou (2.30). Pods of Cotonou is straight, Oloyin is curve, while pod of other genotypes are slightly curve. Seed weight per plot was highest in Cotonou ($0.35kg/m^2$) and least in Oloyin ($0.003kg/m^2$), but moderate in others (Table 4). Despite the high maruca damage rating and the least number of pods per peduncle in Cotonou, the genotype still recorded the highest seed weight per plot, indicating its high potential for tolerance to pest infestation which translates to high seed yield. Yield is a function of weight and number. Cotonou, though with smaller number of pods per peduncle, naturally has much longer pod than others. This could be responsible for the high seed weight per plot. Others with more number of pods per peduncle have shorter pods. Qualitative traits have been reported to be good traits to differentiate among cowpea genotypes as the environment has limited effects on most of them (Ngompe-Deffo *et al*., 2017, Ajayi, 2019).

The proximate analysis and mineral composition of the genotypes are presented in Table 5. Crude protein was significantly higher in Oloyin (23.92%) and least in ART/98-12 (21.15%). The fat composition was highest in Cotonou and Ife BPC (3.21%) than in other genotypes. ART/98-12 (5.12%) and Campala (5.09%) had relatively higher crude fibre compared to other genotypes with Oloyin having the least fibre content of 4.55%, though Oloyin had the highest dry matter content (89.56%). The observed fibre content range of 4.55 – 5.12% was within the range reported by Gondwe *et al*. (2019). High fibre content has a useful effect of adding bulk to food, which in turn relieves constipation (Appiah *et al.,* 2011). High dry matter content is an indication of higher shelf life potential. Dry matter content (DMC) of the genotypes ranged between 89.56% (Oloyin) and Ife Brown (88.48%) which was within the range 89.10 – 89.90% reported by Gondwe *et al.* (2019). Calcium, magnesium and potassium were highest in Cotonou (6.43mg/g, 7.22mg/g, and 1.56mg/g, respectively). These minerals were however low in Ife brown, Ife BPC and ART/98-12 except sodium which was highest in Ife brown (1.73mg/g). The mineral compositions were also low in Oloyin. From the present study, it could be observed that some landraces also known as farmers' variety are better in one nutrient or the other compared to improved genotypes. Oloyin, Campala and Cotonou are not improved varieties, but they outperformed the improved varieties in some of the nutrients and mineral compositions. This is in line with earlier finding of Mamiro *et al*. (2011) who reported that local cowpeas had comparable levels of dry matter, crude protein and nitrogen free extracts (NFE) with improved varieties. They also reported that local cowpea grains could be very good sources of calcium, zinc and iron contents. Gomes *et al*. (2021), working on combinations of improved genotypes, landraces and commercial cowpea varieties also reported that Maringué (MAR) landrace had the most promising accessions for breeding in terms of high yield, high protein and sugar contents.

Number of leaves increased tremendously in Ife BPC (V4) and Oloyin (V6) from week 4 to week 6 (Fig 1). Plant height on the other hand increased sharply from week 4 to week 6 in Cotonou (V2), Ife brown (V3) and Ife BPC (V4) (Fig 2). The poor adaptability of Oloyin to the forest zone may account for the tremendous increase in number of leaves compared to other genotypes. Oloyin grows more vegetatively compared to other genotypes and flowers late. Cotonou is extra-early variety which completes its growth stages fast. This may account for its rapid height from 4 to 6 weeks after planting. The wide variation observed in plant height and number of leaves from week 2 to week 6 after planting in each genotype indicates that the genotypes differed with respect to these traits (Agbogidi and Egho, 2012).

Correlation among the quantitative and qualitative traits

Significant correlation exists among some of the quantitative and qualitative traits (Table 6). Viral severity was strongly correlated with viral incidence

(0.77**) but had negative correlation with plant height at 6WAP (-0.38*). Number of plants affected by virus infection within a plot influences the viral severity. This accounts for the strong positive correlation between viral incidence and severity. Thrips rating was negatively correlated with plant height at 6WAP (-0.45*), number of leaves at 6WAP (-0.45*) and number of pods per peduncle (-0.58**), but positively correlated with days to first flowering (0.63**). This is expected because thrips affect cowpea flowers causing flower drop (Gomes, 2004). Once there is excessive flower drop due to high population of flower thrips, the number of pods formed on the peduncle will reduce. Thrips affect both the leaves and flower of cowpea. They scrape the epidermis and suck the oozing sap. The affected leaves curl and become dry. This in turn delays flowering. This is responsible for the strong positive correlation between thrips damage and days to 50% flowering. The negative correlations for viral severity and thrips damage with plant height, as well as number of leaves suggest that pest and disease attack causes low plant vigour which could result in stunted growth of the plant. Very strong positive correlation has been reported to exist between plant height and number of leaves (Porbeni *et al.,* 2018, Joshua and Namo 2019). Therefore, whatever affect plant height is likely to affect number of leaves in the same direction. Leaf damage had positive correlation with number of bugs (0.37*). Aphids rating was however positive and significantly correlated with plant height (0.45**), number of leaves (0.63**) and number of pods per peduncle (0.68**) but negatively correlated with days to first flowering (-0.49**). This relationship is surprising because when aphids visit cowpea field at the vegetative stage, they may completely smother the plant. Maruca rating was also negative and significantly correlated with viral incidence and days to first flowering. The negative correlation between days to flowering and the pest attack indicated that pest attack could cause forceful flowering, as stress causes forceful flowering in plants (Alidu, 2018). Plant hairiness was negatively correlated with viral incidence (-0.44**) and positively correlated with number of leaves at 6WAP (0.38*). This implies that plants with hairy leaves may have fewer cases of viral incidence. Hairiness may be a form of defense mechanism against vector pests. Fatokun and Singh (2001) noticed some degree of insect pest resistance in some wild *Vigna* species which included *var pubescens* (TV NU110-3A). The reason for this could be due to presence of hairs on the species (Muhammed *et al*., 2009). The positive correlation between plant hairiness and number of leaves implies that species or varieties with more leaves tends to be more hairy. This was also observed in some wild accessions by Muhammed *et al*. (2009). Leaf V-shape marking had a strong correlation with plant height at 6WAP (0.48**), number of leaves at 6WAP (0.35*) and seed weight per plot (0.67**). It was however negatively correlated with days to first (-0.36*) and 50% flowering (-0.49**). Although the role of V-shape marking on cowpea leaf is not well known from literatures, Aliboh *et al*. (1997) however reported that V-shape mark may be used to establish linkage relationship, and if found to be linked to mature plant characters, it could be used to aid selection. Pod shape had a positive correlation with seed weight per plot (0.56**). Seed shape was negatively correlated with number of pods per peduncle (-0.52*) while it showed positive relationship with days to first flowering. Seed shape is correlated with seed development in the pod (Milosevic, 2013). When seed growth is restricted by the pod, the seed shape is influenced (Davis *et al*., 1991). Nkhoma *et al*. (2020) reported that qualitative traits were more important traits for selection as the traits affect the market value of cowpea.

Conclusion

There is wide variation among cowpea landraces and improved varieties. Cowpea landraces have some inherent qualities that could be explored for improvement purposes. Cotonou, a landrace cowpea in this study possesses useful genes for yield, earliness and tolerance to pests. In selecting the best cowpea genotype, critical assessment of quantitative and qualitative traits, including nutritional compositions is very important to determine the best genotype for specific purpose. The strong correlations among some qualitative and quantitative traits suggest that some qualitative traits could be good selection criteria especially when direct selection for a quantitative trait is challenging.

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References

Agbogidi, O.M. and Egho, E.O. (2012). Evaluation of eight varieties of cowpea (*Vigna unguiculata* (L.) Walp) in Asaba agro-ecological environment, Delta State, Nigeria. *European Journal of Sustainable Development*, 1(2): 303-314.

Ajayi, A.T. (2019). Variability among accessions of cowpea (*Vigna unguiculata* L. Walp): From Qualitative Scoring to Quantitative Analyses. *South Asian Research Journal of Agriculture and Fisheries*, 1(2): 54-64.

Akter, A., Hasan, M.J., Kulsum, M., Rahman, M., Paul, A., Lipi, L. and Akter, S. (2015). Genotype x environment interaction and yield stability analysis in hybrid rice (*Oryza sativa* L.) by AMMI biplot. *Bangladesh Rice Journal*, 19(2):83–90.

Aliboh, V.O., Kehinde, O.B. and Fawole,I. (1996). Inheritance of leaf mark, pod dehiscence and dry pod colour in crosses between wild and cultivated cowpeas. *African Crop Science Journal*, 4(3): 283-288.

Alidu, M.S. (2018). Genetic variability for flowering time, maturity and drought tolerance in cowpea (*Vigna ungiuculata* L. WAlp.): A Review paper. *Journal of Agriculture and Ecology Research International*, 17(2): 1-18.

Almeida, W.S., Fernandes, F.R.B., Teofilo, E.M., Herminia C. and Bertini, C.M. (2014). Correlation and path analysis in components of grain yield of cowpea genotypes. *Revista Ciencia Agronomica,* 45(4): 726-736.

AOAC (1990). *Official methods of Analysis of the Association of Chemist*. Washington DC., pp 223-225, 992-995.

Appiah., F., Asibuo, J. Y. and Kuah, P. (2011). Physicochemical and functional properties of bean flours of three cowpea (*Vigna unguiculata* L. Walp) varieties in Ghana. *African Journal of Food Science* **5**(2): 100–104. https://doi.org/10.1038/s41598-019-52360-w

Belay, F., Gebreslasie, A. and Meresa, H. (2017). Agronomic performance evaluation of cowpea [*Vigna unguiculata* (L.) Walp] varieties in Abergelle District, Northern Ethiopia. *Journal of Plant Breeding and Crop Science,* 9(8): 139-143. DOI: 10.5897/JPBCS2017.0640

Boukar, O. and Fatokun, C. (2009). Strategies in cowpea breeding. In: Zerihun, T. (Ed.). New approaches to plant breeding of orphan crops in Africa. Rome: FAO, 2009. cap. 6, p. 69-92

Breseghello, F. and Coelho, A.S.G. (2013).Traditional and modern plant breeding methods with examples in rice (*Oryza sativa* L.). *Journal of Agricultural and Food Chemistry*, 61(35): 8277-8286.

Camacho-Villa, T.C., Maxted, N., Scholten, M. and Ford-Lloyd, B. (2005). Defining and identifying crop landraces. *Plant Genetic Resources,* 3: 373-384.

Chang, S.K.C. (2003). Protein Analysis. In Nielsen, S.S. (Ed.), *Food Analysis*. Kluwer Academic Plenum publisher, New York.

Davis, D.W., Oelke, E.A., Oplinger, E.S., Doll, J.D., Hanson, C.V. and Putnam, D.H. (1991). Cowpea Alternative Field Crops Manual, University of Minnesota, pg 1-10.

Fatokun, C.A. and Singh, B.B. (2001) Improving cowpea-cereals systems in the dry savannas. Annual Report 2001 IITA, Ibadan, Nigeria, 79 pp

Freitas, T.G.G., Silva, P.S.L., Dovale, J.C., Silva, I.N. and da Silva, E.M. (2019). Grain yield and path analysis in the evaluation of cowpea landraces. *Revista Caatinga,* 32(2): 302-311.

Gomes, A.M.F., Draper, D., Nhantumbo, N., Massinga, R., Ramalho J.C., Marque, I. and Ribeiro-Barros, A.I. (2021). Diversity of Cowpea [*Vigna unguiculata* (L.) Walp] Landraces in Mozambique: New Opportunities for Crop Improvement and Future Breeding Programs. *Agronomy,* 11: 991.

Gomez, C. (2004). Pest Control. In Danilo mejia (Ed), *Cowpea Post Harvest Operations.* Pg 42-61, INPho Post harvest Compendium.. FAO, Rome, Italy.

Gondwe, T.M., Alamu, E.O., Mdziniso, P. and Maziya-Dixon, B. (2019). Cowpea (*Vigna unguiculata (L.) Walp*) for food security: an evaluation of end-user traits of improved varieties in Swaziland. Scientific Reports, *9:15991*.

Hall, A.E. (2012). Phenotyping Cowpea for Adaptation to Drought. *Plant Physiology*. 3:155.

Hedge, V.S. and Mishra, S.K. (2009). Landraces of cowpea, (*Vigna unguiculata* (L.) Walp) as potential sources of genes for unique characters in breeding. *Genetic Resources and Crop Evolution*. 56: 615–627.

IBPGR (1983). *International Board for Plant Genetic Resources Cowpea Descriptors*, Rome, Italy.

Iseghohi, I. O. (2015). Genetic diversity of Vigna unguiculata (L) Walp. (Cowpea) Landraces from Derived and Guinea Savannah regions of Nigeria based on microsatellite markers. Proceedings of 39th Annual Conference of Genetics Society of Nigeria. Bauchi, 2015, held at Abubakar Tafawa Balewa University (ATBU), Bauchi. Pp 420-426.

Iseghohi, I.O, Adesoye, A.I., Oludare, D.A, Agunbiade, F.V. and Unachukwu, N. (2019). Assessment of genetic diversity of selected cowpea landraces from Nigeria based on simple sequence repeat markers. *Nigerian Journal of Biotechnology*, 36 (2): 33 – 44.

James, C.J. (1995). *The analytical chemistry of foods.* Chapman and Hall Press, New York. Pages 86.

Joshua, N.N. and Namo, O.A.T. (2019). Agronomic evaluation of some landrace cowpeas (*Vigna unguiculata* (L.) Walp) and their wild relative (Dekindtiana var. Pubescens) for incorporation into cowpea breeding programme. *European Journal of Agriculture and Forestry Research*, 7(5): 12-23.

Kalambe, A.S., Wankhade, M.P., Deshmukh, J.D., Chavan, B.R. and Shinde, A.V. 2019. Correlation studies in cowpea (*Vigna unguiculata*). *Journal of Pharmacognosy and Phytochemistry*, 8(3): 321-323.

Makoi, J. H. J. R., Chimphango, S.B.M. and Dakora, F.D. (2009). Effect of legume plant density and mixed culture on symbiotic N_2 fixation in five cowpea (*Vigna unguiculata* L. Walp.) genotypes in South Africa. *Symbiosis*, 48(1): 57- 67.

Mamiro, P.S., Mbwaga, A.M., Mamiro, D.P., Mwanri, A.W. and Kinabo, J.L. (2011). Nutritional quality and utilization of local and improved cowpea varieties in some regions in Tanzania. *African Journal of Food, Agriculture, Nutrition and Development*, 11(1): 4490-4506.

Milosevic, D. (2013). Characterization of *Vigna unguiculata* (L) collected from Southern Thailand and its tolerance to blackeye cowpea mosaic virus. M.Sc. Thesis. Plant Science, Prince of Songkla University. x +80pp .

Muhammed, M.S., Russom, Z and Abdul, S.D. (2009). Inheritance of hairiness and pod shattering, heritability and correlation studies in crosses between cultivated cowpea (*Vigna unguiculata* (L) Walp) and its wild (*var pubescens*) relative. *Euphytica* DOI 10.1007/s10681-009-0058-6.

Ngompe-Deffo, T., Kouam, E. B., Beyegue-Djonko, H., and Anoumaa, M. (2017). Evaluation of the Genetic Variation of Cowpea Landraces (Vigna unguiculata) from Western Cameroon Using Qualitative Traits. *Notulae Scientia Biologicae*, 9(4): 508-514.

Nkhoma, N., Shimelis, H., Laing, M.D., Shayanowako, A. and Mathew, I. (2020). Assessing the genetic diversity of cowpea [*Vigna unguiculata* (L.) Walp.]

germplasm collections using phenotypic traits and SNP markers. *BMC Genetics,* 21:110

Peksen, A. (2004). Fresh pod yield and some pod characteristics of cowpea (*Vigna unguiculata* L. Walp.) genotypes from Turkey. *Asian Journal of Plant Sciences*, 3(3): 269-273.

Porbeni, J.B.O. Ayo-Vaughan, M.A. and Osunniyi, O (2018). Genetic variability among some miscellaneous legumes for yield-related traits. *Nigerian Journal of Biotechnology*, 35(2): 1-7.

Santos, A., Ceccon, G., Davide, L.M.C., Correa, A.M. and Alves, V.B. (2014). Correlations and path analysis of yield components in cowpea. *Crop Breeding and Applied Biotechnology*, 14: 82-87.

SAS Institute (2009).SAS System for Windows v. 9.3. Cary, NC: SAS Inst. Inc.

Shavrukov, A., Kurishbayer, S., Jatayer, V., Shvidehenko, L., Zotova, F., Koekemoer, S., de Groot, K., Soole, K. and Langridge, P. (2017). Early Flowering as a Drought Escape Mechanism in Plants: How can it Aid Wheat Production? *Frontiers in Plant Science*, 8:1950.

Xu, P., Wu, X.H., Wang, B.G., Liu, Y.H., Qin, D.H. and Ehlers, J.D. (2010). Development and polymorphism of *Vigna unguiculata* ssp. *unguiculata,* microsatellite markers used for phylogenetic analysis in asparagus bean (*Vigna unguiculata* ssp. *sesquipedialis* (L.) Verdc.), *Molecular Breeding,* 25 (4): 675-684.

Table 1: List of cowpea genotypes used for the study and their attributes

s/no	Name	Type	Seed colour	Attribute
1	Campala	Landrace	Brown and white	Medium-sized seed, soft seed coat, broad leaves
2	Cotonou	Landrace	Brick red	Small and shiny seed, long and narrow leaf, extra-early maturing and determinate
3	Ife brown	Improved variety	Brown	Small seed, early-maturing, soft seed coat, broad leaves
4	Ife BPC	Improved variety	Brown	Medium-sized seed, soft coat, intermediate maturity, broad leaves
5	ART/98-12	Improved variety	White	Big seed, soft seed coat, intermediate maturity, broad leaves
6	Oloyin	Landrace	Brown	Big seed, soft seed coat, late maturing and indeterminate, broad leaves

Table 2: Combined analysis of variance of quantitative traits for six cowpea genotypes evaluated in Ibadan across two years

Sources of variation	Df	Mean squares of ANOVA									
		Plant height at 6WAP (cm)	No. of leaves at 6WAP	No. of branches	Viral incidence (%)	Bug (count)	Days to first flowering	Days to 50% flowering	Pods/ Peduncle	Pod Wall Thickness (mm)	Seed weight per plot (kg/m²)
Year	1	4246.26**	24370.79**	2.17	0.18**	0.01	448.53**	86.06**	1.20**	0.18**	0.10
Rep (year)	4	407.22**	972.24**	3.11*	0.45*	0.54	32.81**	8.79	0.01**	0.11**	0.02
Genotype	5	70.85	894.34**	2.67	0.17**	1.35	16.81	44.53**	0.05**	0.06	0.07
Year*genotype	5	32.55	591.50	0.74	0.03	1.36	20.53	30.84	0.05**	0.07	0.03
Error	20	48.09	270.89	1.33	0.02	0.58	8.26	11.45	0.005	0.02	0.04

, **: Significant at P= 0.05, and 0.01 respectively; Df: degrees of freedom; WAP: weeks after planting; No. = Number

Table 3: Combined analysis of variance for qualitative traits for the cowpea genotypes evaluated in Ibadan across two years

Source of variation	Df	Mean squares of ANOVA									
		Plant Hairiness (0-1)	V-Shape marking (0-1)	Pod shape (1-4)	Seed Shape (1-5)	Flower colour (1-5)	Aphids (1-5)	Thrips (1-5)	Maruca (1-5)	Virus severity (1-5)	Leaf damage (1-9)
Year	1	0.44**	1.00**	0.66	1.62	0.61*	196.00**	12.63**	0.21	0.72*	0.17
Rep(year)	4	0.11	0.00	0.31	0.46	0.08	2.55	0.71	0.27	0.34	0.09
Genotype	5	0.51**	0.40**	1.21**	1.42	0.37	4.71	1.99**	0.85**	1.20**	0.27
Year*Genotype	5	0.38**	0.40**	0.21	0.12	0.61**	3.8	2.02**	1.48**	0.31	0.27
Error	20	0.04	0.00	0.23	0.67	0.15	4.79	0.62	0.29	0.18	0.33

, **: Significant at P= 0.05, and 0.01 respectively; df: degree of freedom;
V-shape marking (0-1): 0 for absent, 1 for present; Plant hairiness (0-1): 0 = non hairy, 1 = hairy;
Aphids, Thrips, Maruca and Virus severity (1-5): 1 for no infection, 5 for severe infection; Leaf damage (1-9): 1 for no infestation, 9 for severe infestation; Pod shape (1-4): 1= curved, 2 = slightly curve, 3 = straight and 4 = coiled

Table 4: Mean performance of six cowpea genotypes for some quantitative and qualitative traits evaluated in Ibadan across two years

Genotype	Virus Incidence (%)	Virus severity (1-5)	Pod shape (1-4)	Plant height at 6WAP (cm)	Plant Hairiness (0-1)	V-Shape marking (0-1)	No. of leaves at 6WAP	Thrips severity? (1-5)	Maruca severity? (1-5)	Pods/peduncle	Days to 50% flowering	Seed weight/plot (kg/m²)
Campala	14.96	2.05	SC	12.96	0.00	0.00	28.50	2.00	1.80	3.50	51.67	0.10
Cotonou	2.21	1.33	ST	15.43	0.50	0.50	48.58	2.80	2.67	2.30	46.40	0.35
Ife brown	10.60	1.88	SC	12.57	0.00	0.00	40.62	2.17	2.17	3.21	49.83	0.08
Ife BPC	2.28	1.33	SC	16.09	0.67	0.00	63.67	3.50	1.83	4.58	52.00	0.17
ART/98-12	22.21	2.43	SC	15.71	0.00	0.50	49.73	3.17	1.83	3.68	45.67	0.24
Oloyin	16.96	2.15	CU	16.17	0.17	0.00	55.97	2.83	1.63	3.81	47.17	0.00
LSD	10.13	0.51	-	8.35	0.25	0.00	13.63	1.00	0.80	0.90	3.50	0.30
CV%	72.93	22.15	23.50	17.47	94.87	0.00	38.98	27.69	26.30	5.01	7.07	115.30

LSD: Least significant difference; WAP: weeks after planting;
Aphids, Thrips, Maruca and Virus severity (1-5): 1 for no infection, 5 for severe infection; V-shape marking (0-1): 0 for absence of mark, 1 for presence of mark Plant hairiness (0-1):1-hairy, 0 -non-hairy; Pod shape (1-4): 1-curved (CU), 2 -slightly curve (SC), 3 -straight (ST) and 4 –coiled (CO)

Table 5: Means of nutritional composition* of the six cowpea genotypes evaluated

Genotype	Crude Protein (%)	Crude fat (%)	Crude fibre (%)	Total ash (%)	Moisture Content (%)	Dry matter content (%)	(NFE) (%)	Calcium (mg/g)	Magnesium (mg/g)	Sodium (mg/g)	Potassium (mg/g)
Campala	21.80	2.74	5.09	3.85	10.51	89.50	56.01	3.37	4.87	1.52	1.41
Cotonou	22.86	3.21	4.92	3.66	10.85	89.15	54.50	6.43	7.22	1.47	1.56
Ife brown	22.62	2.64	4.84	3.96	11.53	88.48	54.43	3.02	4.16	1.73	1.33
Ife BPC	23.37	3.21	4.71	3.83	10.80	89.20	54.09	3.87	5.94	1.15	1.41
ART/98-12	21.15	2.61	5.12	3.95	10.57	89.44	56.25	2.73	3.17	1.36	1.17
Oloyin	23.92	3.10	4.55	3.59	10.45	89.56	54.40	5.01	4.54	1.39	1.25
LSD	0.25	0.04	0.08	0.45	0.05	0.05	0.22	0.14	0.03	0.02	0.04
CV (%)	0.42	0.55	0.03	0.46	0.19	0.02	0.16	1.34	0.24	0.62	0.01

NFE: Nitrogen free extract
* On dry weight basis; LSD: least significant difference

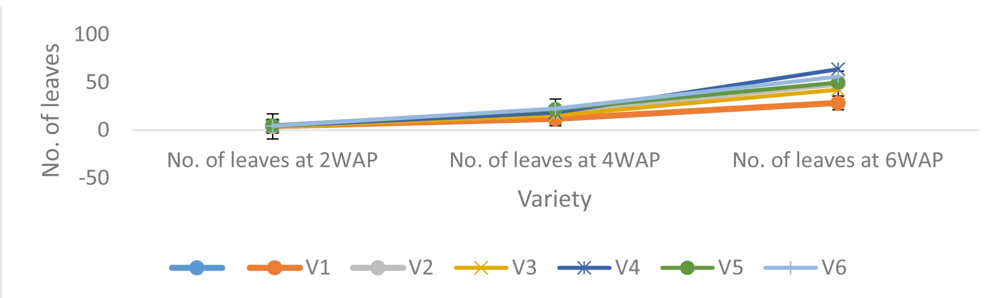

Figure 1: Number of leaves over 6 weeks for the cowpea genotypes evaluated

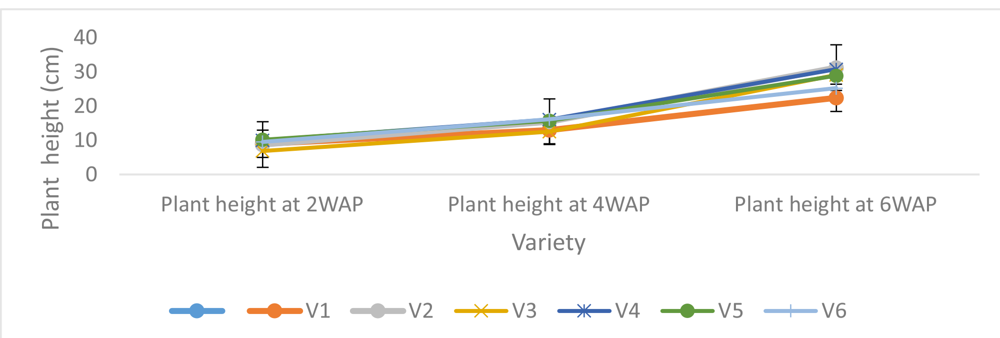

Figure 2: Plant height of the cowpea genotypes over 6 weeks of planting

Table 6: Phenotypic correlation among the qualitative (in rows) and quantitative (in column) traits of the cowpea genotypes

Traits	Viral incidence (%)	Bug (count)	Plant height (6WAP)	Number of leaves (6WAP)	Days to first flowering	Days to 50% flowering	pods/peduncle	Number of branch	Seed weight/plot (kg/m^2)	Pod wall thickness (mm)
Viral severity (1-5)	0.77**	0.20	-0.38*	-0.12	0.10	-0.16	-0.01	-0.02	-0.18	-0.17
Leaf damage (1-9)	0.02	0.37*	-0.12	-0.15	0.14	0.001	-0.16	0.06	0.08	-0.01
Flower thrips (1-5)	0.20	0.04	-0.43**	-0.43**	0.63**	0.30	-0.58**	0.13	0.01	0.14
Aphid (1-5)	-0.32*	-0.14	0.45**	0.63**	-0.49**	-0.18	0.68**	-0.23	-0.21	0.23
Maruca (1-5)	-0.34*	0.25	0.16	0.11	-0.33*	-0.09	-0.02	0.18	0.09	-0.24
Flower colour	-0.22	0.18	0.08	-0.01	-0.19	0.06	-0.09	0.07	-0.07	0.00
Plant hairiness (0-1)	-0.44**	-0.12	0.30	0.38*	-0.21	-0.21	0.04	0.20	0.35	0.26
V-shape marking (0-1)	-0.01	-0.19	0.48**	0.35*	-0.36*	-0.49**	0.11	0.10	0.67**	0.36
Pod shape	-0.24	-0.14	0.04	0.35	-0.14	-0.16	-0.20	0.23	0.56**	0.23
Seed shape	-0.04	-0.21	-0.31	-0.32	0.43*	0.01	-0.52*	0.19	-0.06	0.22

, **: Significant at P= 0.05, and 0.01 respectively; WAP: weeks after planting

Aphids, Thrips, Maruca and Virus severity (1-5): 1 for no infection, 5 for severe infection; V-shape marking (0-1): 0 for absence of mark, 1 for presence of mark; Plant hairiness (0-1): 0 for absence of hair, 1 for presence; Leaf damage (1-9): 1 for no damage of leaf, 9 for severe damage