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Interactive Influence of Location and Variety on Physiological Quality of Cowpea Seeds (*Vigna unguiculata* (L) Walp.)

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Authors' contributions

This work was carried out in collaboration among all authors. Author SAA designed and supervised the study, while author MO managed the study. Authors FEA and BSO co-supervised the study and performed the statistical analysis. Authors FEA and GOA wrote the manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The production environment plays a significant role in the production of high-quality seeds. Therefore, the knowledge of the relative contributions of the different factors that impact seed quality will be important for the management of seed production. The objective of this study was to assess the relative contribution of location and variety to the physiological quality of the cowpea seeds. Seeds of two varieties of cowpea, IT97K-918-118 and 977K-1499-35 were produced at three locations: Ikenne, Ilora, and Ballah. Hundred seed weight, seed moisture content, standard germination, accelerated ageing germination and electrical conductivity tests were carried out on the seeds. The results indicated that the location effect was highly significant (P<0.05) for hundred seed weight, germination percentage, germination rate index, accelerated ageing germination

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percentage and accelerated ageing germination rate index, while the varietal effect was highly significant for only hundred seed weight. However, location alone contributed more than 50% to the observed variability in hundred seed weight, germination percentage, germination rate index and accelerated ageing germination percentage. Seeds from Ballah had the highest viability (germination percentage = 84.67%) but also the lowest vigour (accelerated ageing germination = 11%; electrical conductivity = 64.10µs$cm^{-1}g^{-1}$). Thus, the modulating effect of the environment on the quality of cowpea seeds is not the same for the different components of quality and the choice of location for the production of cowpea seeds should be given a higher priority than a choice of variety *per se.*

Keywords: Cowpea; environment; physiological quality; variety; vigour.

1. INTRODUCTION

Cowpea (*Vigna unguiculata* (L) Walp) is grown over a wide range of agro-ecological conditions across Nigeria. It is a leguminous plant cultivated primarily for its young shoot or leaves, green and tender pods, dried mature and immature seeds. The dried edible seeds contain about 23 - 25% protein [1]. It is equally an important nutritious fodder for livestock [2]. However, the success of cowpea production is greatly influenced by the quality of seeds sown. Seed physiological quality is an assessment of the quality of life within the seed with respect to viability and vigour. Seed vigour is defined as the capacity of a seed lot to germinate and produce normal seedlings under various field conditions (i.e. the rate and uniformity of seedling emergence and stand establishment in the field) [3] and it is the most useful indicator of physiological seed quality. Seed vigour is a product of complex interactions of genetic and environmental factors [4].

Seed quality can be affected by genetic factors as differences exist among species and varieties. The maximum expression of physiological quality is dependent on the genetic make-up, environment and nutrition of the mother plant [3]. Each variety has a specified genetic construct and its expression may be affected to some level by the environment of growth [5]. A minimal relative contribution of Variety to the response of cowpea seeds to storage quality was reported and the variation was attributed to the differences in their chemical composition and other inherent traits of the cowpea varieties [6].

According to [7], the impact of environmental factors on seed quality is greater than that of genetic make-up and it accounts for the majority of variations observed in seed quality. The most obvious environmental factor influencing the climate of a location is its latitude. It affects solar inclination throughout the year-leading to seasonal changes in temperature [8]. The production environment of a crop encompasses the soil type, solar radiation, temperature, amount of rainfall and ambient relative humidity which the crop is exposed to during its growth at a particular location [9]. Environmental factors such as soil moisture and fertility, seed maturity and pre-harvest environment affect the quality of seeds, differences in environmental conditions during development and maturation, the length of seed filling period, concentrations of fat, soluble carbohydrates, proteins and starch have also been identified as potential causes of differences in seed vigour [10].

Germination capacity and vigour are intrinsic properties of the seed that affects its quality. Seed germinability is affected by maternal effects such as temperature, photoperiod, light quality (red/far red ratio), water stress, and positions of seed in fruit and fruit on plant [11]. The uniformity and rate of germination are important agronomic traits, especially in crops that are sown directly in the field, which are influenced by environmental conditions [12]. However, there is a dearth of information on the interplay of factors responsible for seed quality development in cowpea. The objective of this study was therefore to assess the relative contribution of location and variety to the physiological quality of cowpea seeds.

2. MATERIALS AND METHODS

The experiment was conducted using two cowpea varieties: 977K-1499-35 and IT97K-819-118, grown at three production locations: Ikenne (Lat. $6^0 54N^1$ and Long. $3^0 42^1$ E), Ilora (Lat. $7^0$45N, Long. $3^0 42^1$E) and Ballah (Lat. $8^0$30'N, and Long. $4^0$33E). The experiment was laid out in a Randomized complete block design. The seeds were harvested at harvest maturity and seed quality tests were carried out according to ISTA [13] procedures, at the Seed Science Laboratory, Department of Crop Production and

Protection, Obafemi Awolowo University, Ile-Ife, Nigeria.

2.1 Hundred Seed Weight (HSW)

One hundred apparently intact seeds in three replicates for each cultivar and location were weighed and recorded.

2.2 Seed Moisture Content (MC)

Seed moisture content was determined gravimetrically. The initial weights of 10 seeds in triplicates from each variety and location were taken and thereafter placed in the oven at 103±3ºC for 24 h. The seeds were re-weighed after 24 h until a constant weight was reached. The seed moisture content (MC) was calculated as:

$$MC = \frac{\text{Initial weight- Final weight x 100}}{\text{Initial weight}}$$

2.3 Seed Germination Test

One hundred seeds of each variety in three replicates were sown in a plastic bowl half-filled with sterilized riverbed sand. The first and final counts were made on the 3rd and 9th day after sowing, respectively. Germination was assessed as the percentage (GPCT) of seeds producing normal seedlings.

GPCT = Total No of seedlings that emerged on the final count x 100 / Total No of seeds sown

GI = ∑ (Nx)(DAS) / Total No of seedlings that emerged on the final count

where, Nx is the number of seedlings that emerged on day X after sowing, DAS is the day after sowing.

2.4 Accelerated Ageing Test

Fifty seeds of each variety in three replicates were weighed and placed on a mesh over 40 ml of distilled water in accelerated ageing boxes which were then set in an accelerated ageing chamber for 72 h at 43^{0}C. Seeds were re-weighed after being placed in the chamber to calculate moisture gained during ageing. Seeds were later sown in sterilized riverbed sand and seedlings were evaluated for 9 days.

AAT = Total No of seedlings that emerged on the final count x 100 / Total No of seeds sown
AAI = ∑ (Nx)(DAP) / Total no of seedlings that emerged on the final count

Where Nx is the number of seedlings that emerged on day x after sowing, DAP is the day after sowing.

2.5 Electrical Conductivity Test

Fifty apparently intact seeds of each variety were weighed in three replicates and then soaked for 24 h in 200 ml conical flasks containing 100 ml of distilled water. The flasks were covered with aluminium foil to prevent contamination and shaken intermittently. Electrical conductivity of the seeds was measured with Jenway 4510 (Staffordshire, UK) conductivity meter and expressed in $\mu Scm^{-1} g^{-1}$.

Conductivity (COND) = Conductivity (µS) of each beaker – Conductivity of distilled / Weight (g) of seed sample

2.6 Statistical Analysis

The results were statistically analysed using the generalized model (GLM) procedure of SAS [14]. The differences between the means were estimated by Duncan's multiple range test at a significance level of 5%.

3. RESULTS

Location was significant (P<0.01) for hundred seed weight, germination percentage, accelerated ageing germination percentage and accelerated ageing germination index, while the coefficient of determination (R^2) for the same parameters ranged from 69% - 94% (Table 1). Variety and the interaction between variety and location had significant effects on hundred seed weight only. The contribution of Location to the total observed variability was 50% for hundred seed weight, 64% for germination and 79% for accelerated ageing germination percentage while the similar contributions of Variety was only 36.89% for hundred seed weight and much lower for other traits (Table 2). However, the combined contribution of unaccounted sources of variability was higher for seed moisture content (54.94%), germination index (65.94%) and accelerated ageing germination index (58.33%).

Table 1. Mean square values from the analysis of variance for quality traits in seeds of cowpea varieties produced at the three locations

Variables	df	HSW	MC	GPCT	GI	AAT	AAI	COND
REP	2	0.20	2.15	66.67	0.02	24.89	0.62	73.58
LOC	2	7.57**	0.95	1528.67**	0.07	907.56**	0.002	224.42*
VAR	1	11.12**	1.54	50.00	0.05	10.89	4.78	148.08
LOC x VAR	2	0.88*	0.23	144.67	0.003	59.56	1.94	122.99
CV		2.69	7.65	14.05	6.59	43.51	30.60	11.91
R^2%		94.34	45.06	79.61	34.06	84.10	42.61	63.39

**, **indicates significance at P = 0.05 and 0.01 levels of probability, respectively*

REP – Replication VAR – Variety CV – Coefficient of Variation
R^2% - Coefficient of Determination HSW – Hundred seed weight (g) MC–Seed Moisture Content (%)
GPCT – Germination percentage (%) GI – Germination index (days) AAT – Accelerated ageing germination percentage (%) AAI – Accelerated ageing germination index (days)
COND – Electrical conductivity test (μScm⁻¹ g⁻¹) LOC – Location

Table 2. Percentage Relative contributions of the sources of variation to the total sum of squares

TEST	REP	LOC	VAR	LOC x VAR	ERROR
HSW	1.33	50.20	36.89	5.91	5.63
MC	23.60	10.38	8.46	2.56	54.94
GPCT	4.80	64.41	0.17	4.60	25.95
GI	9.80	20.19	7.10	11.67	65.94
AAT	25.00	78.60	0.06	4.60	14.00
AAI	5.20	0.01	19.98	16.29	58.33
COND	9.00	28.70	9.00	15.75	36.60

REP – Replication VAR – Variety CV – Coefficient of Variation
R^2% - Coefficient of Determination HSW – Hundred seed weight (g) MC – Seed Moisture Content (%)
GPCT – Germination percentage (%) GI – Germination index (days) AAT – Accelerated ageing germination percentage (%)
AAI – Accelerated ageing germination index (days)
COND – Electrical conductivity test (μScm⁻¹ g⁻¹) LOC – Location

Table 3. Location and variety mean values for hundred seed weight, moisture content and germination parameters

VARIABLE		HSW	MC	GPCT	GI	AAGPCT	AAGI	COND
LOC	Ilora	16.02^a	13.44^a	53.00^c	3.28^a	3.67^b	3.83^a	69.25^a
	Ballah	16.03^a	13.13^a	84.67^a	3.08^a	11.00^b	3.86^a	64.10^{a,b}
	Ikenne	14.08^b	12.65^a	65.33^b	3.12^a	27.67^a	12.08^b	57.07^b
	Mean	15.37	13.07	67.67	3.16	14.11	6.59	63.47
VAR	1	16.16a	13.37a	66.00a	3.11a	14.89a	4.37a	60.61a
	2	14.59b	12.78a	69.33a	3.21a	13.11a	3.34a	66.34a
	Mean	15.38	13.08	67.67	3.16	14.00	3.86	63.48

VAR – Variety CV – Coefficient of Variation
R^2% - Coefficient of Determination HSW – Hundred seed weight (g) MC – Seed Moisture Content (%)
GPCT – Germination percentage (%) GI – Germination index (days) AAT – Accelerated ageing germination percentage (%) AAI – Accelerated ageing germination index (days)
COND – Electrical conductivity test (μScm⁻¹ g⁻¹) LOC – Location

A comparison of the mean values for location effect showed that seeds from Ilora and Ballah were significantly different from Ikenne for physical quality, that is, one hundred seed weight (Table 3). The mean conductivity value for Ilora was the highest, 69.25 μScm⁻¹g⁻¹, its accelerated ageing germination percentage 3.67% and germination percentage 53.00% was the least. Seeds produced at Ilora therefore had the lowest vigour and viability. Even though, seeds produced at Ballah had the highest germination percentage 84.67%, their vigour was low being 11% for accelerated ageing germination percentage and 64.10 $\mu Scm^{-1}g^{-1}$ electrical conductivity value compared to Ikenne.

4. DISCUSSION

The effect of location *per se* on seed quality was much higher than that of the inherent attributes of cowpea variety. This corroborates the report of [7] that the effect of the environment on seed quality is much greater than the genetic effect. It was further noted that among various factors affecting seed quality, the genetic effect is at minimal in comparison with the environmental effect [15]. This then implies that the choice of seed production location should be given a higher priority when taking seed production decisions. The significant interaction effect also suggests that there is a need to identify locations at which the seed quality of specific varieties is highest. According to [15], genetic differences exist among cultivars for the ability to acquire and maintain good seed quality in different environments. The seed physical trait, measured by hundred seed weight revealed significant differences between the two cowpea varieties used in this study. Changes were reported in cowpea seed sizes with respect to seasonal variation, which also influenced the biochemical composition (protein, potassium and calcium contents) of the cowpea seeds [16].

The seed moisture content of the varieties from the three locations were similar and fairly above 10% as recommended [6] for the storage of cowpea seeds. Therefore, the seed moisture content did not bias the viability and vigour of the seeds produced from the locations.

Seeds produced at Ballah had high germination but lower vigour when compared with Ikenne. The detection of low vigour was a problem of manifestation rather than of genetic limitation because there was massive mould growth in the seeds from Ballah when subjected to accelerated ageing test, compared to seeds from the other two locations. Nevertheless, these seeds however still exhibited high germination potential. Low seed vigour does not directly hinder the ability of the plants to express their genetic potential for maximum yield [15]. The inability of seeds to maintain vigour for a long period poses storage problems [17]. This highlights one of the major challenges for the production of high-quality seeds. While it is impossible to separate the development of viability and vigour in a seed or seed lot, the acquisition of one component can be independent of the other. Possibly, the high amount of rainfall at Ikenne also caused significant damage to seed viability and vigour through pathogen infestations and precocious germination, that reduced seed viability and vigour. This is in agreement with the report that heavy rainfall exerts pest pressure, excessive vegetative growth that results in few pods and lower seed yield [18]. Though there was variation in the germination percentage across the location, the speed of germination as measured by the germination index was the same. Hence the environmental effect on seed quality was greater than the genetic effect, which accounted for a significant amount of variability in seed quality traits. The high proportion of the contributions of unaccounted sources of variation is clear evidence that many other factors apart from variety and location of production contribute significantly to the viability and vigour of cowpea seeds and such factors include season and date of harvest.

5. CONCLUSION

The seed production location of any crop is vital to the physiological quality of the seeds. The modulating effect of the environment on the quality of cowpea seeds is not the same for the different components of quality and the choice of location for the production of cowpea seeds should be given a higher priority than a choice of variety *per se.*

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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