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Contents

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PHYSIOLOGICAL QUALITY OF COWPEA (*Vigna unguiculata* L. Walp) VARIETIES SEEDS OBTAINED FROM PLANTS SOWN IN SEQUENTIAL CROPPING SYSTEM

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ABSTRACT
Cowpea is the major staple pulse crop in sub-Saharan Africa for household nutrition but there is the need to intensify the production of the crop to meet the growing demand. This study aimed to determine the physiological quality of cowpea seeds produced in sequential cropping system. The treatments were factorial combination of seeds obtained from five varieties of cowpea (IT90K-76, IT93K-452-1, IT99K-573-1-1, TVX 3236, Oloyin) planted in two sequence within a growing season. The first planting of the varieties was done in May as soon as the rain started in the study area and they were harvested at different dates between August and September depending on the variety. The second sequence of planting was done immediately after the harvest of the first planting and harvested at different dates between November and December depending on the variety. Data were collected on seed weight, germination percentage and seedling vigour index. Results showed that all the varieties produced significantly heavier seeds in the second sequence than the first except IT93K-452-1 and TVX 3236 plants which produced similar seed weight in the two sequence. Cowpea seeds obtained in the second sequence of planting recorded significantly higher ($P<0.05$) germination percentage and seedling vigour index than seeds obtained in the first sequence except in IT93K-452-1 and TVX 3236 variety which maintained similar germination percentage in the two sequence before storage. Significant variation existed in the viability and seedling vigour of the varieties in storage. Variety IT93K-452-1 stored better, maintaining significantly higher ($P<0.05$) germination percentage and seedling vigour after storage than the other varieties assessed. This implies that IT90K-76, IT99K-573-1-1 and Oloyin seeds obtained from the first sequence of planting are better used as grains but IT93k-452-1 will produce high quality seeds and store significantly longer regardless of time of harvest.

Keywords: Cowpea, Varieties, Germination percentage, Vigour.

INTRODUCTION

Cowpea (*Vigna unguiculata* L. Walp) is an important grain legume in Africa and tropical regions of Latin America and South Asia (Esmaeilzadeh-Hosseini *et al*., 2023). It is a major staple food crop for household nutrition in sub-Saharan Africa, especially in the dry savanna regions of West Africa (Omoigui *et al*., 2018). It plays an important role in food and nutrition security and serve as source of income for farmers and other stakeholders in the value chain. Due to its high nutritional value, cowpea grains are utilized as cheap protein source and food complement in a wide variety of dishes. There is a growing high demand for cowpea. In a bid to meet this demand, much of the focus by farmers has been on increasing the areas under cultivation with little success in increasing the yield per unit area. The yield in sub-Saharan Africa has been very low with just about 24 to 40% of the potential yield obtained on farmers' fields (Omomowo, 2021). A wide gap still exists between the demand for the crop and the supply which explains the recent increase in the price of the crop in Nigeria markets. The poor quality of seeds used by farmers have been identified as a limiting factor contributing to low yields in cowpea (Odindo, 2007, Njojo *et al*., 2019). Availability of quality seeds of improved, high yielding varieties to local farmers is still a bottleneck for increasing the grain yield of cowpea.

Seed is an important input for agricultural production. Improving the availability of high-quality seeds of improved varieties is important to boost agricultural productivity, leading to higher farmers' income, reduced poverty and improved food security (Abdoulaye *et al*., 2009). Seed quality includes genetic quality, physical quality, physiological quality and seed health

(Louwaars, 2007). Physiological quality refers to the seeds' ability to germinate, emerge from the soil and form a vigorous seedling, especially under the stressful conditions prevailing in the fields of most small-holder farmers. Physiological quality is essential to create an optimal and uniform plant density with minimum seeding rates. Physiological quality is influenced by environmental conditions during crop growth, harvesting and storage conditions (Ghassemi-Golezani and Mazloomi-Oskooyi, 2008).

The only way to increase agricultural production is to increase the yield of individual crop per unit area of land, as food requirements have increased over the years while land availability has become less due to increase in population and urban development. There is the need to intensify the production of cowpea to increase the yield per unit area to meet the growing demand. Sequential cropping system refers to growing two or more crops in sequence on the same field per year; the succeeding crop is planted after the preceding crop has been harvested. It is an option to increase the productivity of crop from a unit of land. Its adoption may substitute for expanding cropland acreage which may not always be available and sustainable due to increase in population and urbanization. In an attempt to increase the productivity of crops using the sequential cropping system, it is equally important to evaluate the quality of the seeds obtained in the system as majority of small-holder farmers in developing countries depend on their own saved seed from their crop harvest; the informal seed system. In their survey, Njonjo *et al.* (2019) reported that over 76% of cowpea farmers used farm-saved seeds for propagation. In such a system, seed quality remains unknown (Van Gastel *et al*., 2002). Hence, this study aimed to evaluate the quality of seeds obtained from cowpea varieties planted in sequential cropping system.

MATERIALS AND METHODS

The experiment was carried out in the Crop Production laboratory, Federal University of Technology Minna, Nigeria. The treatments were seeds harvested from five varieties of cowpea (IT93K-452-1 (SAMPEA 8), IT99K-573-1-1 (SAMPEA 14), TVX 3236, IT90K-76 and Oloyin) and two sequence of planting. These were factorially combined and arranged in completely randomized design with three replicates. The plants that produced the seeds harvested in the first sequence were planted on May 5th, 2017 and the second sequence was planted immediately after the harvest of the first planting (in different dates between August and September, 2017 depending on the variety). The second sequence of planting was harvested at varying dates in November and December depending on the variety.

The seeds from all the treatment combinations were collected in small plastic containers stored at initial moisture content of 12% for two weeks after each harvest before testing the quality. The containers were then stored in the incubator at 41.56ºC and relative humidity of 81.2% for 10 weeks to accelerate the ageing process. Data were collected on 100-seed weight in which three replicates of hundred seeds were counted and weighed on a Mettler balance and the means recorded. Seed viability was tested using the seed germination test following the procedures of ISTA (2003). Twent-five seeds in three replicates were taken from each of the lot stored in the incubator every 2 weeks. They were placed in paper towels moistened with 10 ml of distilled water. The paper towel were placed inside a germination chamber and seedlings evaluated at 1 to 7 days after sowing. Germination percentage (GP) was then expressed as:

$$\frac{\text{Number of nor-mal seedlings}}{\text{No of total seeds tested}} x\ 100$$

At seven days, ten normal seedlings were randomly selected from each replicate and the plumule length was measured with the aid of a meter rule and the average found. Seedling vigour index (SVI) was then calculated as follows:

$$SVI = \frac{\textit{seedling plumule length x germination percentage}}{100}$$

Data collected were subjected to analysis of variance (ANOVA) using SAS version 9.1. Means were separated using Duncan multiple range test at P=0.05. Where significant interaction exists throughout the sampling period, interaction means at 0, 6 and 10 weeks are presented.

RESULTS

Plants sown in the second sequence produced significantly heavier seeds (15.37 g) than plant sown in the first sequence (13.89 g). There was significant difference (P<0.01) among the seed weight of the varieties; the order of performance in respect of seed weight was Oloyin > IT99K-573-1-1 > IT90K-76 > IT93K-452-1> TVX

3236. However, there was no significant difference between the values recorded in IT99K-573-1-1 and IT90K-76 (Table 1). The interaction effect of sequence of planting and variety on seed weight was highly significant (P<0.01). All the varieties produced significantly heavier seeds in the second sequence than the first except IT93K-452-1 and TVX 3236 plants which produced similar seed weight in the two sequence (Figure 1).

Seeds obtained from plants sown in the second sequence had significantly higher germination percentage than those obtained in the first sequence of planting throughout the storage period. Among the varieties, Oloyin had significantly highest germination percentage (68.11%) before storage, followed by IT99K-573-1-1 similar to IT90K-76 and the least was observed in TVX 3236 (38%). There was variation in the germination response of the varieties throughout the storage period and GP declined as the storage period progressed from 2 to 10 Weeks in storage (WIS). At 10 WIS, only seeds of IT93K-452-1 remained viable as other varieties had lost their viability at this stage.

Highly significant interactions (P<0.001) existed between the sequence of planting and variety on germination percentage throughout the sampling period. Before storage (0 WIS), there was no significant difference between the germination percentage of seeds obtained in the two sequence of planting in IT93K-452-1 and TVX 3236 varieties. However, in the other varieties, seeds harvested in the second sequence of planting had significantly higher GP than those harvested in the first sequence. At mid storage (6 WIS), all the seeds of the varieties harvested in the second sequence of planting had significantly higher GP than those harvested in the first sequence except IT99K-573-1-1 which had similar GP in both sequence. IT93K-452-1 sown in the second sequence maintained significantly higher GP (100%) than the other varieties whose GP ranged between 57-85% in the second sequence. The least GP in this sequence was obtained in IT99K-573-1-1 (12%). At late storage, there was no significant difference between the GP obtained at 1st and 2nd sequence of planting among all the varieties as most have lost their viability except IT93K-452-1 in which seeds obtained in the second sequence of planting had significantly higher GP (28%) than those obtained in the first sequence (1.33%) (Figure 2).

Seeds obtained in the second sequence had significantly higher seedling vigour index than those obtained in the first sequence throughout the sampling period (Table 2). Among the varieties, TVX 3236 had significantly highest vigour (12.30) before storage followed by IT93K-452-1 (10.15). The least was recorded in IT90K-76 (1.00) similar to Oloyin (2.60). Significant variation existed between the vigour of the varieties in storage, however, IT93K-452-1 maintained significantly higher vigour than the remaining varieties in storage. At late storage (9 WIS), IT99K-573-1-1 and Oloyin had lost their vigour completely and by 10 WIS, all the varieties except IT93K-452-1 had completely lost vigour.

The interaction between sequence of planting and variety on seedling vigour index was significant (P<0.05) throughout the sampling period. Before storage (0 WIS), IT99K-573-1-1 and IT90K-76 planted in the first sequence had similar vigour with those planted in the second sequence. For the remaining varieties however, seeds obtained in the second sequence of planting had significantly higher SVI than those obtained in the first planting. Among the plants sown in the first sequence, TVX 3236 had significantly highest SVI (10.72) followed by IT93K-452-1 (6.16) similar to IT99K-573-1-1 (4.80) and the least was recorded in IT90K-76 (0.90) similar to Oloyin variety (1.16). Among the seeds obtained in the second sequence, IT93K-452-1 had the significantly highest SVI (14.13) similar to TVX 3236 (13.87). The least was recorded in IT90K-76 (1.10).

At 6 WIS, there was no significant difference between the vigour recorded in seeds obtained in the two sequence except in IT93K-452-1 and IT90K-76 in which seeds obtained in the second sequence had significantly higher SVI than the first. IT93K-452-1 maintained significantly higher SVI in 1st and 2nd sequence of planting at mid storage (3.43 and 16.73 respectively). At this storage period, seeds of IT99K-573-1-1 harvested in both sequence had completely lost vigour similar to the seeds of IT90K-76 and Oloyin harvested in the first sequence of planting. At late storage (10 WIS), all the varieties planted in both sequence had lost their viability except IT93k-452-1 obtained in the second sequence.

DISCUSSION

The difference in the germination percentage and vigour of seeds recorded in the two sequence could be attributed to the different environmental conditions prevalent at the period of production of the mother plants. Temperature, photoperiod, water deficits and soil fertility are known for their effects on seed mass, number and quality (Gutterman, 1992; Bewley and Black, 1994; Dornbos, 1995; Wulf, 1995). Temperature was reported to influence seed germination and vigour. High temperatures during seed development was reported to cause early pod ripening and rapid seed maturation and result in small, poor quality seeds in common beans (Siddique and Goodwin, 1980) and annual rye grass (Steadman *et al*., 2004). In seeds of bean, wheat and barley, lower temperatures during and after seed filling significantly influenced the development of seed quality by extending the post maturation phase, resulting in seeds with higher potential longevity (Ellis and Filho, 1992; Sanhewe and Ellis, 1996).

The decline in the Germination percentage and vigour of the seeds with increase in storage period is as a result of ageing. Seed ageing and deterioration affects both seed germination and seed vigour (Mohammadi *et al*., 2011). Seed deterioration is inevitable but the rate can be reduced by paying due attention to the temperature and relative humidity during storage (Adetumbi *et al*., 2009). The accelerating aging test is to predict seed storability. As done in this study, it exposes seeds for short periods to high temperature and high relative humidity, which cause rapid seed deterioration. High vigor seed lots will withstand these stressful conditions, deteriorate at a slower rate and have high germination following aging, compared to low vigor seed lots. The significantly higher germination percentage and vigor index obtained in IT93K-452-1 in storage in this study suggest that the variety will store longer and withstand adverse storage condition better than the other varieties tested.

The significantly lower GP recorded in TVX 3236 compared to the remaining varieties could be attributed to the smaller seed size obtained in this variety. Similar result was reported by Samreen and Shahid (2000) who reported that GP depended on seed size with large seeds having highest GP. Genetic variation is the major cause of variation in size of seed between varieties. The trend of GP observed in this study followed similar trend with the 100 seed weight. The insignificant difference between the GP (at early storage) of TVX-3236 seeds obtained in the two sequence, and the highest value of seedling vigour obtained in the first sequence in this variety could indicate that viable and vigorous seeds could be obtained from this variety irrespective of the production period provided the seeds will not be stored for long. This implies that farmers can multiply these seed early in the season (as soon as rain is established) to produce seeds for the major planting in August to September which is around the time local farmers plant cowpea in the southern guinea savanna of Nigeria. However, if the farmer is to store the seeds for long, seeds harvested in the second sequence of planting (from plants sown in August) is preferable. The significant variation that existed in the varieties in respect of viability, vigour and longevity could be attributed to the variation in the genetic make-up of the varieties.

The higher GP obtained in IT93K-452-1 seeds at 2-6 WIS (100%) compared to the 55% obtained before storage (0 WIS) could be an indication that the variety exhibits some dormancy. Seed dormancy is a physiological adaptation to environmental heterogeneity (Bewly *et al*., 2013). Dormancy provides a strategy for seed to spread germination in time to reduce the risk of plant death and possible species extinction in an unfavourable environment. Previous study on this variety revealed that the rate of imbibition was slower in this variety than the other five varieties tested. The authors attributed the slow imbibition rate to slow permeability of the testa and seed composition (Wada and Abubakar, 2013). Seed testa exerts its role to protect the embryo against adverse environmental condition by controlling germination through dormancy imposition by limiting the detrimental activity of physical and biological agents during seed storage. This could have contributed to the significantly higher viability and vigour recorded in IT93K-452-1 at late storage. This implies that this variety could store longer than the remaining varieties and it is a reflection of the genetic quality of the variety.

CONCLUSION

Variety IT93K-452-1 was superior in quality parameters (germination percentage, seedling vigour index and longevity) than the other varieties assessed. Also cowpea seeds obtained in the second sequence had better quality than those obtained in the first sequence. However viable and vigorous seeds can be obtained in TVX-3236 produced in two sequence within a growing season in the southern guinea savanna of Nigeria.

RECOMMENDATION

Cowpea seeds of IT90K-76, IT99K-573-1-1 and Oloyin harvested in the first sequence should be used as grains while those harvested in the second sequence can be used as seeds. Seeds of TVX 3236 and IT93K-452-1 will produce quality seeds irrespective of when harvested but IT93K-452-1 variety can be recommended as the best variety with the highest seed quality among those tested.

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Table 1: Effect of sequential cropping system on 100 seed weight (g) and germination percentage (%) of cowpea varieties.

Treatments		Germination percentage (Weeks in storage)					
Sequence of planting (S)	100-seed weight	0	2	4	6	8	10
1st planting	13.89b	55.55b	29.87b	12.53b	6.93b	7.73b	0.27b
2nd planting	15.37a	61.47a	80.00a	64.27a	33.33a	26.13a	6.67a
SE±	0.12	0.49	2.79	1.46	1.85	0.20	0.73
Varieties (V)							
IT93K-452-1	14.20c	56.80c	76.67a	68.67a	61.33a	50.67a	14.67a
IT99K-573-1-1	16.24b	64.94b	30.67c	8.00d	2.00d	0.67d	0.00b
TVX 3236	9.68d	38.71d	78.00a	44.00b	16.67b	16.67b	0.00b
IT90K-76	16.00b	64.01b	50.67b	42.67b	13.33bc	10.67bc	2.00b
Oloyin	17.03a	68.11a	38.67c	28.67c	7.33c	6.67c	0.00b
SE ±	± 0.20	0.78	3.75	2.31	2.93	2.37	1.16
Interaction							
S x V	**	**	**	**	**	**	**

Means followed by similar alphabets within the same factor and column are not significantly different using Duncan multiple range test at P=0.05, **- Highly significant (P ≤0.01)

Table 2: Effect of sequential cropping system on seedling vigour index of cowpea varieties.

Treatments	**Weeks in storage**					
Sequence of planting (S)	0	2	4	6	8	10
1st planting	4.75b	2.94b	1.57b	1.00b	0.64b	0.00b
2nd planting	7.86a	6.04a	8.72a	4.68a	2.44a	0.54a
SE±	0.44	0.40	0.47	0.24	0.20	0.07
Varieties (V)						
IT93K-452-1	10.15b	8.38a	11.50a	10.10a	5.36a	1.36a
IT99K-573-1-1	5.54c	3.02c	0.81c	0.00d	0.00c	0.00b
TVX 3236	12.30a	5.03b	4.76b	2.15b	1.38b	0.00b
IT90K-76	1.00d	3.27bc	4.74b	1.27c	0.96b	0.00b
Oloyin	2.60d	2.76c	3.89b	0.71cd	0.00c	0.00b
SE ±	0.78	0.62	0.74	0.39	0.32	0.11
Interaction						
S x V	**	**	*	**	**	**

Means followed by similar alphabets within the same factor and column are not significantly different using Duncan multiple range test at P=0.05. **- Highly significant (P ≤0.01)

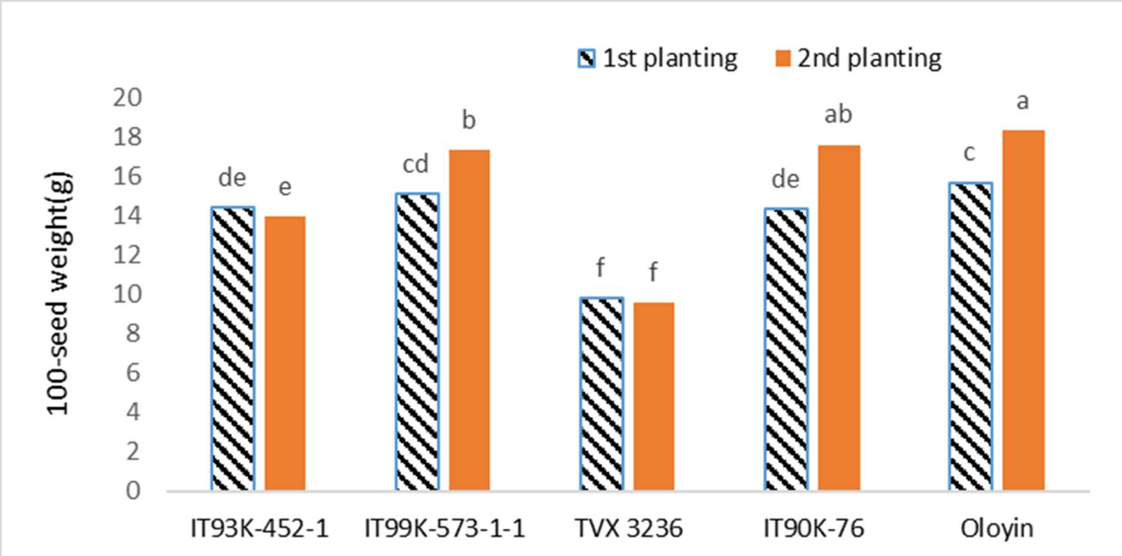

Figure 1: Interaction between sequence of planting and variety on hundred seed weight of cowpea

Bars carrying similar alphabets are not significantly different using DMRT at P =0.05

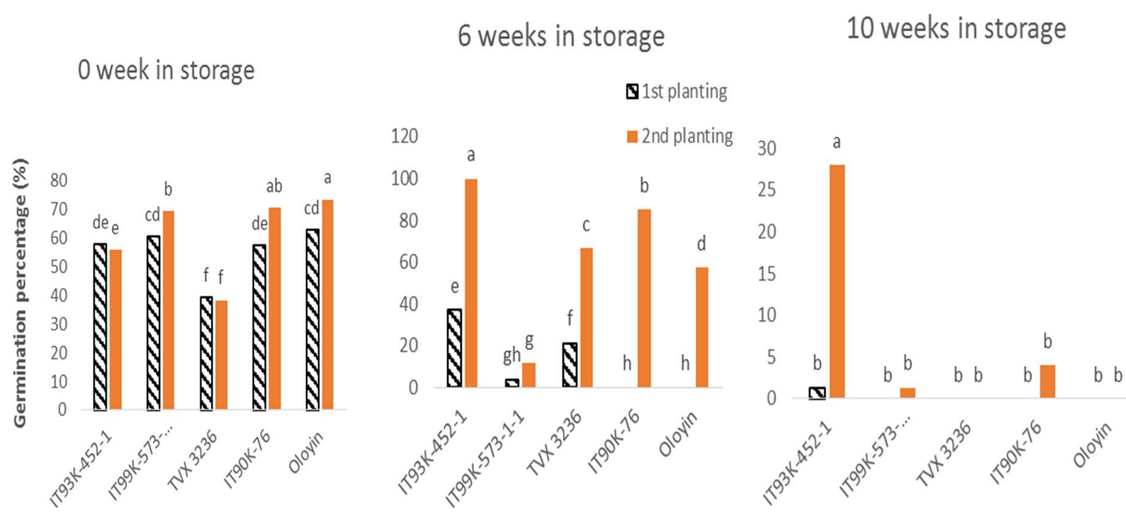

Figure 2: Interaction effect of sequence of planting and variety on germination percentage of cowpea

Bars carrying similar alphabets are not significantly different using DMRT at P =0.05

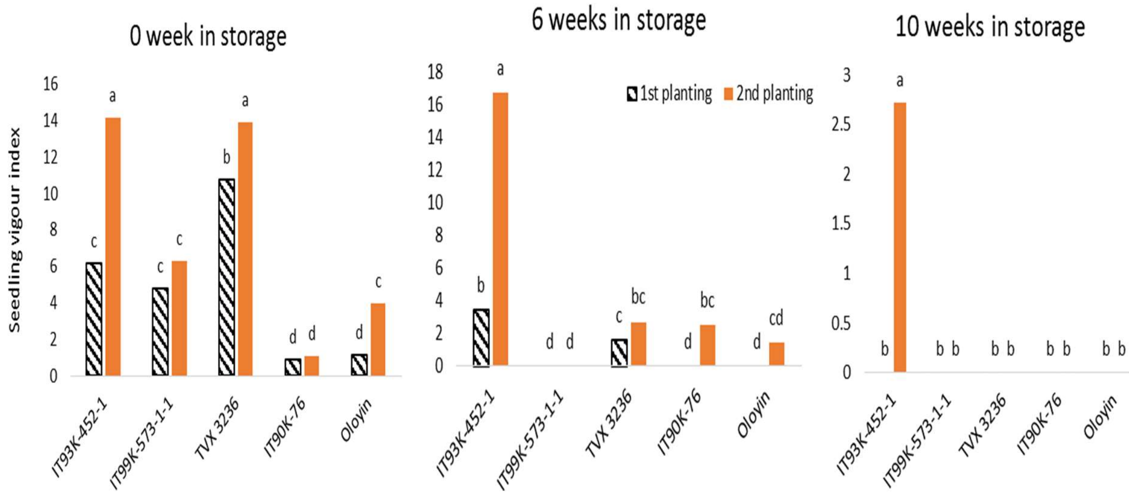

Figure 3: Interaction effect of sequence of planting and variety on seedling vigour index of cowpea
Bars carrying similar alphabets are not significantly different using DMRT at P =0.05