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Research Article

Effect of time of harvest at different moisture contents on physiological and storability attributes of pigeon pea (*Cajanus cajan*)

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ABSTRACT

This study evaluated the effect of time of harvest at different moisture contents on physiological attributes and storability potential of pigeon pea in the tropics. The field experiment with ten pigeon pea genotypes was done in a Randomized Completely Block Design (RCBD) with three replications. The seeds were harvested at maturity on the field at 12, 15 and 17 % moisture content. Harvested seeds from each treatment were divided into three seed lots of 400g each with three (3) replicate each. Packaged seed lots of each treatment were stored under ambient environment. For a total of 240 days, seed samples from each packaged seed lot were collected for analysis at 30-day intervals. The following physiological attributes were evaluated-; Standard germination, Seedling Vigor Index, Acceleration ageing and mean Germination index. Data collected from the above experiment on different characters were subjected to analysis of variance. The study concludes that the anticipation of harvest and drying seed at moisture content above 12 and 15 % in pigeon pea on the field resulted in low and poor physiological performance. Also, pigeon pea harvested with higher moisture (17%) are more susceptible to damage which cause lower viability and seedling vigor with corresponding higher mean germination time. The study showed that, best results across the evaluated attributes during the time of storage were associated with genotypes with the lowest and moderate percentage of moisture at harvest. Hence, lower seed moisture has better physiological performance and therefore, optimal harvest timing for pigeon pea seeds should be at 12 or 15% moisture content but preferably, 15% in other to reduce the rate of seed scattering and wastages through explosive mechanism on the field.

INTRODUCTION

Seed is essential to man's survival as it is an important ingredient in modern Agriculture. Numerous variables, including as the moisture content at harvest and the drying temperature, may have an impact on the physical quality and physiological performance of seeds. [1] reported that seed testing has been developed to minimize the risk of unfavorable factors endangering seed quality by evaluating the quality of seed before they are planted. The seeds of this plant can be dried to a low moisture content without appreciably affecting their viability because pigeon peas are orthodox in nature. According to research by Lisboa et al. [2] on pigeon peas and Rani et al. [3] on pinto beans, one of the key elements affecting seed lifetime is the environment's seed moisture content during storage. Within reason, the higher the moisture content of the seed, the quicker the potential for germination will decline and, ultimately, the lower the overall quality of the seed will be. Harvesting of pigeon peas typically starts when the grain moisture content is between 12 and 15% [4]. According to [5], with good management strategies, the longevity and agricultural productivity of cereals can be enhanced. [5] further reported that grain moisture content is a key indicator of the appropriate harvest period of seeds on the field and could also be used to effectively stabilize cereal products and further increase farmers' income. Researchers among which are [6] reported that harvesting moisture content of legumes can go a long way to determine the green immature grains rate and cracked pod rate, which affect grain quality. Majumdar [7] also stated that there is a risk that postponing harvesting could increase the susceptibility of seeds to environmental harm. Thus, in order to stop the problem, seeds must be harvested at the moment of physiological development, or even better, at harvest maturity. Numerous artificial drying methods aid in the quick reduction of seeds' moisture content, maintaining their quality and stability while facilitating storage. However, according to Garcia [8], the drying process can set off chemical, physical, and biological reactions that can harm seeds' physiological function and physical quality.

In addition, [9] reported that, the harvest moisture content of diverse crop varieties can ultimately affect the quality of different crops to an extent. High moisture content decreases the quality of pigeon peas by increasing the rate of cracked dried pods and increasing the cost, time, damage, and carbon emissions associated with drying grains. [7]. The resultant effect of grain moisture content can varies even within the same seed lot when dried together, grains with high moisture content will continually reduce while grains with low moisture content are over-dried until the moisture content is below 12%, causing drastic increase in rates of cracks of the pods, decreasing the quality of the pigeon pea, and vastly affecting pigeon pea products and revenue [10] reported that for maximum yield of legumes crops, factors like time of sowing, harvesting and, post-harvest management are very germane.

Pigeon peas are typically sown in Nigeria between mid-April and early May. The harvest of pigeon peas typically takes place from the end of January to late February. At the conclusion of the pigeon pea harvest, the weather in south-east Nigeria is characterized by sunshine, a comparatively high daytime temperature, and a high nighttime relative humidity. In these circumstances, the grains dried relatively quickly during the day and significantly more moisture was reabsorbed during the night [11]. These modifications cause the pigeon pea pods to break, which leads to more grains being damaged during processing. Typically, harvesting takes place when the average grain moisture content is under 18% [5] stated that although this may vary from species to species, the ideal period for harvest is when the moisture level in grain is between 18 and 20%. According to a study by [4], the ideal harvest moisture content for long-grain cultivars should be between 18 and 22%, and between 19 and 20% for medium-grain cultivars. Similar findings were made known by [12] in *Jatropha curcas* and [13] in white sesame seeds, and they both showed that the relationship between harvest moisture content and yield was quadratic, suggesting that there is an ideal harvest moisture content. When the crop reaches physiological maturity and the moisture content drops to 14%, the pigeon pea harvesting procedure begins, though management practices may change this. Because cultivar and growing environment have an impact on the ideal harvest moisture content, [4] suggested ranges for long- and medium-grain rice are 18.7 to 23.5% and 21.5 to 24.0%, respectively. Measurements of grain moisture content might be direct or indirect. Hot air in an oven removes moisture from the grains directly for measuring.

In West Africa, pigeon pea production is affected by many problems which include shortage of improved seeds at the required time, quantity and quality among others [14]. According to a study, crop cultivar, ambient temperature, and humidity all affect grain moisture loss [3]. Thus, moisture content has an impact on harvesting time, which then has an impact on the drying process and expenses [15]. Additionally, it has been noted that the moisture content at harvest time is a significant influence in determining the rate of mold growth in maize [16]. Similarly, [17] worked on some selected cereals (wheat, maize, soya beans) on the area of method of harvesting techniques and varying moisture content. They concluded that, optimal moisture content for harvest of all crops is nearly always too high to allow safe storage. Aside from what was said above, a review of the literature revealed that lower moisture contents led to more losses from shattering whereas higher moisture contents led to more losses from poor grain quality. Knowing how moisture content in pigeon pea affects yield and quality at harvest time and during storage after harvest is crucial, especially when formulating specific management recommendations for before and after harvest that consider yield and quality of pigeon pea in different genotypes. Sequel to the above, this study evaluated the effect of time of harvest at different moisture contents on physiological attributes and storability potential of pigeon pea in the tropics.

MATERIALS AND METODS

Seed source

The ten pigeon pea genotypes used for the experiment were sourced from International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State, Nigeria. The ten pigeon pea genotypes used were A8125, AO78-99, AO/TB-78-9, CITA-1, CITA-2, CITA-3, 1CPL 87, NSWCC-18, NSWCC-18b and NSWCC-19. The field experiments was carried out in 2022 under rainfed condition in the University of Agriculture and Environmental sciences, Umuagwo, Owerri, Imo state, Nigeria. The experimental site was located at 5° 28" N latitude and longitude of 5° 81' E at 256 m above mean sea level. It lies in the tropical rainforest zone, characterized by eight months of the rainy season between April and November, punctuated by a short break in August. The location was with an annual rainfall range of 1200 mm to 1649.4 mm (Nigeria Meteorological Department, 2022).

Experimental design

The field experiment was a Randomized Completely Block Design (RCBD) with three replications. The plot size in each replicate was (4m x 4m) with 24 plants /plot at planting distance of 2m x2m. Space of 1m was left in between the plots and at border edges. The total land area of 750 square meters (15m x 5m x 10) was used for the experiment. The experimental plots were maintained through manual hoeing until harvest. Harvesting and threshing of the seeds were performed manually by plucking the pods, when the seeds reached the moisture contents of 12 %, 15 % and 17 %. The monitoring of the seeds moisture content in the field was carried out with the aid of a moisture portable meter (Motopco 998-RF model) and confirmed by the oven method at 105 ± 3 ºC, for 24 h [18]. Each harvested pigeon pea seeds were processed, cleaned and stored in a moisture proof polyethylene bags until usage.

Seed packaging for storage

Seeds from each treatment were divided into three seed lots of 400g each with three (3) replicate each. Packaged seed lots of each treatment were stored under ambient environment. The temperature and relative humidity of the seed stores were monitored and maintained daily using hygrometers. Seed samples were taken from each packaged seed lot for evaluation at 30-days interval for a period of 240 days.

(a) Laboratory assessment

i. Standard germination (%); Three replicates of 100-seeds of each genotype were germinated in 9cm diameter petri dishes inside moisture paper towels with 10ml of distilled water and placed inside an incubator at 25oC.

$$GP = \frac{\text{Total seed germinated after 7 days}}{\text{Total seed sown}} \times 100$$

Germination percentage was calculated based on the equation according to [18].

ii. mean Germination index = E (Nx)(DAP) / Total number of seedlings that germinated on the seventh day

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

iii. Seedling Vigor Index: Seedling vigour level (%) of each treatment was calculated by multiplying percentage normal germination by the average of plumule length of each genotype after 7 days of germination and divided by 100 as modified by [19].

4. Acceleration ageing- Seeds of each genotype were put in net bags in the desiccator containing 40g of Nacl salts dissolved in 100ml of distilled water in the lower chamber. The desiccator was covered and maintain in an incubator at 45+10C for 48 hours of ageing.

Statistical Analyses

Data collected from the above experiment on different characters were subjected to analysis of variance (ANOVA) using SPSS version 17.0 for windows statistical software package and treatment means were separated using Tukey's HSD test at 5 % level of probability.

RESULTS

Table 1 show the mean squares values from analysis of variance for the effect of time of harvest at different moisture contents on physiological attributes of 10 pigeon pea genotypes. Seedling vigour as the effect of harvesting moisture content and genotypic effect showed that at 60,120,180 and 240 DAS, the effect was highly significant at ($p \leq 0.05$).

Table 1. Mean squares values from analysis of variance for the effect of time of harvest at different moisture contents on physiological attributes of 10 pigeon pea genotypes.

Source	Df	0DAS	60DAS	120DAS	180DAS	240DAS
SV						
Rep	2	0.36	124.93	43.57	157.64	107.40
HMC (M)	2	27.02	6984.5**	5901.08**	4781.0**	8682.96**
Genotype (G)	9	27.14	575.85**	503.85**	866.48**	467.30**
M x G	9	23.27	491.58**	441.55**	364.32**	680.68**
Error		50.59	94.86	99.25	161.63	63.21
GM%.						
Rep	9	83.66ns	63.50 *	60.16**	53.71**	47.68 **
HMC (M)	1	23.07	24.21**	20.76	18.60**	16.63
Genotype (G)	9	2032.15**	2013.75**	1192.15**	1162.67**	1055.75**
E x G	9	0.03	0.45	0.39	0.38	0.24
Error		0.053	0.56	0.51	0.21	1.44
MGT						
Rep	2	1.61	1.75	0.85	1.56	1.82
HMC (M)	1	18.28	0.42**	121.73**	6.86**	0.54**
Genotype (G)	9	4.24	25.24**	21.28**	31.74**	20.20**
E x G	9	2.35	23.26**	18.14**	18.41**	29.20**
Error		4.17	4.95	6.00	6.00	3.83

**Significant at 1 % probability level *Significant at 5 % probability level. SV-seed viability, MGT-mean germination time SVI-seedling vigour index, HMC-harvesting moisture content.

Similarly, the interactive effect of harvesting moisture content x genotype was highly significant a 60,120, 180, and 240DAS. For germination percentage, harvesting moisture content was highly significant at 60, and 180DAS respectively. The genotypic effect was also highly significant all through the period of storage while the interactive effect of harvesting moisture content and genotype was not significant throughout the period of storage. The effect of mean germination time on harvesting moisture content and genotype was highly significant at ($p \leq 0.05$) through the period of storage while the interactive effect of harvesting moisture content and genotype on MGT was highly significant at 60, 120,180 and 240 DAS.

Mean performance of 10 pigeon pea genotypes harvested at 12 percentage moisture content for seed viability at 0 – 240 days of storage under ambient conditions is presented in Table 2. Generally, the pigeon pea viability decreases as the days of storage increases. The seed viability at 12% moisture content ranges from 83.33% in A8125 to 57% in AO/TB-99 at 240 DAS. At 0 DAS, all the mean parameters were not significantly different from one another. At 60 DAS, ICPL (73.33%) had the highest value while NSWCC-18b recorded he lowest values. Similarly, CITA- 1 had the highest values at 120 and 180 DAS with (70.66%), (72.66%) and respectively while CITA-3 had the corresponding lowest values of 46.00 and 38.66%, respectively. However, at 240 DAS, NSWCC-18b had the highest with (68.40%) while CITA-3 still maintained the least with 36.60%.

Table 3 shows the mean performance of 10 pigeon pea genotypes harvested at 12 percentage moisture content for mean germination time at 0 – 240 days of storage under ambient conditions. At 0 DAS, all the mean parameters were not significantly different from one another. Similar, observation was recorded at 60 and 120DAS respectively. At 180 DAS, NCWCC-18b had the lead of (3.85 days) while other mean was not significantly different from one another. At 240 DAS, NSWCC-18b (3.95) had the highest MGT while AO78-99 had the least with 3.31 days.

Mean performance of 10 pigeon pea genotypes harvested at 12 percentage moisture content for seedling vigour at 0 – 240 days of storage under ambient conditions is presented in Table 4. At 0 DAS, CITA-1 (61.10) had the highest while CITA-3 with 43.51 had the least. At 60 DAS, CITA-2 (39.05) had the highest while the rest mean was not significantly different from one another. At 120 DAS, CITA-2 (28.37) had the highest while CITA-1 with 25.33 had the least. At180 DAS, CITA-2 (27.95) had the highest while NSWCC-18 with 25.55 had the least. At 240 DAS, CITA-2 (26.24) had the highest while CITA-3 with 21.80 had the least.

Table 2. Mean performance of 10 pigeon pea genotypes harvested at 12 percentage moisture content for seed viability at 0 – 240 days of storage under ambient conditions.

Genotypes	Seed viability %				
	0DAS	60DAS	120DAS	180DAS	240DAS
A8125	83.33 a	58.00 a-f	54.66 b-e	54.66 b-f	52.66 a-d
AO78-99	82.00 a	64.66 a-e	63.33a-d	62.00 a-c	60.00ab
AO/TB-78-9	80.66 a	71.33a-c	68.00 a-c	62.00 a-c	57.00 a-c
CITA-1	83.33 a	70.66 a-c	70.00 a	72.66 a	60.66ab
CITA-2	83.33 a	58.66 a-f	58.00 a-e	60.66 a-d	58.66 a-c
CITA-3	82.66 a	46.00ef	45.33 de	38.66 f	36.60 e
1CPL 87	78.00 a	73.33 a	68.66 a-c	60.66 a-d	60.66 a-d
NSWCC-18	82.00 a	64.00 a-e	64.00 a-d	66.00 a-c	60.00ab
NSWCC-18b	81.33 a	53.33 c-f	52.66 a-c	70.00ab	68.10 a
NSWCC-19	84.66 a	70.66 a-c	69.33 a-c	69.33ab	60.33ab

Means followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability level according toTukey test. SV-Seed viability index DAS –days after storage

Table 3. Mean performance of 10 pigeon pea genotypes harvested at 12 percentage moisture content for mean germination time at 0 – 240 days of storage under ambient conditions.

Genotypes	Mean germination time 0DAS	60DAS	120DAS	180DAS	240DAS
A8125	2.82 a	3.16ab	3.25 a	3.31ab	3.33 ac
AO78-99	2.60 a	2.61ab	3.31 a	3.38ab	3.76a
AO/TB-78-9	2.32a	3.10ab	3.26 a	3.27ab	3.31 ac
CITA-1	2.48 a	3.15ab	3.30 a	3.38ab	3.81ab
CITA-2	2.26 a	2.37ab	3.38 a	3.46ab	3.56ab
CITA-3	2.25 a	2.26ab	3.21 a	3.25ab	3.63ab
1CPL 87	2.40 a	3.10ab	3.15 a	3.18ac	3.36 ac
NSWCC-18	2.92a	2.35ab	3.36 a	3.41 ab	3.60ab
NSWCC-18b	2.43a	2.62ab	3.63 a	3.85a	3.95a
NSWCC-19	2.23 a	2.25ab	3.27 a	3.28ab	3.53ab

Mean followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability level according toTukey test. MGT- Mean germination time, index DAS –days after storage.

Table 4. Mean performance of 10 pigeon pea genotypes harvested at 12 percentage moisture content for seedling vigour at 0 – 240 days of storage under ambient conditions.

Genotype	0DAS	60DAS	120DAS	180DAS	240DAS
A8125	56.87a-d	37.73 a-e	27.15 a-c	26.35 a-c	24.9 a-e
AO78-99	57.69 a-d	38.20 a-e	27.43 a-c	25.90 b-e	24.75 a-e
AO/TB-78-9	54.15a-d	38.70 a-d	27.20 a-c	26.61ab	25.54ab
CITA-1	61.10 a	38.26 a-e	25.33 c-e	24.22 e-j	23.51 c-j
CITA-2	60.88a-b	39.05 a-c	28.37 a	27.95 a	26.24 a
CITA-3	43.51cd	37.46 a-e	26.87 fg	22.75 i-k	21.80 i-k
1CPL 87	50.54 a-d	37.95 a-e	27.72 ab	25.85 b-e	24.80 a-e
NSWCC-18	44.70 b-d	37.32 a-e	25.60 b-d	22.55 i-k	22.20 h-k
NSWCC-18b	47.70 b-d	37.39 a-e	25.52 b-d	24.82 c-h	24.07 b-h
NSWCC-19	55.66 a-d	37.11 b-e	26.30 b-d	23.60 f-k	22.87 f-k

Means followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability level. DAS- days after storage.

Table 5 showed the mean performance of 10 pigeon pea genotypes harvested at 15% moisture content for seed viability at 0 – 240 days of storage under ambient conditions. At 0 DAS, all the mean parameters were not significantly different from one another. At 60 DAS, ICPL (63.33) had the highest while CITA-3 with (36.00%) had the least. At 120 DAS, CITA-1 (60.00%) had the highest while CITA-3 with 35.33% had the least. At180 DAS, CITA-1 (62.66%) had the highest while NSWCC-18 with (28.66%) had the least. At 240 DAS, NSWCC-18b (58.13%) had the highest while CITA-3 with 26.36% had the least.

Mean performance of 10 pigeon pea genotypes harvested at 15% moisture content for mean germination time at 0 – 240 days of storage under ambient conditions was presented in Table 6. There was a down ward trend in mean germination time across the storage period, as the mean germination time decreases as the storage period increases. At 0, 60,120 and 180 DAS, all the mean parameters were not significantly different from one another while at 240 DAS, A8125 (4.63) had the highest while AO78-99 with (1.76) had the least. Table 7 showed the mean performance of 10 pigeon pea genotypes harvested at 15% moisture content for seedling vigour at 0 – 240 days of storage under ambient conditions. At 0 DAS, CITA-1 (41.10) had the highest while CITA-3 with (23.51) had the least. At 60 DAS, CITA-2 (39.05) had the highest while NSWCC-18 with (17.32) had the least. At 120 DAS, CITA-1 (35.33) had the highest while NSWCC-18b with 15.52 had the least. At180 DAS, CITA-1 (34.22) had the highest while NSWCC-18 with (12.55) had the least. At 240 DAS, CITA-1 (33.51) had the highest while CITA-3 with 10.80 had the least.

Mean performance of 10 pigeon pea genotypes harvested at 17 percentage moisture content for seed viability at 0 – 180 days of storage under ambient conditions is presented in Table 8. At 0 and 60 DAS, all the mean parameters were not significantly different from one another. At 120 DAS, NSWCC-19 (19.33) had the highest while CITA-1 with 110.00 had the least. At180 DAS, NSWCC-19 (18.33) had the highest while NSWCC-18b with (10.00) had the least. At 240 DAS, NSWCC-19 (10.33) had the highest while AO78-99 with 07.00 had the least.

Table 5. Mean performance of 10 pigeon pea genotypes harvested at 15 percentage moisture content for seed viability at 0 – 240 days of storage under ambient conditions.

Genotypes	Seed viability % 0DAS	60DAS	120DAS	180DAS	240DAS
A8125	63.32 a	48.00 a-f	44.66 b-e	44.66 b-f	42.56 a-d
AO78-99	62.01 a	54.66 a-e	53.33a-d	52.00 a-c	50.20ab
AO/TB-78-9	60.63 a	58.33a-c	58.00 a-c	52.00 a-c	47.20 a-c
CITA-1	63.33 a	60.66 a-c	60.00 a	62.66 a	50.36ab
CITA-2	63.31 a	48.66 a-f	48.00 a-e	50.66 a-d	48.36 a-c
CITA-3	62.99 a	36.00ef	35.33 de	28.66 f	26.36 e
1CPL 87	59.03 a	63.33 a-c	58.66 a-c	50.66 a-d	50.66 a-d
NSWCC-18	62.80 a	54.00 a-e	54.00 a-d	56.00 a-c	50.30ab
NSWCC-18b	61.23 a	43.33 c-f	42.66 a-c	60.00ab	58.13 a
NSWCC-19	64.63 a	60.66 a-c	59.33 a	59.33ab	50.34ab

Means followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability levelaccording toTukey test. SV-Seed viability index DAS –days after storage,

Table 6. Mean performance of 10 pigeon pea genotypes harvested at 15 percentage moisture content for mean germination time at 0 – 240 days of storage under ambient conditions.

	Mean germination time				
Genotypes	**0DAS**	**60DAS**	**120DAS**	**180DAS**	**240DAS**
A8125	4.42 a-e	4.46ab	4.49 a	4.51ab	4.63 a
AO78-99	4.10 b-f	4.26ab	4.33 a	4.38ab	4.76ab
AO/TB-78-9	4.02c-f	4.10ab	4.26 a	4.28ab	3.31 a
CITA-1	4.48 b-f	4.55ab	4.57 a	4.68ab	4.81ab
CITA-2	4.66 b-f	4.78ab	4.86 a	4.89ab	4.96ab
CITA-3	4.75 d-f	4.85ab	4.88 a	4.95ab	4.99ab
1CPL 87	4.40 d-f	4.50ab	4.55 a	3.58ab	4.66 a
NSWCC-18	4.62a-d	4.78ab	4.85 a	4.91 b	4.97ab
NSWCC-18b	4.63a-d	3.66ab	3.71 a	3.80ab	4.85ab
NSWCC-19	4.63 b-f	4.65ab	4.71 a	4.88ab	4.89ab

Mean followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability level according toTukey test. MGT- Mean germination time, index DAS –days after storage.

Table 7. Mean performance of 10 pigeon pea genotypes harvested at 15 percentage moisture content for seedling vigour at 0 – 240 days of storage under ambient conditions.

Genotype	0DAS	60DAS	120DAS	180DAS	240DAS
A8125	36.87a-d	27.73 a-e	17.15 a-c	16.35 ab	14.9 a-e
AO78-99	37.69 a-d	28.20 a-e	17.43 a-c	15.90 b-e	14.75 a-e
AO/TB-78-9	34.15a-d	28.70 a-d	17.20 a-c	16.61ab	15.54ab
CITA-1	41.10 a	38.26 a	35.33 a	34.22 a	33.51 a
CITA-2	40.88a	39.05 a	29.37 a	17.95 ab	16.24 ab
CITA-3	23.517cd	17.46 a-e	16.87 fg	12.75 ab	10.80 ab
1CPL 87	30.54 a-d	27.95 a-e	17.72 ab	15.85 b-e	14.80 a-e
NSWCC-18	24.70 b-d	17.32 e	15.60 d	12.55 i-k	12.20 h-k
NSWCC-18b	27.70 b-d	17.39 a-e	15.52 d	14.82 c	14.07 b-h
NSWCC-19	35.66 a-d	27.11 b-e	26.30 b-d	23.60 b	22.87 ab

Means followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability level. DAS-days after storage.

Mean performance of 10 pigeon pea genotypes harvested at 17 percentage moisture content for mean germination time at 0 – 240 days of storage under ambient conditions is presented in Table 9. Mean germination time increases as the days of storage increases while the mean germination time was not significantly different from one another as the days of storage increases. The mean values range from 5.32 in AO/TB-78-9 to 9.81in CITA-1.

Mean performance of 10 pigeon pea genotypes harvested at 17 percentage moisture content for seedling vigour at 0 – 240 days of storage under ambient conditions is presented in Table 10. At 0 DAS, all the mean parameters were not significantly different from one another. At, 60 DAS, CITA-2 (9.37) had the highest while the rest of the mean were not significantly different from one another. At 120, 180 and 240 DAS, CITA-2 had the highest value of (9.37), (7.95) and (6.24), respectively while CITA-3 with 2.87, NSWCC-18 (2.55) and CITA-3 with (1.80) had the least respectively.

Table 11 shows effect of genotype on seed quality parameters evaluated across artificial ageing treatments. CITA-1 had an outstanding performance across the artificial ageing with 63.42% germination %, 70.87% seed germination %, 9.02 seedling vigour index and 0.75 mean germination time while the lowest was recorded across in CITA-3 with 27.87% germination %, 30.76% seed germination %, 1.82 seedling vigour index and 0.13 mean germination time.

Table 8. Mean performance of 10 pigeon pea genotypes harvested at 17 percentage moisture content for seed viability at 0 – 180 days of storage under ambient conditions.

	Seed viability %				
Genotypes	**0DAS**	**60DAS**	**120DAS**	**180DAS**	**240DAS**
A8125	23.33 a	20.00 a	14.66 b	10.66 ab	09.66 a
AO78-99	22.00 a	20.66 a	13.33a-c	12.00 a-c	07.00ab
AO/TB-78-9	20.66 a	20.33a	18.00 a	12.00 a-c	07.12 ab
CITA-1	23.33 a	20.66 a	10.00 e	12.66 a-c	08.66ab
CITA-2	23.33 a	18.66 a	18.00 a	10.66 a-d	08.36 ab
CITA-3	22.66 a	20.00a	15.33 b	10.66 a-d	09.66 bc
1CPL 87	28.00 a	20.33 a	18.66 a	10.66 a-d	08.66 ab
NSWCC-18	22.00 a	20.00 a	14.00 b	11.00 a-c	09.00a
NSWCC-18b	21.33 a	20.33 a	12.66 a-c	10.00a-d	09.10 a
NSWCC-19	24.66 a	20.66 a	19.33 a	17.33a	10.33a

Means followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability level according toTukey test. SV-Seed viability index DAS –days after storage,

Table 9. Mean performance of 10 pigeon pea genotypes harvested at 17 percentage moisture content for mean germination time at 0 – 180 days of storage under ambient conditions.

	Mean germination time				
Genotypes	0DAS	60DAS	120DAS	180DAS	240DAS
A8125	5.82 a-e	6.46ab	7.45 a	8.41ab	8.63 a
AO78-99	5.60 b-f	6.26ab	7.33 a	8.38ab	8.76ab
AO/TB-78-9	5.32c-f	6.10ab	7.26 a	8.26ab	8.31 a
CITA-1	5.48 b-f	6.15ab	7.30 a	8.38ab	9.81ab
CITA-2	5.66 b-f	6.38ab	7.38 a	8.36ab	9.56ab
CITA-3	5.75 d-f	6.25ab	7.25 a	8.25ab	9.63ab
1CPL 87	5.40 d-f	6.10ab	7.15 a	8.18ab	9.36 a
NSWCC-18	5.92a-d	6.35ab	7.35 a	8.41 b	9.60ab
NSWCC-18b	5.83a-d	6.62ab	7.61 a	8.60ab	8.95ab
NSWCC-19	5.63 b-f	6.22ab	7.25 a	8.28ab	8.53ab

Mean followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability level according toTukey test. MGT- Mean germination time, index DAS –days after storage.

Table 10. Mean performance of 10 pigeon pea genotypes harvested at 17 percentage moisture content for seedling vigour at 0 – 240 days of storage under ambient conditions.

Genotype	0DAS	60DAS	120DAS	180DAS	240DAS
A8125	10.87a	7.73 a-c	7.15 ab	6.35 ab	4.9 a-e
AO78-99	10.69 a	8.20 ab	7.43 ab	5.90 b-e	4.75 a-e
AO/TB-78-9	10.15a	8.70 ab	7.20 ab	6.61ab	5.54ab
CITA-1	10.10 a	8.26 ab	5.33 c-e	4.22 e-j	3.51 c-j
CITA-2	10.88a	9.05 a	9.37 a	7.95 a	6.24 a
CITA-3	10.51a	7.46 a-c	2.87 fg	2.75 i-k	1.80 i-k
1CPL 87	10.54 a	7.95 a-c	7.72 ab	5.85 b-e	4.80 a-e
NSWCC-18	10.70 a	7.32 a-c	5.60 b-d	2.55 i-k	2.20 h-k
NSWCC-18b	10.70 a	7.39 a-c	5.52 b-d	4.82 c-h	4.07 b-h
NSWCC-19	10.66 a	7.11 a-c	6.30 b-d	3.60 f-k	2.87 f-k

Means followed by the same alphabets along the columns within a character are not significantly different from one another at 5 % probability level. DAS-days after storage

Fig. 1. Seed physiological Assessment of pigeon pea during storage.

Fig. 2. An established pigeon pea farm at flowering stage.

Table 11. Effect of genotype on seed quality parameters evaluated across artificial ageing treatments.

Genotype	Rate of seed germination (%)	Seed germination (%)	Seedling vigour index	Mean germination time
A8125	46.76e-i	55.20b-h	3.23e-i	1.54a
AO78-99	46.20e-i	49.09d	2.61f-i	0.29fg
AO/TB-78-9	54.54b-g	62.42b-g	5.92b-e	0.75abc
CITA-1	63.42b-f	70.87bc	9.02a	0.75abc
CITA-2	22.31j	24.65j	2.56f-i	0.16g
CITA-3	27.87ij	30.76ij	1.82i	0.13g
1CPL 87	52.54b-h	62.65b-g	4.29d-i	0.47b-g
NSWCC-18	70.09b-c	76.31b	8.07abc	0.65a-e
NSWCC-18b	47.31d-i	49.09d-i	2.41ghi	0.36efg
NSWCC-19	53.08b-g	56.87b-h	5.43d-h	0.63a-f

DISCUSSION

Many researchers in the field of seed science have regarded seed viability, seedling vigour index, germination rate, as some of the essential and inevitable components of any evaluation of seed quality. In this study, considerable and significant variation existed among the seed treatments and storage period. Seed moisture content at harvest and the storage climate are two important elements that affect seed lifetime [20,21]. Furthermore, it was discovered that, within certain bounds, the higher the seed moisture content, the quicker the potential for germination would decline, leading to a loss in the overall quality of the seed. According to research, the final physiological phenomena in the course of seed aging is a fall in germination percentage. In this research, reduction in seed viability was lowest in seeds harvested at 17 % moisture content over the period of storage. The seed viability % decreased at 12% MC from (84.66- 36.66 %) at 240 DAS while (24.66- 08.36%) at 17% MC at 240 DAS. The superiority and discrepancies in the seed viability of 12% and 17% MC was as a result of high rate of microbial activities due to high moisture content in 17% MC compare to fewer activities at 12 % MC. However, the physiological effectiveness of seeds that are germinating is dependent on the seed vigor, and seedling vigor and germination potential of any seedlings are manifestations of this [20]. Similarly, vigour index value of any seed is the totality of germination and seedling growth of such seed, which is also regarded as a good index to measure the vigour of seeds at large [4]. In seed science, it is an established fact that, loss of vigour precedes loss of viability and ultimately leads to death of the seeds.

Seeds harvested at 12 and 15 % moisture content did better in storage compared to those harvested at 17% moisture content. For all of the variables examined, there was a significant interaction between the harvest moisture content and environment as determined by the F test ($p \leq 0.05$). Regardless of the moisture content at harvest, there was a noticeable deterioration across all treatments during storage periods. Additionally, seeds that were harvested with more moisture suffered more severe damage. The seeds harvested with 17 % of moisture content were more susceptible to damage in storage, this was noticed as there was a sharp reduction in seed viability, mean germination time and seedling vigour between (60–240) DAS, suggesting that the intrinsic deterioration process was triggered by seed storage conditions under various treatments. The diversity and loss in seed viability and vigor observed across all storage treatments may be caused by the physiological aging process, which may vary from treatment to treatment, the depletion of food reserves, or both. [1]. This was relatively in agreement with the previous works [11, 20], who reported genotypic differences in seed quality of soybean and pigeon pea, respectively under ambient storage environment. Earlier works also reported similar finding under ambient and modified environment in pigeon pea seeds [1,2]. Researchers reported that one of the major factors influencing seed longevity is seed moisture content at harvest and that of the storage environment [20,21]. The researcher determined that, within certain bounds, the higher the moisture content of the seed, the quicker the germination potential would decline and, ultimately, the lower the quality of the seed would be. This was evidenced in this finding as mean germination time for seeds harvested at 12, 15, and 17% moisture content at 240DAS were 3, 4 and 8 days respectively. This suggest that, in a population of pigeon pea genotypes, different storage time, moisture content of seeds and storage environment, there is possibility of selecting desirable combinations among the sources of variation. According to scientific research, the final physiological sign of aging is a drop in germination rate. In the present study, reduction in seed viability % was lowest in seeds harvested at 12% MC ranging from (84.66 to 36.60%) while 17% ranges from (28.00 to 07.00%). Compared to dry seeds, seeds with a higher moisture content are more vulnerable to harm during the drying process.

CONCLUSION

The study concludes that the anticipation of harvest and drying seed at moisture content above 12 and 15 % in pigeon pea resulted in low and poor physiological performance. Also, pigeon pea harvested with higher moisture are more susceptible to damage which cause lower viability and seedling vigour with corresponding higher mean germination time. The study showed that, lower seed moisture has better physiological performance and should be harvested at 12 or 15% moisture content but preferably, 15% moisture content in other to reduce the rate of seed scattering and wastages through explosive mechanism.

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