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Research Article

Effect of time of harvest at different moisture contents on seed yield attributes of ten pigeon pea (*Cajanus cajan*) genotypes

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ABSTRACT

Grain moisture content is a key indicator of an appropriate harvest period of seeds on the field and could also be used to effectively stabilize cereal products especially when physical attributes is to be evaluated. This study evaluated effect of time of harvest at different moisture contents on seed yield attributes of ten pigeon pea genotypes. The ten pigeon pea genotypes used for the experiment were sourced from International Institute of Tropical Agriculture (IITA) Ibadan, Oyo State, Nigeria. The field experiment was 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. At each harvested moisture content, the following seed yield parameters were evaluated periodically on five observational plants from each net plot-; number of pods per plant, number of seeds/pod, seed yield/plant, pod weight /plant, 100 seed weight/plot and seed production efficiency. Data collected were subjected to analysis of variance and Principal component analysis was used to identify characters that contributed majorly to variation within the genotypes under each treatment. The result showed that NSWCC-18b, NSWCC-19 and NSWCC-18 had an outstanding performance in the entire seed- yield attributes, evaluated for various moisture contents and could therefore, be used as dependable genotypes in pigeon pea seed development program. It is thereby, recommended that, pigeon pea seeds should be harvested at 15% moisture content for effective maintenance of quality, quantity and vigor.

INTRODUCTION

Pigeon pea is a perennial crop and may be cropped for 2-3 years, however, its seed yields usually drop significantly after the first year. Under controlled and intensive farming, yields of 2.5 ton/ha can be achieved [1]. The seeds of this plant can be dried to a low moisture level without considerably affecting their viability, making pigeon peas orthodox in nature. 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. According to earlier reports, all the linear dimensions of the pigeon pea seeds increased linearly as the seed moisture content increased [2]. However, the researcher attributed the findings to the absorption of moisture and expansion within the pigeon pea seeds which resulted into mean and equivalent diameter of pigeon pea to increase non-linearly with increase in moisture content. Previous studies found that moisture content had an impact on the bulk density, particle density, hardness, and angle of repose of various grains, including sunflower, neem nuts, pumpkin, gram, pigeon pea, soya bean, karingda, canola seed, paddy, mung bean, corn, and pistachio nuts. These studies concluded that moisture content is one of the key factors that must be considered when evaluating physical attributes [3-5]. Delay in harvesting time after physiological maturity give room for pest infestation, lower quality of the grains and ultimately reduces the yield [6].

Pigeon pea harvesting operations usually commence when the grain moisture content is about 12–15%. According to previous report with good management strategies, the longevity and agricultural productivity of cereals can be enhanced [7]. Another study 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 [8]. Researchers [9-12] 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. Another study revealed that the risk of delaying harvesting can increase the vulnerability of seeds to environmental harm [13]. Thus, in order to stop the problem, seeds must be harvested at the moment of physiological development, or even better, at harvest maturity. 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 [5]. The resultant effect of grain moisture content can vary 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, pod dehiscence and vastly affecting pigeon pea products and revenue [14,15]. Earlier study [16] reported that for maximum yield of legume crops, factors like time of sowing, harvesting and post-harvest management are very useful.

Numerous artificial drying methods aid in the quick reduction of seeds' moisture content, maintaining their quality and stability while facilitating storage. However, earlier work observed that the drying process can set off chemical, physical, and biological responses that can harm seeds' physiological performance and physical quality [17].

In addition, another study [9] reported that, the harvest moisture content of diverse crop varieties can ultimately affect the quality of different crops to an extent. They were able to demonstrate that high moisture content decreases the quality of pigeon peas by significantly increasing the rate of cracked dried pods and increasing the cost, time, damage, and carbon emissions associated with drying grains. The resultant effect of grain moisture content can vary even within the same seed lot when dried together, seeds with high moisture content will continually reduce while seeds 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. [8] reported that for maximum yield of legumes crops, factors like time of sowing, harvesting and, post- harvest management are very germane. Aside, the above, literature review showed that, higher moisture content can result in more losses from poor grain quality while lower moisture content resulted in more losses from shattering (seed/pod, average seed weight and 100 seed weight). Knowledge about the influence of moisture content on pigeon pea in relation to its effect on seed yield attributes is meager. Sequel to the above, this study evaluated effect of time of harvest at different moisture contents on seed yield attributes of pigeon pea (*Cajanus cajan*) genotypes.

MATERIALS AND METHODS

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 were carried out in 2021/22 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 Metrological 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. Each harvested pigeon pea seeds were processed, cleaned and stored in a moisture proof polyethylene bags until usage. At each harvested moisture content, the following seed yield parameters were evaluated periodically on five observational plants from each net plot.

1. Number of pods per plant: Average value of summation of pods from 5-randomly selected plants from each plot.
2. Number of seeds/pod: Mean number of well-formed seeds from five randomly selected pods.
3. Seed yield/plant (g): mean value of seed weights from five randomly selected plants per plot.
4. Pod weight /plant (g): Average value of summation of pods from 5-randomly selected plants within each plot.
5. 100 seed weight/plot (g): Average values of 100 seed weight in gram from 5- randomly selected plants within each plot.
6. Seed production efficiency (%): Estimated from the ratio of seed weight to pod weight from five randomly selected plants [18].

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. Principal component analysis was used to identify characters that contribute majorly to variation within the genotypes under each treatment.

RESULTS

Table 1 shows mean square values from analysis of variance for the effect of harvesting at various levels of moisture content on seed yield attributes of 10 pigeon pea genotypes. No significant different was recorded on the effect of cropping year for all the seed–yield characters examined. However, the effect of moisture content on the seed-yield characters were significant at ($p<0.01$) except in the number of seed/pod, number of pods per plant and seed production efficiency which were not significant. Also, effect of genotype were significant ($p<0.01$) on 100 seed weight, number of pods/plant and pod weight/plant. The effect of genotype and moisture content interaction was significant at ($p<0.01$) for 100 seed weight and at ($p<0.05$) for seed production efficiency while it was not significant for the rest of seed-yield characters.

Mean performance of 10 pigeon pea genotypes at 12% moisture content of harvest for seed yield attributes across two cropping years is presented in Table 2. No significant different was recorded among the values for number of seed/pod, as all the values were no statistically different from one another. For 100 seed weight, NSWCC-18b (10.10) and AO/TB-78-9 (9.31) jointly had the highest values while CITA-2 had the lowest value of (6.90). Similarly, for number of pod/plant, NSWCC-18b (675.50) and NSWCC-18(706.76) jointly had the highest values while CIA-1 (124.12) maintained the least value. The pod weight/plant highest value was recorded in ICPL-87(275.09) while the least value was recorded in CITA-2(124.12). ICPL-87(103.41) recorded the highest value for seed weight/pod while CITA-1 (39.23) had the least. The seed production efficiency was statistically not different from one another.

Mean performance of 10 pigeon pea genotypes at 15% moisture content of harvest for seed yield attributes across two cropping years is presented in Table 3. No significant different was recorded among the values for number of seed/pod, as all the values were no statistically different from one another. For 100 seed weight, NSWCC-18b (09.10) and NSWCC-18 (9.08) jointly had the highest values while CITA-3 had the lowest value of (6.00). Similarly, for number of pod/plant, NSWCC-18b (775.50), NSWCC-19(786.00) and NSWCC-18(806.79) jointly had the highest values while CITA-1 (318.08) maintained the least value. The pod weight/plant highest value was recorded in ICPL-87(100.41) while the least value was recorded in CITA-1(123.93). ICPL- 87(103.41) recorded the highest value for seed weight/pod while CITA-1 (40.23) had the least. The seed production efficiency was statistically not different from one another.

Table 1. Mean square values from analysis of variance for the effect of harvesting at various levels of moisture content on seed yield attributes of 10 pigeon pea genotypes.

Source of var.	Df	NSP	100seedwt	NPP	PWP	SWP	SPE
Rep	2	0.78	10.01	431714.68	187523.87**	22331.29**	1211.12
Year(Y)	1	1.06	2.04	218125.62	12354.08	149.44	331.34
Error (A)		0.53	1.04	108076.41	6173.04	76.71	146.17
Moisture (MC)	2	0.14	180.05**	427348.01	605247.47**	34509.28**	375.41
Genotype (G)	9	0.34	8.47**	610345.28**	44358.38*	45661.37	947.26
M X G	9	0.24	5.33**	226167.12	30465.95	4011.21	1044.39*

NSP-Number of seed/pod,100SW-100seedweight, PPP-Pod per plant ,PWP-Pod weight per plant ,SWP- Seed weight per plant ,SPE-– Seed production efficiency

Table 2. Mean performance of 10 pigeon pea genotypes at 12% moisture content of harvest for seed yield attributes across two cropping years.

Genotypes	NSP	100seedwt	NPP	PWP	SWP	SPE
A8125	3.83[a]	8.28 [ab]	463.50[ab]	196.38 [b]	72.81 [c]	39.17 [a]
AO78-99	3.91 [a]	8.65 [ab]	418.75 [ab]	125.80 [c]	46.20 [c]	37.67 [a]
AO/TB-78-9	4.08 [a]	9.31 [a]	480.41 [ab]	161.68 [b]	52.84 [c]	30.43[a]
CITA-1	4.08 [a]	8.35 [ab]	218.08 [ac]	117.93 [c]	39.23 [d]	33.01 [a]
CITA-2	4.08 [a]	6.90 [b]	274.16 [ac]	124.12 [c]	53.54 [c]	59.04 [a]
CITA-3	4.16 [a]	7.00 [ab]	281.91 [ac]	216.22 [b]	69.64 [c]	33.54[a]
1CPL 87	3.66 [a]	7.20 [ab]	448.50 [ab]	275.09 [a]	103.41 [a]	31.25 [a]
NSWCC-18	3.91 [a]	9.08 [ab]	706.79 [a]	202.33 [b]	64.33 [c]	32.43 [a]
NSWCC-18b	4.25 [a]	10.10 [a]	675.50 [a]	203.26 [bs]	78.43 [c]	37.92 [a]
NSWCC-19	4.00 [a]	9.28 [ab]	686.00 [a]	164.54 [b]	58.80 [c]	35.46 [a]
S.E	0.17	0.58	131.47	57.23	22.28	10.00

Mean followed by the same alphabets along the columns within a character are not significantly differs from one another at 5 % probability level.SWP – Seed weight/plant, NPP – Number of pods/plants, PWP – Pod weight/plant, NSP – Number of seeds/pod, SPE – Seed production Efficiency.

Table 3. Mean performance of 10 pigeon pea genotypes at 15% moisture content of harvest for seed yield attributes across two cropping years.

Genotypes	NSP	100seedwt	NPP	PWP	SWP	SPE
A8125	4.83a	7.28 [ab]	563.50ab	199.38 [b]	71.81 [b]	38.17 [a]
AO78-99	4.91 [a]	7.65 [ab]	518.75 [ab]	130.80 [c]	45.20 [b]	36.67 [a]
AO/TB-78-9	4.08 [a]	8.31 [ab]	580.41 [ab]	166.68 [b]	51.84 [b]	29.43[a] [a]
CITA-1	4.08 [a]	7.35 [ab]	318.08 [ab]	123.93 [c]	40.23 [c]	32.01 [a]
CITA-2	4.08 [a]	6.90 [b]	374.16 [ab]	129.12 [c]	54.54 [b]	57.04 [a]
CITA-3	4.16 [a]	6.00 [ab]	381.91 [ab]	221.22 [b]	70.64 [b]	32.54
1CPL 87	4.66 [a]	7.20 [ab]	548.50 [ab]	280.09 [a]	100.41 [a]	29.25 [a]
NSWCC-18	4.91 [a]	9.08 [a]	806.79 [a]	207.33 [b]	60.33 [b]	30.43 [a]
NSWCC-18b	4.25 [a]	9.10 [a]	775.50 [a]	210.26 [b]	75.43 [b]	35.92 [a]
NSWCC-19	4.00 [a]	8.28 [ab]	786.00 [a]	169.54 [b]	54.80 [b]	33.46 [a]
S.E	0.18	0.54	132.36	59.14	22.11	09.00

Mean followed by the same alphabets along the columns within a character are not significantly differs from one another at 5 % probability level.SWP – Seed weight/plant, NPP – Number of pods/plants, PWP – Pod weight/plant, NSP – Number of seeds/pod, SPE – Seed production efficiency.

Mean performance of 10 pigeon pea genotypes at 17% moisture content of harvest for seed yield attributes across two cropping years is presented in Table 4. No significant different was recorded among the values for number of seed/pod, as all the values were no statistically different from one another. For 100 seed weight, NSWCC-18b (10.10) had the highest values while CITA-2 had the lowest value of (6.90). Similarly, for number of pod/plant, NSWCC-18 (706.79) had the highest values while CITA-1 (218.08) maintained the least value. The pod weight/plant highest value was recorded in ICPL-87(275.09) while the least value was recorded in CITA-1(117.93). ICPL- 87(101.41) recorded the highest value for seed weight/pod while CITA-1 (39.23) had the least. The seed production efficiency was statistically not different from one another. A view of mature dried seeds is given in Fig. 1 and the pods in Fig. 2.

Principal component analysis showing the Eigen values of seed yield characters in 10 pigeon pea genotypes across various moisture content of seed yield are shown in Table 5. Principal component analysis is techniques which identify the character that contributes most of the variation within a group of entries. It is also common numerical techniques which reduce the dimensions of multivariate data by removing inter-correlation among variables. The seed yield characters accounted for 44.27 % of the total variation in PC1while the second (PC2), third (PC3), fourth (PC4) and fifth (PC5) accounted for 21.14, 15.41, 10.46 and 4.43% of the variability, respectively with a cumulative value 44.27, 66.41, 81.82, 92.28 and 97.71, respectively. In the first principal component (PC1), characters such as seed weight/plant, number of pods/plant, pod weight/plant,100-seed weight and seed production efficiency recorded significant factor scores of between 0.41 and 0.93 to the discrimination among the 10 pigeon pea genotypes. In the second principal component (PC2), pod weight/plant, 100-seed weight and seed weight had significant contribution to the variation but PC3 was dominated by 100-seed weight and seed /pod contributing between 0.52 and 0.31. The fourth principal component (PC4) was dominated by seed pod/plant (0.74). At the PC5, only number of seed/pod (0.31) significantly contributed to the major variation.

Table 4. Mean performance of 10 pigeon pea genotypes at 17% moisture content of harvest for seed yield attributes across two cropping years.

Genotypes	NSP	100seedwt	NPP	PWP	SWP	SPE
A8125	3.83[a]	8.28 [ab]	463.50[ab]	196.38 [b]	72.81 [b]	39.17 [a]
AO78-99	3.91 [a]	8.65 [ab]	418.75 [ab]	125.80 [c]	46.20 [b]	37.67 [a]
AO/TB-78-9	4.08 [a]	9.31 [ab]	480.41 [ab]	161.68 [b]	52.84 [b]	30.43 [a]
CITA-1	4.08 [a]	8.35 [ab]	218.08 [ac]	117.93 [c]	39.23 [c]	33.01 [a]
CITA-2	4.08 [a]	6.90 [b]	274.16 [ab]	124.12 [c]	53.54 [b]	59.04 [a]
CITA-3	4.16 [a]	7.00 [ab]	281.91 [ab]	216.22 [b]	69.64 [b]	33.54[a]
1CPL 87	3.66 [a]	7.20 [ab]	448.50 [ab]	275.09 [a]	101.41 [a]	31.25 [a]
NSWCC-18	3.91 [a]	9.08 [ab]	706.79 [a]	202.33 [b]	64.33 [b]	32.43 [a]
NSWCC-18b	4.25 [a]	10.10 [a]	675.50 [ab]	203.26 [bs]	78.43 [b]	37.92 [a]
NSWCC-19	4.00 [a]	9.28 [ab]	686.00 [ab]	164.54 [b]	58.80 [b]	35.46 [a]
S.E	0.17	0.58	131.47	57.23	22.28	10.00

Mean followed by the same alphabets along the columns within a character are not significantly differs from one another at 5 % probability level.SWP – Seed weight/plant, NPP – Number of pods/plants, PWP – Pod weight/plant, NSP – Number of seeds/pod, SPE – Seed production Efficiency.

Table 5. PCA showing the Eigen values of seed yield characters in 10 pigeon pea genotypes across various moisture content.

Variables	PC1	PC2	PC3	PC4	PC5
Seed/pod	-0.001	-0.05	**-0.31**	**0.74**	**-0.31**
100-seed weight	**0.41**	**-0.46**	**0.52**	-0.10	0.03
Pod/plant	**0.93**	-0.10	-0.11	0.003	-0.02
Pod weight/plant	**0.90**	**-0.81**	-0.16	0.03	-0.02
Seed weight/plant	**0.91**	**-0.34**	-0.14	-0.005	-0.01
Seed production efficiency	**0.87**	-0.16	-0.16	-0.08	0.01
Eigen valve	4.02	1.92	1.40	0.95	0.40
Proportion of variation (%)	44.27	21.14	15.41	10.46	4.43
Cumulative variation (%)	44.27	66.41	81.82	92.28	97.71

Bolded- Value above **0.30** was considered with major contribution.

Fig. 1. Dried pigeon pea sedes.

Fig. 2. An established pigeon pea plant with matured pods.

DISCUSSION

Many researchers in the field of seed science have regarded number of pod/plant, number of seed/ pod, seed yield/plant, pod weight/plant and 100 seed weight as some of the essential and inevitable components of any evaluation of seed quality and quantity. In this study, considerable and significant variation existed among the seed-yield attributes evaluated. Pigeon pea seeds harvested at 12% moisture content had the highest 100 seed –weight but recorded the lowest seed/pod, number of pods/plant and pod weight/pod. This finding could be attributed to the fact that, pigeon pea at 12% moisture content was able to attain the highest physiological and field maturity before harvesting on the field. At this stage, the food nutrients (protein, carbohydrates, minerals and dry- matter were all at their fullest before harvesting on the field. Moreover, 12% MC was lower enough and un-conducive for microbial activities to occur within the seed lot. 12% MC have been considered save for both for harvesting and storage [19]. This was closely followed by pigeon pea harvested at 15% MC. This could be attributed to availability of water content in the seeds that allowed fewer activities of micro-organisms within the seed lot with evidence of perforated holes around the seeds. The least 100 seed weight was recorded in 17%MC. However, 12%MC had the lowest seed/pod, number of pods/plt and pod weight/plt. The above finding could be attributed to the opening of the pods on the plant stands while on the field through a phenomenon called pod dehiscence. In accordance with a different study [20], pod dehiscence results in pod shattering. This event happens when the mature pod's ventral or dorsal suture separates, causing seeds to scatter. Pod dehiscence is primarily observed in Leguminosae and Cruciferae [21, 22]. Although pod shattering is a crucial and important method of plant reproduction, it does not contribute to the formation of seeds, according to seed science [23]. The morphological traits of pods' shatter resistance have a link to one another [24]. The resistance created by the pod shatter coupled with the mechanical force capability of the abscission layer, according to previous studies [24,25], negate the dehiscence degree, especially when it's stronger. Similar observations about the important cell structures (fiber cap cells, outer valve marginal cells) that automatically control pod dehiscence when the moment is right were reported earlier [26,27]. These findings support earlier research showing that a number of variables, including apparent morphological traits, plant cell structure, environmental moisture, and physical circumstances, jointly control pod dehiscence. The pods opened at this stage and allowed seeds to scattered on the field, invitation and infestation of pests (birds) and rodents, thereby reducing both quality and quantity of the seeds and even in some cases, the pods fall of from the supporting branch [16]. Similar findings were reported earlier [11,6] where delay in harvesting time after physiological maturity give room for pest infestation, lower quality of the grains and ultimately reduces the yield. Also, given that they were reliant on the spatial dimensions of the grain, the seed surface area and seed volume rose linearly as the seed moisture content increased [28,2].

However, the above phenomen of explosive mechanism was addressed when the harvesting was carried out at 15% MC. Although, the seed weren't at their feild-maturity and physiological stage on the field, but the harvest was conducted before the explosive mechanism set in. This resulted in the pigeon pea harvested at 15% MC to record the highest seed/pod, seed production efficiency and second highest 100-seed weight after 12%MC. The quality and the quantity of the seeds were preserved and the rest of the MC were reduced through drying naturally. This finding corroborates the earlier work [29] in rice. Pigeon pea harvested at 17% MC, had the highest pod/plant and pod weight/plant. Although, the above findings didn't translate to the quantity and even the quality of the seed pods as the seeds were seen with perforated holes and insect infestation. This could have been as a result of high rata of respiration within the seed lot, which gave room for uncontrolled activities of micro-organisms causing deterioration. Seed deterioration is an irreversible process, as high-quality seeds cannot be made from low quality seeds. According to some descriptions, the process is cumulative, permanent, degenerative, and unstoppable [30]. This ultimately led to the reduced seed weight of the pigeon pea seed and seed quality causing the 17% MC to have the lowest 100-seed weight and seed production efficiency despite having the highest pod weight/plant. The outstanding pod weight/plt recorded must have been as result of the high moisture content in the seeds. Similar research findings were reported [3,4]. They found that the effect of moisture content was evident in the bulk density, particle density, hardness, and angle of repose of various grains, including sunflower, neem, pumpkin, gram, pigeon pea, soya, canola, paddy, mung bean, corn, and pistachio. They concluded that moisture content is one of the key factors that must be considered when evaluating physical attributes. According to earlier works [2,13], it is important to understand the physical and mechanical characteristics of pigeon pea grains when designing the machinery that will be used to handle, transport, process, and store the crop. Pigeon peas have a different moisture level when they are harvested than when they are milled or stored, which affects the pigeon pea's physical and mechanical characteristics. As a function of grain moisture content ranging from 6.2 to 30.2% (wb), the physical characteristics of pigeon pea, including length, width, thickness, bulk density, particle density, porosity, surface area, volume, angle of repose, and hardness, have been assessed.

CONCLUSION

The study concludes that NSWCC-18b, NSWCC-19 and NSWCC-18 had an outstanding performance in the entire seed- yield attributes evaluated for various moisture contents and could therefore, be used as dependable genotypes in pigeon pea seed development program. It is thereby, recommended that, pigeon pea seeds should be harvested at 15% moisture content for effective maintenance of quality, quantity and vigor.

AUTHORS CONTRIBUTION

Olufelo Joseph Olusola - field mapping, data analysis and result interpretation

Alegiledoye Abiodun Oladimeji. – field mapping, data collection and result interpretation

Eze Chinedu Norbert - field mapping, seed processing and packaging.

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