Global Research in Environment and Sustainability
May 2023, Vol. 1, No. 3, pp. 21-28

Comparative Study of Suitable Drying Methods for Storing Pigeon Pea (*cajanuscajan*) and Mung Bean (*vignaradiata (l.) r. wilczek*) Under Humid Tropical Conditions

Olufelo, Joseph. Olusola[1] and Eze, Chinedu Norbert[2]

1. Department of Crop Production, University of Agriculture and Environmental Sciences Umuagwo Owerri, Imo- State, Nigeria
2. Department of Biological Sciences, University of Agriculture and Environmental Sciences Umuagwo, Owerri, Imo- State, Nigeria

Abstract:
The study evaluated several suitable drying techniques of pigeon pea and mung beans seeds under humid tropical conditions. Freshly harvested seeds of pigeon pea NSWCC-7D and mung bean TVr- used for research were subjected to the following drying techniques- Sun drying, Shade drying and Partial Shade drying and stored under ambient condition for 300days. Seed samples were taken from each packaged seed lot for evaluation at 60-days interval and were evaluated for- Standard germination (SG), Rate of moisture absorption (MA), Dry matter production (DMP) and Seedling Vigor Index (SVI). Data analyses showed that seed quality parameters measured diminished with increase in storage time with seed dried under shade showing distinct highest (DMP), (SVI) (SG) and lowest (MA). Shade drying method registered the maximum dry matter (34.20 mg) compared to sun (28.60 mg) in pigeon pea and (32.30 mg) compared to sun (27.40 mg) in mung bean. Seeds dried under the shade had the overall best performance in all the physiological attributes evaluated while seeds dried under sun, had the least performance. Therefore, for maintenance of physiological qualities of mung bean and pigeon pea seeds under tropical humid condition, seeds should be dried under shade before packaging into storage house.

Keywords: Sun drying; shade drying; storage; germination percentage; seed moisture; dry matter.

INTRODUCTION

Pulses are legume-dried seeds, such as lentils, pigeon pea, chickpeas, and beans. According to Sehrawat *et al., (*2015), the functional attributes and benefits of pulses have not yet been fully explored there is therefore, needs to ensure proper storage and maintenance of its seed quality of the little available seeds. Mung bean, although still classified as an underutilized crop, is a legume cultivated throughout Africa and Asia for its edible seeds and sprouts (Asari, *et al.*, 2019). Seeds are stored for days, weeks, months or year during which it deteriorates, moving inexorably towards death. According to Tiwari and Kuntal, (2014), pigeon pea and mung beans are orthodox in nature (the seeds of this plant can be dried to low moisture content without significantly reducing their viability). However, Kancha, *et al.*, (2017) and Sarkar and Kang (2018) reported that one of the major factors influencing seed longevity is seed moisture content before the commencement of the storage and its environment when the storage commences. Within limits, the higher the seed moisture content, the faster the decrease in germination capacity and ultimately a reduction in the overall quality of the seed. In West Africa, Mung bean and pigeon pea production are affected by many problems which include shortage of improved seeds at the required time, low acceptability, quantity and quality challenge among others Lisboa, *et al* 2014. Mutungi *et al* (2014) in their findings, revealed that poor or unfavorable seed production environment affect the quality and quantity of seeds and this resultantly, affects the storage potential of seeds. Poor storage system is a problem that results in decrease in yield quality and production of pigeon pea and mung bean. Vales and Murdock, (2014), reported an average seed storability potential of some major crops in Nigeria under ambient conditions to be within the range of six and eight months, this limited performance is due to high environmental condition (temperature and relative humidity) which characterized the storage conditions.

Drying of seeds is the process of reducing the seed moisture content to a barest minimal, thereby creating an uncondusive environment for microorganism to flourish. Deterioration in seeds during storage is an inevitable and unavoidable process in seeds but then environment can be conditioned to slow down the process. Vijaya, *et al*., (2020) reported high temperature and high relative humidity caused severe and rapid deterioration of viability and vigour of groundnut and sesame seeds while they reported that the seed quality of both seeds was better enhanced at reduced temperature and relative humidity. Sehrawat *et al., (*2015) reported that the green immature grains rate and cracked pod rate of pigeon pea and mung bean seeds are been affected by the moisture content of the seeds at harvest and the harvest date after physiological maturity which jointly determine the grain quality. In addition, moisture content at the harvest time has been reported by Prochnow *et al*., (2015) to be an important factor that determines rice milling quality in storage. They opined that if the grains are left too long on the field after physiological maturity, the seeds stand the chance of been wasted, through explosive mechanism, as pods opens automatically when dried. The seeds are also prone to birds and pest attacks thereby causing drastic reduction in quality and quantity of pigeon and mung bean seeds Maiorano *et al*.,2014. These consequentially affect the farmers' income negatively by reducing the quantity of the seeds. The environmental conditions that exist during the growth period and harvesting time affect the seed quality and storability which ultimately affects drying process and costs (Adebisi, *et al* 2011). Thus, the environment plays a major role in determining the seed storability and quality. According to Abdollahpour et al., (2020), high moisture content increases the cost and time for drying grains, the damage to grains, and carbon emissions, as well as considerably increases the rate of cracked dried pods, thus decreasing the pigeon pea quality. Sequel to the above, there is need to protect and preserve the quality and quantity of pigeon pea and mung beans especially after physiological maturity on the field and recommend through comparative study of suitable drying methods for storing pigeon pea and mung bean under humid tropical conditions.

MATERIALS AND METHOD

Seed Materials

The pigeon pea and mung bean seeds used for the experiment were sourced from Institute of Agricultural research and Training, Ibadan, Nigeria. The seeds were multiplied in the research farm of Crop Production department of University of Agriculture and Environmental sciences, Owerri, Nigeria in 2020 and 2021 under rainfed condition.

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. Freshly harvested seeds of pigeon pea NSWCC-7D and mung bean TVr- obtained from the research farm formed the base material for the study. The seeds were subjected to the following treatments

N1 – Sun drying (Completely under sun)
N2 – Shade drying (Completely under shade)
N3– Partial Shade drying (Partially under tree shade)

Seed Packaging for Storage

The experiment was a Randomised blocked design (RBD) with three replicates with eighteen treatments. The pods were dried to the uniform moisture content of 10% and packed in cloth bags and stored under ambient condition for 300days. Seed samples were taken from each packaged seed lot for evaluation at 60-days interval for a period of 300 days and the following parameters were evaluated.

Quality Assessment

i. Laboratory assessment

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 25°C.

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

Germination percentage was calculated based on the equation according to ISTA (2015).

ii. Rate of moisture absorption: The moisture of each treatment was measured using manometer

iii. Dry matter production (mg 10 seedling^{-1}): The dry matter of each were calculated using F-750 dry matter meter

iv. 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 Adebisi *et al* (2011).

Data Analysis

All data collected were subjected to analysis of variance using statistical Analysis software (SAS™, 2010). Significant mean was separated using Duncan's multiple Range Test at the 5% level of probability.

RESULTS

Effect of drying methods on moisture content (%) of pigeon pea - NSWCC-7D and mung bean TV-r across storage period is presented in Table 1. The observed fluctuation and significant difference in moisture content could be attributed to seed treatment and Period of storage (Table.1). Among the various seed treatments, the Seeds dried under shade registered the minimum fluctuation in moisture content (10.1 to 10.7 per cent) in pigeon pea seeds and (10.0 -10.4 per cent) in mung beans while the highest moisture fluctuation was recorded in seeds dried all through under the sun with (10.2- 11.1 percent) in pigeon pea and (10.1 -10.6 per cent) in mung bean.

Table 1: Effect of drying methods on Moisture content (%) of pigeon pea and mung bean TV-r across storage period

Treatment	N	N2	N3	Mean
pigeon pea				
0 DAS	10.4	10.1	10.3	10.3
60DAS	10.6	10.6	10.6	10.6
120 DAS	11.1	10.7	10.9	10.8

180 DAS	10.8	10.7	10.6	10.7
240 DAS	10.4	10.4	10.3	10.3
300DAS	10.2	10.1	10.2	10.1
Mean	10.58	10.45	10.50	
	P	T	PXT	
	0.051	0.026	0.077	
C.D (0.05)	0.102	0.053	0.154	
Mung bean				
0 DAS	10.1	10.0	10.0	10.50
60DAS	10.2	10.1	10.1	10.13
120 DAS	10.4	10.3	10.2	10.30
180 DAS	10.6	10.4	10.5	10.53
240 DAS	10.3	10.2	10.3	10.26
300DAS	10.1	10.1	10.2	10.13
Mean	10.28	10.20	10.21	
	P	T	GXT	
	0.051	0.026	0.077	
C.D (0.05)	0.112	0.053	0.154	

N1=Sun drying, N2 = Shade drying N3= Partial Shade drying, P=period of storage, T= seed treatment

Effect of drying methods on germination percentage of pigeon pea - NSWCC-7D and mung bean TV-r across storage period is presented in Table 2. The observed fluctuation and significant difference in germination percentage could be attributed to seed treatment and Period of storage (Table 2). The decline in germination was recorded across all the treatment evaluated ranging from (98-42%) in pigeon pea seeds and (93- 38%) in mung bean from (95 to 47%) was observed during storage period. Among the various seed treatments, the Seeds dried under shade registered the highest germination % (98 to 54 per cent) in pigeon pea seeds and (93 -46 per cent) in mung beans while the lowest germination % was recorded in seeds dried all through under the sun with (94- 42%) in pigeon pea and (90 -38 %) in mung bean.

Table 2: Effect of drying methods on germination percentage of pigeon pea - NSWCC-7D and mung bean TV-r across storage period

Variables	N1(%)	N2(%)	N3(%)	Mean
pigeon pea				
0 DAS	94	98	95	95.66
60DAS	86	92	84	87.33
120 DAS	72	83	78	77.66
180 DAS	58	68	62	62.66
240 DAS	51	59	52	54.00
300DAS	42	54	47	47.66
Mean	67.12	75.66	69.6	
	P	T	PXT	
	0.551	0.014	0.892	
C.D (0.05)	1.112	0.028	1.140	
Mung bean				
0 DAS	90	93	91	91.33
60DAS	82	84	82	82.66
120 DAS	71	76	62	69.66
180 DAS	54	61	53	56.00
240 DAS	42	52	46	46.66

300DAS	38	48	44	43.33
	62.83	69.0	63.00	
	P	T	PXT	
	0.541	0.016	0.557	
C.D (0.05)	1.082	0.032	1.114	

N1=Sun drying, N2 = Shade drying N3= Partial Shade drying, P=period of storage, T= seed treatment

Table 3: Effect of drying methods on seedling vigour of pigeon pea - NSWCC-7D and mung bean TV-r across storage period.

Variables	N1	N2	N3	Mean
pigeon pea				
0 DAS	3206	3234	3273	3237
60DAS	2972	2591	2737	2766
120 DAS	1537	2132	2010	1893
180 DAS	1193	1480	1183	1285
240 DAS	996	1385	990	1123
300DAS	572	1050	789	804
Mean	1746	1978	1830	
	P	T	PXT	
	10.857	7.321	18.178	
C.D (0.05)	21.714	14.642	36.356	
Mung bean				
0 DAS	2479	2530	2495	2501
60DAS	2395	2100	2015	2170
120 DAS	1295	1870	1860	1675
180 DAS	1105	1538	1440	1361
240 DAS	1180	1410	1220	1270
300DAS	880	1310	1060	1083
Mean	1555	1793	1681	
	P	T	PXT	
	9.605	7.456	17.061	
C.D (0.05)	19.21	14.912	34.122	

N1=Sun drying, N2 = Shade drying N3= Partial Shade drying, P=period of storage, T= seed treatment

Effect of drying methods on seedling vigour of pigeon pea - NSWCC-7D and mung bean TV-r across storage period is presented in Table 3. There was a general declination of seedling vigour across all treatments. Seedling vigour decreases as storage period increases across all treatment. Among the various seed treatments, the Seeds dried under shade registered the highest seedling vigour of (1050) in pigeon pea seeds and (1310) in mung beans at 300 DAS. The lowest seedling vigour was recorded in seeds dried all through under the sun with (572) and (880) in pigeon pea and mung bean, respectively at 300DAS.

Table 4, showed the effect of drying methods on dry matter production of pigeon pea - NSWCC-7D and mung bean TV-r across storage period. There was a general declination of dry matter production across all treatments. Dry matter production decreases as storage period increases across all treatments. Among the various seed treatments, the Seeds dried under shade registered the highest production of dry matter ranging from 44 mg at 0DAS to 34 mg at 300 DAS in pigeon pea while mung bean recorded 42.50 mg at 0DAS and 36.89 mg at 300DAS. Conversely, seeds dried all through under the sun recorded the lowest dry matter production of 44 mg at 0DAS to 32 mg at 300 DAS in pigeon pea while mung bean recorded 42.00 mg at 0DAS and 30.40 mg at 300DAS.

Table 4: Effect of drying methods on dry matter production (mg) of pigeon pea - NSWCC-7D and mung bean TV-r across storage period

Variables	N1	N2	N3	Mean
pigeon pea				
0 DAS	44.10	44.20	44.30	44.20
60DAS	42.00	43.90	42.60	42.83
120 DAS	37.40	40.20	38.30	38.63
180 DAS	35.30	37.40	36.00	36.23
240 DAS	34.10	35.50	35.40	35.00
300DAS	28.60	33.40	34.20	32.06
Mean	36.91	39.10	38.46	
	P	T	PXT	
	0.027	0.019	0.043	
C.D (0.05)	0.054	0.038	0.092	
Mung bean				
0 DAS	42.30	42.50	42.40	42.40
60DAS	40.00	40.71	39.80	40.17
120 DAS	37.00	37.52	37.00	37.01
180 DAS	34.00	34.72	34.30	34.34
240 DAS	31.90	33.60	32.70	32.73
300DAS	27.40	33.30	31.52	31.40
Mean	35.93	37.05	36.28	
	P	T	PXT	
	0.019	0.012	0.031	
C.D (0.05)	0.038	0.024	0.062	

N1=Sun drying, N2 = Shade drying N3= Partial Shade drying, P=period of storage, T= seed treatment

DISCUSSION

There were differential responses in pigeon pea and mung bean genotypes for germination %, dry matter production, seedling vigour and moisture content during storage. The seed quality parameters measured diminished gradually with increase in storage time with seed dried under shade showing distinct highest dry matter production, seedling vigour index, germination % and lowest moisture content. The reduced moisture fluctuations and high dry matter production, seedling vigour index, germination % might have occurred due to very cool temperature environment the pigeon pea and mung bean were subjected to after 300 DAS of storage. A sharp reduction in germination percentage and dry matter production between (60–180) DAS was noticed, suggesting that the intrinsic deterioration process was triggered by seed storage conditions under various conditions. The variation and decline in germination percentage during storage may be due to depletion of food reserves, decline in synthetic activity as reported by Abdollahpour *et al* (2020) or may be due to the physiological ageing process Adebisi *et al*., (2019). This was relatively in agreement with the works of Vales and Murdock, (2014), and Kancha *et al.*, (2017), who reported genotypic differences in seed quality of soybean and pigeon pea, respectively under ambient storage environment. Adebisi *et al*., (2019) and Lisboa *et al*., (2014) also reported similar finding under ambient and modified environment in pigeon pea seeds.

Many researches 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. Kancha *et al*., (2017) and Elli *et al* (2019) reported that one of the major factors influencing seed longevity is seed moisture content at harvest and that of the storage environment. The scientist established that within limits, the higher the seed moisture content, the faster the decrease in germination capacity and ultimately a reduction in the overall quality of the seed. This suggest that, in a population of pigeon pea and mung bean genotypes, different storage time, moisture content of seeds and storage environment, there is possibility of selecting desirable combinations among the sources of variation.

Decline in germination % is the last physiological phenomenon in the process of ageing. In the present study, reduction in germination was lowest in seeds dried under the sun over a period of storage. The germination % decreased from (94- 42 %) in pigeon pea and (90 -38%) in mung bean after 300 DAS, the scotching of the sun must have affected the seed weight, seed viability and dry matter production. The superiority of shade dried seeds in maintaining higher germination (54%) compared to Sun drying (48 %) in storage at 300DAS was due to safe drying method which protected the seed coat from cracking, there by maintaining its germination percent and conserving its dry matter production.

However, Seedling vigour and dry matter production of any seedlings are the manifestations of the physiological efficiency of the germinating seeds which depends on the seed vigour (Kancha *et al*., 2017). Seed vigour is usually characterized by the weight of the seedlings after a period of growth, a physiological phenomenon influenced by the reserve metabolites, enzyme activities and growth regulators. 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 (Sarkar and Kang, 2018). Researchers have proven that; loss of vigour precedes loss of viability and this was obvious at 300DAS in both pigeon pea and mung beans seeds where decrease in vigour index value was faster in sun dried seed compared to shade dried seed. Shade drying method registered the maximum dry matter (34.20 mg) compared to sun (28.60 mg) in pigeon pea and (32.30 mg) compared to sun (27.40 mg) in mung bean. This clearly showed that the sun-dried seeds might have experienced a slight injury to membrane due to higher temperature prevailed during drying. The result is in consonant with Maiorano *et al*., (2014) in maize kanels.

CONCLUSIONS

In this study, seeds dried under the shade had the overall best performance in all the physiological attributes evaluated over the period of storage while seeds dried under sun, had the least performance. It is therefore, recommended that for maintenance of physiological qualities of mung bean and pigeon pea seeds under tropical humid condition, their seeds should be dried under shade before packaging into storage house.

REFERENCES

Abdollahpour, S A. Kosari-Moghaddam and Bannayan, M. (2020). Prediction of wheat moisture content at harvest time through ANN and SVR modeling techniques, Information Processing in Agriculture, https://doi.org/10.1016/j.inpa.

Adebisi, M. A., Abdul-Rafiu, A. M. and Ewuzie, C.O. (2011). The use of multiple seed vigour test to predict field emergence and potential longevity in three *capsicum species*. *Seed Science and Biotechnology* 5(1): 25-28.

Adebisi, M.A., Kehinde, T.O, Oladipo, T.E, and Lawal, I.O. (2019). Longevity and vigour of pigeon pea (*Cajanus cajan*) seed stored under ambient humid tropical conditions. *Acta Agriculturae Slovenia* 114(2):191-203.

Asari, T., Patel, B.N., Patel, R., Patil, G. B and Solanki, C. (2019). Genetic variability, correlation and path coefficient analysis of yield and yield contributing characters in mung bean (*Vignaradiata* (L.) Wilczek). *International Journal of Chemical Studies*, 7:383-387.

Elli, M.A., Ravalo, E.J. and Smith, R.S. (2019) Method of pigeon pea seed storage in Puerto Rico. *The journal of Agriculture of the University of Puerto Rico:*63(4), *423-427.*

International Seed Testing Association. (2015). International rules for seed testing. *Seed Science and Technology* 3: (2):299-335.

Kancha, P., Narit, G, and Jagmeet K. (2017). Physiological evaluation of pigeon pea (*Cajanus cajan) (*L) Millips.) genotypes for flowering and pod set. *Research on Crop;* 14(2), 478- 482.

Lisboa, C.F., Cunna, I.R, Teixeira, I.A. and Devilla. (2014). Physiological deterioration of pigeon pea seeds during storage. *Africa journal of Agricultural research:9:(48) 3473-3479.*

Maiorano A, Fanchini D, Donatelli M. and Mimycs (2014). Moisture, a process-based model of moisture content in developing maize kernels. *European Journal of Agronomy; 59:86–95.*

Mutungi C., Affognon H., Njoroge A, Baributsa D, and Murdock, L. (2014) Storage of mung bean (*Vignaradiata* [L.] Wilczek) and pigeon pea grains (*Cajanuscajan* [L.] Millsp) in hermetic triple-layer bags stops losses caused by *Callosobruchus maculatus* (F.) (*Coleoptera: Bruchidae*). *Journal of. Stored Prod. Res*: 58:39–47.

Prochnow, A, Risius H, Hoffmann T, and Chmielewski, F.M. (2015). Does climate change affect period, available field time and required capacities for grain harvesting in Brandenburg, Germany? *Agric For Meteorol*; 203:43–53.

Sarkar T.K., and Kang Y.S. (2018). Artificial neural network-based model for predicting moisture content in rice using UAV remote sensing data. *Korean J. Remote Sens.*; 34:611–624.

Sehrawat, N., Yadav, M., Bhat, K., Sairam, R. and Jaiwal, P. (2015). Effect of Salinity Stress on Mungbean (*Vignaradiata* (L.) Wilczek) during Consecutive Summer and Spring Seasons. *Journal of Agricultural Sciences*, 60, 23-32.

Tiwari and Kuntal,. D. (2014). Impart of different storage conditions on seed germination and viability of some medicinal plants. *Africa journal of Agricultural research*.9: (20) *1578-1585.*

Vales, M.I., and Murdock, L.L. (2014). Effect and economics storage of pigeon pea seed in triple layer plastic bags. *Journal of stored products research:* 58, *29-38.*

Vijaya, V, Geetha1 and Bhaskaran, M. (2020). Standardization of suitable drying methods for storing groundnut and sesame seeds. *International Journal of Current Microbiology and Applied Sciences*, 9(5): 478-485.