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Seed Health Quality In Common Bean (Phaseolus Vulgaris L.):

Effect Of Moisture Content, Packaging Material And Storage Condition

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Abstract

Background: Common bean (Phaseolus vulgaris L.) has recently been introduced in Ghana and is being promoted for cultivation. A major challenge that hinders the realization of the full potential of the crop is lack of quality seeds for production. Seeds harvested can deteriorate in storage if adequate measures are not taken to reduce seed ageing and fungi infection; especially in the humid regions characterized with high temperature and relative humidity.

Objective: The study was therefore conducted to assess the effects of seed moisture content, packaging material and storage temperature on the seed health quality of stored common bean seeds in the humid region of Ghana.

Methodology: Seeds were dried to 8 and 11% Moisture Content (MC), packed in plastic container and polythene bag, and stored under ambient (24-33 0C, 52-95%) and cold storage (15-160C, 68-70%) condition for eight months. The experimental design was a 2 x 2 x 2 factorial in CRD. Samples were taken at intervals of 2, 4, 6 and 8 months in storage for fungi determination using the plotter paper method.

Results: Aspergillus spp., Rhizopus spp. and Penicillium spp. were the major fungi observed over the 8 months period. Seeds dried to 11% initial moisture content had lower incidence of A. flavus compared to 8% initial moisture content at all sampling period. Seeds dried to 8% moisture content, packed in plastic container and stored at 150C under cold condition had the highest percentage incidence (0.17%) of A. niger at 2 months in storage and also 1.93% incidence at 8 months in storage due to seed age. Low incidence (0.46-1.14%) of Penicillium spp. was observed in seeds packed in polythene bag whilst seeds packaged in plastic container had the higher incidence (0.48-1.88%) during the storage duration. Seeds packed in polythene bag recorded the lowest percentage incidence (1.22%) of Rhizopus spp. compared to seeds packed in plastic container (2.01%).

Conclusion: The findings suggest that common bean seeds packaged in polythene bags can be dried to 11% MC and stored under ambient conditions for at least eight months without significant seed health quality deterioration. This information is relevant for seed growers, producers and input dealers for the common bean storage in the humid tropics.

Keywords: Moisture content, packaging material, storage condition, Aspergillus spp. Penicillium spp.

Introduction

Common bean (Phaseolus vulgaris L) is the most important legume crop consumed globally. It is cultivated on about 28.78 million hectares with an annual production of 26.83 million tonnes. The nutritional, economic and sustainable production systems of the crop make it "grain of hope" (FAO, 2016; Nordenstedt et al., 2017). It holds great promise for fighting hunger, food security, increasing income and improving soil fertility (Yeboah et al., 2021; Demelash, 2018).

Although it is a cheap source of protein in countries of production, Ghana continues to import it in canned forms making it costly and inaccessible to most Ghanaians. Ghana imported 153 tons of beans from United Kingdom, China, Lebanon, UAE, India, USA, among others with an estimated value of US$153,000 between 2015 and 2019 (FAOSTAT, 2020). Some four commercial varieties (Ennepa, Adoye, Nsroma and Semanhyia) have officially been released in 2016 by Council for Scientific and Industrial Research-Crops Research Institute and are being promoted for production and utilization. In other countries where the crop has been cultivated for a long time, certain constraints have been identified as limitation to achieving the full production potential. One such constraint is seed-borne diseases which cause yield losses ranging from 80-100% (Ribeiro et al., 2019; Nordenstedt et al., 2017). Fungi diseases have been found to thrive in humid areas where conditions are conducive for their growth (Francisco and Usberti, 2008). For effective promotion and successful adoption of such new legume crop in Ghana, good quality seeds will play an important role. Poor seed quality can be linked to lack of suitable seed production technologies, unsuitable storage, packaging, delayed and high moisture content at harvest, high temperature and relative humidity and gaseous exchange (Alves et al., 2017; Demelash, 2018). The study was therefore conducted to assess the effects of seed moisture content, packaging material and storage temperature on the seed health quality of stored common bean seeds in the humid region of Ghana.

Materials and Methods

Seed Source and Multiplication

The study was conducted at the research field of the Council for Scientific and Industrial Research-Crops Research Institute (CSIR-CRI) located at Fumesua (01º36'W; 06º43'N.), in the Ejisu Municipal Assembly in the Ashanti Region. The area falls in the forest agro-ecological zone. The predominant soils are Ferric acrisol (FAO, 1998) and inherently low in fertility and moisture retention. The location has a bimodal rainfall pattern with annual average of 1255 mm in 2020. The mean annual temperature is 27^{0}C. Seeds of common bean variety ***Nsroma*** (red seeded), was sourced from CSIR-Crops Research Institute Legumes Division. Seed multiplication field was established in May, 2019. Planting was done at a spacing of 60 cm x 20 cm with three seeds per hill and thinned to two seedlings per hill two weeks after planting. All the good agronomic practices were done including weed and insect control. Harvesting was done manually at harvest maturity when all the leaves have turned brown. Manual threshing was done after harvest by beating the harvested pods in sacks with sticks. Threshed seeds with moisture content above 14% were dried to 11% moisture content (MC) and sorted to remove debris, rotten and broken seeds.

Experimental procedure on seed storage

The experimental design for the seed storage studies was 2x2x2 factorial (two moisture content, two packaging material and two storage condition) in a completely randomized design with three replicates. The moisture contents (MC) were 8% and 11%, whereas the packaging materials comprised plastic container and polythene bag, and the storage conditions being ambient and cold storage. Dehumidification of seed from 14% MC after harvest to 11 and 8% MC was done using a Munter's model MX 1500E dehumidifier. Samples were taken periodically to check the MC with an agraTronix MT-16 Grain Moisture Tester. Seeds dried to 11 and 8% MC were packaged in moisture-proof polythene bags, 10 cm x 10 cm and 0.2 mm thick, and heat-sealed, whiles another portion of the same moisture contents were also packed in plastic containers (0.75 mm thick). Sets of packaged seeds of each lot were stored in a warehouse constructed for ambient seed storage at 24.43-33.40 ^{o}C and relative humidity of 52.17-95.45% (recorded during the study period) and another portion stored in cold room at 15 ^{o}C $\pm$ 2 for 8 months. Both facilities were located about 50 m apart at Kwadaso (245 m asl N 06^0 40. 696 W001 40, 321^0) in the Forest Agro-Ecological Zone characterized by high temperature and relative humidity. The seeds were arranged on wooden shelves and a hygro-thermometer fixed for data on temperature and RH during the entire 8 months period.

Incidence of Fungi: The fungal load was identified and enumerated using the blotter test after seed were stored and evaluated at 2, 4, 6, and 8 months. The seeds were evaluated for the incidence of seed-borne pathogens at the Seed Pathology Laboratory of CSIR-Crops Research Institute, Kumasi, Ghana. One hundred and fifty seeds were taken from a working sample and

plated on moist blotter paper in Petri dishes (10 seeds per Petri dish). The plates were incubated at 26 °C for 7 days under an alternating cycle of 12 h of near ultraviolet light and 12 h of darkness. The seeds were then examined under low power of a compound microscope to identify the fungal pathogens present, and the percentage incidence of micro-flora was recorded. Observations were made for the presence and specie of seed-borne fungi (Khan ***et al***., 2018).

Data analyses were performed using Statistix 9.1 statistical software package. Tukey's Honestly Significant Difference (HSD) test was used to separate treatment means.

Results and Discussions

Temperature and Relative Humidity Conditions of the Ambient and Cold Room Environments

The highest temperature under the ambient condition was 33.4 °C recorded in November, 2019 whiles the lowest was 25.4 °C recorded in July, 2020 (Table 1). The highest and lowest relative humidity recorded were 95.45% and 52.17% in October, 2019 and February, 2020, respectively. Under the cold storage condition, the lowest temperature was observed in May, 2020 (15.9 °C) and the highest in January, 2020 (16.81 °C). The highest RH under the cold condition was 70.30% in October, 2019 whilst the lowest was 68.54% in January, 2020.

Table 1. Temperature (°C) and relative humidity (%) recorded during the storage period

	Monthly Average Temperature and Relative Humidity			
	Ambient Condition		Cold Condition	
Month	Temperature (°C)	Relative Humidity (%)	Temperature (°C)	Relative Humidity (%)
Oct. 2019	26.35	95.45	16.57	70.30
Nov. 2019	33.40	68.53	16.17	68.79
Dec. 2019	28.51	73.92	16.33	68.70
Jan. 2020	29.66	80.44	16.81	68.54
Feb. 2020	29.24	52.17	15.79	69.74

Mar. 2020	29.45	72.59	15.63	69.46
Apr. 2020	26.72	66.35	15.58	69.39
May. 2020	29.06	73.70	15.58	69.18
Jun. 2020	26.72	77.69	15.57	
Jul. 2020	25.43	85.80	15.58	69.47

Effect of Moisture Content, Packaging Material and Storage Condition on Percent Incidence of *Aspergillus flavus (A. flavus)*

Moisture content had significant ($p<0.05$) effect on the percentage incidence of ***Aspergillus flavus*** (A. ***flavus***) at all the sampling periods (Figure 1). Seeds dried to 11% MC had lower percentage incidence of A. ***flavus*** than seeds dried to 8% MC. Low seed moisture content is supposed to reduce fungal growth and preserve seed quality in storage (Khan ***et al***., 2018). The high percentage incidence recorded here could be attributed to cracks during drying the seeds to 8% MC resulting in moribund tissues serving as point of infection (Scariot ***et al***., 2017). Packaging material also significantly ($p<0.05$) influenced seeds at 4 and 6 months in storage (Figure 1). At 4 months in storage, seeds packed in plastic container had low percentage incidence (7.48%) as compared to 8.21% recorded in seeds packed in polythene bag. However, at 6 months in storage seeds packed in polythene bag recorded low percentage incidence of A. ***flavus***, 2.02% lower than the incidence observed in seeds packed in plastic container. For the storage condition at 6 months in storage, seeds stored under ambient condition had low percentage incidence (7.30%) of A. ***flavus*** compared to 8 months in storage (8.58%) (Figure 1). This variation could be attributed to increase in relative humidity from 73.70 to 85.80% at 6 and 8 months respectively (Table 1). Increase in relative humidity leads to faster seed ageing and growth of fungi (Owolade ***et al***., 2011).

Effect of Moisture Content × Packaging Material on Percent Incidence of *Aspergillus flavus*

Moisture content × packaging material interaction was significant ($p<0.05$) at 2 and 6 months in storage. Seeds dried to 11% MC and packed in polythene bag recorded lower incidence at both periods (Table 2). Also seeds dried to 8% MC recorded higher incidence of A. ***flavus*** at both sampling periods. This could be linked to cracks in the seeds dried to 8% as seeds have their safe minimum moisture content limits below which seed could be damaged (Jittanit, 2007).

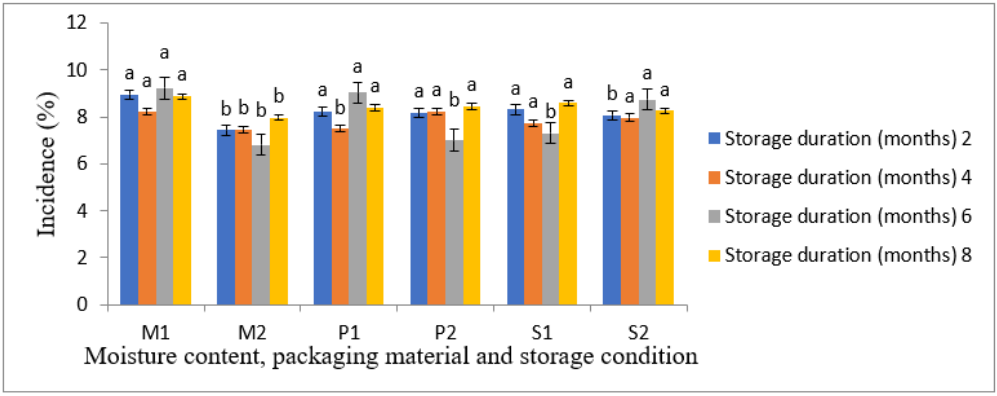


Figure 1. Effect of moisture content, packaging material and storage condition on the percentage incidence of A. ***flavus*** over 8 months storage duration (M1=8% moisture content, M2=11% moisture content, P1=Plastic container, P2=polythene bag, S1=ambient storage, S2=cold storage). Bars with different letters in the figure are statistically different at $p < 0.05$. Error bars represent the standard error of means.

Table 2. Effects of moisture content and packaging material on the percent incidence of Aspergillus flavus during eight months storage

		Incidence (%)			
		Storage duration (months)			
Seed moisture content (%)	Packaging material	2	4	6	8 months
8	plastic container	7.87	8.08	9.27	8.95
8	Polythene	7.78	6.88	8.78	7.85
11	plastic container	8.38	8.38	9.17	8.78
11	Polythene	7.12	8.03	4.85	8.10
Grand mean		7.79	7.85	8.02	8.42
HSD (0.05)		0.88	1.192	2.546	0.643

Effect of Moisture Content x Storage Condition on Percent Incidence of *Aspergillus flavus*

At four months in storage there was no significant ($p>0.05$) interaction effects. However, there were significant interaction effects for the other storage durations. For instance significant ($p<0.01$)

interaction effect was observed at 8 months in storage (Table 3). Seeds dried to 8% MC and stored under ambient condition recorded the highest incidence (9.30%) compared to the lowest incidence (8.08%) observed in seeds dried to 11% MC and stored under ambient condition. During seed processing, any damage to the seed predisposes it to fungal infections. Also storage of seeds in an uncontrolled condition results in significantly higher ***Aspergillus spp***. (Owolade ***et al***., 2011).

Table 3. Effects of moisture content and storage condition on percent incidence of *Aspergillus flavus* during eight months storage

		Incidence (%)			
Treatment interaction		**Storage duration (months)**			
Seed moisture content (%)	Storage condition (°C)	2	4	6	8 months
8	Ambient	7.88	8.27	9.27	9.30
8	Cold	8.37	8.20	8.78	8.43
11	Ambient	7.47	7.23	9.17	8.78
11	Cold	7.43	7.68	4.85	8.08
Grand mean		7.79	7.85	8.02	7.87
HSD (0.05)		0.88	1.192	2.546	0.643

Effect of Packaging Material x Storage Condition on Percent Incidence of *Aspergillus flavus*

Packaging material and storage condition interactions were also significant ($p<0.05$) at 6 and 8 months in storage (Table 4). Seeds packed in plastic container and stored under cold storage condition significantly ($p<0.05$) had the lowest percentage incidence of A. ***flavus*** (7.97%) than the incidence observed in seeds packed in plastic container and stored under ambient storage condition (8.83%). The difference could be attributed to the low temperature in the cold storage as high temperature increases infection of seed-borne pathogens especially in uncontrolled environment (Owolade ***et al***., 2011).

Effect of Packaging Material and Storage Condition on Percent Incidence of *Aspergillus niger* (A. *niger*)

Moisture content recorded significant ($p<0.05$) effect on percent incidence of A. ***niger*** at 4 months in storage (Figure 2). This was not significantly different from what was observed in percentage incidence of A. ***flavus*** where seeds dried to 11% MC had lower incidence than seeds dried to 8% MC. Packaging material recorded significant ($p<0.001$) variations at 6 months in storage. Seeds packed in polythene bag had 45.63% lower incidence of A. ***niger*** than the highest observed in seeds packed in plastic container. Storage condition significantly ($p<0.05$) influenced the percent incidence of A. ***niger*** at 2 and 6 months in storage. Seeds stored under ambient storage condition recorded lower incidence than those stored under cold storage condition (Figure 2). High relative humidity in the cold storage could cause increase in the percentage incidence of A. ***niger***.

Table 4. Interactive effect of packaging material and storage condition on seed percent incidence of ***Aspergillus flavus*** of common bean seeds during storage

Treatment interaction		**Incidence (%)**			
		Storage duration (months)			
Packaging material	Storage conditions (^{0}C)	2	4	6	8
Plastic	Ambient	7.82	7.53	9.35	8.83
Plastic	Cold	7.83	7.43	5.90	7.97
Polythene	Ambient	7.53	7.90	8.70	8.33
Polythene	Cold	7.97	8.52	8.112	8.55
Grand mean		7.79	7.85	8.017	8.42
HSD (0.05)		0.878	1.192	2.546	0.643

Figure 2. Effect of moisture content, packaging material and storage condition on the percentage incidence of ***Aspergillus niger*** over 8 months storage duration (M1=8% moisture content, M2=11% moisture content, P1=Plastic container, P2=polythene bag, S1=ambient storage, S2=cold storage). Bars with different letters in the figure are statistically different at $p < 0.05$. Error bars represent the standard error of means.

Effect of Moisture Content x Packaging Material on Percent Incidence of *Aspergillus niger*

Moisture content and packaging material interactions were significant ($p<0.05$) at 6 months in storage (Table 5). The lowest incidence was recorded in seeds dried to 8% MC and packed in polythene bag, 68.96% lower than the highest observed in seeds dried to 8% MC and packed in

plastic container. This differs from other experiments where plastic containers have performed better in preserving seed quality than polythene bags (Khalequzzaman ***et al.***, 2012, Naseri and Mousavi, 2015). The result in this study is similar to Nahar ***et al.***, (2009) where bean seeds packed in polythene bag performed better probably due to the creation of unfavourable micro condition within the container or inter granular humidity creating conducive environment for fungal growth (Pessoa ***et al.***, 2016). Also infections increased with increase in storage period due to seed ageing.

Table 5. Interactive effect of moisture content and packaging material on the percent incidence of ***Aspergillus niger*** during eight months storage

Treatment interaction		**Incidence (%)**			
		Storage duration (months)			
Seed moisture content (%)	Packaging material	2	4	6	8
8	Plastic	0.17	0.40	1.72	1.93
8	Polythene	0.47	0.78	0.53	0.45
11	Plastic	0.50	0.33	1.48	0.82
11	Polythene	0.38	0.15	1.20	0.93
Grand mean		0.38	0.42	0.65	1.03
HSD (0.05)		0.376	0.654	0.970	2.653

Effect of Moisture Content, Packaging Material and Storage Condition Percent Incidence of *Penicillium* spp

Moisture content had significant ($p<0.01$) influence on the percentage incidence of ***Penicillium*** spp. at 2 and 8 months in storage (Table 6). In both storage durations, seeds dried to 8% MC recorded higher percent incidence of ***Penicillium*** spp., 1.95% and 1.78% respectively, compared to the lowest observed in seeds dried to 11% MC which recorded 1.08% and 0.60 respectively. However, at 4 and 6 months in storage, the incidence levels of ***Penicillium*** spp. were lower than those observed at 2 and 8 months in storage. ***Penicillium*** seed-borne infections are mostly higher in seeds with high moisture content and also increase with time (Oshone ***et al.***, 2014; Khalequzzaman ***et al.***, 2012; Francisco and Usberti, 2008). In this study the alternating level of incidence could be attributed to the effect of time linked to the initial physical quality such that if there is any physical damage its effect will show up with time. It has been shown that the seeds dried to 8% MC may have suffered some damages during drying making it susceptible to infections due to dead tissues serving as nutrients for the fungal growth.

Packaging material significantly ($p<0.001$) affected the percent incidence of ***Penicllium*** spp. at 2 and 8 months in storage. Seeds packed in polythene bag recorded the lowest incidence compared to seeds packed in plastic container at both sampling periods. This result compares well with other researches where polythene bag has maintained seed quality better than other packaging material (Claudio ***et al.***, 2019; Silva ***et al***., 2019; Rugut ***et al***., 2010; Nahar ***et al***., 2009).

Storage condition significantly ($p<0.001$) influenced the percentage incidence of ***Penicillium*** spp. significantly at 6 and 8 months in storage. At 6 months in storage seeds stored under ambient storage condition had the lowest (0.33%) incidence compared to seeds stored under cold storage (0.93%). However, the reverse was observed at 8 months in storage with seeds stored under ambient having the lowest (0.88%) as compared to the highest observed in seeds stored under cold condition (1.51%). It has been shown that fungi have different roles of infection due to wide range of nutrient requirements and capacity of tolerance for varying environments and become active when conditions are favourable and ***Penicillium*** species have been cited as one of such fungi (Francisco, and Usberti, 2008; Sinha, ***et al***., 1999).

Table 6. Effect of moisture content, packaging material and storage condition on the percent incidence of *Penicillium* spp. over 8 months storage duration

Incidence (%)				
	Duration (months)			
Treatments	2	4	6	8
8% Moisture content	1.95	0.60	0.44	1.78
11% Moisture content	1.08	0.93	0.81	0.60
Plastic container	1.88	0.85	0.48	1.93
Polythene bag	1.14	0.68	0.77	0.46
Ambient storage (^{0}C)	1.46	0.83	0.33	1.51
Cold storage (^{0}C)	1.56	0.70	0.93	0.88
Grand mean	1.51	0.77	0.63	1.19
HSD (0.05)	0.505	0.492	0.595	0.567

Effect of Moisture Content x Packaging Material on Percent incidence of *Penicillium* spp

Moisture content and packaging material interactions were very significant ($p<0.001$) at 2 and 8 months in storage with similar trend of alternating effects as in the individual factors (Table 7). At 2 months in storage seeds dried to 8% MC and packed in plastic container had lower percentage incidence of ***Penicillium*** spp., 0.85% lower than the highest observed in seeds dried to 11% MC and

packed in plastic container. However, 8 months in storage, seeds dried to 11% MC and packed in polythene bag recorded significantly lower percentage incidence of ***Penicillium*** spp. than the highest observed in seeds dried to 8% MC and packed in plastic container. This is attributed to the effect of seed ageing as build-up of fungi becomes pronounced in aged seeds and also membrane repair. The period of membrane repair is shorter for seeds with high moisture content than low moisture content (Marcos Filho, 2005).

Table 7. Interactive effects of moisture content and packaging material on the percent incidence of *Penicllium* spp. at two and eight months in storage

		Incidence (%)	
Treatment interaction		**Storage duration (months)**	
		2	8
Seed moisture content (%)	Packaging material		
8	Plastic	0.85	3.10
8	Polythene	1.30	0.47
11	Plastic	2.92	0.75
11	Polythene	0.98	0.45
Grand mean		1.51	1.19
HSD (0.05)		0.970	1.087

Effect of Moisture Content, Packaging Material and Storage Condition on Percent Incidence of *Rhizopus* spp.

Rhizopus spp. incidence was significantly ($p<0.05$) influenced by moisture content at 4 and 8 months in storage (Table 8). Seeds dried to 11% MC reduced the percent incidence of ***Rhizopus*** spp. at 4 months in storage, but recorded the highest incidence level at 8 months in storage whilst seeds dried to 8% MC had the highest at 4 months in storage but lowest incidence at 8 months in storage. Seeds with low MC without any physical damage are able to maintain good quality for longer period, and the results indicate that increase in seed age resulted in increase in the level of ***Rhizopus*** spp. incidence in seeds dried to 11% MC whilst 8% MC reduced the incidence level.

Packaging material influenced percentage incidence of ***Rhizopus*** spp. significantly ($p<0.001$) at 8

months in storage. Seeds packed in polythene bag recorded the lowest incidence 1.22% compared to the highest (2.01%) observed in seeds packed in plastic container. This indicates that polythene bag can safely be used to reduce the ***Rhizopus*** spp. incidence in common beans seeds up to 8 months in storage. Seeds stored under ambient storage condition also significantly ($p<0.001$) reduced the incidence of ***Rhizopus*** spp. better than seeds stored under cold storage condition. The growth of ***Rhizopus*** spp. like most fungi seed-borne diseases are negatively affected by low temperature environment, however, high humidity in the storage condition (Table 1) can increase the incidence over the 8 months period.

Table 8. Effect of moisture content, packaging material and storage condition on the percent incidence of *Rhizopus* spp. over 8 months storage duration

	Incidence (%)			
	Duration (months)			
Treatments	2	4	6	8
8% Moisture content	0.40	0.53	0.92	0.95
11% Moisture content	0.48	0.08	1.15	2.28
Plastic container	0.48	0.30	1.06	2.01
Polythene bag	0.40	0.31	1.01	1.22
Ambient storage (^{0}C)	0.52	0.30	1.13	3.03
Cold storage (^{0}C)	0.36	0.31	0.93	0.192
Grand mean	0.44	0.30	1.03	1.61
HSD (0.05)	0.060	0.145	0.098	1.026

Effect Moisture Content x Storage Condition on Percent incidence of *Rhizopus* spp.

Moisture content and storage condition interactions also showed some very high significance ($p<0.001$) variations at 8 months in storage (Table 9). Seeds dried to 8% MC and stored under cold storage condition had the lowest incidence, 0.02% lower than the highest observed in seeds dried to 11% MC and stored under ambient storage condition which had 4.18%. This result compares well with the first two Harrington rules, and also to similar studies where seeds with lower moisture content stored in low temperature are able to remain viable at 8 months in storage (Nagaveni, 2005; Harrington, 1972).

Table 9. Interactive effects of moisture content and storage condition on the percentage incidence of *Rhizopus* spp. at eight months in storage

Seed moisture content (%)	Storage condition (°C)	
8	Ambient storage	1.88
8	Cold storage	0.02
11	Ambient storage	4.18
11	Cold storage	0.37
Grand mean		1.61
HSD (0.05)		0.741

Effect of Packaging Material x Storage Condition on Percent incidence of *Rhizopus* spp

Packaging material and storage condition interaction were significant ($p<0.001$) in 8 months in storage (Table 10). Seeds packaged in polythene bag and stored under cold storage condition recorded the lowest percentage incidence of ***Rhizopus*** spp., 0.12% lower than the highest 3.75% observed in seeds packed in plastic container and kept under ambient storage condition. Though polythene bag is pervious compared to plastic container, the effect of the low temperature in the cold room (15.58°C) slowed down the growth of ***Rhizopus*** compared to the plastic container under the ambient condition where temperature was high (25.43°C) (Assefa and Srinivasan, 2016; Mbofung ***et al.***, 2012; Rugut ***et al.***, 2010).

Table 10. Interactive effects of moisture content and storage condition on the percent incidence of *Rhizopus* spp. at eight months in storage

Treatment Interactions		Incidence (%)
Packaging material	Storage condition (°C)	
Plastic container	Ambient storage	3.75
Plastic container	Cold storage	0.227
Polythene bag	Ambient storage	2.32
Polythene bag	Cold storage	0.12
Grand mean		1.61
HSD (0.05)		0.741

Conclusion

The study showed the implications of excessive drying and seed coat integrity on susceptibility of bean seed to fungi invasion. Drying of common bean seeds to 8% moisture content resulted in higher fungi infections. Seed growers in the humid region can dry the common bean seeds to 11% moisture content, package in polythene bag and store under either cold or ambient condition for a period of eight months without significant seed quality deterioration. Findings of this study are relevant for both producers and input dealers in the humid region of Ghana challenged with seed deterioration in storage due to the high temperature and relative humidity.

References

Assefa, F. and K. Srinivasan (2016). Effect of relative humidity and temperature on shelf life of sorghum, lentil and Niger seeds. International Journal of Applied Agricultural Sciences. Vol. 2, No. 6, 2016, p. 83-91. doi: 10.11648/j.ijaas.20160206.12.

Alves, M. V. P., Von Pinho, E. V. R. Santos, H. O. Alves, G. C. P. and R. W. Pereira (2017). Physiological and Biochemical Characterization of Jilo Seeds (Solanum gilo) in Different Harvest Times. American Journal of Plant Sciences, 8, 2569-2595. https://doi.org/10.4236/ajps.2017.810174.

Claudio, A. A., A. C. Polizel, E. M. Bonfim-Silva, N. M. C. Alves, T. J. A. Silva and A. P. A. B. Damasceno (2019). Physical and physiological quality of safflower seed stored in different packages and temperatures. Journal of Agricultural Science, 11 (2) p. 330-338.

FAOSTAT (2020). http://www.fao.org/faostat/en/#data/TM (accessed on 23/3/2021).

FAO (Food and Agricultural Organization) (2016). Phaseolus bean postharvest operations. Post-harvest compendium.

FAO (1998). World reference base for soil resources. World Soil Resources Report 84. Rome, FAO.

Francisco, F. G. and R. Usberti (2008). Seed health of common bean stored at constant moisture and temperature. Sci. Agric. (Piracicaba, Braz.), 65 (6) p. 613-619, November/December 2008.

Harrington, J. F. (1972). Seed storage and longevity. In: Seed Biology Journal, (3): p. 145- 245. Academic press.

Jittanit, W (2007). Modelling of seed drying using a two-stage drying concept. PhD Thesis Submitted to School of Chemical Sciences and Engineering, The University of New South Wales.

Khalequzzaman, K. M, M. M. Rashid, M. A. Hasan and M. M. A. Reza (2012). Effect of storage containers and storage periods on the seed quality of French bean (Phaseolus vulgaris). Bangladesh J. Agril. Res. 37 (2): p. 195-205, June 2012.

Khan, A. A., K. U. Sarker, M. M. Haque, M. T. Rubayet and I. H. Mian (2018). Storage container, seed moisture level and storage condition effects on germination and prevalence of seed-borne fungi of onion seed. Global Journal of Science Frontier Research: D Agriculture and Veterinary (18): 3 .1.0 p. 8-16.

Marcos-Filho, J (2005). Seed physiology of cultivated plants. Piracicaba: FEALQ, (12) 2005. p. 495.

Mbofung G. C. Y., A. S. Goggi, L. F. S. Leandro and R. E. Mullen (2012). Effects of storage temperature and relative humidity on viability and vigour of treated soybean seeds. Crop Science: Published ahead of print 21 Jan. 2012; doi: 10.2135/cropsci2012.09.0530.

Nagaveni, P. K. (2005). Effect of storage conditions, packing materials and seed treatments on viability and vigour of onion seeds. M. Sc. (Agri.) Thesis submitted to University of Agricultural Sciences, Dharwad.

Nahar, K., M. H. Ali, A. K. M. R. Amin and M. Hasanuzzaman (2009). Moisture content and germination of bean (Phaseolus vulgaris L.) under different storage conditions. Academic Journal of Plant Sciences 2 (4): 237-241, 2009.

Nordenstedt N, D. Marcenaro, D. Chilagane, B. Mwaipopo, M. L. RajamaÈki, S. Nchimbi-Msolla, et al. (2017). Pathogenic seed-borne viruses are rare but Phaseolus vulgaris endornaviruses are common in bean varieties grown in Nicaragua and Tanzania. PLoS ONE 12(5): e0178242. https://doi.org/10.1371/journal.pone.0178242.

Oshone, K., S. Gebeyehu and K. Tesfaye (2014). Assessment of common bean (Phaseolus vulgaris L.) seed quality produced under different cropping systems by smallholder farmers in eastern Ethiopia. African journal of food, agriculture, nutrition and development. 14 (1) p. 8566-8584.

Owolade O. F., J. O. Olasoji and C. G. Afolabi (2011). Effect of storage temperature and packaging materials on seed germination and seed-borne fungi of sorghum (Sorghum bicolor (L.) Moench.) in South West Nigeria. African Journal of Plant Science, 5(15), p. 873-877, 6th December, 2011.

Pessoa, E. B., F. A. C. Almeida, A.F. Neto and J. F. Vieira (2016). Treatment of bean seeds with plant extracts for controlling Zabrotes subfasciatus and its effects on physical and physiological quality during storage. 11(42), p. 4233-4241.

Ribeiro, T., S. R. S. Rovaris, J. A. F. Esteves, S. A. M. Carbonell and A. F. Chiorato (2019). Selection of common bean lines obtained by the genealogical and bulk methods for disease resistance and agronomic traits. Chilean Journal of Agricultural Research 79 (3) pp. 456-463 July-September 2019 doi:10.4067/S0718-58392019000300456.

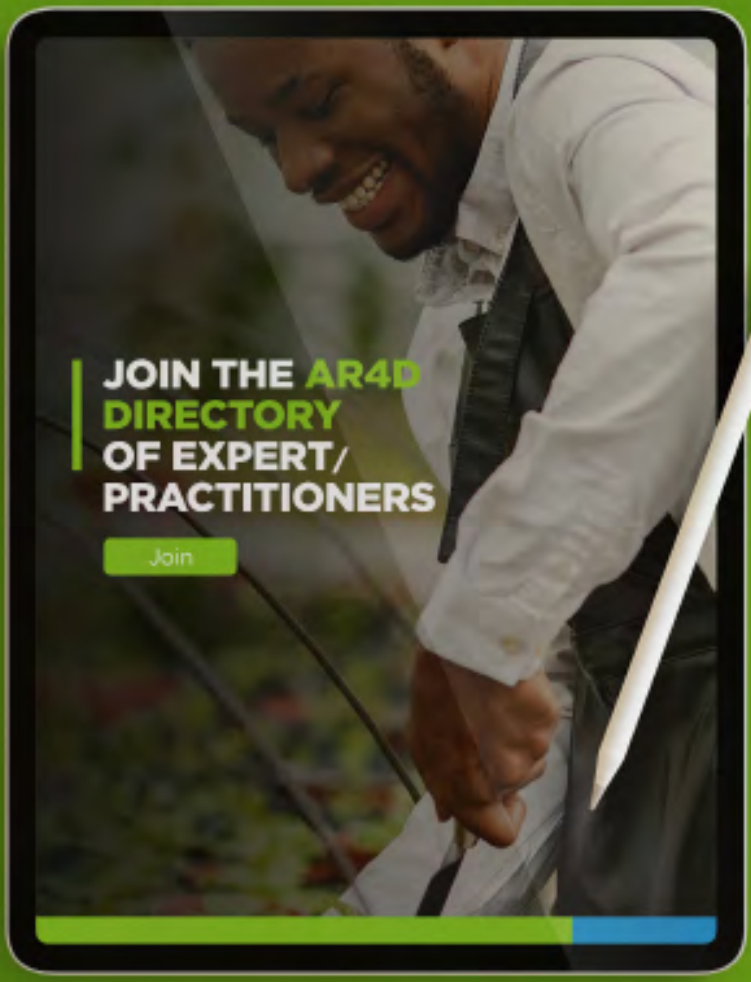
Rugut, E., R. Muasya, and L. Gohole (2010). Longevity of bean (Phaseolus vulgaris) seeds stored at locations varying in temperature and relative humidity. Journal of Agriculture, Pure and Applied Science and Technology, 5 p. 60-70 (2010).

Santos, F., P. F. Medina, A. L. Lourenção, J. J. D. Parisi, and I. J. Godoy (2016). Damage caused by fungi and insects to stored peanut seeds before processing. ttps://www.researchgate.net/publication/294425181 DOI: 10.1590/1678-4499.182. Seed Science Research (2010) 20, 1–12.

Scariot, M. A, G. Tiburski, F. W. R. Júnior, L. L. Radünz, and M. R. R. Meneguzzo (2017). Moisture content at harvest and drying temperature on bean seed quality. e-ISSN 1983-4063 - www.agro.ufg.br/pat - Pesq. Agropec. Trop., Goiânia, (47): 1 p. 93-101, Jan./Mar. 2017.

Sinha, A., S. K. Singh and J. Qaisar (1999). Seed mycoflora of French bean and its control by means of fungicides. Tropenlandwirt, v.11, p.59-67, 1999.

Yeboah, S., J. Asibuo, P. Oteng-Darko, E. A. Adjei, M. Lamptey, E. O. Danquah , B. Waswa and L. Butare (2021). Impact of Foliar Application of Zinc and Magnesium Aminochelate on Bean Physiology and Productivity in Ghana. Hindawi International Journal of Agronomy Volume 2021, Article ID 9766709, 9 pages https://doi.org/10.1155/2021/9766709.



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