Research Paper

How do Different Storage Conditions Affect the Seed Longevity? Empirical Evidence from Chilli (*Capsicum annuum* L.) Seeds of Variety MI 2 in Sri Lanka

R.A.I.S. Ariyarathna[1*], S.L. Weerasena[2], C.K. Beneragama[3]

[1] *Seed Certification Service, Department of Agriculture, Sri Lanka**
[2] *Formerly Department of Agriculture, Sri Lanka*
[3] *Department of Crop Science, Faculty of Agriculture, University of Peradeniya, Sri Lanka*

**Corresponding author: indira.ariyarathna@gmail.com*

ARTICLE INFO

Article history:
Received: 27 May 2021
Revised version received: 27 October 2021
Accepted: 10 December 2021

Citation:
Ariyarathna, R.A.I.S., Weerasena, S.L., Beneragama, C.K. (2022). How do different storage conditions affect the seed longevity? Empirical evidence from chilli (*Capsicum annuum* L.) seeds of variety MI 2 in Sri Lanka. *Tropical Agriculturist*, 170 (2), 12-22.

Abstract

Some farmers in Sri Lanka have often experienced poor field performances of chilli seeds even when the germination percentage of these seeds under the laboratory condition fulfills the certification standards. In the present study, chilli seeds (Var. MI 2) packed in triple laminated aluminum foils were used to determine the effect of different storage conditions on seed quality parameters over a period of two years. Four storage conditions tested were; constant low temperature (17±1 °C, with 60-65% RH), ambient conditions at Gannoruwa, Kundasale, and Mahailuppallama. Survival of seeds of variety MI 2 under constant low temperature, and under ambient conditions at all three locations decreased over 24 months period of storage. Seeds at low temperature successfully maintained germination and moisture content within the seed certification standards throughout the storage period. Germination and field emergence declined gradually under ambient conditions where the fastest decline in germination and field emergence were noted in the seeds stored in Gannoruwa and in Mahailuppallama. The moisture content did not vary significantly over the two year period under the ambient environmental storage conditions. Number of seeds infected with *Aspergillus, Rhizopus*, saprophytic mycelium and *Penicillium* were significantly affected by storage time, storage condition and their interaction. With these findings, it can be recommended that the seeds of chilli variety MI 2 with good initial germination (86%), field emergence (80%) and seed moisture (8.0%), packed in triple laminated aluminum retail packets, could be stored safely for 2 years under the low temperature storage condition while in the ambient condition at Gannoruwa, Kundasale, and, Mahailuppallama for 12, 15 and 6 months, respectively.

Keywords: Field emergence, Germination, Seed health, Storage conditions

Introduction

Chilli (*Capsicum annuum* L.) is one of the most significant cash crops in Sri Lanka. The total extent under cultivation is 13,553 ha, and the total annual production was reported as 79,003 mt (Department of Census and Statistics, 2018). Poor performance of the crop in the field is a result of numerous factors that include poor seed quality, adverse environmental conditions, poor water and soil quality, improper field preparation, non-uniform establishments, and other malmanagement practices. Even if all the field practices are adequately manipulated, the use of poor-quality seeds will hamper the success of the crop. Seed quality comprises several attributes, for instance, genetic quality, physical quality (size, shape, weight, and colour), and physiological quality (seed germination, viability, vigour, and seed health). The provision of high-quality seeds to farmers at the right time is of great importance to guarantee food security (FAO, 2016).

Some farmers in Sri Lanka experience poor field performance even if the germination percentage of the seeds meets the certification standards. In addition, the farmers are not aware of the proper way of handling and storing seeds after purchasing till planting. According to the Seed Act No. 22 of 2003, it is compulsory to display the seed expiry date on the label, by which the farmers can decide the date of planting before the seeds are deteriorated. However, the information regarding the seed longevity of chilli under local conditions is scarce to determine the storage period and suitable storage conditions for local chilli varieties. Research findings of other countries have recorded that the longevity of stored seeds is determined primarily by storage conditions and other factors that are used to store seeds (Adsul *et al*., 2018; Pradhan *et al.*, 2012; Shelar *et al*., 2008).

Therefore, this study attempted to elucidate the aforesaid behaviour of chilli seeds considering two critical environmental factors, temperature and RH, of the three agro-ecological zones to determine how those factors affect the longevity and to determine the effective period of storage of chilli seeds packed in triple- laminated aluminum foil over time to maintain the local certification standards.

Materials and Methods

Chilli pods of variety MI 2 used in this study were obtained from a quality-certified field in Nikeweratiya (7.7464° N: 80.1317° E). Initial germination and moisture percentage of MI 2 seed lots were 83% and 9%, respectively. The chilli pods were then delivered to the Pelwehera processing center for processing and drying to 8% moisture level in order to meet the requirements for seed certification. 7.8 kg of processed seed lots were packed in polypropylene and polysack bags separately as bulk and again transported to the Vegetable Seed Center of the Department of Agriculture (DOA) at Gannoruwa, where they were repacked in the triple-laminated aluminum foil packs with 10 g of seeds in each pack to mimic the retail packs. Seed packets from the seeds packed in poly sack were stored in three locations representing the three

major agro-climatic zones of Sri Lanka: (a) Gannoruwa Vegetable Seed Centre (Mid Country Wet Zone), (b) Kundasale Seed Sales Centre (Mid Country Intermediate Zone), and (c) Mahailluppallama Seed Sales Centre (Low Country Dry Zone) of the DOA under ambient conditions. All the above steps were followed to mimic the usual procedure in the seed value chain from the seed collection to the end-user. In addition, same amount of retail packets from seeds stored in polypropylene bags was kept under controlled temperature conditions (17±1 °C at 60-65% Relative Humidity (RH)) at the cold storage of the Seed Certification Service, Gannoruwa, as a control. All seed packs were sampled at monthly intervals over a period of 24 months and subjected to laboratory and field tests at Gannoruwa, Peradeniya. The experiment design was Completely Randomized Design with a two-factor factorial (storage period x storage conditions) arrangement, and each combination was replicated three times.

Standard laboratory tests for moisture content, germination, and field emergence were performed following the guidelines of the International Seed Testing Association (ISTA, 2015), after treating the seeds with 0.01% of Thiram.

Seed health status was examined by the widely accepted blotter test (Limonard, 1968) while focusing on detecting seed-borne fungi, *Colletotrichum capsici*, the causal organism of anthracnose, and other influential fungus groups such as *Aspergillus, Rhizopus, Penicillium*, and saprophytic mycelium at different storage conditions.

Maximum and minimum daily temperatures, and morning and evening RH values were obtained from the Natural Resources Management Center (NRMC) of the DOA.

The data were analyzed using SAS. The survival curves under different storage conditions were analyzed by probit analysis (Roberts and Ellis, 1989). The time in months that maintained the seed certification standards (75%) as p_{75} was calculated by a regression equation. Other percentage data were transformed to arcsine before analysis.

Results and discussion

Temperature and relative humidity of storage environments

Mean monthly maximum and minimum air temperature (T) and the relative humidity (RH) of the selected locations during the two-year storage period are shown in Table 1.

Seed germination

Seed lots at the farmer level and those after the processing stage maintained the seed certification standards satisfactorily. The percentage of germination was above 75% and the moisture level was below 9% (Table 2). The tested seed quality parameters were significantly higher in processed seeds compared to farmer-grown seeds. Germination percentage in processed seeds increased due to the removal of unfilled grains, half-filled grains, inert matter, weed seeds, damaged seeds, and off-sized seeds during processing, as described by Ferguson *et al*., (1988).

Table 1. Mean annual temperature and relative humidity at the storage locations during the study period of 24 months

Storage Conditions	Mean Temperature (°C)		Mean Difference between Max and Min	Mean RH (%)		Mean Difference between Morning and Evening
	Max	Min		Morning	Evening	
Low Temperature Condition	17±1	17±1	±1	65	65	0
Gannoruwa (MCWZ)	29.7±1.3	21.4±1.4	8.3±1.8	78.8±3.0	69.2±7.4	9.6±6.5
Kundasale (MCIZ)	30.6±1.4	20.7±1.6	9.9±1.8	77.3±4.2	63.8±6.3	13.6±6.3
Mahailuppallama (LCDZ)	32.7±1.7	23.3±1.8	9.4±1.5	83.1±4.7	60.8±8.2	22.4±6.8

Table 2. Initial seed quality of chilli variety MI 2 used in the study

Quality parameter	At the Farm gate	After processing
Germination (%)	83 ± 1.7[b]	86 ± 1.5[a]
Moisture (%)	9.0 ± 0.2	8.0 ± 0.2
Vigour index	125.3 ± 1.2[b]	130.7 ± 2.0[a]
Field emergence (%)	80 ±1.5[b]	85 ± 3.2[a]

The germination of chilli seed was significantly affected by storage time, storage conditions, and their interaction (P<0.0001). Seed germination curves fitted by probit analysis for variety MI 2 at different storage conditions over 24 months are presented in Figure 1. Survival of seeds at constant low temperatures (17±1°C) with 65% RH, and under ambient conditions decreased over a 24-month period of storage. However, seeds stored at low temperatures successfully maintained germination above the minimum standards throughout the storage period, compared to ambient conditions where germination declined gradually. The fastest decline in germination was observed in the seeds stored in Mahailuppallama. In the present study, when germination curves of seed lots of variety MI 2 were compared under different storage conditions, the time taken to drop the germinability to the minimum seed certification standard for germination (i.e., 75%, denoted as p_{75}) derived from the probit plots of Figure 1 differed considerably (Table 3). Seeds with high initial viability and low moisture contents survived longer in storage (Walters *et al*., 2005). Even though good storage conditions maintained the viability of seeds, it declined with the duration of the storage (Walters *et al.*, 2005). Seed aging or seed deterioration is commonly described as the loss of seed viability over time (Coolbear, 1995). Hence, it is necessary for commercial seeds to be assessed for viability periodically to detect the loss in viability during storage before they fall below the standards.

Seed aging during storage is an inevitable phenomenon. The degree and the speed of decline in seed quality strongly depend on storage conditions, plant species, the initial quality of seeds (Balešević-Tubić *et al*., 2005, 2010), and seed genetic traits (Malenčić *et al*., 2003).

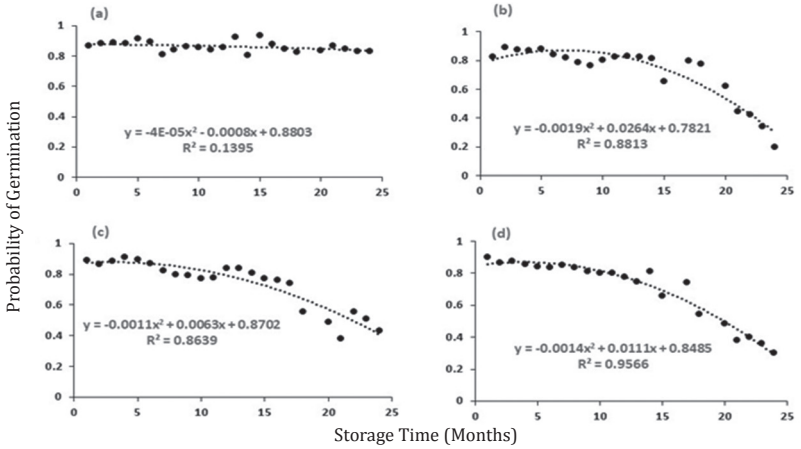

Figure 1. Seed survival curve of chilli variety MI 2, packed in triple-laminated Aluminium foil, under different storage conditions over time, expressed as the probability of germination fitted by probit analysis: (a) Low temperature conditions (b) G-Gannoruwa (MCWZ); (c) K-Kundasale (MCIZ); (d) MI- Mahailuppallama (LCDZ)

Table 3. Mean initial germination, moisture and time taken to reach the minimum seed certification standard of 75% germination (P_{75}) and coefficient of determination (r^2) observed in chilli seeds stored in different environmental conditions

Storage Condition	Initial Germination At storage (%)	Initial Moisture At storage (%)	Estimated P_{75} (Months)	r^2
Low Temperature Condition	81*	8.0	74.9	0.13
Gannoruwa	84	8.0	15.0	0.88
Kundasale	84	8.0	17.2	0.86
MahaIlluppallama	84	8.0	13.2	0.95

**Standard deviations were within the 8%, and are not shown here for clarity.*

They further concluded that significant differences in quality exist among cultivars of a given crop during storage. Seed structure and climate origin were also recognized as genetic factors related to seed longevity (Probert *et al*., 2009).

Seed survival percentage of P_{75} of seeds stored under ambient environmental conditions in all three locations varied between 13.2 to 17.2 months. As previously reported, temperature and relative humidity negatively influence the viability of stored seeds even under ideal storage conditions (Shaban, 2013). Seeds stored in ambient conditions lose their viability and vigour very fast due to the changes in temperature and RH in the storage environment (Adriana *et al.*, 2012). Similar results have been reported in seeds of okra, tomato and bean stored in normal environmental conditions in Sri Lanka (Ariyarathna *et al*., 2020; 2020a; 2020b).

Seed moisture

Storage time and storage conditions did not significantly affect the moisture content of the chilli seeds stored in ambient conditions. In the present study, there was almost no possibility that the equilibrium

moisture content in the seeds would fluctuate, as the chilli seeds were packed and sealed in triple-laminated aluminum foil packaging. The moisture content of the seed in the MI 2 chilli variety did not vary significantly over the two year period when stored under different storage conditions (Table 4). At any given time during the experimental period, the seed moisture content was below 9%, which is the seed certification standard for chilli in Sri Lanka. The moisture content of seeds stored under low temperature conditions was significantly higher than that of ambient storage conditions (Table 4).

Table 4. Effect of four different storage conditions on seed moisture of chilli variety MI 2 over the 24 months storage period

Storage Condition	Moisture
Low Temperature Condition	8.40^{a} ±0.06
Gannoruwa	8.25^{b}±0.06
Kundasale	8.23^{b}±0.05
Mahailuppallama	8.23^{b}±0.06
CV (%)	3.1

Means with the same superscript letters within rows are statistically non-significant (P>0.05)

The optimum moisture content in seeds increases as the storage temperature decreases (Vertucci and Roos, 1993). With all the above findings, however, it can be concluded that seed moisture did not have a significant influence on the longevity of seeds in the present study.

Field emergence

Storage time (P<0.02) and interaction between storage time × storage condition (P<0.0001) significantly affected field emergence in the chilli variety MI 2 as shown in Table 5. As revealed in the previous studies, seedling emergence in the field is controlled by an array of interacting factors, including genetic constitution, seed dormancy, seed vigour, depth of planting, soil aeration, temperature, and water supply (Forcella, 2000; Samarah and Al-Kofani, 2008). The present study showed that the seeds of variety MI 2 maintained the field emergence above 70% until the end of two years only under the seeds stored at low temperature condition whereas a progressive decline was observed up to 12 months.

Table 5. Effect of storage condition and storage time on field emergence of chilli variety MI 2

Storage Time (Months)	Field Emergence (FE %)			
	Storage condition			
	Low Temperature condition	Gannoruwa	Kundasale	MahaIlluppallama
1	85.6^{a}	81.0^{a}	85.6^{a}	85.3^{a}
6	82.3^{a}	79.0^{a}	81.6^{b}	75.0^{b}
12	76.3^{bc}	68.6^{b}	71.3^{c}	66.0^{c}
18	75.0^{bc}	52.6^{c}	66.3^{d}	48.3^{d}
24	70.3^{c}	18.0^{d}	48.3^{e}	24.3^{e}
CV (%)	6.1	4.9	3.0	7.3

Means with the same superscript letters within rows are statistically non-significant (P>0.05)

Relationship between germination and field emergence

A comparison of germination percentage and field emergence percentage of chilli variety MI 2 kept under different storage conditions over the experimental period is presented in Figure 2. Field emergence percentage of seeds was significantly different with laboratory germination values among the locations, even when the seeds were stored under controlled temperature and RH conditions. However, it varied significantly at the end of the 2 years of storage.

Field emergence of seeds stored at three ambient environmental conditions was significantly different after 12 months of the study period. When the seeds were stored for a longer duration under fluctuating environmental conditions, even inside a triple-laminated sealed packet, field emergence and germination varied with the storage time. It is well known that the packing material has a strong influence on the seed deterioration at storage, particularly in relation to moisture absorption (Sultana *et al*., 2015). In the present study, the packaging materials did not allow any moisture absorption.

Therefore, the observed deterioration in the chilli seeds with storage time was merely due to temperature and RH fluctuations in the storage environment. Similar correlations were found between standard germination and field emergence when pea (*Pisum sativum*) seed lots were studied L.) under different agro-climatic conditions. However, these standard germination values could not be directly used to predict field emergence (Ladonne,1989).

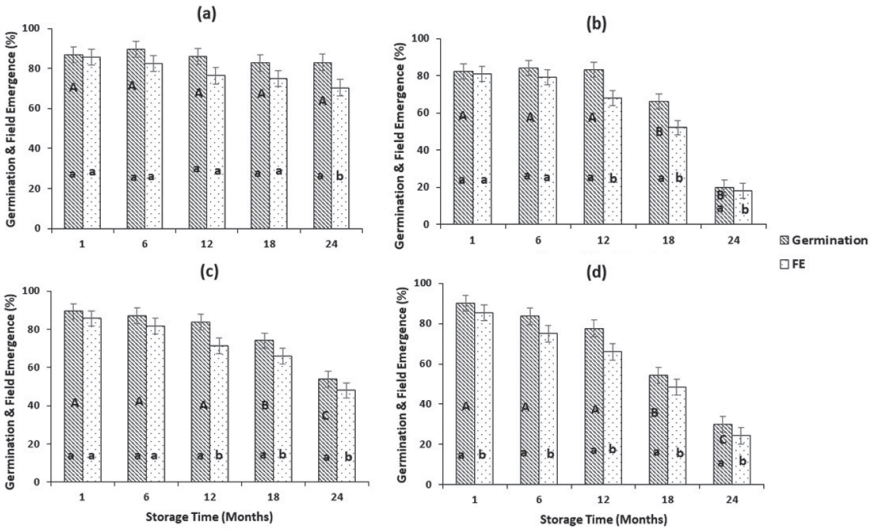

Figure 2. Comparison between Laboratory Germination and Field mergence (FE) percentages in chilli variety MI 2 at four different storage conditions over the storage time. (a) Low temperature condition -LT; (b) Gannoruwa -MCWZ; (c) Kundasale - MCIZ; (d) Mahailuppallama - LCDZ.

Different uppercase letters within germination show significant difference between storage time and different lowercase letters show significant differences between Germination and FE with the time period at p=0.05 level.

Detection of fungi growing on chilli seeds

Anthracnose is one of the major biological barriers to commercial chilli production. The disease damages the mature fruits in the field as well as during storage under favorable conditions for the fungi (Kumar and Kerketta, 2018). However, fungal species responsible in causing anthracnose were not detected at four different storage conditions over one-year period. Fungal groups detected in the study are presented in Figure 3. The Number of seeds infected with *Aspergillus* spp., *Rhizopus* spp., saprophytic fungi, and *Penicillium* spp. was significantly affected by storage time, storage condition, and their interaction (P<0.05). Seeds stored in Gannoruwa were severely affected, and the number of infected seeds was significantly low in the seeds stored at low temperature. Infected seeds as a percentage of *Aspergillus* spp., *Rhizopus* spp. and saprophytic fungi exceeded the seed certification standard (5%) in seed stored at Gannoruwa during the first 12 months of storage. More than 5% of *Aspergillus* spp. infected seeds were also observed at Mahailluppallama during the 12 months, while *Penicillium* spp. infected seeds were observed only in low temperature conditions and at Mahailluppallama. Variations in infected seed quantity within the storage condition with time may be due to identified and unidentified pathogens competing with one another for space and nutrients that caused the loss of turgidity of the fungal hyphae and reduced the fungal growth by producing volatile metabolites (Yan and Anh, 2018). When chilli is grown in areas with high temperatures, RH, and rainfall, seeds may get contaminated before and after processing. Hence, it is recommended to treat the chilli seeds with a fungicide, as seeds are unlikely to germinate without a fungicide, both in the lab and in the field.

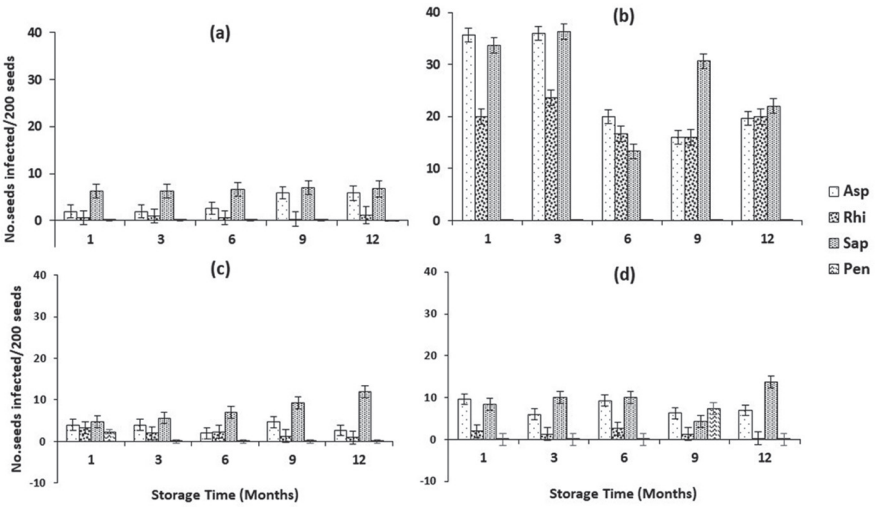

Figure 3. Detection of four groups of fungus, ASP:Aspergillus, Rhi: Rhizopus, Sap: saprophytic fungi and Pen: Penicillium at different storage conditions over one year period. (a) Low temperature; b) Gannoruwa; c) Kundasale ; d)Mahailuppallama.
Means and SE± determined by LSD mean separation at P=0.05 level.

To determine the effective storage period of processed seeds of the chilli variety MI 2, standard laboratory germination, field emergence, and moisture content were considered. Those determinants varied according to the seed lot, even within the same crop and variety. Therefore, standard laboratory germination could be considered as potential germination, and it can be predicted using the probit analysis. In addition, factors responsible for the difference between potential germination and field emergence need to be considered.

Although moisture content does not significantly affect the longevity of the seed lot, other factors of the storage conditions must be considered to reduce the differences between germination and field emergence. The present study revealed that monitoring and controlling storage conditions such as temperature, RH, and fungal contaminations are crucial factors to consider in targeting the long-term storage of chilli seeds.

Conclusion

It can be concluded that the seeds of the chilli variety MI 2 with good initial germination (86%), field emergence (80%), and seed moisture (8.0%), packed in triple-laminated aluminum retail packets, could be stored for 2 years under the low temperature storage condition (17±1 °C and 60-65% RH) without decline of seed qualities. Further, the same seed lot could be stored effectively for one year under ambient conditions in MCWZ without compromising the minimum percentage of germination (75%) prescribed by the seed certification authority in Sri Lanka. The same seeds, when stored in MCIZ, preserved minimum germination for up to 15 months. However, ambient conditions in LCDZ could support seed storage for only up to 6 months. Considering the two different climatic parameters in the storage locations, high RH and high temperature proved detrimental to chilli seed storage even when seeds were packed in triple-laminated aluminum packets. The findings would be useful to the local seed industry to selectively tailor chilli seed storage in the most conducive environments and to take precautionary measures such as conditioned storage when storing seeds in the LCDZ, where crop and seed production is concentrated in the country.

Acknowledgements

Prof. L.D.B. Suriyagoda is gratefully acknowledged for the guidance in statistical analyses. Devoted efforts made by the all the staff of Seed testing laboratory, seed health testing laboratory, post control unit I, and Seed and planting material division of the DOA are also acknowledged.

References

Abdul-Baki, A. A., & Anderson, J. D. (1973). Vigor determination in soybean seed by multiple criteria 1. *Crop science, 13*(6), 630-633.

Adsul, A. T., Chimote, V. P., & Deshmukh, M. P. (2018). Inheritance of seed longevity and its association with other seed-related traits in soybean (Glycine max). *Agricultural research, 7*, 105-111.

Ariyarathna, R. A. I. S., Weerasena, S. L. and Beneragama, C. K. (2020). Sustenance of Seed Germination Potential of Two Okra (*Abelmoschus esculentus* L. Moench) Varieties under Different Environmental Conditions in Sri Lanka. *Tropical Agricultural Research,* 31(1), 21-30.

Ariyarathna, R. A. I. S., Weerasena, S. L., & Beneragama, C. K. (2020). Quality Deterioration of Commercial Bean (Phaseolus vulgaris) Seeds Stored under Contrasting Environmental Conditions in Sri Lanka. *International Journal of Applied Sciences and Biotechnology,* 8(1), 33-44.

Ariyarathna, R. A. I. S., Weerasena, S. L., & Beneragama, C. K. (2020). Deleterious Effects of Storage Environmental Conditions on The Seed Quality of Two Varieties of Tomato (*Solanum lycopersicum* L.) Stored in Triple Laminated Aluminum Packing in Sri Lanka. *International Journal of Applied Sciences and Biotechnology*, 8(4), 437-447.

Balešević-Tubić Malenčić S, Tatić Đ, Miladinović J 2005. Influence of aging process on biochemical changes in sunflower seed. *Helia*, 28(42): 107–114.

Balešević-Tubić, S., Tatić, M., Đorđević, V., Nikolić, Z., & Đukić, V. (2010). Seed viability of oil crops depending on storage conditions. *Helia*, 33(52), 153-160.

Coolbear, P. (1995). Mechanism of seed deterioration. In A.S. Basra (Eds.), Seed quality: basic mechanisms and agricultural implications (pp. 223-277). Food Product Press, New York.

DCS. (2018). Department of Census and Statistics, Sri Lanka.

FAO. (2016). *Seed and seed quality: Technical information for FAO emergency staff.* FAO Seed and Plant Genetic Resources Service Rome, Italy

Ferguson, J.M. (1988). *Metabolic and Biochemical Changes during the Early Stages of Soybean seed Deterioration*. [Doctoral dissertation, University of Kentucky].

Forcella, F., Arnold, R. L. B., Sanchez, R., & Ghersa, C. M. (2000). Modeling seedling emergence. F*ield Crops Research*, 67(2), 123-139.

ISTA. (2015). International Rules for seed Testing vol. 2015, introduction i-9A4, Switzerland

Kumar, P., Kerketta, A. (2018). Chilli anthracnose: A review of causal organism and their managements. *International Journal of Chemical Studies*, 6(1) 1711-1714.

Ladonne, F. (1989). Relationship between standard germination test, conductivity test and field emergence of pea seeds. *Acta Horticulturae*. 253,153-162.

Limonard, T. (1968). Ecological aspects of seed health testing. *Proceedings of the International Seed Testing Association*, 33(1), 343-513.

Malenčić, D., Popović, M., & Miladinović, J. (2003). Stress tolerance parameters in different genotypes of soybean. *Biologia plantarum*, 46, 141-143.

Pradhan, B. K., & Badola, H. K. (2012). Effect of storage conditions and storage periods on seed germination in eleven populations

of Swertia chirayita: a critically endangered medicinal herb in Himalaya. *The Scientific World Journal*, 2012.

Probert, R. J., Daws, M. I., & Hay, F. R. (2009). Ecological correlates of ex situ seed longevity: a comparative study on 195 species. *Annals of botany*, 104(1), 57-69.

Roberts, E. H., & Ellis, R. H. (1989). Water and seed survival. *Annals of botany*, 63(1), 39-39.

Samarah, N. H., & Al-Kofahi, S. (2008). Relationship of Seed quality tests to field emergence of artificial aged barley seeds in the semiarid mediterranean region. *Jordan journal of agricultural sciences*, 4(3), 217-230.

Shaban, M. (2013). Study on some aspects of seed viability and vigor. *International Journal of Advanced Biological and Biomedical Research, 1*(12), 1692-1697.

Shelar, V. R., Shaikh, R. S., & Nikam, A. S. (2008). Soybean seed quality during storage: a review. *Agricultural Reviews*, 29(2), 125-131.

Sultana, R., Chowdhury, M., Islam, M., Mohsin, S., Faruq, A. (2015). Effect of seed treatments and storage periods on the incidence of seed borne disease and seed quality of okra seed (*Abelmoschus esculentus*). *International Journal of Sustain Agriculture Technology,* 11(9), 28-35.

Vertucci, C. W., & Roos, E. E. (1993). Theoretical basis of protocols for seed storage II. The influence of temperature on optimal moisture levels. *Seed Science Research*, 3(3), 201-213.

Wain-Tassi, A. L., Santos, J. F. D., Panizzi, R. D. C., & Vieira, R. D. (2012). Seed-borne pathogens and electrical conductivity of soybean seeds. *Scientia Agricola*, 69, 19-25.

Walters, C., Wheeler, L. M., & Grotenhuis, J. M. (2005). Longevity of seeds stored in a genebank: species characteristics. *Seed Science Research*, 15(1), 1-20.

Yan, Z. K., & Anh, V. T. T. (2018). Effect of Trichoderma sp. on Anthracnose Disease of Stored Chilli. *Borneo Journal of Resource Science and Technology,* 8(2), 90-102.