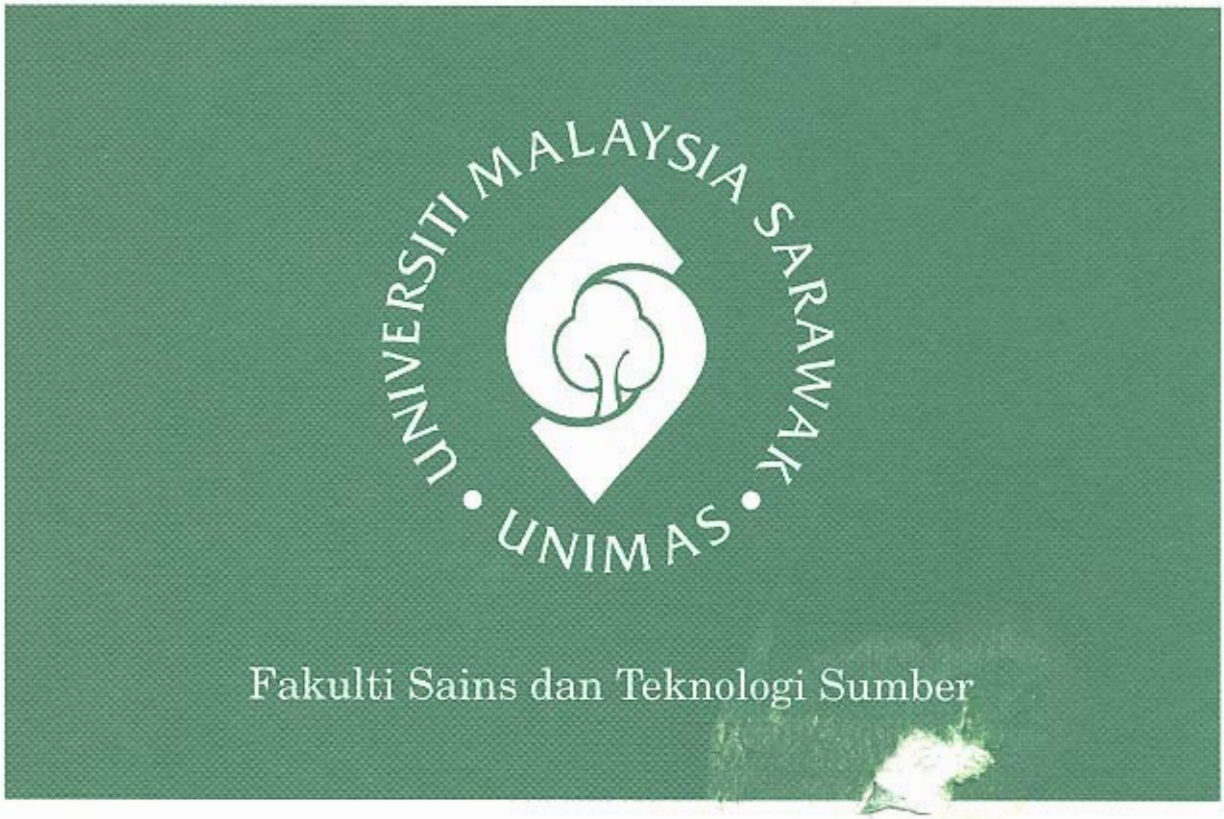

EFFECTS OF STORAGE TEMPERATURE ON SEED MATURATION OF *DILLENIA SUFFROTICOSA*

Mohamad Safri B. Alwi Umar

Bachelor of Science With Honours
(Plant Resource Science and Management)
2004

Effects of Storage Temperature on Seed Maturation of *Dillenia suffroticosa*

Mohamad Safri B. Alwi Umar

This project is submitted in partial fulfillment of the requirements for the degree of Bachelor of Science With Honours (Plant Resource Science and Management).

Faculty of Resource Science and Technology
University Malaysia Sarawak
March 2004

EFFECTS OF STORAGE TEMPERATURE ON SEED MATURATION OF *DILLENIA SUFFROTICOSA*

Mohamad Safri
Plant Resource Science and Management
Faculty of Resource Science and Technology
Universiti Malaysia Sarawak

Abstract

A study was conducted to evaluate the effect of storage temperatures on *Dillenia suffroticosa* seed maturation. Seeds were stored in four different environments: ambient room (28-30°C and 70-80% RH), refrigerator (4-5°C and 42% RH) and cold room (8°C and 10% RH) for 0-14 days. The highest mean percentage of moisture content occurred in matured fruit of upper part of inflorescence (M3) with 5.8% stored in cold room and refrigerator for the first week of storage. The mean percentage declined between 0.1-0.4 percent each week in all maturation levels for all temperature levels of storage. The lowest percentage of moisture content recorded in matured fruit of lower part of inflorescence (M2) with 4.0% after six week of storage. Storage in cold room has the highest mean percentages of moisture content as compared to seeds kept in refrigerator and in ambient room. Matured ripe fruit (M1) has the highest mean percentage of germination stored in cold room with 37%, 48%, 66% at the second, third and fourth week respectively. It was followed by M3 stored in ambient room with 32%, 45% and 56%. The lowest percentage of germination recorded was occurred in M2 with 16% after six week of storage. Seeds storage in refrigerator for all maturation levels gave the lowest percentages as compared to storage in ambient room and in cold room for the entirely six weeks.

Key words: *Dillenia suffroticosa,* seed storage, moisture content and germination.

Abstrak

Satu kajian telah dijalankan untuk menilai kesan suhu penyimpanan ke ataskematagan biji Dillenia suffroticosa. Biji disimpan pada empat suhu yang berbeza: suhu bilik(28-30°C dan 70-80% RH), peti sejuk (4-5°C dan 42% RH) dan bilik sejuk (8°C dan 10% RH) selama 0-14 hari. Peratus min kandungan kelembapan tertinggi ialah buah matang bahagian atas pada jambangan bunga (M3) dengan 5.8% disimpan dalam bilik sejuk dan peti ais pada minggu pertama penyimpanan. Peratusan min menurun sebanyak 0.1-0.4peratus setiap minggu pada semua peringkat kematangan dan juga pada setiap suhu penyimpanan. Peratusan kandungan kelembapan terendah dicatatkan oleh buah matang bahagian bawah pada jambangan bunga (M2) dengan 4.0% selepas enam minggu disimpan. Penyimpanan di dalam bilik sejuk mempunyai peratusan kandungan kelembapan paling tinggi jika dibandingkan dengan suhu bilik dan peti sejuk. Buah matang yang masak (M1) mencatatkan peratusan min tertinggi untuk percambahan apabila disimpan di dalam bilik sejuk dengan 37%, 48% dan 66% pada minggu kedua, ketiga dan keempat. Ini diikuti oleh M3 disimpan dalam suhu bilik dengan 32%, 45% dan 56%. Peratusan percambahan terendah dicatatkan oleh M2 dengan 16% selepas enam minggu disimpan. Penyimpanan biji benih di dalam peti sejuk untuk semua peringkat kematangan memberikan peratusan terendah jika dibandingkan dengan penyimpanan pada suhu bilik dan bilik sejuk selama enam minggu disimpan.

Kata kunci:Dillenia suffroticosa, penyimpanan biji benih, kandungan kelembapan dan percambahan.

INTRODUCTION

In tropical forests management and reforestation programs, seeds still remain as the main source of planting material. The quality and availability of seeds is therefore an important factor in the forest resource management (Jayanthi *et al.,* 1998). Tropical tree seeds are recalcitrant and are sensitive to desiccation and low temperature. They have a short (a few weeks to a few months) viability periods (King & Roberts, 1980). The seeds have to be stored at a critical moisture content which is usually little lower than the seed moisture content at harvest, and lose viability with decrease in their moisture content (Mittal *et al.,* 1998). Thus, efficient seed storage plays an important role in the management of tropical forests.

Seed longevity varies greatly among species. Not all seeds respond in the same way to the environment before and during storage. According to Roberts (1973), there are two categories of seed storage behavior, orthodox and recalcitrant. Species with orthodox seeds can be maintained satisfactorily *ex situ* over a long term in appropriate environments, but short term storage is usually the best that can be achieved with seeds which show recalcitrant seed storage behavior under well-defined and well-controlled environment. Ellis *et al.* (1990). have introduced new categories of seed storage behavior in 1990, intermediate or semi-recalcitrant which is between orthodox and recalcitrant. These third categories exhibit some degree of desiccation tolerance and freezing sensitivity. Several of the pioneer trees in the area (fast growing, short living plants) which are common in early successional vegetation and large recent gaps are known for producing seeds that can be stored for a long time in dry conditions without loosing their ability (Vazquez-Yanes *et al.* 1998). Many factors that can affected seed viability during storage such as genetic effects, seed structure and composition, seed maturity, mechanical damage, relative humidity, moisture content and temperature. However, only two

factors that are most important factors influencing seed storage life are moisture content and temperature.

Studied by P. bulan (1993) "pepper seeds quality under different environments", In this study, fresh and matured pepper seeds are stored in four different environments: ambient room (28-30°C and 70-80% RH), air conditioned room (22-23°C and 45-50% RH), refrigerator (4-5°C an 42% RH) and incubator (40°C and 40% RH) for 0-14 days. These seeds were evaluated for effects of changes in temperature and relative humidity of storage environment on the seed quality. Seed germination was evaluated on three layers of moist filter paper in Petri dishes (25 seeds x 4 replicates) at 30°C without light in the germinator. In this project moisture content of seeds were determined by air oven method of 24 hours at 103°C using two replicates and calculate on wet-weight basis which similar with my project but in mine the temperature use is 60°C for 2 days or 48 hours. The method for germination is also the same but in my project cold room are used to replace incubator and no germination done in air condition room. According to Mittal *et al.* (1998) in their study "Effect of seed treatments and storage temperature on storability of *Syzgium cuminii* seeds" seed moisture content determination are also using oven-dry method with temperature 103°C for 17 hr. seed germination using ten replicates of 10 seeds were germinate in moist vermiculite in plastic pots in a growth room at 26±1 °C with 12 hours light.

Dillenia suffroticosa L. is one of the pioneer tree species found in Sarawak and belongs to the family Dilleniacieae and includes local species as Simpoh. *D. suffroticosa* is mainly propagated by seeds. Birds play an important role to distribute the seeds as they eat the fruit. *D. suffroticosa* has many different vernacular names. It is known as "Simpoh" in Sarawak, Peninsular Malaysia and Brunei, "San" in Thailand, "Simpor" in Sabah and "Simpur" in

Sumatra. This tree grows vigorously on eroded soil, wasteland, forest edges and swampy areas (Hoogland, 1972).

This tree has large leaves, and large yellow flowers. It can grow up to 5m (Polunin, 1987). They are pollinated by bees which collect its pollen or by small beetles and flies that scramble over it. Almost every flower sets fruit. The unripe fruits are surrounded by thick red sepals. Meanwhile the ripe fruit split open into pinkish star-shaped segments to reveal seeds covered in red arils. This tree can live for 50-100 years (Corner, 1997). The timber of D. *suffroticosa* is a sinker species. It is hard and tough, containing siliceous deposits. Sapwood is pale pink/yellow 25 to 50 mm in depth and the heartwood is a chocolate red color darkening on exposure. The wood has rough texture. Logs sometimes contain black stain and are inclined to end split. Sapwood said to be resistant to lyctus. *D. suffroticosa* wood needs care in air drying to avoid distortion and splitting. This wood is easy to shrink if over drying. At 15% moisture it weighs about 16 to 22 kg per cubic foot. There is a superficial resemblance to Keruing (Dipterocarpus Sp.) but it contains no resin ducts. Fairly easily permeable by preservatives and is said to be of low to medium durability. This wood is strong and tough (Polunin, 1987).

Quarter sawn wood presents an attractive, but not pronounced, silvery surface because the wide rays which are then exposed provide decorative grain. In this form and properly dried, *D. suffroticosa* may be used for paneling, furniture and flooring. A fairly hard and heavy wood to be considered for veneer but tested by C.S.I.R.O. Small quantities may be special quarter sliced for decorative needs. A general purpose is for constructional material in boat building for stringers and bottom boards. In Japan this wood is used for flooring. This wood also can be use for making stairs, posts, beams, sills, frames, piling, fencing, gunstocks

(Polunin, 1987). Other use is for making Sleepers for logging railways. In Sarawak, this tree has not been exploited much compare to other country like Japan. The leave are use to wrap food and young shoots are cook as vegetables. As this tree is a pioneer species, it can provide food and shelter for other plants and creatures. It provides shade for other less hardy plants to establish themselves.

In the present study effort is made to evaluate the effects of different conditions of environment on the storage of *D. suffroticosa* seeds. The effects of storage temperature on the levels of seed maturity is also investigated.

MATERIAL AND METHOD

Material

Fresh and matured fruits were collected from areas in Matang and Semariang. The seeds were extracted from the fruits by separating them from the aril and washed thoroughly using tap water. The seed is washed to remove the aril which can enhance the growth of fungi as this can lead to deterioration. Seed were then dried in ambient room under shade for two days. Dried seeds were stored in an air tight bottle to maintain moisture content and viability. Seeds were categorized into 3 maturation levels which are matured ripe fruit (M1), matured fruit of lower part of inflorescence (M2), matured fruit of upper part of inflorescence (M3).

Method

Moisture content test

Seed moisture content was determined for the three maturation (M1, M2, and M3) levels. For each maturation level, 4 replicates of 15 seeds each were placed into saucers made up of

aluminum foil, weighted and then put in the oven at 60°C for 48 hours. Afterwards, the dry weight is recorded. Moisture content of the seeds is calculated according to Association of Official Seed Analysts (AOSA, 1985).

$$\text{Moisture content (\%)} = \frac{a - b}{b - a} \times 100\ \%$$

a = weight of seeds – weight of aluminum foil

b = weight of (a) = weight of seeds before placing in oven

c = weight of (a) = weight after drying in oven

Seed germination test

The germination test was to find out the ability to geminate according to the environment temperature. Seed germination was made according to rules for seed testing (AOSA, 1976). For each maturation level, 4 replicates of 50 seeds each were germinated using compost as a medium in plastic containers at ambient room (28-30°C). Observations were made twice a week up to six weeks. Seeds emerging from the compost media were considered germinated.

Storage of seeds

Seeds from the three levels of maturation (M1, M2, M3) were stored in different environments [ambient room (28-30°C and 70-80%RH); refrigerator (4-5°C and 42%RH); cold room (8°C and 10%RH)] for 0 to 14 days. Samples of seed were withdrawn from different storage environments every 2 days for evaluation of the capacity to germinate up to 14 days.

RESULTS AND DISCUSSION

Initial seed quality

Moisture content

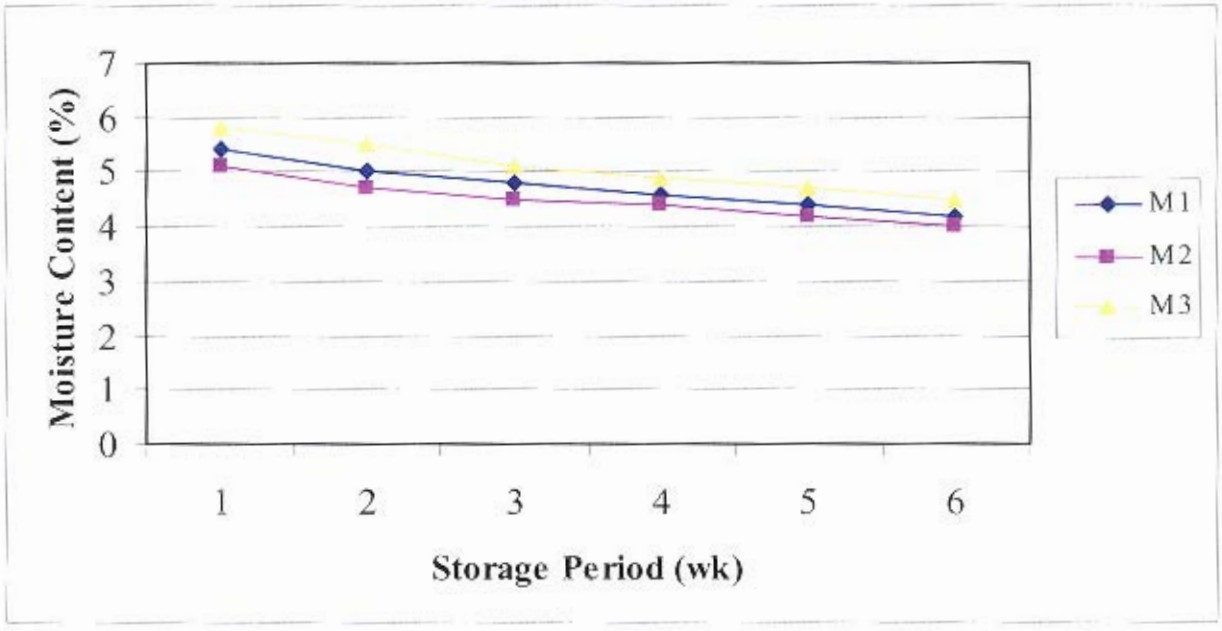

Figure 1: Moisture content of *D.suffroticosa* seeds of different maturation levels stored in ambient room (28-30°C; 70-80%RH).

The seeds of *D.suffroticosa* obtained and separated into three maturation (M1, M2, M3) levels gave different percentages of moisture content when stored in ambient room (Figure1). Matured fruit of upper part of inflorescence (M3) have the highest percentages moisture content from first week (5.8%) up to the sixth week (4.5%). Moisture content of seeds from matured fruit of lower part of inflorescence (M2) was the lowest up to the end of six week of storage.

Mean initial moisture content of seeds for all maturation level was 4.8% stored for six weeks at 60°C. The mean percentage declined between 0.1-0.4 percent each week for all maturation levels. The percentage for M3 was the highest with 5.8% followed by M1 (5.4%) and M2 (5.1%). Moisture content for M2 was the lowest with 4.0% after six week of storage. According to Mittal *et al.* (1998), if the seeds are treated to lower their moisture content, some

of the seeds already having lower moisture content would be dried below their critical moisture content. The F value for this was 7.29 and P=0.01.

Seed germination

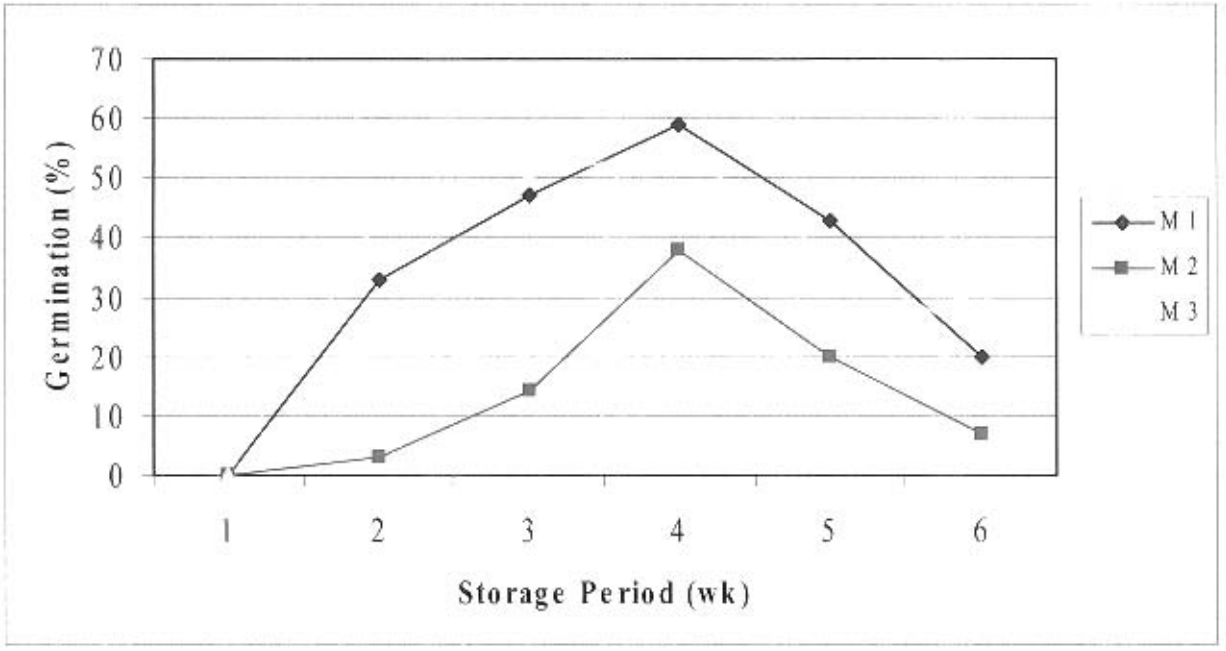

Figure 2: Germination of *D.suffroticosa* seeds of different maturation levels stored in ambient room (28-30°C; 70-80%RH).

Seeds of *D. suffroticosa* harvested, processed and utilized were of different maturation (M1, M2, and M3) levels. The seed germination for these maturation levels reached maximum percentages of germination at the fourth week.

Mean percentage of germination and moisture content of seeds at the three maturation levels were as shown in Figure 2. It was observed that germination of seeds for matured fruit of upper part of inflorescence (M3) has the highest with 44%, 50% and 55% at second, third and fourth weeks respectively. Germination of seeds from matured ripe fruit (M1) was moderate and slightly lower than matured fruit of upper part of inflorescence (M3), except at the fourth week where the percentage was 59 percent. Seeds obtained for matured fruit of lower part of inflorescence (M2) gave the lowest percentages as compared to M1 and M3 for the entirely

six weeks. After fifth week the germination percentage was decline between 14-23% for all maturation levels. The F value for this was 4.65 and significance at 0.01. No germination of seeds occurred in all maturation levels for the first week of sowing. Germination was influenced by moisture content. But sometimes for some seed such as beetroot (*Beta vulgaris*) and spinach (*Spinacea oleaucea*), excessive amount of water reduce the permeability of the coat to oxygen and inhibit germination (Gulliver and Heydecker, 1973).

Storage of seeds

Moisture content of seeds stored in cold room

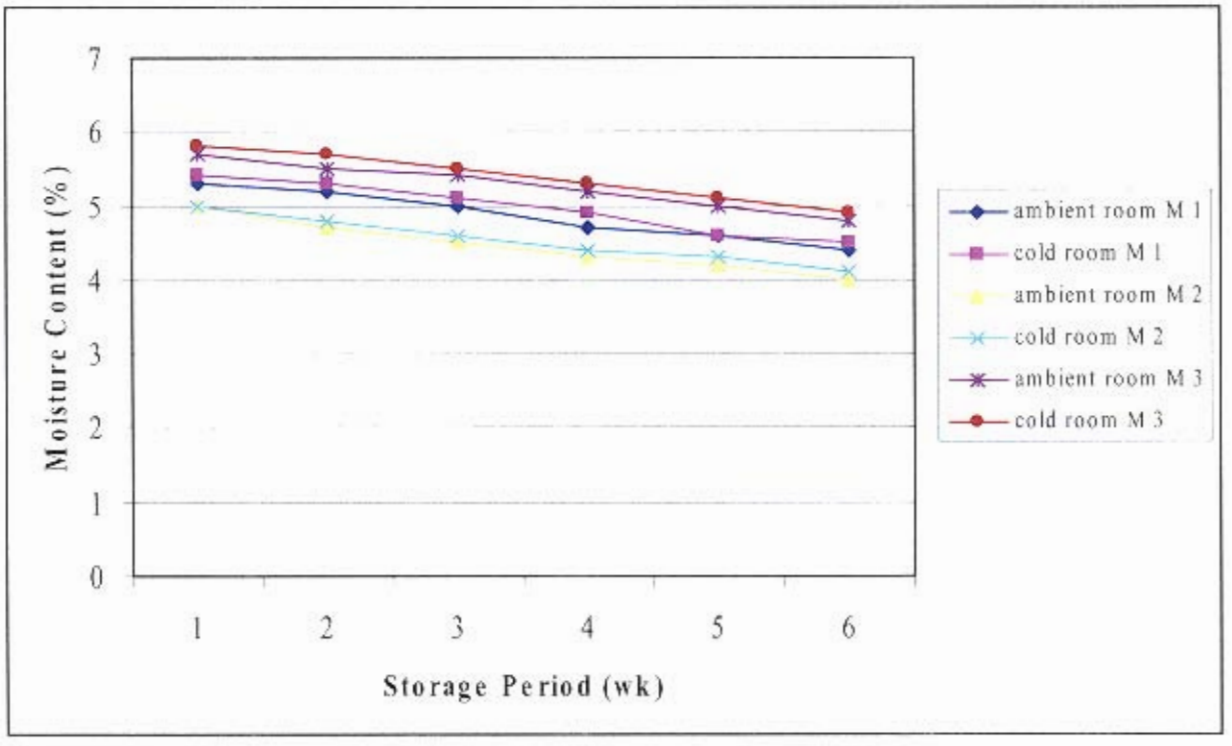

Figure 3: Moisture content of *D. suffroticosa* seeds of different maturation levels stored in cold room (8°C and 10%RH).

The moisture content of *D. suffroticosa* seeds kept in cold room (8°C; 10%RH) produced higher percentages of moisture content as compared to those seeds kept in ambient room (28-30°C; 70-80%RH) for all maturation levels stored up to six weeks.

Mean percentages of moisture content for seeds for the three maturation levels and stored in cold room is showed in Figure 3. Matured fruit of upper part of inflorescence (M3) has the highest percentage of moisture content with 5.8 % stored in cold room followed by matured ripe fruit (M1) with 5.4 % and matured fruit of lower part of inflorescence (M2) with 5 % on the first week of storage. The range of mean was between 5.8-4.0 percent moisture content for seeds at all maturation levels. Seed moisture content percentages declined between 0.1-0.4 percent each week up to six weeks. The lowest percentage recorded for seeds moisture content occurred in M2 with 4.0% after six week of storage. Storage in cold room has the highest mean percentage of moisture content as compared to seeds kept in ambient room. However the different in the means of the moisture content was about 0.1% only. The F value for seeds stored in ambient room was 2.82 and in cold room was 2.03 and P=0.01.

Moisture content of seeds stored in refrigerator

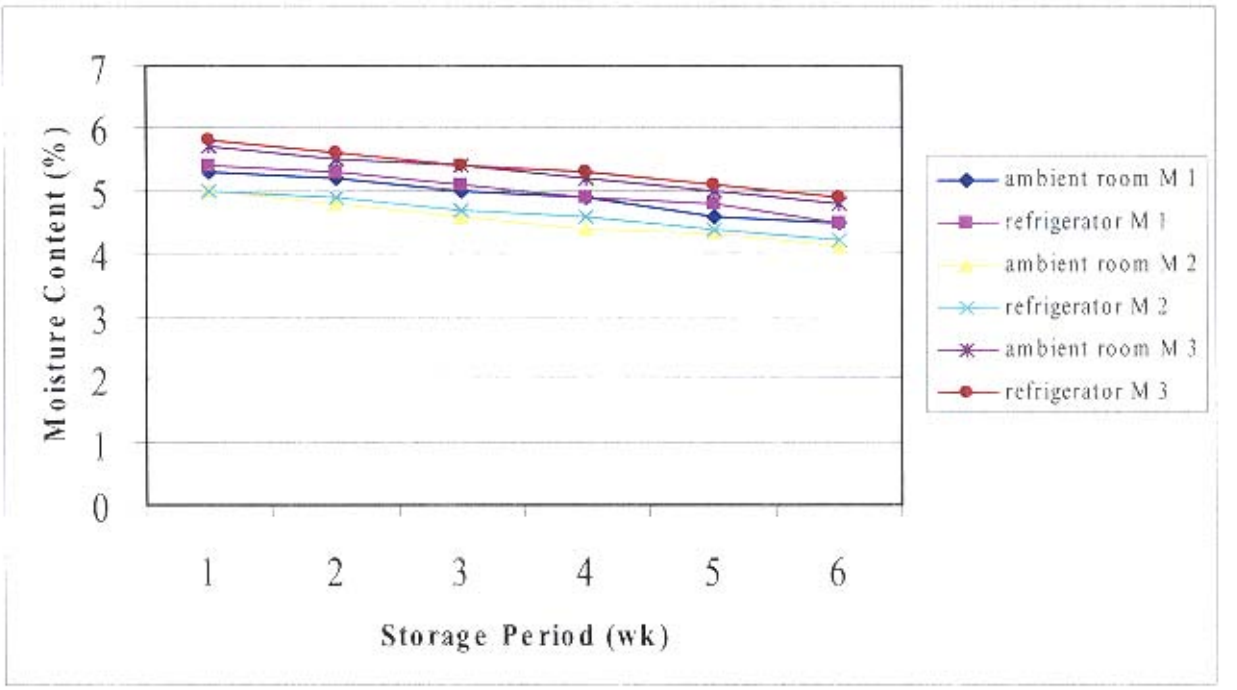

Figure 4: Moisture content of *D. suffroticosa seeds* of different maturation levels stored in refrigerator (4-5°C; 42%RH).

The moisture content of *D. suffroticosa* seeds kept in the refrigerator (4-5°C; 42%RH) produced higher percentages of moisture content as compared to those seeds kept in ambient room for all maturation levels stored up to six weeks.

The highest percentage of moisture content occurred in matured fruit of upper part of inflorescence (M3) with 5.8% followed by matured ripe fruit (M1) with 5.4% and matured fruit of lower part of inflorescence (M2) with 5%. Storage in refrigerator has the highest mean percentage of moisture content as compared to seed kept in ambient room however the different in the means of the moisture content was about 0.1% and the mean was almost the same after six week of storage. The mean percentage declined between 0.1-0.4 percent each week up to six week. The lowest percentages recorded occurred in M2 with 4.0%. The F value for this was 2.37 and P= 0.01.

Germination of seeds in cold room

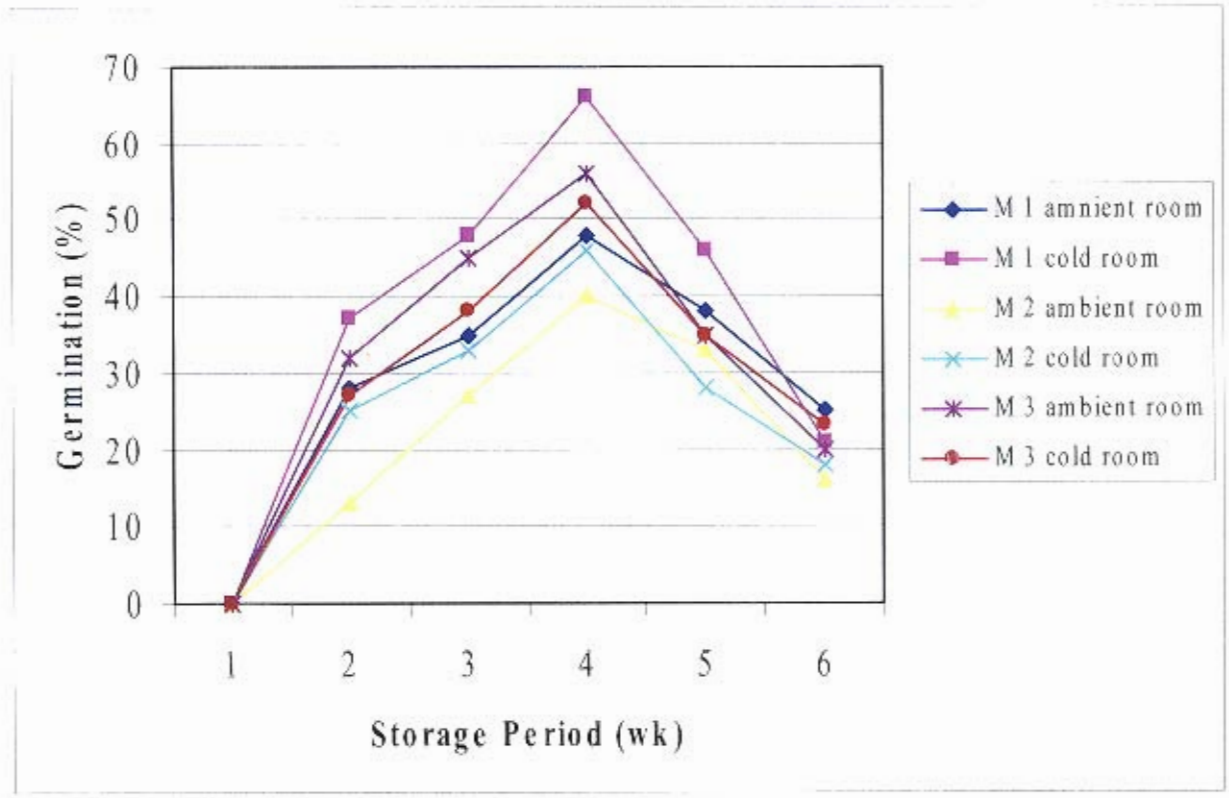

Figure 5: Germination of *D. suffroticosa* seeds of different maturation levels stored in cold room (8°C; 10%RH).

The germination of *D. suffroticosa* seeds kept in cold room (8°C; 10%) produced higher percentages of germination as compared to those seeds kept in ambient room (28-30°C; 70-80%RH) except for M3, stored up to six weeks.

The highest percentage of germination was occurred in matured ripe fruit (M1) with 37% on second week, 48% for third week and 66% for fourth week followed by matured fruit of upper part of inflorescence (M3) and matured fruit of lower part of inflorescence (M2). No germination of seeds occurred in all maturation levels for the first week of sowing. After fourth week of storage the percentage declined drastically between 26-18% in all maturation levels. The lowest percentage was occurred in M2 with 16% stored in ambient room after six week of storage. There were big different in mean percentages of germination between cold room and ambient room with 3-18%. The F value for cold room is 21.19 and F value for ambient room is 18.05 and P=0.01. Mean percentage for M1 stored in cold room was higher than M1 stored in ambient room but on the last week M1 stored in cold room was lower than stored in ambient room. For M2, seeds mean percentage for cold room was higher than stored in ambient room after six weeks of storage. But for M3, storage in ambient room was higher than storage in cold room with the different was about 5%. Figure 5 showed the comparison between storage in ambient room and cold room.

Germination in refrigerator

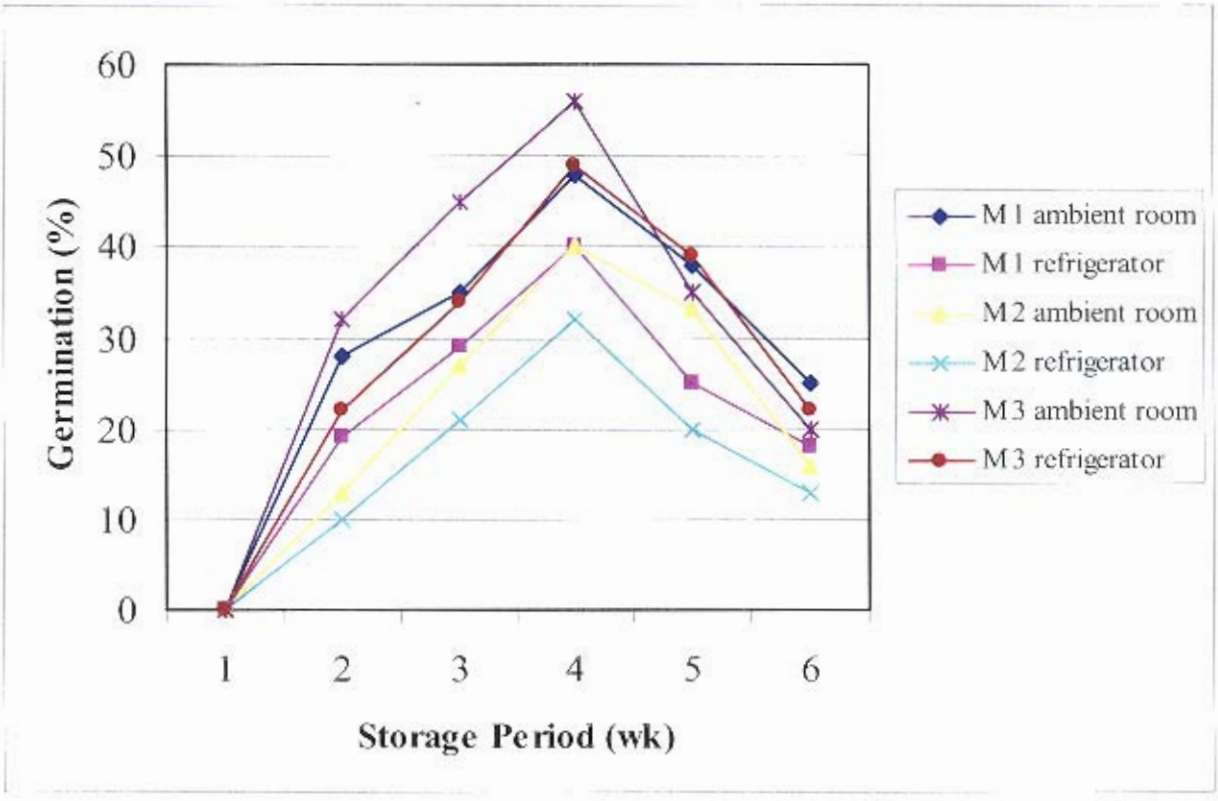

Figure 6: Germination of *D. suffoticosa* seeds of different maturation levels stored in refrigerator.

The germination of *D. suffroticosa* seeds kept in ambient room (28-30°C; 70-80%RH) produced higher percentages of germination as compared to those seeds kept in refrigerator (4-5°C; 42%RH) for all maturation levels stored up to six weeks.

Mean percentages of germination for seeds stored in refrigerator is showed in Figure 6. The highest germination occurred in matured fruit of upper part of inflorescence (M3) with 22%, 34% and 49% at second, third and fourth weeks respectively. This is followed by matured ripe fruit (M1) and matured fruit of lower part of inflorescence (M2). It was observed that matured fruit of lower part of inflorescence (M2) has the lowest mean percentage with 13% after six week of storage. Storage in refrigerator has lower mean percentages of germination compared to storage in ambient room with the different between 2-13% for all maturation level. According to Mittal *et al.* (1998), storability of *Syzygium cuminii* seeds stored at 5°C did not

germinate in storage even after 20 weeks. The F value for this was 12.39 and P=0.01. After fourth week of storage, the percentages declined between 7-25% in all maturation levels. No germination of seeds occurred in all maturation levels for the first week of sowing.

CONCLUSION

The data for mean percentages of moisture content are showed in Appendix 1. The highest mean percentage of moisture content occurred in matured fruit of upper part of inflorescence (M3) with 5.8% stored in cold room and refrigerator and 5.7% stored in ambient room for the first week of storage. The mean percentage declined between 0.1-0.4 percent each week in all maturation levels as long as storage temperature. The lowest percentage of moisture content recorded in matured fruit of lower part of inflorescence (M2) with 4.0% after six week of storage. Storage in cold room has the highest mean percentages of moisture content as compared to seeds kept in refrigerator and in ambient room. However the different in the means of the moisture content was about 0.1%. Data analysis using univariate of variance showed that there were significant different in moisture content of seeds with 0.99 and P=0.05. Seeds when detached from the parent tree, they lost or gained moisture to or from the surrounding atmosphere until their moisture content reaches a point of equilibrium with the humidity and temperature of the surrounding air. This is known as the equilibrium moisture content (EMC). Once it has been reached, it would be maintained as long as the humidity and temperature of the air remained constant. If they change, the seeds would again lose or gained moisture until a new EMC is reached. The phenomenon can be used to explain how the moisture content percentage was different in each temperature used for storage.

The data for mean percentages of seeds germination are showed in Appendix 2. Matured ripe fruit (M1) has the highest mean percentage of germination stored in cold room with 37%, 48%, 66% at the second, third and fourth week respectively. It was followed by matured fruit

of upper part of inflorescence (M3) stored in ambient room with 32%, 45% and 56%. The lowest percentage of germination recorded was occurred in matured fruit of lower part of inflorescence (M2) with 16% after six week of storage. Seeds storage in refrigerator for all maturation levels gave the lowest percentages as compared to storage in ambient room and in cold room for the entirely six weeks. No germination of seeds occurred in all maturation levels for the first week of storage. There were significant different in seeds germination with 0.91 and P=0.05. Germination conditions can be varying in different species of tree. In this study, the refrigerator temperature may be not suitable for the germination of *D. suffroticosa* seeds that caused the germination percentage was the lowest.

ACKNOWLEDGEMENT

I wish to express my appreciation to my project supervisor, Dr. Petrus Bulan for his guidance, encouragement and dedication in completion of his patient and assistance during the preparation of this thesis. My deepest appreciation also goes to the Faculty of Resource Science and Technology for its teaching and technical support.

REFERENCE

AOSA, 1985. Rules for Testing Seeds of Association of Official Seed Analysts. Journal Seed Technology. Vol.6.no.2. p 126.

Corner E. J. H., 1997.Wayside Trees of Malaya. Malayan Nature Society. Vol.1.no. 4. pp 232-233.

Ellis, R.H., Hong, T.D. and Roberts, E.H., 1990. An intermediate category of seed storage behavior? I. Coffee. Journal of Experimental Botany 41: pp 1167-1174.

Gulliver, R. L. and Heydecker, W. 1973. Establishment of seedling in a changeable environment. In *Seed Ecology*, ed. W. Heydecker, Butterworth, London, pp. 433-462.

Hoogland, R.D. 1972. Dilleniacea in: Flora of Thailand, vol. 2. no. 2. p. 101.

Polunin I., 1987. Plants and Flowers of Singapore, Times Edition.

Jayanthi N, HorY. L and Krishnapillay B., 1998. A comparative study on the effect and temperature on storability of an orthodox and a semi-recalcitrant tropical forest tree seed. IUFRO Seed Symposium 1998 "Recalcitrant Seeds" Proceeding of The Conference: pp 48-52.

King, M.W. and Roberts, E.H 1980. Maintainance of recalcitrant seeds in storage. Pp. 53-89 in Chin, H.F. & Roberts, E.H. (Eds.) Recalcitrant Seeds. Tropical Press Sdn. Bhd., Kuala Lumpur, Malaysia.

Mittal R.K., Hansen H.J., Thomsen K., 1998. Effect of seed treatments and storage temperature on storability of *Sysygium cuminii* seeds. IUFRO Seed Symposium 1998 "Recalcitrant Seeds" Proceeding of The Conference: pp 53-61.

Petrus B., 1993. Pepper seeds quality under different environment, Malaysian Natural Resources Proceedings of Tropical Natural Resources Symposium: pp 205-207.

Roberts, E.H., 1973. Predicting the storage life of seeds. Seed Science and Technology 1: pp 499-514.

Vazquez-Yanes C., Orozco-Segovia A. and Sanchez-Coronado M.E., 1998. Recalcitrance among the seeds of the woody plants growing at the northern limit of the tropical rain forest in the American Continent, IUFRO seed symposium 1998 "recalcitrant seeds" proceeding of the conference: pp 329-332.

APPENDIXES

Appendix 1: Mean percentages of seeds moisture content

Table 1: *D. suffroticosa* seeds moisture content stored in ambient room.

storage week	moisture content in ambient room %		
	M1	M2	M3
1	5.4	5.1	5.8
2	5	4.7	5.5
3	4.8	4.5	5.1
4	4.6	4.4	4.9
5	4.4	4.2	4.7
6	4.2	4	4.5

Table 2: Moisture content of *D. suffroticosa* seeds of different levels of maturation stored in cold room.

storage week	M1		M2		M3	
	ambient room	cold room	ambient room	cold room	ambient room	cold room
1	5.3	5.4	5	5	5.7	5.8
2	5.2	5.3	4.7	4.8	5.5	5.7
3	5	5.1	4.5	4.6	5.4	5.5
4	4.7	4.9	4.3	4.4	5.2	5.3
5	4.6	4.6	4.2	4.3	5	5.1
6	4.4	4.5	4.0	4.1	4.8	4.9

Table 3: Moisture content of *D.suffrotcosa* seeds of different levels of maturation stored in refrigerator.

storage week	M1		M2		M3	
	ambient room	refrigerator	ambient room	refrigerator	ambient room	refrigerator
1	5.3	5.4	5	5	5.7	5.8
2	5.2	5.3	4.7	4.9	5.5	5.6
3	5	5.1	4.5	4.7	5.4	5.4
4	4.7	4.9	4.3	4.6	5.2	5.3
5	4.6	4.8	4.2	4.4	5	5.1
6	4.4	4.5	4.0	4.2	4.8	4.9

Appendix 2: Mean percentage of seeds germination

Table 4: Germination of *D. suffroticosa* seeds of different maturation levels stored in ambient room.

storage week	Germination in ambient room %		
	M1	M2	M3
1	0	0	0
2	33	3	44
3	47	14	50
4	59	38	55
5	43	20	37
6	20	7	23

Table 5: Germination of *D. suffroticosa seeds* of different maturation levels stored in cold room.

storage week	M1		M2		M3	
	ambient room	cold room	ambient room	cold room	ambient room	cold room
1	0	0	0	0	0	0
2	28	37	13	25	32	27
3	35	48	27	33	45	38
4	48	66	40	46	56	52
5	38	46	33	28	35	35
6	25	21	16	18	20	23

Table 6: Germination of *D. suffroticosa* seeds of different maturation levels stored in refrigerator.

storage week	M1		M2		M3	
	ambient room	refrigerator	ambient room	refrigerator	ambient room	refrigerator
1	0	0	0	0	0	0
2	28	19	13	10	32	22
3	35	29	27	21	45	34
4	48	40	40	32	56	49
5	38	25	33	20	35	39
6	25	18	16	13	20	22

Appendix 3: Analysis of data

Table 7: Moisture content of seeds stored in ambient room.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.716111111	5	0.543222222	7.297015	0.002358
Within Groups	0.893333333	12	0.074444444		
Total	3.609444444	17			

Table 8: Germination of seeds stored in ambient room.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4605.611111	5	921.1222222	4.650827	0.013611
Within Groups	2376.666667	12	198.0555556		
Total	6982.277778	17			

Table 9: Moisture content of seeds stored in ambient room.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.513333333	5	0.302666667	2.822798	0.065361
Within Groups	1.286666667	12	0.107222222		
Total	2.8	17			

Table 10: Moisture content of seeds stored in cold room.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.724444444	5	0.344888889	2.028758	0.146363
Within Groups	2.04	12	0.17		
Total	3.764444444	17			

Table 11: Moisture content of seeds stored in refrigerator.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.536111111	5	0.307222222	2.373391	0.102128
Within Groups	1.553333333	12	0.129444444		
Total	3.089444444	17			

Table 12: Germination of seeds stored in ambient room.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4096.944444	5	819.3888889	18.05263	3.27E-05
Within Groups	544.6666667	12	45.38888889		
Total	4641.611111	17			

Table 13: Germination of seeds stored in cold room.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	5187.166667	5	1037.433333	21.19614	1.42E-05
Within Groups	587.3333333	12	48.94444444		
Total	5774.5	17			

Table 14: Germination of seeds stored in refrigerator.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2807.166667	5	561.4333333	12.39975	0.000213
Within Groups	543.3333333	12	45.27777778		
Total	3350.5	17			

Table 15: Moisture content of seeds in all storage conditions and all maturation levels.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	5.88	8	0.74	6.33	0.00	0.53
Intercept	1317.20	1	1317.20	11344.32	0.00	1.00
MATURAT	5.68	2	2.84	24.46	0.00	0.52
STORAGE	0.17	2	0.09	0.75	0.48	0.03
MATURAT * STORAGE	0.03	4	0.01	0.06	0.99	0.01
Error	5.23	45	0.12			
Total	1328.31	54				
Corrected Total	11.11	53				

Table 16: Germination of seeds in all storage conditions and all maturation levels.

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	1764.04	8	220.50	0.78	0.62	0.12
Intercept	37709.80	1	37709.80	134.18	0.00	0.75
MATURAT	845.48	2	422.74	1.50	0.23	0.06
STORAGE	644.59	2	322.30	1.15	0.33	0.05
MATURAT * STORAGE	273.96	4	68.49	0.24	0.91	0.02
Error	12647.17	45	281.05			
Total	52121.00	54				
Corrected Total	14411.20	53				