Research article

The Influence of Packaging Materials and Storage Duration on Seed Quality of Sesame (*Sesamum indicum* L.)

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Abstract The process of seed deterioration can lead to some physiological changes, such as a progressive decrease in germinability, an increase mean time for germination, an increase in the number of abnormal seedlings and a subsequent lower tolerance to adverse storage conditions. This study was conducted to determine the seed quality losses associated with the use of different types of packaging materials used for storage under farm condition. The study was conducted in collaboration with sesame farmers in Pwintphyu Township, from August 2016 to March 2017 (pre-monsoon seed storage) and in Pakokku Township, from January 2017 to August 2017 (post-monsoon seed storage). The sesame seeds were stored in the farmers' houses using two types of packaging materials; woven polypropylene bags and pioneer super bags. The data were recorded before storage and at two-month intervals during the eight month storage period. The results show that the germination percentage and germination index means of the pre-monsoon seeds stored in woven polypropylene bag are significantly higher than for those stored in super bags. However, the packaging material used has no significant influence on the germination percentage and germination index of post-monsoon sesame seeds. In regard to storage duration, there was significant variation in the germination percentage and germination indexes depending on storage method for both pre-monsoon and post-monsoon seeds. Although the seedling vigour measures of index I and II for pre-monsoon seeds stored in woven polypropylene bag are significantly higher than for those of seeds stored in super bags, there is no difference in seedling vigour indexes I and II for post-monsoon seeds with the use of different packaging methods. However, the seedling vigour indexes I and II of both pre- and post-monsoon seeds varied significantly with duration of storage. Germination percentage and germination indexes are different for the two packaging materials examined, for pre-monsoon sesame storage. The germination percentage and germination indexes of stored seeds in super bags are significantly lower than that in woven polypropylene bags, whereas, this effect was not observed in post-monsoon sesame. Black sesame cultivated in both pre-monsoon and post-monsoon seasons has a different dormancy period, and any effect of packaging materials on this dormancy release time is not evident, for both seasons. Therefore, hermetic (super bag) storage can be used in post-monsoon sesame without adverse effects on germination. However, without further research, hermetic storage appears to not be suitable for pre-monsoon sesame, due to its negative effect on germination.

Keywords sesame, germination percentage, germination index, seedling vigour index

INTRODUCTION

A seed's storage environment greatly influences the period of seed survival. The type of packaging used during the storage of seeds helps in lessening the speed of deterioration by maintaining the initial moisture content of the seeds stored, and by diminishing the seeds' respiration rate (Brooker et al., 1992). Longevity of seed viability in storage is influenced by the initial quality of the seed stored as well as the storage conditions. However, irrespective of initial seed quality, unfavourable storage conditions, particularly air temperature and air relative humidity, contribute to acceleration of seed deterioration in storage (Walters et al., 2010; Hansen, 2011). Maintaining seed viability and vigour during storage also depends on the type of packaging employed. Seeds in packaging which enables the exchange of water vapor with the environment can absorb water under high relative humidity, easily decaying seeds (Filho, 1998).

OBJECTIVES

The study was conducted to determine losses in seed quality associated with the use of different types of packaging materials used during storage and under farm conditions.

METHODOLOGY

Experimental Sites and Design

The study was conducted in collaboration with the sesame farmers in Pwintphyu Township, during the period August 2016 to March 2017 and in Pakokku Township from January 2017 to August 2017, with both of these townships situated in Magway Region, Myanmar. The black sesame seeds (Samou Nei) were stored in the farmers' houses using two types of packaging materials, woven polypropylene bags and pioneer super bags. The woven polypropylene bag is permeable bag and pioneer super bag is non-permeable poly-ethylene bag with thickness of 0.078 mm. The pioneer super bags (which consists of a two layer bag, with a bag inside a polypropylene outer), and as much air as possible was removed from super bag before it was taped closed. The bags were stored together with other bags using different storage methods. This storage treatment was undertaken in the houses of six farmers in each township. The data were recorded before storage and at two-month intervals during the eight month storage period. Germination tests (germination percentage, germination rate), vigour tests (seedling vigour index I, seedling vigour index II) were conducted to determine seed quality.

Germination Percentage

The germination test was performed using the top paper method. Four replications of one hundred seeds, randomly distributed on wet filter paper in petri dishes 9 cm in diameter, were examined. Each dish was placed into an incubator set to a constant temperature of 25°C throughout the testing period. The germinated seeds (2 mm radicle elongation) were counted daily, up to the tenth day, to calculate the germination rate (ISTA, 2004).

Germination Index

The germination index was computed using the following formula:

$$G.I = \frac{N_1}{D_1} + \frac{N_2}{D_2} + \frac{N_3}{D_3} + \cdots\cdots + \frac{N_n}{D_n}$$

where,

N1, N2, …, Nn: Number of seedlings on day 1st, 2nd and nth day after sowing

D1, D2, …, Dn: Number of days after sowing

Seedling Vigour Index

This was calculated by measuring the germination percentage and seedling length of the same seed sample. The seedlings were grown by the rolled paper towel method. Fifty seeds each, in four replications, were germinated in moist paper towel, in such a way that the micropyles were oriented towards the bottom to avoid root twisting. The rolled paper towel mediums were kept in an incubator, with temperature maintained at 25 °C. After 10 days, the paper towel substrates were removed and five normal seedlings were randomly selected. Their lengths were measured and a mean seedling length calculated. To determine dry weight, the seedlings were removed from the substrate and dried in an oven at 100°C temperature for 24 hours, then cooled and weighed. The seed vigour indexes were calculated by multiplying the germination percentage by seedling dry weight (g) (Index I) or by seedling length (mm) (Index II). The seed lot showing the higher seed vigour index was considered to be more vigorous (Adbdul-Baki and Anderson, 1973).

Vigour index -I: Germination (%) × total dry weight of seedling (g)

Vigour index -II: Germination (%) × seedling length (mm)

Statistical Analysis

All data were analyzed with analysis of variance (ANOVA) by using Statistix (version 8.0) and comparison of treatment means was done using the LSD test at 5 % level of significance.

RESULTS AND DISCUSSION

Effect of Different Packaging Materials and Storage Durations on the Quality of Pre-monsoon Sesame

Germination percentage:

The means of germination percentage of seeds stored in woven polypropylene bags was significantly higher than that of those stored in super bags. These results indicate that woven polypropylene bags are more suitable to store pre-monsoon sesame seeds to maintain good quality seeds. In hermetically storage, high moisture contents in stored grain can loss in germination and viability. The dryness of stored grain in pre-monsoon may not be enough for safety storage in hermetical bags. The mean value of germination percentage of pre-monsoon sesame varied with storage duration. The minimum germination percentage for sesame seeds was found at the initial storage time and this percentage increased significantly after two months storage and again after four months storage. The increase in germination percentages were positively correlated with the duration of storage up to a period of six months then decreased slightly. It can be said that the physiological quality of sesame stored for six-month did not decrease during storage. Therefore, the results show that the best storage duration for pre-monsoon sesame seeds, in relation to germination rates is six-month (Table 1).

These results compare with those reported by Prashant et al. (2016), whose study of the variability of germination percentage with the duration of seed storage for Seasamum indicum, found that maximum germination percentages occur after short term storage (68-75%), followed by mid-term, and minimum germination percentages occurred in seeds stored for long terms. The mean germination percentage of pre-monsoon sesame seeds was significantly different, and was affected by packaging

materials and storage duration (Table 1). However, it can be seen that the variations in the germination percentage means during the storage periods depend primarily on the packaging material used for storage. The best germination of pre-monsoon sesame could be achieved from seed stored in woven polypropylene bags for six months (Fig. 1). This agrees with the study carried out by Lima et al. (2014) that concluded that the physiological quality of sesame stored for six months does not decrease during storage.

Table 1 Mean effects of packaging materials and storage durations on the quality of pre-monsoon sesame

Treatment	Germination (%)	Germination index	Seedling vigour index I	Seedling vigour index II
Packaging materials (P)				
Super bag	31.583 b	6.821 b	0.055 b	226.520 b
Woven polypropylene bag	51.708 a	12.197 a	0.086 a	390.570 a
$LSD_{0.05}$	6.207	1.610	0.012	50.666
Storage duration (D)				
Initial storage	1.583 d	0.720 e	0.003 d	14.010 d
2 months	22.979 c	6.264 d	0.043 c	181.910 c
4 months	38.208 b	9.885 c	0.064 b	228.050 c
6 months	74.604 a	16.625 a	0.119 a	637.790 a
8 months	70.854 a	14.052 b	0.124 a	480.970 b
$LSD_{0.05}$	9.814	2.546	0.019	80.109
Pr > F				
P	<0.0001	<0.0001	<0.0001	<0.0001
D	<0.0001	<0.0001	<0.0001	<0.0001
P x D	0.0010	0.0001	0.0099	0.0002
CV (%)	28.66	32.57	32.08	31.58

Note: In each column, means with the same letter are not significantly different at 5 % level.

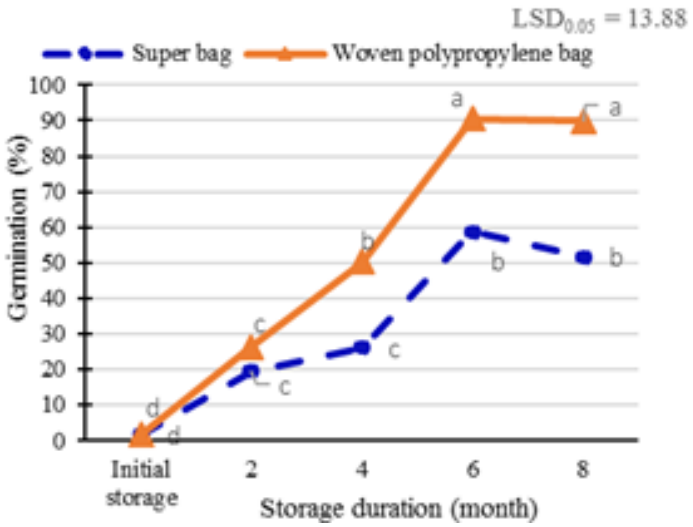

Fig. 1 Combination effect of packaging materials and storage durations on germination percentage of pre-monsoon sesame

Germination index:

The maximum germination index is seen from seed stored in woven polypropylene bags followed by seeds stored in super bags. The mean germination indexes varied significantly with the duration of storage. It is the effect of dormancy of stored seed, the germination index of stored seeds increased

with storage duration due to dormancy release and reached the maximum after six months storage when the dormancy fully release. Germination indexes significantly differed for the two packaging materials, except at the two-month storage interval, and this difference was greatest at six months, when seeds stored in woven polypropylene bag storage displayed the greatest germination index.

Seedling vigour index I and II:
The seedling vigour indexes I and II, for seeds stored in woven polypropylene bag were significantly higher than for those seeds stored in super bags. Seedling vigour depends on the germination percentage, seedling length and seedling dry weight. And maintaining the viability and seed vigor during storage also depends on the type of packaging employed (Filho, 1998). The maximum reading for seedling vigour index I is seen after eight months of storage, although this is not significantly different to the index I measurement at the six-month storage interval. The pre-monsoon sesame seeds stored for longer than four months show a higher seedling vigour index I when stored in the woven polypropylene bag. In relation to seedling vigour index II, the lowest measurements occur in the initial storage but these germination index rates increase with duration of storage. The results indicate that the most vigorous seedlings are those stored in woven polypropylene bags for six months.

Effect of Different Packaging Materials and Storage Durations on the Quality of Post-monsoon Sesame

Germination percentage:
The mean values of germination percentages of post-monsoon sesame are statistically similar for the two packaging materials, super bags and woven polypropylene bags. The packaging materials do not show an influence on the germination percentages of post-monsoon sesame seeds. However, the differences in the mean germination percentages of post-monsoon sesame are significant when storage duration is considered (Table 2). The interaction effects between packaging materials and storage duration exhibit non-significant effects on mean germination percentages for post-monsoon sesame (Fig. 2). It can be seen that mean germination percentages, which vary with storage duration, are not dependent on the packaging material used for storage. It can also be seen that water proof, air tight containers are a suitable packaging type to maintain germination of post-monsoon sesame above 90% at the eight-month interval of storage.

Germination index:
Although the germination index for seeds is similar for the two packaging materials, these indexes varied significantly with storage duration. However, the interaction effects between packaging materials and storage durations were not significant in germination index measurements for post-monsoon sesame (Table 2). It can be said that the changes of germination index during storage are not influenced by the packaging material used for storage.

Seedlings vigour index I and II:
Seedling vigour indexes I and II for seeds stored in different packaging is not different, however, these index measurements varied significantly with storage duration. Seedling vigour indexes I and II at the initial storage interval, exhibit minimum values and significantly differ to seeds stored for longer durations. The combination effect of packaging materials and storage duration on seedling vigour indexes is not significant (Table 2). This shows that the variations in seedling vigour indexes observed over time are not governed by the packaging materials. Although germination percentage and the germination index are numerically higher for seeds stored in super bags, seedling vigour indexes I and II are higher for seed in woven polypropylene bags.

Table 2 Mean effect of packaging materials and storage durations on the quality of post-monsoon sesame

Treatment	Germination (%)	Germination index	Seedling vigour index I	Seedling vigour index II
Packaging materials (P)				
Super bag	74.317 a	18.637 a	0.142 a	618.290 a
Woven polypropylene bag	74.375 a	19.148 a	0.143 a	620.640 a
$LSD_{0.05}$	5.226	1.626	0.016	45.080
Storage duration (D)				
Initial storage	26.750 c	8.800 c	0.045 c	174.050 d
2 month	65.333 b	17.645 b	0.119 b	566.170 c
4 month	94.625 a	22.585 a	0.182 a	669.290 b
6 month	94.521 a	23.412 a	0.173 a	951.510 a
8 month	90.500 a	22.017 a	0.195 a	734.290 b
$LSD_{0.05}$	8.263	2.572	0.025	71.278
Pr > F				
P	0.9822	0.5298	0.8417	0.9167
D	<0.0001	<0.0001	<0.0001	<0.0001
P × D	0.7791	0.1849	0.6766	0.8691
CV (%)	13.52	16.55	21.08	13.99

Note: In each column, means with the same letter are not significantly different at 5 % level.

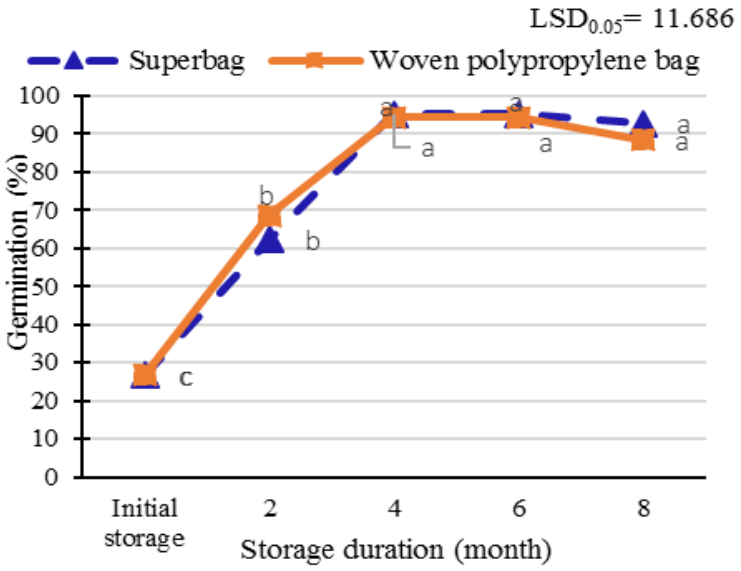

Fig. 2 Combination effect of packaging materialsnstorage durations on germination percentage of post-monsoon sesame

CONCLUSION

Black sesame seed cultivated in both pre-monsoon and post-monsoon seasons has different dormancy periods. The maximum germination rates occur after 6 months storage for pre-monsoon sesame but at 4 months storage for post-monsoon sesame. There was no observed differences in the effects of the materials used for storage on the dormancy release time for sesame seeds, for either pre- or post-monsoon seasons. Hermetic storage can be used for post-monsoon sesame without adverse effects on germination. However, hermetic storage is not suitable for pre-monsoon sesame, as it has a negative effect on germination. More research should be conducted to investigate the reasons for this.

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