

## **EFFECT OF PACKAGING MATERIALS ON GERMINABILITY OF LOCAL HYBRID MAIZE SEEDS**

G.A. GUNAWARDHANA, W.M.R KUMARI, S.S. PATHTHINIGE  
and H.M.S. BANDARA

*Field Crop Research and Development Institute, Mahailuppallama, Sri Lanka*

### **ABSTRACT**

Maize cultivation is mainly distributed in the dry zone of Sri Lanka that mainly occupied by exotic hybrid varieties. Local maize hybrid *Sampth* faces huge competition from the exotic varieties due to several reasons, among which poor packaging during storage and low seed germinability are quite significant. A proper seed storage technique yet to be developed for this variety for the dry zone of Sri Lanka where average temperature and relative humidity (RH) are approximately 30°C and 80% respectively, a condition where rapid degradation of the seed germinability can occur if seeds are not appropriately packed. Seed germinability is affected mainly by temperature and moisture content. Secondary factors such as insect and disease attacks also affect germinability severely. Stored seeds exposed to outside environment will absorb moisture until it reaches equilibrium with the environment depending on environmental temperature and RH leading to loss of germinability. Therefore, two experiments were conducted to study the effect on germinability of packaging material and packing methods. In the first experiment, four available packaging materials *viz.* woven polypropylene (WPP), woven polypropylene lined with low density polyethylene (LDPE), black LDPE (BLPE) and Metalized polyethylene terephthalate (MPET), were tested to select the best packaging material to store *Sampth* seeds in the DL<sub>1</sub> region of the dry zone of Sri Lanka. The packaging material which maintained lowest seed moisture contents, microbial and pest infestations, MPET, proved to be the best material preserving germinability of 90% at six and half months of storage. Seeds stored in other materials lost germinability below 80% at or before three months of storage. Study was further extended to find out the effect of vacuum packing and normal packing using MPET on germinability of seeds of *Sampth* against *Ruwan*, a popular open pollinated variety. Results revealed that vacuum packing can preserve germinability 1.5 times greater than the normal packing at 9 months of storage. Results also revealed that there was no difference in storage behavior of the hybrid or the open pollinated variety in either packing methods.

**KEYWORDS:** Maize, Packing materials, Seed storage

### **INTRODUCTION**

Maize cultivation in Sri Lanka has gradually increased over the last several years and became the most important coarse grain crop, covering a cultivated extent of 52,000 ha by the year 2008 (Sri Lanka customs, 2008). With the expansion of cultivation, exotic hybrid varieties became popular and imported 707 tons of seeds in 2008 (Sri Lanka Custom, 2008), indicating the higher dependency of seed industry on imported seeds. To fulfill a long felt need of the country, the first local hybrid maize variety '*Sampth*' was released in year 2004. However, loss of germinability within 3-4 month of

storage in woven polypropylene (commonly called as 'Poly sack') bags was recognized as the major reason for the poor popularity of the local hybrid.

Maize seeds are orthodox seeds where the moisture content of dried seeds reaches equilibrium with the relative humidity of surrounding air (Nkhoma and Mwila, 1997). Increase in seed moisture content and temperature reduce seed longevity where the later is the most influential factor (Justice and Bass, 1978). Germinability of seeds stored using a given packaging material will depend on permeability to water vapor and air of the material. Various authors have reported that packaging material with low permeability to water vapor and gases can preserve germinability (Muangkaeo *et al.*, 2005, Gc, 2006, Janara, 2006).

Metthananada *et al.* (2002) reported that gauge 500 LDPE can be used to store maize seeds of variety *Ruwan* in the wet and intermediate zones of Sri Lanka. However, neither loss of germinability of *Sampath* hybrid under dry zone conditions nor methods for extending seed longevity have been investigated up to date. The present study attempted to identify an effective packaging material for preserving germinability of the local hybrid maize seeds. The best-identified packing material was used to study the possibility of extending the seed longevity of hybrid and OPV maize seeds using vacuum packing.

## MATERIALS AND METHODS

Two studies were carried out at the Field Crops Research and Development Institute, Mahalluppallama during 2008/09 *maha* and 2009 *yala* seasons.

### Experiment I

#### Effect of packaging material on germinability of 'Sampath' seeds

Local hybrid maize variety 'Sampath' F1 seeds harvested from 2008 *yala* was used for the study. Seeds were threshed manually and treated with Pirimiphos methyl 25 ml/ 10 l of water followed by sun drying to reach moisture content below 12.0%. Sun dried seeds were packed immediately after reaching room temperature in 2 kg packs using four different packaging materials viz. woven polypropylene or (WPP), Woven polypropylene with inner low density polyethylene gauge 500 liner (WPP+LDPE), black low density polyethylene of gauge 300 (BLPE) and metalized polyethylene terephthalate (MPET). Permeability of each material to oxygen and water vapor are given in Table 1. Packs were arranged over wooden racks in one layer and stored under ambient conditions. All the treatments were arranged in Completely Randomized Design with 3 replicates.

Initial properties of the seeds were measured before seeds are being packed. Initial standard germination of seeds used was determined using sand bed method and the initial moisture content was determined by constant-temperature oven method (ISTA, 2008). Presence of stored grain insect pests was determined by taking a pest count by visual observation of the presence of adult pest/larvae/pupae/eggs/debris and counting the number of damaged seeds out of 100 seeds. As an indicator of microbial count number of seeds with mycelia growth was taken by placing 50 surface sterilized seeds over a dampen tissue on a covered tray and visual observation of morphological characters after 7 days.

**Table 1. Permeability of packaging materials**

<i>Material</i>	<i>O<sub>2</sub> transmission rate (cc/m<sup>2</sup>/24 h at 1 atm, 22°C, 90% RH)</i>	<i>H<sub>2</sub>O transmission rate (g/24 hr/ m<sup>2</sup> at 37°C, 90% RH)</i>
Woven polypropylene	-	-
Low density polyethylene (Gauge 500)	800-2600	18
Low density polyethylene (Gauge 200)	2000-7500	9
Metalized PET	<1.2	<0.8

Source: Sacharow, 1976 and Hanlon, 1992

Three packages from each packaging material were randomly picked and opened to obtain samples in 20 days interval for 6½ months (8 months from the time of harvesting) and standard germination, moisture content, presence of pest and microbial counts were determined as described in the initial measurements. Remaining seeds after sampling were discarded.

## Experiment II

### Effect of vacuum packaging vs. normal packaging on maize hybrid and OPV seeds using MPET

Local hybrid maize variety *Sampath* F1 seeds and open pollinated variety *Ruwan* seeds harvested from 2008/09 *maha* season crops were used for the study. Seeds were threshed manually and treated with Pirimiphos methyl 25 ml/ 10 l of water followed by sun drying to reach moisture content below 12.0%. The best selected packing material from the experiment I (MPET) was used for the study. Sun dried seeds of both varieties were packed using normal packing method and vacuum packing method using the selected packing material in 2 kg packs immediately after reaching room temperature. The experimental design was 2-factor factorial CRD with 3 replicates.

Initial standard germination, initial moisture content, presence of stored grain pests and initial disease count were determined before seeds are being packed using the methods described in the experiment I. Three packages from the four treatments were picked randomly and seed samples were obtained in 30 days interval for 9 months (for approx. 12 months from harvesting time) and standard germination, moisture content, presence of pest and diseases were determined as described in the initial measurements. Remaining seeds after sampling were discarded.

### Data analysis

Germination percentages, pest and microbial counts of treatments were analyzed using SAS Statistical software by procedure CATMOD (Binary data analysis). ANOVA was performed to find the treatment effect for moisture content of seeds during storage time and mean separation was done by DMRT. Regressions lines for moisture content and microbial counts were fitted using MINITAB software.

## RESULTS AND DISCUSSION

### Experiment I

#### Effect of packaging material on germinability of *Sampath* seeds

Maximum and minimum air temperature and RH of the research station during the study period is given in table 2. Daily maximum temperature ranged between 29-32° C and RH reached maximum of 96% during the storage period.

**Table 2. Monthly average temperature and relative humidity at Mahailuppallama during study period**

Month and Year	Average Temperature °C		Monthly Average RH % (Relative Humidity)					
	Maximum	Minimum	6.00 am	9.00 am	12.00 am	3.00 pm	6.00 pm	9.00 pm
October,2008	32.1	22.7	94	85	66	67	79	87
November,2008	30.7	22	95	89	71	70	81	89
December,2008	29.3	21	96	91	76	74	81	91
January,2009	29.5	19.9	96	91	71	68	75	90

Source: Data base, Mahailuppallama meteorology recording station. Department of Meteorology.

### Seed moisture contents

Seeds stored in WPP reached to a moisture contents above 14% within 25 days (Table 3) and moisture content was significantly higher than the seeds stored in other packages. Seeds stored in Bl.PE and LDPE+WPP reached

moisture contents above 14% after 2 and 5½ months respectively, while MPET was able to maintain seed moisture content below 12 % throughout the storage period.

**Table 3. Average moisture content (%) of seeds stored in different packaging materials at different sampling dates**

Packaging materials	Percent moisture content (wet basis)							
	0 DAP	25 DAP	46 DAP	66 DAP	91 DAP	140 DAP	170 DAP	198 DAP
WPP	11.4	14.5 <sup>a</sup>	14.9 <sup>a</sup>	15.0 <sup>a</sup>	15.4 <sup>a</sup>	15.6 <sup>a</sup>	15.7 <sup>a</sup>	15.9 <sup>a</sup>
WPP+LDPE	11.4	11.5 <sup>b</sup>	11.2 <sup>c</sup>	11.5 <sup>b</sup>	11.6 <sup>b</sup>	12.3 <sup>b</sup>	15.8 <sup>a</sup>	15.8 <sup>a</sup>
Bl.PE	11.4	11.4 <sup>b</sup>	12.3 <sup>b</sup>	14.4 <sup>a</sup>	14.8 <sup>a</sup>	15.6 <sup>a</sup>	15.8 <sup>a</sup>	15.1 <sup>a</sup>
MPET	11.4	11.3 <sup>b</sup>	10.9 <sup>c</sup>	12.7 <sup>b</sup>	11.7 <sup>b</sup>	11.5 <sup>b</sup>	11.2 <sup>b</sup>	10.2 <sup>b</sup>
CV%		1.5%	1.9%	1%	2%	1.5%	1.7%	2%

Mean values with followed by the same letter are not significantly different at P= 0.05. Mean separation by DMRT method. DAP: days after packing

Seeds absorb moisture from surrounding environment until they reach equilibrium moisture content; a value depends on the type of seed, storage temperature and RH. Equilibrium moisture content of yellow dent maize seeds at 25°C in 75% and 90% RH is 14.8% and 19.1% respectively (Justice and Bass, 1978). It can be assumed from the data that equilibrium moisture content of the maize seeds stored in dry zone would be approximately 15-16%. Seeds stored in WPP are exposed to the surrounding environment through the gaps between its woven threads, thus reach equilibrium moisture rapidly as revealed by the results.

As the permeability of LDPE to water vapor is high (Table 1), at 66 days seeds stored in Bl.PE reached moisture contents above 14% which is significantly higher than the that of WPP+LDPE and MPET at the same date. Seeds stored in LDPE+WPP have gained added protection from 2 layers in packaging, thus reached moisture content above 15% after 5½ months. MPET proved to be the least pervious to moisture and thus moisture content of seeds stored in this package was stable since seeds have not absorbed moisture from outside compared to the other packages throughout the storage period. Moisture content of the seeds store in MPET at the final date of storage was significantly lower than other packages

### **Insect pest and diseases infestations**

Average number of seeds damaged by insects is given in table 4. Seeds stored in WPP, Bl.PE and WPP+LDPE were completely affected by insect pest after 170 and 198 days respectively, where a high population of stored

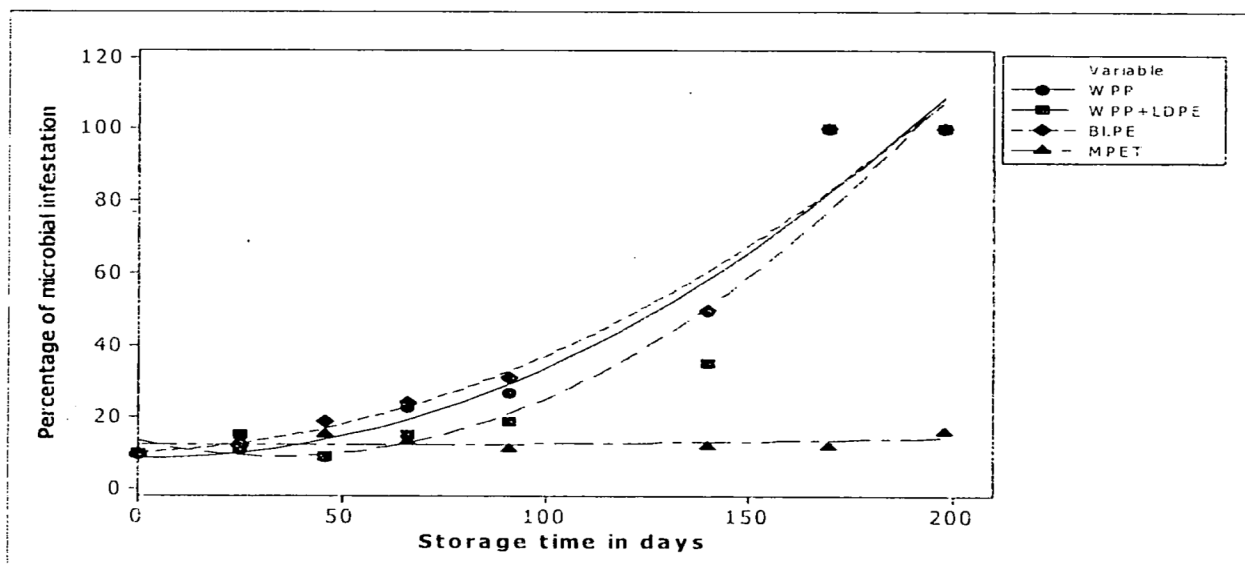
grain pests was observed in these samples. Increase of moisture contents, easily penetrable packaging materials and availability of oxygen inside the package due to high permeability to oxygen (Table 1) may result in proliferation of insects. Low moisture contents restrict insect activities and maximum recommended moisture content for safe storage for maize is 11-12 % (Flanders, 2010). On contrast, MPET was able to maintain damaged seed count below 2% throughout the study period with no storage pests.

**Table 4. Percentage of seeds damaged by stored grain pest of seeds stored in different packaging material during storage time**

Packaging material	% damage seeds						
	25 DAP	46 DAP	66 DAP	91 DAP	140 DAP	170 DAP	198 DAP
WPP	2	5	5	16	14	100	100
WPP+LDPE	0	0	0	0	15	35	100
BI.PE	0	2	2	7	13	100	100
MPET	0	0	0	0	2	2	2

DAP: Days after packing

Microbial infestations of the seeds stored in different packaging materials are given in and figure 1. Seeds stored in WPP, WPP+LDPE and BI.PE were completely infected after 170 days.



$$\text{WPP} = 8.647 - 0.0108 \text{ time} + 0.002607 \text{ time}^2, R^2 = 95.2\%$$

$$\text{WPP+LDPE} = 13.43 - 0.2547 \text{ time} + 0.003715 \text{ time}^2, R^2 = 91.8\%$$

$$\text{BI.PE} = 10.12 + 0.0446 \text{ time} + 0.002253 \text{ time}^2, R^2 = 95.2\%$$

$$\text{MPET} = 11.8 + 0.0107 \text{ time}, R^2 = 14.7\%$$

**Figure 1. Percentage of microbial infestation of seeds stored in different packaging material during study period**

Microbial infestation of seeds stored in these three materials showed high positive relationship with time, while it was stable in MPET. Saprophytic and parasitic seed borne fungi remain dormant will grow after moisture content of cereals reach above 14% (Justice and Bass, 1976). As permeability to moisture and O<sub>2</sub> are higher in WPP and BI.PE, they provide a better environment for growth of microorganisms.

MPET can protect seeds from insect pest and disease due to its high barrier for gas and water vapor and prevent entering insects from outside by its slippery surface characteristics. Further other three materials were easily damaged by an insect multiplied inside the package as well, which was not observed in MPET. Increase in insect pest and diseases directly reduce the germination of stored seeds. Further, it was also observed that some of the WPP and BI.PE packs were damage by rodents indicating that they are disadvantageous as packaging materials.

### **Seed germinability**

Effect of packaging material on seed germinability is shown in Fig. 2. Seeds stored in all packaging materials maintained seed germinability above 80% during first 66 days in storage without significant differences in germinability (Chi-square Probability>0.05). Germinability of seeds stored in WPP, BI.PE, WPP+LDPE started to decline significantly (Chi-square probability<0.001) after 91, 140 and 170 days respectively. The former 2 materials were able to maintain germinability above 80% for only about 2 months, while combination of WPP+LDPE was able to maintain the same germinability for about one month longer. In contrast, seeds stored in MPET maintained seed germination above 80% throughout 6.5 months storage period which is equivalent to 8 months from the harvesting date.

As all the packages were stored under same environmental conditions, effects of temperature and RH on seeds stored in different packages are similar. Therefore, characteristics of packaging materials, which resulted in differences in, seed moisture contents, pest and microbial counts (Table 3, 4 and Fig. 1) could be considered as the causes for differences in germinability. Among these factors moisture content is the most influential factor, which in turn triggers pest and microbial proliferation (Flanders, 2010, Justice and Bass, 1976). Results confirm that seeds stored in materials with higher permeability reach higher moisture content within shorter time and loss germinability faster, followed by seeds stored in materials with comparatively lower permeability.

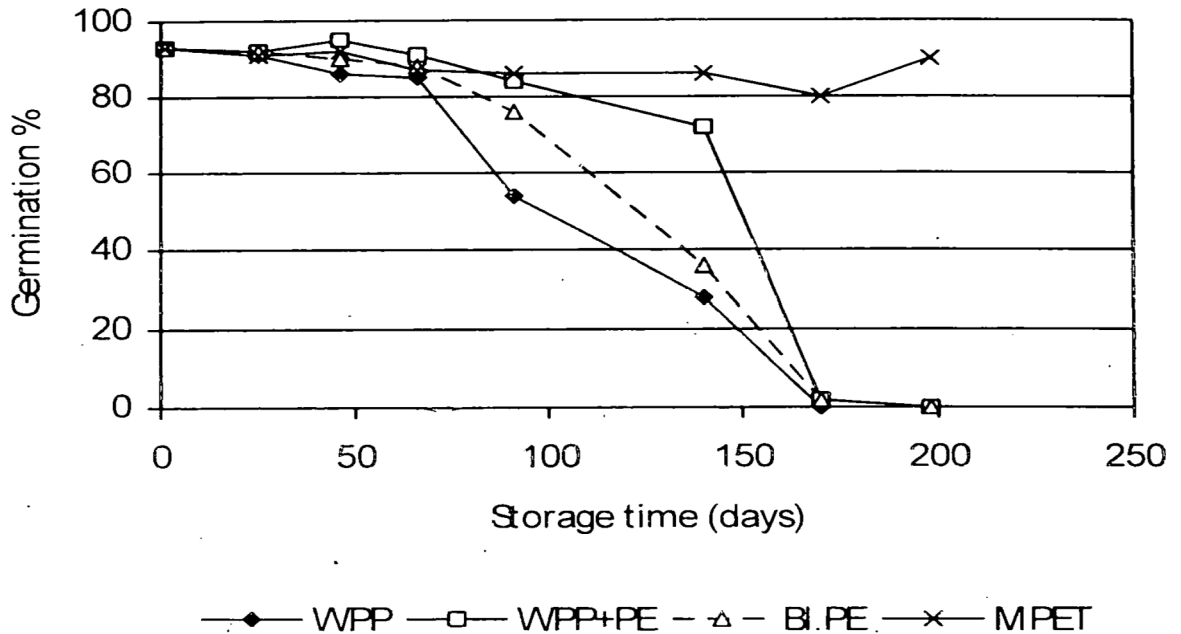


Figure 2. Effect of different packaging materials on germination percentage during the storage period

## Experiment II

### Effect of vacuum packaging vs. normal packaging on maize hybrid and OPV seeds using MPET

Air temperature and RH of the research station during the study period is given in Table 5. Daily maximum temperature was around 30° C and RH ranged around 53-95.

#### Seed moisture contents

Average percent moisture content of the seeds stored in normal and vacuum MPET packs are given in table 6. Initial moisture percentages were 8.87 and 8.94 respectively. Although data shows increase of moisture content with time, there were no significant relationship between moisture content and time of storage in both varieties in any packing method, indicating that all the packages were able to maintain a stable moisture content below 12% without reaching equilibrium with environment due to good moisture barrier properties of the MPET.

Interaction effect between variety and packaging method was not significant. However the main effect of packing methods was significant. Therefore, treatment combinations were considered as individual treatments

viz. normal packed Ruwan (RN), vacuum packed Ruwan (RV), normal packed Sampath (SN) and vacuum packed Sampath (SV).

**Table 5. Monthly average temperature and relative humidity at Mahailuppallama during the study period**

Month and Year	Average Temperature °C		Monthly Average RH % (Relative Humidity)					
	Maximum	Minimum	6.00 am	9.00 am	12.00 am	15.00 pm	18.00 pm	21.00 pm
March, 2009	33.9	21.8	95	87	61	55	66	86
April, 2009	33.5	23.9	93	83	66	61	73	85
May, 2009	33.7	25.4	90	79	65	60	68	83
June, 2009	32.8	24.9	91	81	65	61	70	84
July, 2009	33.4	24.8	86	78	61	55	64	77
August, 2009	33.0	24.5	88	80	61	56	67	80
September, 2009	32.7	24.5	88	77	61	58	65	80
October, 2009	33.3	22.9	92	82	58	53	67	81
November, 2009	30.4	22.6	95	90	77	74	84	91
December, 2009	29.7	22.7	95	93	80	77	86	92
January, 2010	30.6	20.8	95	91	69	65	73	89

Source: Data base, Mahailuppallama recording station, Department of Meteorology.

**Table 6. Average moisture (%) content of the seeds of the varieties *Sampath* and *Ruwan* in Normal and Vacuum packed MPET during the storage period**

Variety, Packing method	Percent moisture content (Wet basis)							
	0 DAP	30 DAP	65 DAP	92 DAP	120 DAP	153 DAP	215 DAP	276 DAP
Ruwan, normal	8.87 a	9.7 a	10.2 a	11.6 a	11.5 a	11.3 a	11.4 a	11.3 a
Sampath, normal	8.94 a	8.7 b	10.4 a	10.9 b	10.8 b	10.4 b	10.6 c	10.6 b
Ruwan, vacuum	8.87 a	8.8 b	9.7 b	10.7 c	10.2 c	10.2 b	10.4 b	10.3 b
Sampath, vacuum	8.94 a	8.3 b	8.4 c	9.8 c	10.3 c	10.0 b	9.8 d	9.9 c
CV%		2.1	1.3	1.03	1.49	1.3	0.2	1.16

Mean values followed by the same letter are not significantly different at P= 0.05. DAP: days after packing.

Vacuum packed seeds of both varieties showed significantly lower moisture content than the normal packed seeds during the storage period (Table 6). Vacuum packaging removes the initial air and water vapor inside the package, which may also reduce moisture absorption by seeds.

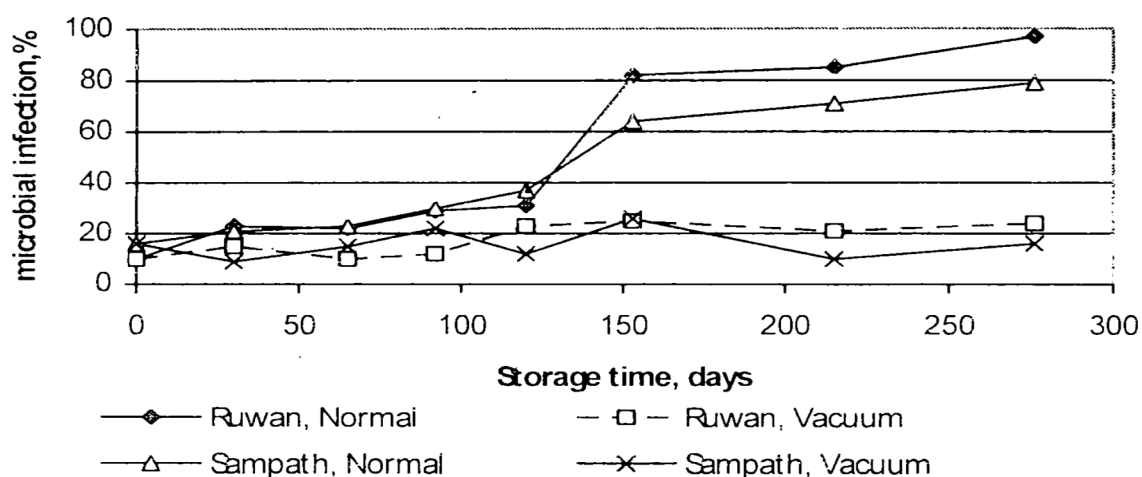
### **Insect pest and microbial infestation**

Average number of seeds damaged by insects in each packaging method in both varieties is given in table 7. Number of seeds damaged by pests was low and no insects/larvae/pupae or debris was found. Thus these damaged seeds can be attributed to field infestations and no insect

multiplication or entering through packaging material during storage period has

**Table 7. Percentage of seeds damaged by stored grain pest of seeds of the varieties *Sampath* and *Ruwan* in Normal and Vacuum packed MPET during the storage period**

Variety/ packing method	% No. damage seeds /100 seeds							
	0 DAP	30 DAP	65 DAP	92 DAP	120 DAP	153 DAP	215 DAP	276 DAP
Ruwan, Normal	2	2	2	2	2	2	2	4
Ruwan, Vacuum	2	2	2	2	2	1	2	3
Sampath, Normal	2	2	1	1	0	0	0	0
Sampath, Vacuum	2	1	1	0	0	0	0	0



**Figure 3. Changes in microbial infestation of seeds stored in different packaging material during study period**

Average number of seeds infected with microorganism increased in normal packed seeds of both varieties, while it was minimum in vacuum packed seeds (Fig. 3). Vacuum packing limits oxygen and water vapor for the growth and multiplication of microorganisms, thus even after 9 months of storage presence of microorganisms were lower compared to that of normal packed seeds.

### Seed germinability

According to the binary data analysis, interaction effect was not significant between variety and packaging method. Therefore interaction term was not included in the model. Main effect of packing methods was significant. Therefore, treatment combinations were considered as individual treatments as in the analysis of moisture content. Percent germinability of the

seeds of two varieties in both packing methods is given in Fig. 4. Up to 5 months of storage, germinability of all treatments was above 75%. At 9 months of storage (i.e. approximately 12 months from the date of harvesting), germinability of normal packed seeds of both varieties reduced significantly (chi square  $P < 0.001$ ) compared to that of the vacuum packed seeds. Vacuum packing can preserve germinability by 1.5 times higher compared to normal packing at 9 months storage and extend storability by 2 months.

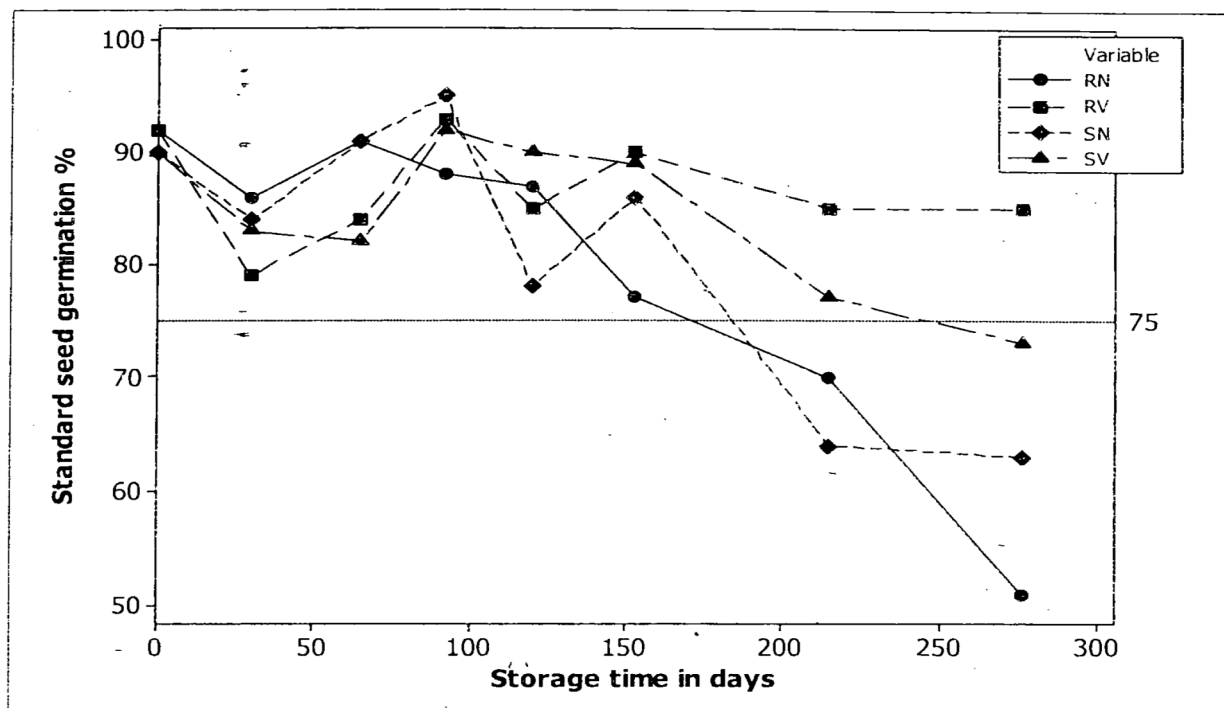


Figure 4. Variation of germination percentage of the seeds of the varieties *Sampath* and *Ruwan* in Normal and Vacuum packed MPET during the storage period

### CONCLUSION

Seeds of maize hybrid *Sampath* can maintain germinability above 80% only for less than 3 months when stored using woven poly propylene, black polyethylene, woven poly propylene + low density poly ethylene under ambient conditions of DLI region of Sri Lanka. Thereafter, due to increase in moisture contents, insect and microbial infestations germination drops. However, Metalized Polyethylene Terephthalate preserved the 80% germinability for six and half months (8 months after harvesting) with comparatively low moisture contents, disease and microbial infestations. Vacuum packing using Metalized polyethylene Terephthalate can preserve germinability up to 9 months with 1.5 times higher germinability compared to normally packed Metalized polyethylene Terephthalate. Further, seeds of hybrid variety *Sampath* and open pollinated variety *Ruwan* showed no difference in storage behavior in either packing method.

## REFERENCES

- Flanders, K.L. 2010. Stored Grains: Insect Control Recommendations. Alabama Cooperative Extension Systems. US Department of Agriculture.
- Ge, Y. D. 2006. Efficacy of indigenous plant materials and modified storage structures to insect pests of maize seed during on-farm storage. *Journal of the Institute of Agriculture and Animal Science*. 27:69-76.
- Hanlon, J. 1992. Handbook of Package Engineering. Technomic Publishing, Lancaster, PA.
- ISTA, 2008. International rules for seed testing. The International Seed Testing Association, Bassersdorf, Switzerland.
- Janara, R, Srichuwong, S and Vearasilp, S, Selected Commercial Packaging Materials Affecting Fatty Acid Deterioration during Soybean Seed Storage. Conference on International Agricultural Research for Development, Stuttgart-Hohenheim.
- Justice, O.L and L.N. Bass. 1978. Principles and practices of seed storage, US Government Printing office, Washington DC.
- Metthananda, K.A., S.L. Weerasena and Y. Liyanage. 2002. Effect of storage environment, packing material and seed moisture content on storability of Maize (*Zea mays* L.) seeds. *Annals of the Sri Lanka Department of Agriculture*. 3:131-142.
- Muangkao, R., S. Srichuwong, and S. Vearasilp. 2005. Influence of packaging materials and storage time on seed viability and chemical component of rice seed. Conference on International Agricultural Research for Development, Stuttgart-Hohenheim.
- Nkhoma, C.N and G.P. Mwila. 1997. Seed Storage. In Zambia Seed Technology Handbook, Ministry of Agriculture, Food and Fisheries, Zambia.
- Sacharow, S. 1976. Handbook of Package Materials. The Avi Publishing Company Inc., Connecticut.