

## **EFFECT OF STORAGE ENVIRONMENT, PACKING MATERIAL AND SEED MOISTURE CONTENT ON STORABILITY OF MAIZE (*Zea mays* L.) SEEDS**

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### **ABSTRACT**

Most seed lots fail to germinate when stored for about 5 - 6 months in woven polypropylene sacks (poly-sacks) at 12% moisture level, which is the method used in Sri Lanka to store maize seeds. This has become a constrain to increasing the crop extent. Therefore, it is necessary to find alternate methods to store maize seeds for a longer period without losing viability below the required minimum. Well-dried maize seeds were packed in poly-sack, clear and white polythene bags. Two moisture levels were used *viz.* 8% and 12%. These were stored in four environments; at Rahangala, Kundasale, and Peradeniya under ambient conditions and in a cold room at the vegetable seed centre, Gannoruwa. Standard germination and field germination were tested every 30days after starting the experiment. Germination of maize seeds stored in poly-sacks under room temperature in Peradeniya, Kundasale and Rahangala had viability below acceptable levels after 6 months, 8 months, and 10 months respectively. Longest storability was recorded in cold room with all packaging used and at both moisture levels. Seeds stored at Rahangala ranked 2<sup>nd</sup> in storability. Storage in poly-sacks was good only under cold room conditions. Seeds stored in polythene at both 12% and 8% moisture levels were superior in storability compared to those stored in poly-sacks in maintaining the germination level in all the environments tested. Effect of low seed moisture was prominent only towards the declining phase of seed germinability in different treatments, which were after 12 months.

**KEYWORDS:** Maize, Storage, Relative humidity, Temperature, Moisture content, Packing material.

### **INTRODUCTION**

Maize is a widely cultivated (about 35,000ha. in *yala* season) coarse grain in the dry zone of Sri Lanka. There is a potential to increase the extent. Seed maize has to be stored from harvesting to next planting season (usually about 7 – 9 months) and safe storing of maize seed has become an important issue in Sri Lanka. Harrington (1958) reported that safe storing conditions are those, which maintain seed quality without loosing of vigour for three years. Delouche *et al.* (1973) pointed out that such conditions are not always economically justified. Harrington (1972) Delouche *et al.* (1973) Lovato and Balboni (1997) reported that maximum of 13% as the safe seed moisture for storage of cereals. As shown by Joao Abba and Lovato (1999) in addition to seed moisture, storage temperature and relative humidity are highly important in safe storage of maize seeds. They have also suggested that maize seed should be packed in waterproof materials for long term storage. A study done in Sri Lanka on maize seed storage using variety "Badra" has demonstrated that prolonged storability could be obtained if they are stored as cobs in an environment with low relative humidity and temperature

(Silva, 1987). This study has also shown that extracted seeds could maintain viability for a longer period when stored in polythene bags compared to jute gunnies. However, the study by Silva (1987) is not based on data on field germination. An experiment done on rice seed storage, has shown that woven polypropylene sacks (poly-sacks) are suitable if seed moisture content is high (Abeysiriwardane, 1985).

Department of Agriculture, one of the major suppliers of maize seeds to farmers, used to store maize seeds in poly-sack bags and also as cobs in its seed stores in Rahangala where average environmental temperature is around 20° C and relative humidity is around 70%. It is reported that about 50% of the stored maize seed failed to maintain the required level of viability/vigour up to the planting time. This has become a problem in promoting maize cultivation in Sri Lanka. Information on the effect of different packing materials under different environmental conditions in Sri Lanka on the storability of maize seed is not available. Therefore, the present experiment was undertaken in 1999/2000 at the Seed Testing Laboratory, Peradeniya, to identify suitable packing methods and storage environments to maize seeds that would facilitate the maintenance of seed viability and vigour during the short term.

## MATERIALS AND METHODS

Maize seed of variety "Ruwan" cultivated during 1998/1999 *maha* season was used for the study. Seeds were fumigated using phostoxin before starting the experiment to control corn weevil. Seeds were sun dried to 12 % and 8% moisture content. Initial standard germination and moisture content were tested in both seed lots (12% and 8% moisture status) before starting the experiment. They were packed in 5kg bags as per different treatment in four replications for each location. Seeds with 12% moisture were packed in Poly-sacks (PS), white polythene (gauge 500), and in clear polythene (gauge 500). In addition, seeds with 8% moisture were packed in clear polythene of gauge 500 in the same manner mentioned above. Sets of all four treatments with four replications were stored at four different environments; cold room at the Seed Centre at Gannoruwa, under room temperature at the Seed Testing Laboratory at Peradeniya, and at seed stores in government farms at Rahangala and Kundasale. Treatments in each location were arranged in a Completely Randomized Design (CRD). Samples were drawn at monthly intervals for testing Standard Germination (SG) and field performance. Seed moisture content was measured at the beginning, at 5 months, 10 months, and at 15 months of storage. Sampling in polythene bags was done by inserting a sampling instrument through a hole at the base of each bag. These holes were tape sealed soon after drawing the sample.

Testing of SG, seed moisture content and field evaluation were conducted at the Seed Testing Laboratory at Peradeniya as follows.

### **Standard Germination**

Four 50-seed replicates were placed in 20 x 30cm trays between two layers of 1cm of sterile silty sand and kept moistened at 60% water holding capacity level using distilled water. The trays were placed at 30°C constant temperature for nine days (ISTA, 1996).

### **Seed moisture content determination**

Two replications of 5g of ground seed were tested in an oven at 130° C for four hours.

### **Field performance evaluation**

Plastic pots of 20cm diameter were filled with normal field soil and 25 seeds were planted at 1cm depth at an equal spacing. They were arranged in a Completely Randomized Design with four replications. No fertilizer was added but adequately watered. Number of healthy seedlings was recorded at 3 weeks after planting and the percentage of healthy seedlings in each treatment was calculated.

### **Data analysis**

Results were tested by analyzing the data using analysis of variance (ANOVA). Percentage data were transformed by using angular (arcsine) transformation to homogenize variances (table 4).

## **RESULTS AND DISCUSSION**

Effect of packing material and storage environment on seed viability is given in figures 1 to 4. Storability of maize is highly dependent upon the packing material and storage environment. Lowest storability was recorded from seeds stored in woven polypropylene sacks (poly-sacks) with 12% moisture whereas the highest storability was from seeds packed in clear polythene with 8% moisture content. This was true in all the environments except in cold room (18 – 20 °C & 55-60% RH) where packaging materials had no effect and seed germination remained high even up to 15 months of storage (figures 1 to 4). Second best storability was recorded from seeds stored at Rahangala where average

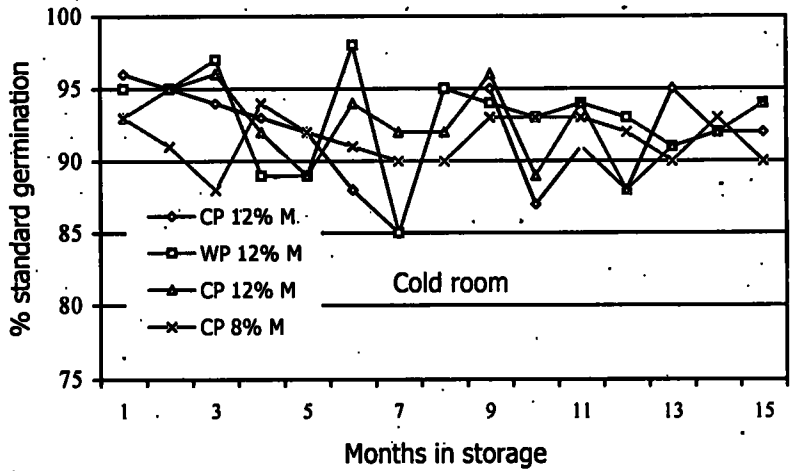


Figure 1. Effect of packing material on storability of maize seed stored at the Cold room (PS – Poly-sack, WP – White polythene, CP – Clear polythene, M – Moisture).

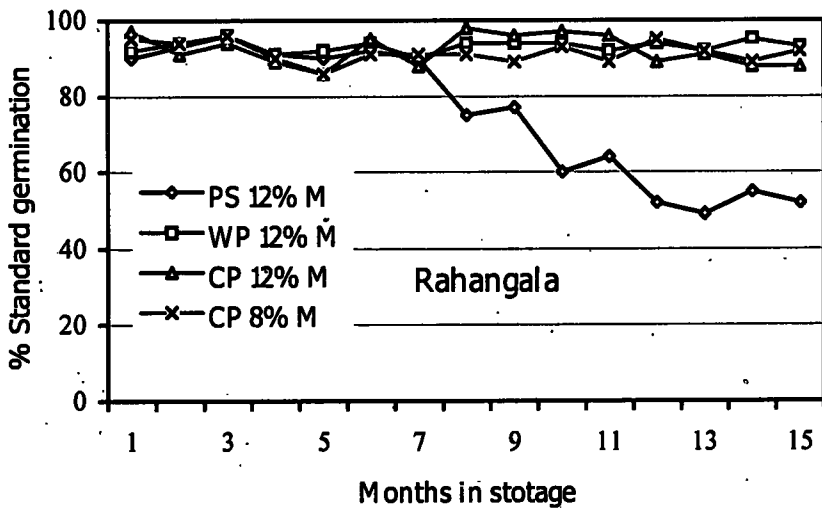


Figure 2. Effect of packing material on storability of maize seed stored at Rahangala (PS – Poly-sack, WP – White polythene, CP – Clear polythene, M – Moisture).

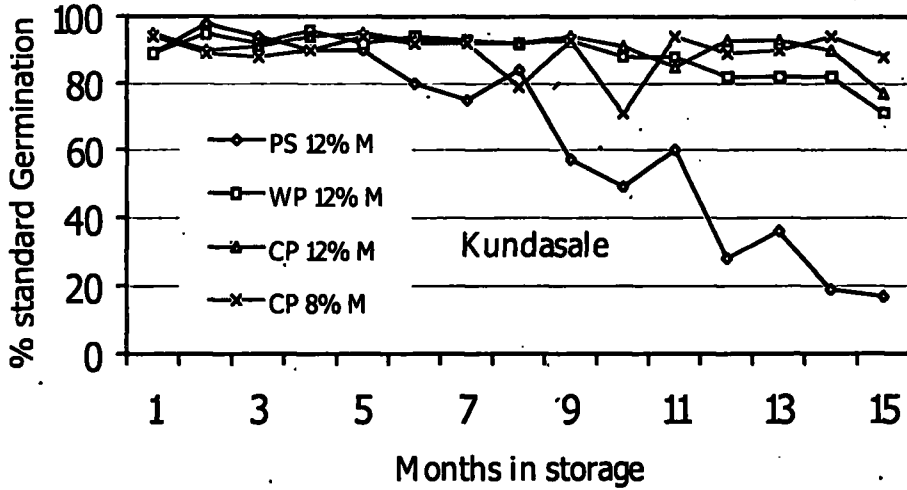


Figure 3. Effect of packing material on storability of maize seed stored at the Kundasale (PS - Poly-sack, WP - White polythene, CP - Clear polythene, M - Moisture).

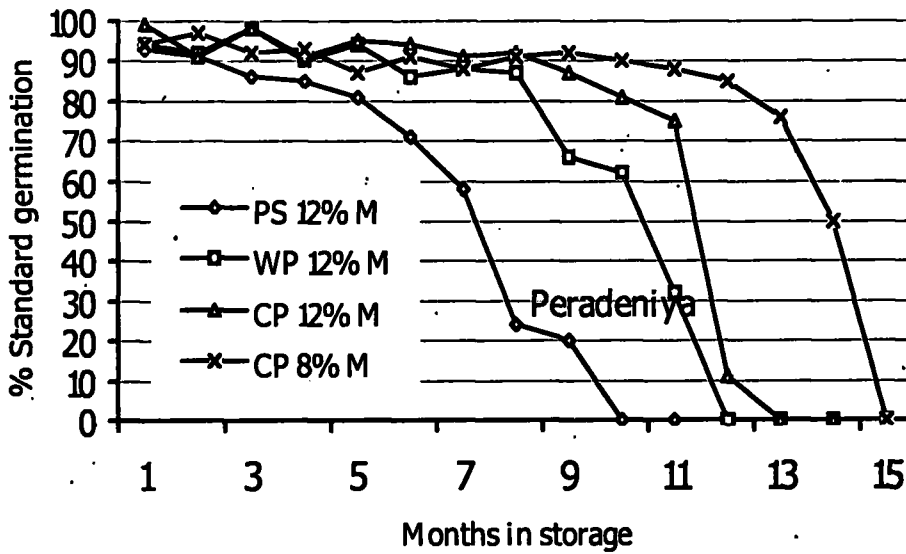


Figure 4. Effect of packing material on storability of maize seed stored at Peradeniya (PS - Poly-sack, WP - White polythene, CP - Clear polythene, M - Moisture).

environmental temperature and relative humidity were 23.3/15.3 °C (day/night) and 77% respectively during the storage period (tables 1, 5 and 6). However, viability of seeds packed in poly-sacks with 12% moisture declined below 80% by 6 months even at Rahangala (figure 2). Environment in Peradeniya was the worst for seed storage (figure 4). Seeds packed in poly-sacks failed by 6 months and in white and clear polythene with 12% moisture by 8–10 months in this environment. However, seeds packed in clear polythene with only 8% moisture managed to stay sufficiently viable up to 13 months even in Peradeniya (figures 1 to 4).

**Table 1. Average of the Temperature and RH data in all the environments during the study period.**

<i>Location</i>	<i>Parameter</i>	
	<i>Temperature °C</i>	<i>% Relative Humidity</i>
Peradeniya	29.5 – 20.6	82.3 – 74.0
Kundasale	29.8 – 20.4	79.6 – 67.6
Rahangala	23.8 – 15.3	77.8 – 76.3
Cold room	18 – 20	55 – 60

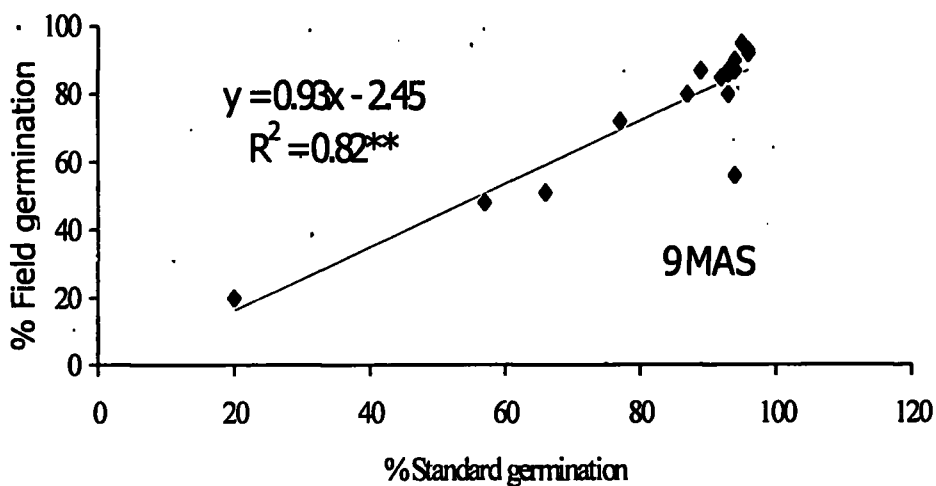
Field germination was always lower than in standard laboratory germination. The difference varied from 4 – 28% between different treatments (table 2). Difference was highest in seeds packed in poly-sacks in Peradeniya location whereas in the cold room the differences were minimum. It was also observed that the differences were less during the first few months of storage but have reached their maximum around 10 months after storage and again declined towards 15 months period (table 2).

Regression analysis indicated that there are significant correlations between percent SG and percent field germination after 9 months of storage. (figures 5 to 7).

Seed moisture content increased over time in all the treatments (table 3). Increases were minimum in seed stored in the cold room. The highest increase was observed in Peradeniya where recorded relative humidity was highest during the study period (tables 1, 5 and 6). Among packing materials, seed packed in poly-sacks showed the highest increase in seed moisture content over time (table 3)

**Table 2. Difference between % standard germination and % field germination in different treatments at 5, 10 and 15 months after starting the experiment. (M – month, WP – white polythene, CP – Clear polythene).**

Packing method	Difference in each Location (%)											
	Peradeniya			Kundasale			Rahangala			Cold room		
	5M	10M	15M	5M	10M	15M	5M	10M	15M	5M	10M	15M
Poly-sack 12% moisture	25	-	-	15	23	14	8	15	10	4	7	8
Polythene 12% (Ave. of WP & CP)	11	28	18	12	20	12	10	12	9	8	9	9
Polythene 8% moisture	8	12	7	8	10	8	8	10	7	8	9	8



**Figure 5. Relationship between standard germination and field germination at 9 months after storage (MAS – months after storage, \*\* - significant at 1% level probability).**

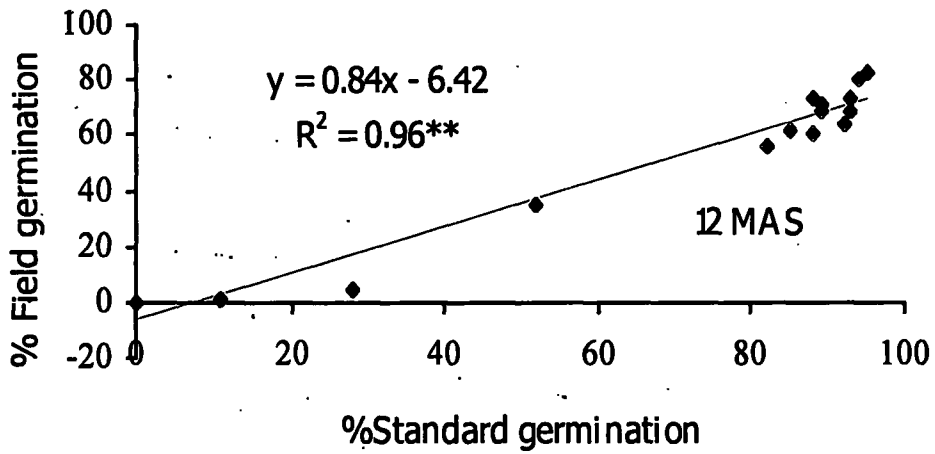


Figure 6. Relationship between standard germination and field germination at 12 months after storage (MAS – months after storage, \*\* - significant at 1% level probability).

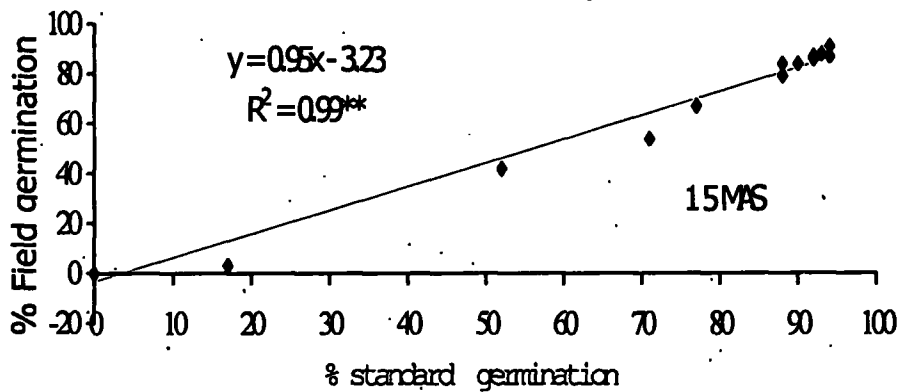


Figure 7. Relationship between standard germination and field germination at 15 months after storage (MAS – months after storage, \*\* - significant at 1% level probability).

**Table 3. Equilibrium seed moisture content (%) of different treatments at different months (M) after storage.**

<i>Location</i>	<i>Packing Method</i>	<i>0 M</i>	<i>5 M</i>	<i>10 M</i>	<i>15 M</i>
Peradeniya	Polysack – 12% Moisture	12.02	14.5	15.0	15.8
	White Polythene -12% M	12.02	12.8	13.2	14.5
	Clear Polythene - 12% M	12.02	12.2	12.5	13.0
	White Polythene - 8% M	8.01	9.0	9.5	10.0
Cold room	Polysack – 12% Moisture	12.02	12.2	12.3	12.4
	White Polythene -12% M	12.02	12.2	12.3	12.4
	Clear Polythene - 12% M	12.02	12.1	12.2	12.4
	White Polythene - 8% M	8.01	8.1	8.2	8.1
Kundasale	Polysack – 12% Moisture	12.02	14.0	14.2	14.3
	White Polythene -12% M	12.02	12.4	12.5	13.5
	Clear Polythene - 12% M	12.02	12.2	12.3	12.5
	White Polythene - 8% M	8.01	8.2	8.3	8.4
Rahangala	Polysack – 12% Moisture	12.02	12.8	13.4	13.8
	White Polythene -12% M	12.02	12.1	12.2	12.1
	Clear Polythene - 12% M	12.02	12.2	12.3	12.3
	White Polythene - 8% M	8.01	8.2	8.3	8.2

**Table 4. Results of the statistical analysis.**

<i>Source of variation</i>	<i>Standard germination</i>	<i>Field germination</i>
Packaging material (P)		
- 12% M Vs 8% M	**	**
- Poly-sack Vs Polythene	**	**
- Within polythene	ns	ns
Location (L)		
- Cold room Vs others	**	**
- Within others	*	*
Storage time (T)	**	**
P x L	**	**
P x T	**	**
L x T	**	**
P x L x T	**	**

\*\* - Differences are significant at 1% level of probability

**Table 5. Monthly Maximum and Minimum temperature (C°) in different study locations.**

Month	Monthly Maximum and Minimum temperature (C°) in each location					
	Peradeniya		Rahangala		Kundasale	
	Max.	Min.	Max.	Min.	Max.	Min.
June, 99	28.5	20.8	24.6	15.3	29.0	19.7
July	28.6	21.7	24.4	17.0	29.2	21.9
August	29.1	21.2	25.0	15.6	30.0	22.5
September	30.3	20.7	24.7	15.1	31.1	21.1
October	28.8	20.7	22.3	16.4	28.7	20.9
November	29.5	20.1	22.0	15.6	29.4	19.8
December	28.8	19.0	21.3	14.1	28.4	18.9
January,00	29.1	18.6	21.2	14.1	28.5	19.6
February	30.4	19.2	23.3	14.3	29.9	19.4
March	31.1	19.5	23.9	12.9	31.0	19.4
April	31.2	21.1	24.9	14.8	31.7	21.2
May	31.2	21.9	26.3	15.2	32.1	22.0
June	28.3	22.1	23.6	17.0	29.1	21.7
July	29.1	21.5	24.5	15.9	29.9	18.2
August	28.1	20.1	23.1	16.8	29.3	18.9
September	29.7	20.5	25.3	14.6	30.1	20.5
Average	29.5	20.6	23.8	15.3	29.8	20.4

Source: Data base, NRM, Department of Agriculture, Peradeniya

Early failure of maize seeds stored in poly propylene sacks (poly-sacks) at Peradeniya, Rahangala, and Kundasale locations could be due to absorption of moisture through the perforations. Variation in pattern of declining seed viability measured by the present standard germination test could be due to variation in relative humidity and temperature in different locations (table 1, 5 and 6). Delouche *et al.* (1973) suggested the need of an adequate protective system such as conditioning of seed store environment and packaging of seeds with sufficiently moisture proof materials to prevent moisture absorption by seeds. Comparatively longer storability recorded for maize seeds packed in polythene with 12% or 8% moisture levels in all the environments support this suggestion. Increased difference between SG and field germination in seed stored in poly-sacks could be due to faster deterioration associated with high seed moisture.

**Table 6. Monthly Relative humidity (%) data at different study locations.**

<i>Month</i>	<i>Monthly Relative humidity (%) at different study locations</i>					
	<i>Peradeniya</i>		<i>Rahangala</i>		<i>Kundasale</i>	
	<i>9.00am</i>	<i>4.00pm</i>	<i>9.00am</i>	<i>4.00pm</i>	<i>9.00am</i>	<i>4.00pm</i>
June, 99	84	79	74	72	77	68
July	83	75	81	61	72	61
August	82	77	67	68	73	63
September	81	76	64	65	73	65
October	87	83	78	79	81	80
November	83	79	78	81	82	74
December	81	72	82	80	81	70
January,00	83	71	85	78	83	70
February	87	70	83	83	99	64
March	84	63	79	71	84	62
April	81	73	77	78	83	67
May	77	69	72	77	72	62
June	83	76	74	74	78	72
July	79	68	72	68	73	65
August	83	75	85	86	78	69
September	78	74	85	96	75	65
Average	82.3	74.0	77.8	76.3	79.6	67.6

Source: Database, NRMC, Department of Agriculture, Peradeniya

As shown by Cardwell (1984) seed vigour get lowered with the increase seed moisture especially in environments with high temperature and relative humidity. Strong positive correlation between percentage of standard germination and percentage of field germination indicates that the level of field germination is higher in samples with high laboratory standard germination. Correlation coefficient of  $< 1$  indicate that the level of field germination is always less than the level of laboratory standard germination. Highly significant  $r^2$  suggest that one could predict the level of field germination by using the regression formula once the results of the standard germination test is available.

### CONCLUSION

Maize seeds should be stored in moisture proof containers such as polythene (gauge 500) after drying to a minimum of 12% moisture. Storing them in considerably low RH (Below 70%) and temperature (20° C) could further extend retention of viability. Seeds packed in non-moisture proof materials should be stored in cold rooms wherever possible (18 – 20 °C and 55-60% RH) in order to obtain prolonged storability. More studies are needed to validate the regression

formula to predict the level of field germination on the basis of the results of the standard germination.

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