

An alternative storage technique for maintaining maize seed quality in West Timor

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Abstract

The average maize yields in the province of East Nusa Tenggara (ENT), Indonesia of 2.2 t/ha is far lower than the national average of 4.5 t/ha. The low viability of maize seed is one factor responsible for this low yield. Most farmers sow their own seed after having stored it during the intervening dry season in a traditional cooking hut. Degradation during the storage period results in grain loss and poor seed germination. Addressing storage issues is one way to improve crop production in West Timor (ENT province). A maize storage trial using a factorial design was conducted in Nunmafo village in West Timor from May 2010 to February 2011. Four different maize seed storage techniques were compared over three time periods, after which seed germination rates were measured. The four treatments were: traditional storage (husk covered cobs hung in a traditional cooking hut); seed in sealed double plastic bags stored in the cooking hut; maize seed in sealed double plastic bags buried underground (UMS); and seed sealed in double plastic bags and placed in controlled cold storage cabinet ($\leq 5^{\circ}\text{C}$). Both temperature and humidity were monitored throughout the experiment in all treatments. The results showed that the UMS technique maintained significantly higher seed viability compared to both the traditional storage technique and to hut storage of bagged seed. Seed viability following UMS was not significantly different from that obtained following cold storage. The simple act of storing dry seed underground under conditions that provided stable temperature and humidity improved seed viability from about 20% to approximately 80 % in seed samples from three villages. This provides farmers with a storage technique that provides high seed viability for the following season and reduces the quantity of planting seed required to obtain optimum crop density.

Key Words

Germination, seed quality, temperature, air humidity, maize, West Timor

Introduction

Maize is an important commodity in Indonesia and as a source of carbohydrate, second only to rice. The five largest maize producing provinces in Indonesia are East Java, Lampung, North Sulawesi, East Nusa Tenggara (ENT) and South Sulawesi. In ENT, maize is consumed as a staple food (Rachman, 2007). In the last decade maize production in ENT (comprising the three main islands of West Timor, Flores and Sumba) has increased 18%, with maize yield increasing 17%. However, the average provincial yield in 2010 of 2.7 t/ha was still lower than the national average of 4.4 t/ha, and much lower than the potential yield of the widely used open pollinated variety Lamuru (7.6 t/ha) (Adnan *et al.*, 2010; Statistical Year Book of Indonesia, 2010).

An issue that contributes to the poor yield in West Timor (one of the major regions of ENT) is the quality of seed used for sowing. Farmers in ENT sow their own seed after having stored it during the intervening dry season hung above the cooking fire in traditional huts (Saenong *et al.*, 2007; Swastika *et al.*, 2004). Insect pest damage is a major factor responsible for decline in quantity, quality and germination potential of the stored seed (Johannessen, 2008; Olakojo & Akinlosotu, 2004). For instance, farmers in Natal and Nigeria experienced 10-20% grain loss in all traditional storage methods over 6-9 months because of insect pest activities (Thamaga-Chitja *et al.*, 2004; and Adejumo & Raji, 2007). High temperature and high moisture are other major factors affecting grain quality in storage. Both high temperature and high humidity can cause rapid decline in germination, malting quality, baking quality, colour, oil composition, and many other quality characteristics (Strahan and Page, 2003). Therefore, the identification of an effective storage technique for planting seed is important in maintaining quality and reducing economic loss through poor plant stands and resulting poor yields.

The damage and wastage of maize grain can be minimized by employing well managed, improved storage techniques (Strahan and Page, 2003). The use of plastic bags and metal containers to protect grain in some countries is increasing (Gommert, 2010). For instance, farmers in Indonesia, Philippines and Thailand stored rice seed in plastic bags and achieved seed germination rates greater than 90% (Mendoza & Gummert, 2007). In Malawi and Kenya, farmers reduced maize grain losses from 50% to 10-20% after storing seed for 3 months using outdoor, airtight metal silos able to store 1,800 kg of maize seed (CIMMYT, 2010).

In the light of these encouraging results elsewhere, a maize storage trial has been conducted in West Timor to investigate whether simple alternative storage options can be implemented to improve the germination and quality of maize seed reserved for the next season's planting by village farmers.

Materials and methods

A maize storage trial using a 4x3x3 factorial design was conducted in Nunmafo village in West Timor of ENT province, Indonesia from May 2010 to February 2011. Four different techniques for the storage of maize seed from three villages (Ajaobaki, Amol and Nunmafo) were compared over three time periods (three, six and nine months) after which seed germination rates were measured. Thirty harvested cobs of landrace maize were collected for testing from 7 farmers in each of the 3 villages, so each treatment was replicated seven times in each village. The four storage treatments were: Treatment 1: Maize cobs hung traditionally in a cooking hut (cooking hut cob) as control; Treatment 2: Maize seed contained in sealed double plastic bags and placed in the cooking hut (cooking hut seed in plastic bag); Treatment 3: Maize seed contained in sealed double plastic bags and placed in a 1m deep hole and covered up with soil (buried seed in plastic bag); and Treatment 4: Maize seed contained in sealed double plastic bags and stored in a controlled cold storage cabinet at $\leq 5^{\circ}\text{C}$ (seed in plastic bag at $< 5^{\circ}\text{C}$).

Storage treatments

The cobs to be stored using the traditional technique were dried in the sun for 3 days. Seed for the other treatments was removed from the cob and dried at 60°C to achieve a seed moisture content below 13% calculated by the method of Hellevang, 1995. These seeds were distributed to all treatments.

Germination test

Seed germination was evaluated in the seed testing laboratories of the local government office in Kupang using the sand method germination test (ISTA, 2007). Fifty seeds were planted at 5 cm depth in sand. Boxes were watered daily to maintain moisture content with germination evaluated ten days after sowing.

Data collection and analysis

Normal germination and seed moisture data were collected at three, six and nine months after storing. Air temperature and relative humidity were recorded over the 9 months at a 45 minutes time step using four Tinytag data loggers that each data logger worked in each treatment. Data was analysed using the Minitab 15 program for ANOVA (Montgomery, 2009)

Results and discussion

Results comprised of the germination rate and seed moisture content (Table 1) and analysis of variance (Table 2), and its correlation to the temperature and relative air humidity of the storages (Table 3).

Table 1. The average of seed germination and moisture content of West Timor maize landraces stored by four different storage techniques over 9 months.

Different storage techniques over 9 months					
Village	Storage time (months)	Storage technique			
		Treatment 1	Treatment 2	Treatment 3	Treatment 4
----- Germination (%) -----					
Ajaobaki	3	88 (11.4)	87 (12.0)	90 (12.2)	94 (12.8)
	6	56 (12.7)	70 (12.3)	87 (11.9)	92 (12.6)
	9	28 (13.4)	55 (12.2)	80 (11.8)	85 (12.6)
Amol	3	75 (11.7)	85 (12.1)	89 (12.1)	91 (12.3)
	6	42 (12.7)	67 (12.2)	84 (12.0)	89 (12.3)
	9	18 (13.4)	52 (12.2)	78 (11.8)	83 (12.4)
Nunmafo	3	78 (11.9)	84 (12.1)	87 (12.3)	90 (12.5)
	6	47 (12.7)	67 (12.4)	84 (12.1)	88 (12.4)
	9	19 (13.4)	50 (12.3)	77 (12.0)	83 (12.6)

Note: Numbers in parentheses are % moisture of seed. N = 7.

The trend of the germination rate of the four storage techniques (Table 1) shows that seed germination declined for all treatments and all villages during the storage period however, the rate of decline varied between villages and treatments. Treatment 1 dropped the fastest, to $<50\%$ viable seed after 6 months and $<40\%$ after 9 months. Treatment 2 maintained higher seed viability with germination after 9 months being between 40 and 60%. Treatment 3 and 4 both maintained a significantly higher level of germination after 9 months of between 70 and 90%.

A relatively small but significant variation in germination results for the four treatments was observed among

the three villages (Table 2). This probably reflects variation in the germination rate prior to commencement of the treatments, where the germination rate was 95%, 93%, and 92% from Ajaobaki, Amol and Nunmafo villages respectively.

Seed moisture content varied differently over time among treatments. In Treatments 1 and 2 the seed moisture content increased slightly over nine months, while over the same period Treatment 3 resulted in a small decrease, while Treatment 4 maintained stable moisture content of around 12%. (Table 1)

Table 2. Analysis of variance (F value) for seed moisture and germination vs village, variety, storage period and storage techniques of West Timor maize landraces.

Source	df	Seed moisture	Normal germination
Storage technique	3	50.8*	367.4*
Village	2	2.9	12.8*
Storage period	2	42.8*	315.4*
Storage technique*Village	6	1.5*	2.5*
Storage technique*Storage period	6	52.8*	57.7*
Village*Storage period	4	0.1	0.1
Storage technique*Village*Storage period	12	0.1	0.1

Note: * Significant at $P < 0.05$

The analysis of variance (Table 2) shows that all the single factors (villages, storage periods and storage techniques) and the interaction between storage technique and village and storage technique and storage period significantly influenced seed germination at P value less than 0.05.

Table 3. Temperature and relative air humidity in the four storage techniques during nine months from May 2010 to February 2011.

Treatment	Temperature (mean)			Relative humidity (mean)		
	3 months	6 months	9 months	3 months	6 months	9 months
	----- °C -----			----- % RH -----		
Treatment 1	27 (\pm 4)	28 (\pm 5)	28 (\pm 5)	71 (\pm 36)	75 (\pm 31)	73 (\pm 31)
Treatment 2	27 (\pm 2)	27 (\pm 3)	27 (\pm 3)	56 (\pm 3)	55 (\pm 3)	56 (\pm 3)
Treatment 3	27 (\pm 1)	27 (\pm 1)	27 (\pm 1)	61 (\pm 0)	62 (\pm 1)	62 (\pm 1)
Treatment 4	1 (\pm 1)	1 (\pm 1)	1 (\pm 1)	73 (\pm 2)	73 (\pm 2)	72 (\pm 2)

Note: Numbers in parentheses are standard deviations of the temperature and humidity.

While the mean storage temperature was relatively stable and similar for each un-refrigerated treatment (Table 3) the standard deviation of this statistic was much higher in Treatment 1 and higher in Treatment 2 compared to that in Treatments 3 and 4, over the life of the experiment.

By contrast significant differences were observed among the mean relative humidity of all four treatments (Table 3). In addition the standard deviation of humidity measurements was very large for Treatment 1 compared to that of all other treatments. Treatment 3 experienced the most stable humidity levels of all the four treatments.

Conclusion

In conclusion, the UMS technique (Treatment 3) was equivalent to cold storage (Treatment 4), but superior to the traditional storage technique (Treatment 1) and to storage in sealed double plastic bags placed in the traditional cooking hut (Treatment 2), in terms of preserving seed viability during storage of West Timorese maize landraces. The stability of temperature and humidity conditions may be an important factor in maintaining this viability over time. The simple act of storing dry seed ($< 13\%$ seed moisture content) in sealed doubled plastic bags underground has the potential to maintain seed viability at above 80 % resulting in higher rates of crop establishment, lower seeding rates and optimum planting densities.

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