ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Afr. J. Food Agric. Nutr. Dev. 2017; **17(3):** 12395-12412 **DOI: 10.18697/ajfand.79.16035**

EFFECTS OF STORAGE METHODS AND SEASONS ON SEED QUALITY OF JUTE MALLOW MORPHOTYPES (*CORCHORUS OLITORIUS*) IN SIAYA AND KAKAMEGA COUNTIES, KENYA

Maina FNW[1]*, Gohole LS[2] and RM Muasya[3]

Maina Faith

*Corresponding author email: maina_faith@yahoo.com

[1,2]School of Agriculture and Biotechnology, University of Eldoret, P.O. Box 1125-30100 Eldoret, Kenya

[3]South Eastern Kenya University, P.O Box 170-90200, Kitui, Kenya

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

ABSTRACT

Jute mallow is an important source of nutrients, income and traditional medicine in Kenya. It is extensively grown and consumed in Western Kenya. However, its production is constrained by lack of quality seeds due to varied farmers' agronomic and postharvest practices. The aim of the study was to investigate the effect of storage methods on seed quality of jute mallow in Western Kenya. Seeds of two morphotypes of *C. olitorius*(with 70% and above germination)were stored in clay pots, transparent plastic jars, brown paper bags and polythene bags at room temperature in Kakamega and Siaya Counties. Seeds were also stored in a freezer at Chepkoilel campus in Eldoret at -2^{0}C. In Kakamega County, average room temperature was 23^{0}C and relative humidity was 85% during the storage period of May to July 2006. In Siaya County, the average room temperature was 25^{0}C and relative humidity was 80% during the same period. Between December and February 2006, the average room temperature was 26^{0}C while relative humidity was 80% in Kakamega County. In Siaya County, the average temperature was 28^{0}C and relative humidity 65% for the same period. Storage duration was 90 days, which is the length of time farmers in the study areas store jute mallow seeds to avoid seed dormancy. Seed viability and vigourof the seeds was determined. Data obtained were subjected to Analysis of Variance (ANOVA) and T-tests using Statistical Analysis Software (SAS) programme. Season of growth and storage methods influenced the seed quality. Seeds stored in clay pots, brown paper bags, plastic transparent jars and freezer had higher seed quality than those stored in polythene bags. Even though there was varied response to different storage methods, generally it was recommended that in order to obtain high quality seeds, farmers should store jute mallow seeds in clay pots or brown paper bags or plastic transparent jars or freezer.

Key words: jute mallow, seed vigour, seed viability, storage methods, *Corchorusolitorius*

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

INTRODUCTION

African leafy vegetables are an important source of nutrients, income and traditional medicine in Kenya [1]. Jute mallow has high amounts of beta carotene, vitamin E, riboflavin, folic acid, ascorbic acid, calcium, proteins and some phenolic compounds [2]. It is an important source of a income especially for rural women who are involved in production and sale in Western Kenya [3, 4]. Jute mallow roots are used for relieving toothache among the Luos of Kenya, treatment of abdominal pain, tackling menstrual and pregnancy problems as well as treating gonorrhea [5, 6, 7]. However, the true potential of this vegetable is not being exploited among African farmers, due to varied agronomic, storage and marketing challenges [8].

Studies have shown that in the past these vegetables were collected from the wild, but as the pressure on land increased the vegetables have become domesticated, hence the need for quality seed [9]. Most farmers use farm-saved seed for the production of jute mallow vegetables. The quality of the seed is variable due to the differences in agronomic, harvest and postharvest practices by farmers. Limited research has been undertaken on the production of quality jute mallow seed on farmers' fields and seed storage methods [10, 11, 12]. The effect of agronomic, harvest and postharvest practices except storage on seed quality has been reported elsewhere [13, 14]. This paper, therefore, focuses on the effect of storage methods on quality of jute mallow seeds.

Seed storage has been shown to affect seed quality, hence influence germination potential [15]. Factors that affect seed quality in storage include duration of storage, temperature in storage structure, seed moisture and the relative humidity in the storage structure, oxygen pressure during storage and pests and diseases [15]. These factors vary with the type of storage method used. Farmers use various storage structures such as earthen pots, polythene bags, glass containers, and plastic jars, which influence seed quality differently depending on the crop species in question [16]. Studies with other crops like beans, maize and cowpeas show that storage of seed in plastic containers that were tightly sealed resulted in high quality seed. Seeds stored in pots sealed with cow dung were also of good quality. Custom made plastic bags were also tested found to and maintain seed quality. However, the normal polythene bags do not achieve the same effect as the custom made plastic bags. The longer a seed is stored the more the seed deteriorates due to the slow respiration that occurs in all stored seeds. Respiration depletes food reserves that are required for seed germination [16].

Harrington's rule states that 1% decrease in moisture content nearly doubles storage potential of seed and a 5^0C decrease in temperature also nearly doubles the storage life [17]. Studies on different species also indicate that seed quality is reduced at high relative humidity [18, 19, 20].

This implies that in order to maintain seed quality during storage, seeds must be dried to low moisture levels and be stored under conditions of low humidity. However, it is important to note that reducing moisture below 6% damages the seed of most crop species. Storing seeds below 0^0C damages some seeds and they may not be able germinate later [17]. Sometimes oxygen is evacuated in order to reduce the respiratory activities of the seed and also as a fumigation measure. In this study, no evacuation of oxygen was done as the study focused on storage methods that can be easily replicated by farmers at minimum cost. Pests and disease causing organisms can also destroy the embryo of the seed or use up the food reserves, which are needed for germination, hence the need to control them [16]. Seed deterioration in storage varies from species to species. This study set out to investigate the response of jute mallow seeds to different storage conditions.

Aim of study
To determine the effect of storage methods on seed quality of jute mallow seeds in Western Kenya.

Hypothesis
Storage methods affect the quality of jute mallow seeds.

MATERIALS AND METHODS

Seed collection and field experiments
Jute mallow seed samples were collected from farmers in Kakamega and Siaya Counties using scientific germplasm collection techniques during the month of December 2004. This entailed selecting ten seed collection sites per district along transects made in each district. Collection sites were selected based on the ecological variations in the study area. Sampling was done in farmers' fields, in farmers' stores and in market centers. Collection in farmers' fields was done at regular intervals of three paces along small transects made at each site. Different members of the team walked the three different transects and sampled from plants that produced a lot of seeds. Twenty percent of seed available on each plant was collected. Number of plants sampled per site was 21 and the seeds from different plants were kept separate. This was done to capture as much of genetic alleles in the population as possible. Care was taken not to harvest empty pods or immature seeds from the farms. Pods found on the ground were not collected as they may have been subjected to deterioration. Characterization and multiplication of the jute mallow morphotypes was done in green houses at the University of Eldoret between February and October 2005. Field experiments were conducted in Kakamega and Siaya in the long rains season (March to May 2006) and short rains season (September to November 2006). The procedures and results of these three stages have been reported elsewhere [13, 14].

Storage
Seeds from the field experiments with high percent germination were selected for storage (Table 1). These were red and glossy leafed jute mallow morphotypes (*C. olitorius*morphotypes) seeds harvested at black pod stage from non-defoliated plants, hand shelled and dried in the sun. Seeds from the long rains season were stored between May and July 2006 and those from the short rains season were stored from December 2006 to February 2007. Seeds were stored at two sites - Kenya Agricultural Research Institute (KARI) in Kakamega County (UM_0 zone) and Agricultural Training Center (ATC) in Siaya County (LM_1 zone). Some were also stored in a freezer at -2^{0}C

DOI: 10.18697/ajfand.79.16035

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

at Chepkoilel campus in Eldoret. Average room temperature was 23^0C and relative humidity 85% between May and July 2006 in Kakamega County. In Siaya County, the average room temperature was 25^0C and relative humidity 80% during the same period. Between December and February 2006 the average room temperature was 26^0C while average humidity was 80% in Kakamega County. In Siaya County, the average temperature was 28^0C and relative humidity 65% for the same period.

Moisture content determination before storage

Materials and equipment

Seeds, foil paper, oven, desiccators and electronic weighing machine

Procedure

Five replicates of 50 seeds for each storage method for each of the two varieties were weighed individually and placed in foil paper. They were then dried in a well ventilated oven at 103^0C for 17 hours [21]. Seeds were cooled in desiccators for about 30 minutes. Weights were measured for each storage method. Moisture content was determined by the following formula

$$\%\ \text{Seed moisture content} = \frac{\text{Initial seed weight before drying (g)} - \text{Seed weight after drying (g)}}{\text{Initial seed weight before drying (g)}} \times 100$$

Storage experiments

Materials

Seeds, freezer, pots, plastic jars, polythene bags, brown paper bags, foil paper, maximum and minimum thermometer and hydrometer.

Procedure

Five grams of seed was put in each storage container (clay pots, brown paper bags, plastic transparent jars, polythene bags and foil paper for freezer). There were three replicates for each storage method. Clay pots and plastic transparent jars had lids to keep away pests. Brown paper and polythene bags were secured at the top for the same reason. Seeds in foil paper were placed in a freezer set at - 2^0C and relative humidity 80%. Other storage containers were placed in a room which allowed in sunlight. Seeds were stored for 90 days as farmers in Western Kenya normally store their seeds for this duration to overcome dormancy [13]. Temperature and humidity in the rooms were monitored daily using maximum and minimum thermometer and hydrometer, respectively.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

Laboratory tests

Materials and equipment
Seeds, petri dishes, filter paper, and distilled water, forceps, magnifying lens and growth chamber.

Procedure
The seeds from the storage containers were subjected to seed viability and vigour tests. For each storage method, four replicates of 100 seeds were placed in petri dishes lined with three moist filter papers. Petri dishes were placed in a growth chamber set at 24^0C and 70% relative humidity [21]. Distilled water was added to the petri dishes once every two days to keep filter papers moist. Number of seeds that germinated normally were counted daily at 9:00 am for seven days and removed. Percent germination was determined after seven days. Seed vigour was calculated using the formula below.

$$\textit{Speed of germination index} = \sum N/D \qquad [17]$$

N- Number of normal seedlings that germinated per day; D - Day after sowing.

Data collected was analyzed using the SAS software using Analysis of variance (ANOVA) testatP≤0.05. T-tests were used to compare seed quality across the seasons and sites.

RESULTS

Seed moisture
Average seed moisture levels before storage for both jute mallow morphotypes were 11% in Siaya County and 12 % in Kakamega County.

Effect of storage methods and seasons on seed quality of red leafed jute mallow morphotype
Season of growth significantly (P≤0.05) affected percent germination and speed of germination in Kakamega County (Table 2). Seeds from the long rain had significantly (P≤0.05) higher percent germination (83.1%) than those from the short rain season (78.4%) in Kakamega County.

Storage methods significantly (P≤0.05) affected percent germination and speed of germination in Kakamega County (Table 2). Seeds stored in brown paper bags, plastic transparent jars had significantly (P≤0.05) higher percent germination (85.5% and 84.5%, respectively) than other methods of storage (pots 76.8%, freezer 80.8% and polythene bag 76.1%) in this county (Figure 1).

DOI: 10.18697/ajfand.79.16035

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

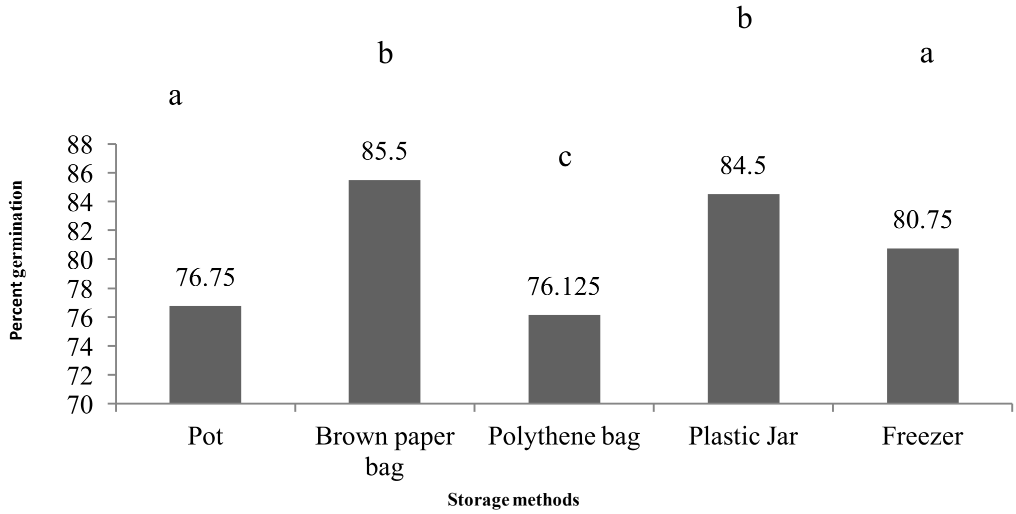

Figure 1: Effect of storage methods on percent germination of red leafed jute mallow (*C. olitorius*) seeds stored in Kakamega County
Means with the same letters are not significantly different at P≤ 0.05

Effect of storage methods and seasons on seed quality of glossy leafed jute mallow morphotypes

Unlike the red leafed morphotypes, season significantly (P ≤ 0.05) affected percent germination only in Kakamega and Siaya Counties (Table 3). Seeds from the long rain had significantly (P≤0.05) higher percent germination than those from the short rain season in both counties (Figure 2). There was no interaction between seasons and storage methods for percent germination in the two counties.

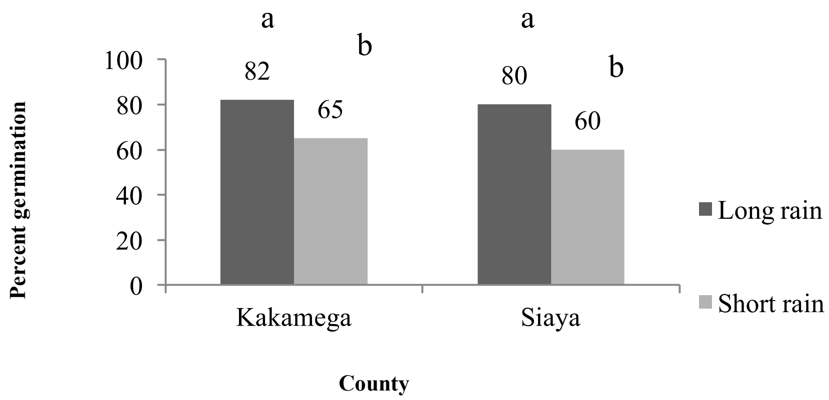

Figure 2: Effect of seasons on percent germination of glossy leafed jute mallow morphotype (*C. olitorius*) seeds from the long rain and short rain in Kakamega and Siaya Counties
Means with the same letters within each county are not significantly different at P≤ 0.05

Method of storage significantly (P ≤ 0.05) affected percent germination of seeds in Kakamega and Siaya Counties (Table 3). Seeds stored in clay pots and freezer had

DOI: 10.18697/ajfand.79.16035

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

significantly (P ≤ 0.05) higher percent germination than those stored in other containers (Figure 3).

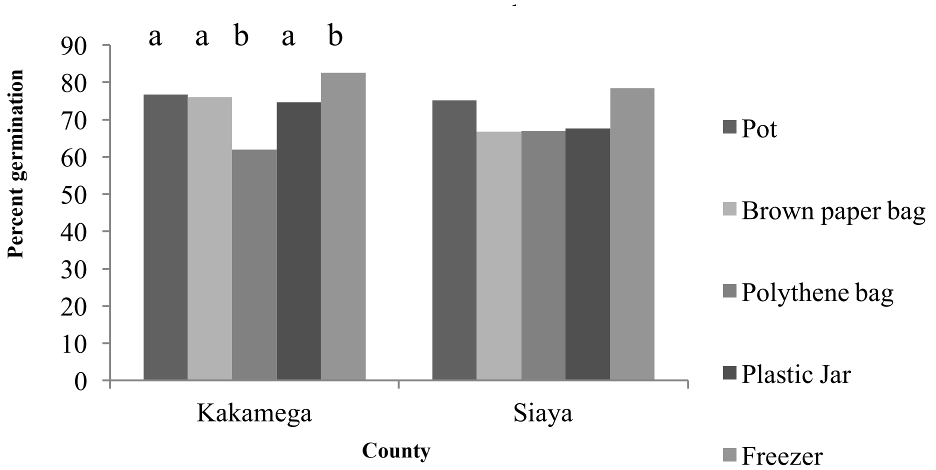

Figure 3: Effect of storage methods on percent germination of glossy leafed jute mallow morphotype seeds stored in Kakamega and Siaya Counties Means with the same letters within each county are not significantly different at P≤ 0.05

Interactions for red leafed morphotype

There was significant (P ≤ 0.05) interaction between season and storage methods for speed of germination index in Kakamega County (Table 2). Seeds obtained after the long rain season and stored in brown paper bags and plastic jars (both 0.85) had significantly (P≤0.05) higher speed of germination index than other combinations in this interaction (Figure 4).

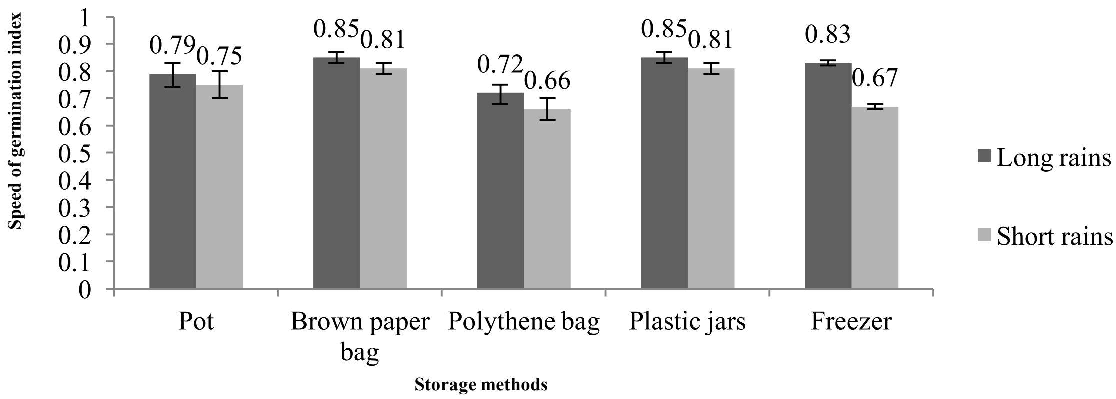

Figure 4: Effect of storage method and seasons on speed of germination indices of red leafed jute mallow morphotype (*C. olitorius*) seeds in Kakamega County

In Siaya County, season and method of storage significantly interacted for percent germination and speed of germination index (Table 2). Seeds obtained after the long

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

rain season and stored in clay pots had significantly (P≤0.05) higher percent germination (79%) than the rest of the combinations of season and storage methods (Figure 5).

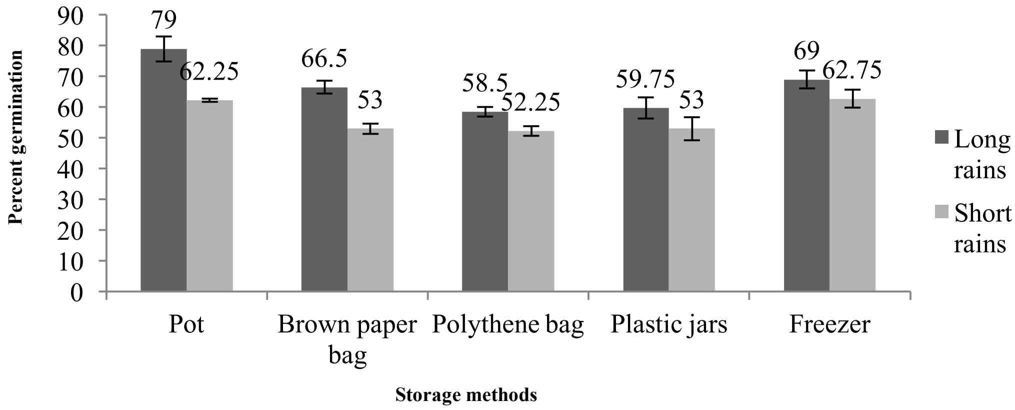

Figure 5: Effect of storage methods and seasons on percent germination of red leafed jute mallow morphotype (*C. olitorius*) seeds in Siaya County

Seeds obtained after the long rain season and stored in the freezer had (P≤0.05) significantly higher speed of germination index compared to the rest (Figure 6).

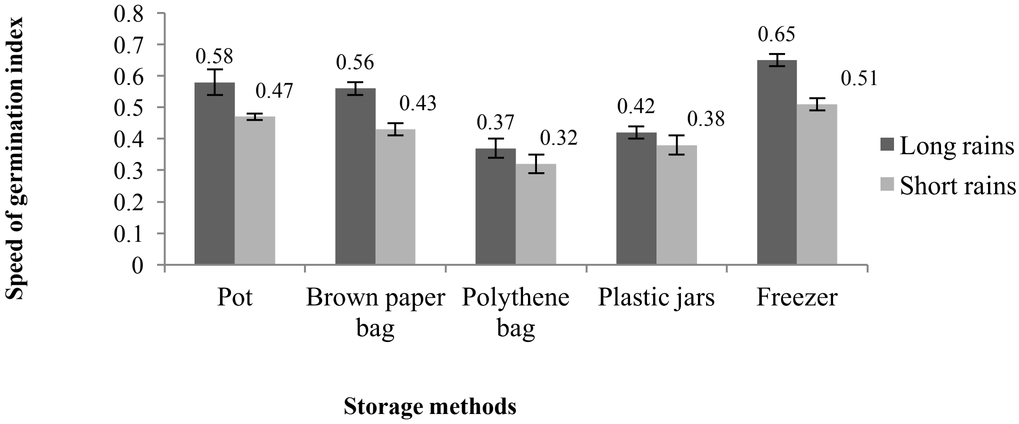

Figure 6: Effect of storage methods and seasons on speed of germination indices of red leafed jute mallow morphotype (*C. Olitorius*) seeds in Siaya County

Interactions for glossy leafed morphotype

In both counties there was interaction between storage methods and seasons of growth in relation to speed of germination test (Table 3). Seeds harvested during the long rain season and stored in a freezer at Chepkoilel campus in Eldoret at -2^{0}C had significantly (P ≤ 0.05) higher speed of germination than those stored in Kakamega County (Figure 7).

DOI: 10.18697/ajfand.79.16035

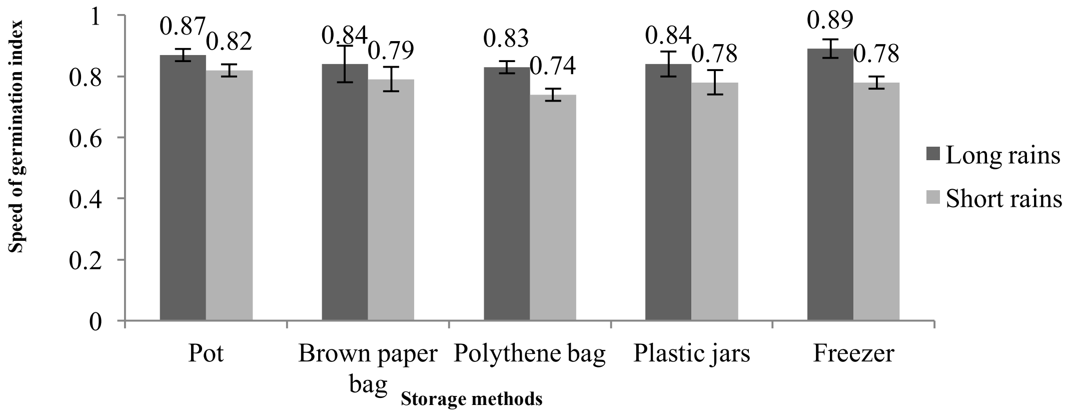

Figure 7: Effect of storage methods and seasons on speed of germination indices of glossy leafed jute mallow morphotype (*C. olitorius*) seeds in Kakamega County

In Siaya County, seeds harvested during the long rain season and stored in the clay pots had significantly ($P \leq 0.05$) higher speed of germination compared to others (Figure 8). Speed of germination index was quite low for polythene bags (Figure 8). A large proportion of the seeds (30%) were covered with moulds. At both sites, moisture accumulated in the polythene bags during storage.

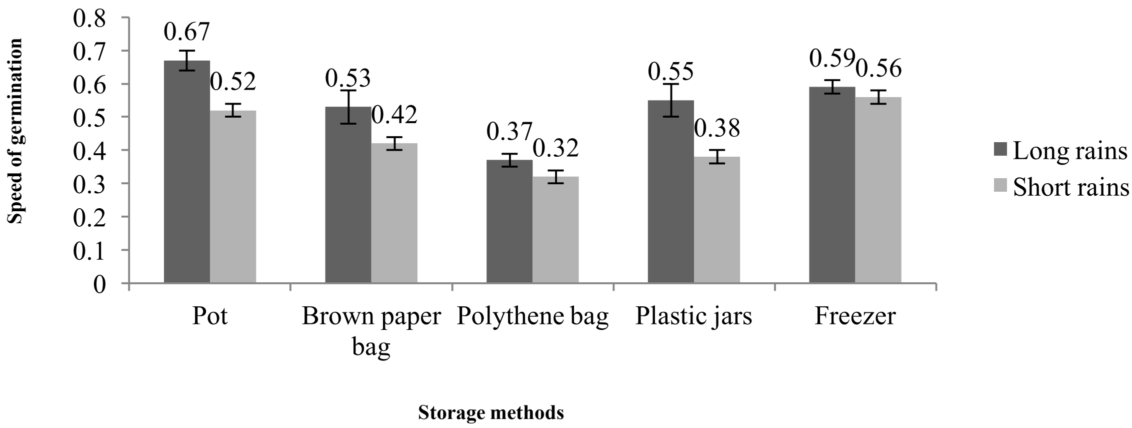

Figure 8: Effect of storage methods and seasons on speed of germination indices of glossy leafed jute mallow morphotype (*C. olitorius*) seeds in Siaya County

DISCUSSION

Average seed moisture levels before storage for both jute mallow morphotypes (*C. olitorius*) was 11% in Siaya County and 12 % in Kakamega County. This is close to what is recommended for most crops seeds before storage. A study on spider plant has showed that seed moisture levels of 11 - 12% reduced deterioration of seeds to moulds and increased respiration in the seed [20]. Moisture content of the seeds was determined before storage to ensure that seeds stored had the same moisture levels and

DOI: 10.18697/ajfand.79.16035

the variation in percent germination and speed of germination indices was due to differences in storage conditions in each storage container.

There were significant interactions between season and storage methods in Kakamega County for the speed of germination index and in Siaya County, for both percent germination and speed of germination index for the red leafed jute mallow morphotype (*C. olitorius*) (Table 2). Season and method of seed storage also significantly interacted for the speed of germination index in both Kakamega and Siaya Counties for the glossy leafed jute mallow morphotype (Table 3). This indicated that seeds from the long rains season had higher seed quality and retained their quality better during storage than those from the short rains season across the storage methods, for both morphotypes. This can be explained by the fact that sufficient moisture during the long rain season ensures that the process of photosynthesis goes on well and provides essential assimilates for proper seed formation [20]. Jute mallow is also susceptible to moisture stress owing to its shallow rooting system hence does better in long rains than in the short rains season [23].

Percent germination and speed of germination index of both jute mallow morphotypes in Siaya were much lower than those from Kakamega, indicating that the latter is more suitable for jute mallow production. This is because Kakamega County gets more rainfall than Siaya County. As noted before, jute mallow requires fairly high levels of moisture to grow well and develop good seeds [24].

Apart from seasons and sites influencing seed quality, method of storage also significantly affected percent germination and speed of germination index in both Kakamega and Siaya Counties for the two jute mallow morphotypes. Generally, the most suitable methods of storage were plastictransparent jars, clay pots, brown paper bag, or freezer. Polythene bags had the lowest percent germination and speed of germination index in both Kakamega and Siaya Counties. A study on wheat seeds reported similar findings [25]. These observations are due to the fact that each type of storage container provides certain storage conditions. Temperature, humidity, oxygen pressure and access of pests and disease to the seeds will vary from one type of storage container to another and these conditions of storage affect seed quality [26, 27].

Covered clay pots are reported to have cool and dry conditions [28]. This explains why the seeds in the pots had good seed quality. Seeds require cool and dry conditions to prevent absorption of moisture that causes deterioration by moulds and other storage fungi [4, 27]. These conditions also slow down respiratory activities which reduce food reserves in the seed necessary for germination of seed. Similar results were obtained for *Curcubitae* sp. seeds [28]. Clay pots and brown paper bags also have numerous pores that ensure gaseous exchange between the storage container and the atmosphere. This ensures a good supply of oxygen which is needed by the seeds which respire slowly during storage. Temperatures in the clay pots and freezer also tend to be lower than the ambient temperatures which ensure that the seeds do not respire too fast, producing toxic compounds that kill the embryos of the seeds [16]. The plastic transparent jars may have enclosed enough air to ensure oxygen availability [16]. Due to the way the polythene bags were secured they enclosed less air. Limited amount of oxygen may have affected the respiring seeds adversely [16]. Polythene bags had a lot of moisture trapped which may have caused fungi and other microorganisms to flourish. Other studies also indicate that polythene bags are not suitable for seed storage due to accumulation of moisture that leads to rotting of seed [28]. Storing seed in clay pots and brown paper bags also provided dark conditions which are associated with preserving seed quality. The plastic jars and polythene bags used in this study were transparent hence exposed the seeds to light. Light has been associated with reducing the life of seeds due to the fact that photoreceptors found in seeds are stimulated and this leads to increased metabolic reactions that breakdown stored food [29].

Storing seeds in clay pots, brown paper bags and plastic transparent jars was comparable to storing seeds in the freezer. At farm level, farmers may not afford to use freezers due to high cost and sometimes lack of electricity. However, they should embrace the use of clay pots, brown paper bags and plastic transparent jars which are readily available and do not cost much. They can re-use the brown paper bags used for packaging wheat or maize flour to store seeds instead of buying them. Recycled plastic transparent jars with lids can also be easily obtained from the home or market.

There were differences between the percent germination and speed of germination indices for most of the storage methods. This is in line with other studies that indicate seed speed of germination index is more sensitive to storage than percent germination depending on the crop species [26].

CONCLUSION

From this research, it can be concluded that site, season and storage methods affect seed viability and vigour of jute mallow seeds. Farmers need to consider both season and storage method to obtain quality seed for both jute mallow morphotypes. Farmers from both counties should store seeds from the long rains season in order to get good quality seeds for planting. Farmers in Kakamega County should store red leafed morphotype jute mallow seeds in brown paper bags or freezer because they gave high quality seed compared to plastic papers and pots. In Siaya County, they should store red leafed morphotype jute mallow seeds in pots or freezer. If freezers are not available, they can use pots. Farmers in both Kakamega and Siaya Counties should store the glossy leafed jute mallow morphotype seeds in pots.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 1: Percent germination of the jute seeds stored

County	Morphotype	Percent Germination (%)	
		Seeds from the long rain season	Seeds from the short rain season
Kakamega	Red leafed morphotype	92.8%	88.8%
	Glossy leafed morphotype	93.5%	89.5%
Siaya	Red leafed morphotype	87%	75%
	Glossy leafed morphotype	85%	70%

DOI: 10.18697/ajfand.79.16035

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 2: Analysis of variance (ANOVA) for the effect of season and storage for red leafed jute morphotype seeds in Kakamega and Siaya Counties

County	Seed quality Parameter	Source	DF	Mean Square	F Value	Pr> F
Kakamega	Percent germination	Season (s)	1	225.6250	7.21	0.0117*
		Storage (t)	4	148.0250	4.73	0.0044*
		s x t	4	4.5000	0.14	0.9643ns
		Error	30	31.2750		
	Speed of germination index	Season (s)	1	216.2250	6.73	0.0145*
		Storage (t)	4	286.7875	8.93	<.0001*
		s x t	4	130.2250	4.05	0.0096*
		Error	30	32.1166		
Siaya	Percent germination	Season (s)	1	883.6000	35.39	<.0001*
		Storage (t)	4	1287.0375	51.55	<.0001*
		s x t	4	1763.4125	70.63	<.0001*
		Error	30	24.9666		
	Speed of germination index	Season (s)	1	30.6250	1.21	0.2801ns
		Storage (t)	4	792.9100	31.33	<.0001*
		s x t	4	1121.9843	44.33	<.0001*
		Error	30	25.3103		

* Significant at P≤ 0.05; ns – not significant at P≤ 0.05
s – Season; t – storage; sxt – Season and storage interaction; Error– mean error

DOI: 10.18697/ajfand.79.16035

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 17 No. 3
July 2017
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

Table 3: Analysis of variance (ANOVA) for the effect of season and storage for glossy leafed jute morphotype seeds in Kakamega and Siaya Counties

County	Seed quality Parameter	Source	DF	Mean Square	F Value	Pr> F
Kakamega	Percent germination	Season (s)	1	1918.2250	22.26	<.0001*
		Storage (t)	4	465.3125	5.40	0.0021*
		s x t	4	152.7875	1.77	0.1603ns
		Error	30	86.1583		
	Speed of germination index	Season (s)	1	5444.4522	84.25	<.0001*
		Storage (t)	4	1686.9059	26.10	<.0001*
		s x t	4	200.3024	3.10	0.0301*
		Error	30	64.6252		
Siaya	Percent germination	Season (s)	1	4305.6250	76.58	<.0001*
		Storage (t)	4	233.7125	4.16	0.0085*
		s x t	4	111.4375	1.98	0.1227ns
		Error	30	56.2250		
	Speed of germination index	Season (s)	1	12840.2897	266.62	<.0001*
		Storage (t)	4	177.3577	3.68	0.0148*
		s x t	4	240.5706	5.00	0.0033*
		Error	30	48.1597		

* Significant at $P \leq 0.05$; ns – not significant at $P \leq 0.05$
s – Season; t – storage; sxt – Season and storage interaction; Error – mean error

DOI: 10.18697/ajfand.79.16035

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

REFERENCES

1. **Maundu PM, Ngugi GW and CH Kabuye** Traditional Food Plants of Kenya. Nairobi, Kenya, Kenya National Museum of Kenya, 1999.

2. **AVRDC.** Discovering Indigenous Treasures: Promising Indigenous Vegetables from Around the World, AVRDC - The World Vegetable Center, 2009.

3. **Mnzava N and JA Chweya** Cat's Whiskers (*Cleome gynandra* L.,) **In:**Promoting the Conservation and Use of Underutilized and Neglected Crops 11. Institute of Plant Genetics and Crop Plant Research, Gatersleber/International Plant Genetic Resources, Rome, Italy1997: 23-28.

4. **Schippers RR** African Leafy Vegetables: An Overview of the Cultivated Species. Catham, UK, Natural Resources Institute/ACP-EU Technical Centre for Agricultural and Rural Cooperation, 2002.

5. **Ruibaihayo JE, Kakonge E, Kawongo J, Hart T and J Mugisha** Mechanisms for Sustainable Vegetable Production and Utilization of Indigenous Vegetables in Uganda. **In:** J S Tenywa (Ed.). Proceedings of African Crop Science Conference 2002; (**2**):133-135.

6. **Kokwaro JO** Seasonal Traditional Vegetables of Kenya. **In:**HDIhlenfeldt (Ed.). Proceedings of the Twelfth Plenary Meeting Aetfat, Symposium VII, Int. Alleg. Bot. Hamburg, Band 23b S, 1988 Hamburg (Germany). MitteilungenAus Dem InstitutFurAllgemeineBotanik, Hamburg 1990: 911-928.

7. **Keller GB** African Nightshade, Eggplant, Spider Flower *et al*. Production and Consumption Aspects of Traditional Vegetables in Tanzania from the Farmers' Point Of View. Goettingen: Georg-August Universität (Msc Thesis) 2004.

8. **Abukutsa MOO** Strategic Repositioning of Agrobiodiversity in the Horticulture Sector for Sustainable Development in Africa, CTA and FARA, 2011: 8-16.

9. **Ndinya C** Seed Production and Supply System of Three African Leafy Vegetables inKakamega District. **In:** MO Abukutsa, AN Murithi, VE Anjichi, K Ngamau, SG Agong, A Frinket, B Hau and H Stutzel (Eds.). Proceedings of the Third Horticulture Workshop on Sustainable Horticulture Production in the Tropics, Maseno University, 2005: 60- 7.

10. **Walingo A, Lung'aho C and S Shibaro** Market Survey of Indigenous Vegetables in Western Kenya. **In:** JS Tenywa (Ed.). Africa Crop Science Conference Proceedings 2001;**5**: 665-669.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 17 No. 3 July 2017 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

11. **Oirschot Q, Westby A and K Tomlins** Food Africa: Improving Food Systems in Sub-Saharan Africa. Responding to a Changing Environment. Food Africa Workshop, Yaounde Cameroon, 2003.

12. **Adebooye OC, Ajayi SA, Baidu-Forson JJ and JT Opabode** Seed Constraint to Cultivation and Productivity of African Indigenous Leaf Vegetables. *Afric. J. Biotech.* 2005; **4 (13)**: 1480-1484.

13. **Maina FNW, Muasya RM and LS Gohole** Influence of agronomic and postharvest practices on seed production of two ALVs in Western Kenya. *J. of Tech. and Socioecon. Dev.* 2011;**1**: 56 – 62.

14. **Maina FNW, Muasya RM and LS Gohole** Morphological characterization of jute mallow, *Corchorus sp*. to assess its genetic diversity in Western Kenya. *BaratonInterdisp. Research J.*2012;**2**: 21-9.

15. **Coolbear P** Mechanisms of Seed Deterioration. **In:** Basra, AS. (Ed.). Seed Quality Basic Mechanisms and Agricultural Implications. Binghamton, New York, Food Products Press, 1995.

16. **Bewley JD and M Black** Seeds Physiology of Development and Germination. 2nd Edition, New York, USA, Plenum Press 1994.

17. **Hong TD and RH Ellis** A Protocol to Determine Seed Storage Behaviour. Rome, Italy IPGRI Technical Bulletin No. 1 (JMM Engel and J Toll eds.) International Plant Genetic Resources Institute, 1996.

18. **Suma A, Screenivasan K, Singh AK and J Radhamani** Role of Relative Humidity in Processing and storage of seeds and Assessment of Variability in Storage Behaviour in *Brassica* sp. and *Eruca sativa*, *The Sci. World J.*2013; **1**:1-9.

19. **Gupta A and KR Aneja** Seed deterioration in soybean varieties during storage-physiological attributes. *Seed Res.*2004;**4**:239-250.

20. **Rugut E, Muasya R and L Gohole** Longevity of Bean (*Phaseolus vulgaris*) seeds stored at different locations varying in temperatures and relative humidity. *J. of Agric. Pure Appl.Sci and Tech*. 2010; **5**:60-70.

21. **International Seed Testing Association (ISTA).** Seed Science and Technology. Zurich, Switerland The International Seed Testing Association, 2004.

22. **Maguire JD** Speed of Germination-Aid in Selection and Evaluation for Seedling Emergence and Vigour *Crop Sci. J.*1962;**2**:176 - 7

23. **Kamotho NG, Mathege PW, Muasya RM and ME Duloo** Effects of Packaging and Storage Conditions on Quality of Spider Plant (*Cleome gynandra*L.) Seed L.*Afric. J. of Food, Agric., Nutri.and Dev.* 2013; **13**:8368-87.

24. **Fasinmirin JT and AA Olufayo** Yield and Water Use Efficiency of Jute Mallow (*CorchorusOlitorius*) under Varying Soil Water Management Strategies *J. of Med. Plants Res.* 2009;**3**:186-191.

25. **Malaker P, Mian IH, Bhuiyan KA, Akanda AM and MMA Reza** Effect of storage containers and time on seed quality of wheat *Bangladesh J Agric Res*2008; **33(3)**: 469-477.

26. **Abukutsa-Onyango MO** Seed Production and Support Systems for African Leafy Vegetables in Three Communities in Western Kenya. *Afric. J. of Food, Agric., Nutri. and Dev.* 2007; **7 (3)**: 1-16.

27. **Walters C and J Engels** The Effects of Storing Seeds under Extremely Dry Conditions. *Seed Sci. Res.*Supplement1998;**1**: 3-8.

28. **Watson JW and PB Eyzaguirre** Home Gardens *In Situ* Conservation of Plant Genetic Resources in Farming Systems. **In**: Watson JW and PB Eyzaguirre (Eds.). Proceedings of the Second International Home Gardens Workshop, 17-19 July 2001, Witzenhausen, Federal Republic. Rome Italy IPGRI 2002.

29. **Walters C, Wheeler LM and MJ Grotenhuis** Longevity of Seeds Stored in a Genebank: Species Characteristics. *Seed Sci. Res.* 2005; **15**:1–20.

DOI: 10.18697/ajfand.79.16035