Effect of Harvest and Postharvest Practices on Seed Quality of Jute Mallow Vegetables

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Abstract

African leafy vegetables (ALVs) are an important source of nutrients, income and traditional medicines in Kenya. However, their production has been constrained by lack of high quality seed due to varied farmers' harvest and post harvest practices. Limited research has been undertaken on the production of quality ALVs seed on farmers' fields. This study was carried out to investigate to identify optimal harvest and post harvest practices as far as seed quality of jute mallow (an ALV) is concerned. Field experiments were established in Kakamega and Siaya districts using Random Complete Block Design (RCBD) with 3 replicates. Agronomic, harvest and post harvest practices identified during a farmers' survey were used in these field experiments. Seed viability (measured by % germination) and vigour (measured by speed of germination index) was determined for the seeds obtained from the field experiments. Data obtained from field experiments was subjected to ANOVA and T-tests using Statistical Analysis Software (SAS). In Kakamega, seeds harvested at black pod stage from non defoliated plants, which were hand shelled and dried in the sun had higher percent germination and speed of germination indices for both seasons. In Siaya, jute mallow seeds harvested from non defoliated plants at black pod stage had significantly higher percent germination and speed of germination indices than other combinations. Season and site significantly affected percent germination and speed of germination index of the seeds harvested during field experiments. It was concluded that seasons, harvest and post harvest practices need to be considered by farmers in their quest to obtain good quality jute mallow seeds.

Key words: Jute mallow; Seed quality, germination indices, vigour

Introduction

Communities in western Kenya have utilized several species of African Leafy Vegetables (ALVs) for food and valued them for their taste, nutritional qualities and medicinal properties (Abukutsa-Onyango, 2004). However, lack of high quality seed remains a major constraint to the production of these vegetables (Adebooye, *et al*., 2005). Seed quality refers to the genetic, physical, physiological and sanitary status of the seed (Hampton, 2000). Of interest to the present study is the physiological status of the seed. Physiological seed quality refers to the germination capacity, viability, characteristics related to dormancy and the vigour of the seed. Seed viability refers to the ability of a seed to give a normal seedling when planted under normal sowing conditions (ISTA, 2004). Seed vigour refers to the sum total of all the attributes that give effective plant stand in the field. Vigour is positively related to the ability of a seed population to establish in optimum and suboptimum soil environments (ISTA, 2004).

Agronomic, harvest and post harvest practices have been shown to influence seed viability and vigour (either positively or negatively) depending on the crop species in question (Fairey and Hampton, 1997). These factors include leaf defoliation, seed harvest time, threshing and drying methods which were investigated in this study. A survey conducted in Kakamega and Siaya districts before the field experiments found that most farmers established their crop by drilling, dried the pods for 3 days at harvest, and threshed the pods using sticks. There was great variation in weeding and leaf defoliation frequency (Maina et al., 2011). Due to the large number of agronomic, harvest and post harvest practices this study varied stage of leaf harvesting, pod harvest, threshing methods, drying methods and standardized planting methods, weeding frequency and used farm yard manure during planting.

Materials and methods

Field experiments

The experiments were conducted on 2 sites between April to June 2006 for the 1st season and August to October 2006 for the 2nd season. The first site was at Kenya Agricultural Research Institute (KARI) at Kakamega found in the UM_0 zone. The second site was at Agricultural Training Center (ATC) in Siaya which is found in LM_1 zone.

Seed used were obtained from the study area using scientific germplasm collecting techniques with the help of gene bank personnel. Jute mallow seeds exhibited dormancy which was broken by mechanical scarification using sand paper. The seeds were then sown in wooden boxes in a polythene house at Chepkoilel campus – Eldoret. Different morphotypes of jute mallow were characterized and isolated. Jute mallow morphotypes (*Corchorus sp.*) sown in the field experiments were – green stemmed morphotype with large, glossy elliptic leaves (GL) and the red stemmed morphotype with small, non glossy ovate leaves (RL). Seeds for the field experiments were tested in the laboratory the ISTA protocol and found to have on average 95% germination percentage before sowing (ISTA, 2004). Agronomic practices used were those practiced by majority of farmers in the study area. The land was ploughed twice just before the rains at the two sites. The land was then subdivided into plots as shown in the field layout (Figure 1). Randomized complete block design was used with 3 replicates and each plot measured 3m × 2m. Each block had 8 plots.

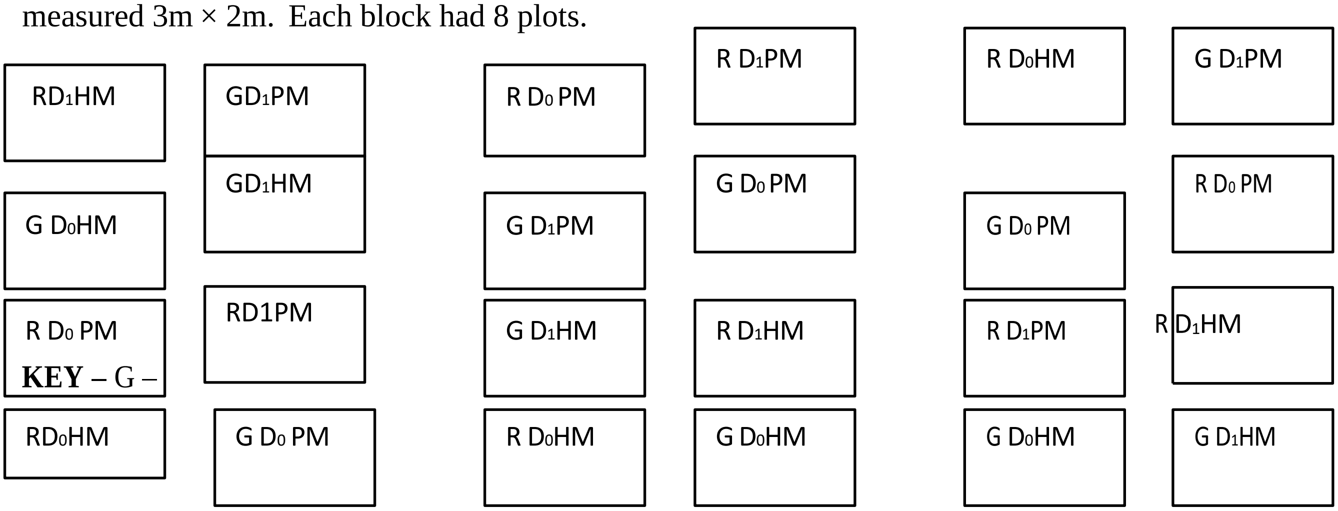


Figure 1 Jute mallow field layout

KEY – G – Glossy leaved morphotype; R – Red leaved morphotype; D_0 – No defoliation; D_1 – defoliated once per week; PM – physiological maturity; HM – Harvest maturity

Small drills were made in the plots using sticks at a spacing of 15 cm from each other. Manure was then applied in the drills at the rate of 2 Kg/m^2. Jute mallow seeds were scarified with sand paper to break dormancy. Seeds of both vegetables were sown in drills and covered lightly with soil. Seed rates used were 2.5 g/m^2 for both vegetables. Weeding was done 3 times during the growing season (at 3 weeks; 6 weeks and 8 weeks).

After 3 weeks, plants in some of the plots were defoliated once a week while others were not defoliated as shown in field layouts (Figure 1). After 90 days, seeds were harvested at brown and black pod stages. Munsell®colour charts for plant tissues were used to determine the pod colour at harvest (Munsell, 1977).

For each pod maturity stage, the pods were divided into two and one half was dried in the sun while other was dried in the shade for 6 hours per day for 3 days. For each drying regime the pods were subdivided into two. One half was threshed using a stick while for the other half seeds were removed from the pods by hand. Seeds obtained from each combination of morphotype/morphotype, harvest and post harvest practices (field experiments) were taken to the laboratory for germination tests.

Laboratory experiments

Jute mallow seeds from the field experiments were subjected to germination tests. Seed germination protocol used was according to International standards for testing seed viability and vigour (ISTA, 2004). Four replicates of 100 seeds of each combination of morphotype, harvest and post harvest practices were placed on individual petri dishes lined with 3 moist filter papers (moist paper substratum). The petri dishes were place in a growth chamber set at 24^0C and 70% relative humidity. Distilled water was added to the petri dishes regularly to ensure the filter paper was kept moist throughout the experimental period. Number of seeds that germinated normally was recorded at 9:00 am for 7 days. The seedlings were removed daily. Percent germination was determined after 7 days. Percent germination was used to determine seed viability. Seed vigour was determined by speed of germination test which was incorporated in the standard germination test described above.

The speed of germination index was determined by the formula below.

$$\textit{Speed of germination index} = \sum N/D$$

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

The higher the speeds of germination index the higher the seed vigour.

Results

Percent germination and speed of germination index were significantly ($P \leq 0.05$) affected by 3 way interactions between (i) morphotype X seed maturity X defoliation, (ii) morphotype X defoliation X threshing method and (iii) seed maturity X defoliation X threshing methods for both seasons in Kakamega (ANOVA table not shown).

Seeds from glossy and red leafed jute mallow morphotypes that were harvested at black pod stage from non defoliated plants had the highest percent germination and speed of germination index for both the long and short rain seasons (Table 1 and 2). Similarly, seeds from both morphotypes that were harvested at black pod stage and hand shelled had the highest percent germination and speed of germination index compared to other combinations for both seasons (Table 1 and 2).

Table 1 Percent germination of significant three way interactions between morphotype, harvest and post harvest factors for jute mallow in the long and short rain seasons in Kakamega

PXMXD		**LR** Mean±SE		**SR** Mean±SE	
GLBR	D0	91.87±	0.81	88.00±	0.79
GLBR	D1	87.62±	0.82	83.62±	0.82
GLBL	D0	93.50±	0.67	89.37±	0.71
GLBL	D1	85.62±	0.65	81.62±	0.65
RLBR	D0	91.00±	1.15	87.00±	1.15
RLBR	D1	86.87±	1.00	82.87±	1.00
RLBL	D0	92.75±	0.75	88.75±	0.74
RLBL	D1	88.87±	0.70	85.50±	0.65

PXMXT		**LR** Mean± SE	**SR** Mean± SE
GLBRHS		89.62±1.38	85.62±1.38
GLBR	ST	89.50±1.13	84.62±1.13
GLBL	HS	90.00±0.81	86.00±0.81
GLBL	ST	89.50±1.02	85.37±1.02
RLBR	HS	88.37±0.94	84.37±0.94
RLBR	ST	89.50±1.40	85.50±1.40
RLBL	HS	91.37±0.78	87.68±0.69
RLBL	ST	90.25±0.94	86.56±0.90

MXDXT			**LR** Mean± SE	**SR** Mean± SE
BR	D0	HS	93.75±0.83	86.12±1.06
BR	D0	ST	89.12±0.77	88.87±0.78
BR	D1	HS	89.25±0.72	84.25±0.62
BR	D1	ST	85.25±0.80	82.25±1.08
BL	D0	HS	95.31±0.41	90.00±0.58
BL	D0	ST	90.93±0.46	88.12±0.78
BL	D1	HS	89.25±0.62	83.31±0.83
BL	D1	ST	85.25±0.59	83.81±0.81

P – Morphotype; M – Seed maturity; R – Drying; D – Defoliation; T – threshing; GL – glossy leafed morphotype; RL – red leafed morphotype; BR–Brown pod stage; BL–Black pod stage; SHD - Shade drying; SUN - Sun drying ; D0 – No defoliation, D1 – defoliated once a week ; HS – hand shelling , ST – stick threshing

It then follows that, irrespective of the morphotype in question, seeds harvested at black pod stage from non defoliated plants and hand shelled had the highest percent germination and speed of germination index compared to other combinations for both seasons. It is important to note that the percent germination and speed of germination values were high (in the 80s and 90s) for both seasons in Kakamega.

Table 2 Speed of germination index of significant three way interactions between morphotype, harvest and post harvest factors for jute mallow in the long and short rain seasons in Kakamega

PXMXD		**LR** Mean±SE	**SR** Mean±SE	**PXMXT**	**LR** Mean± SE	**SR** Mean± SE
GLBR	D0	0.90±0.01	0.87±0.01	GLBRHS	0.87±0.01	0.84±0.01
GLBR	D1	0.86±0.01	0.83±0.01	GLBRST	0.88±0.01	0.83±0.01
GLBL	D0	0.92±0.01	0.88±0.01	GLBLHS	0.89±0.01	0.85±0.01
GLBL	D1	0.83±0.01	0.80±0.01	GLBLST	0.88±0.01	0.84±0.01
RLBR	D0	0.89±0.01	0.86±0.01	RLBRHS	0.87±0.01	0.83±0.01
RLBR	D1	0.84±0.01	0.82±0.01	RLBRST	0.88±0.01	0.84±0.01
RLBL	D0	0.90±0.01	0.87±0.01	RLBLHS	0.89±0.01	0.86±0.01
RLBL	D1	0.86±0.01	0.84±0.01	RLBLST	0.89±0.01	0.85±0.01

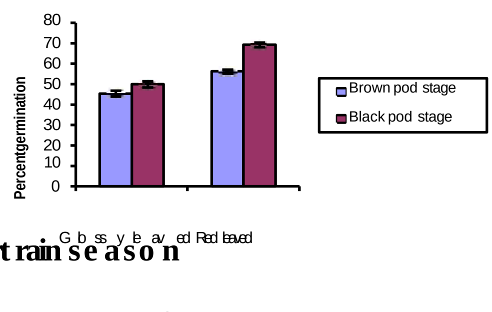
MXDXT			LR Mean± SE	SR Mean± SE
BR	D0	HS	0.92±0.01	0.85±0.01
BR	D0	ST	0.88±0.01	0.87±0.01
BR	D1	HS	0.88±0.01	0.83±0.01
BR	D1	ST	0.85±0.01	0.81±0.01
BL	D0	HS	0.94±0.01	0.89±0.01
BL	D0	ST	0.88±0.01	0.86±0.01
BL	D1	HS	0.88±0.01	0.82±0.01
BL	D1	ST	0.84±0.01	0.82±0.01

Key: P - Morphotype; M – Seed maturity; R – Drying; D – Defoliation; T – threshing; GL – glossy leafed morphotype; RL – red leafed morphotype; BR–Brown pod stage; BL–Black pod stage; SUN - Sun drying ; D0 – No defoliation, D1 – defoliated once a week ; HS – hand shelling , ST – stick threshing

In Siaya, percent germination and speed of germination index were significantly ($P \leq 0.05$) affected by 2 way interactions between morphotype and seed maturity, and seed maturity and defoliation for the two seasons (ANOVA tables not shown). The percent germination and speed of germination indices for significant interactions are shown in Figure 2 and 3.

Long rain season

(i)



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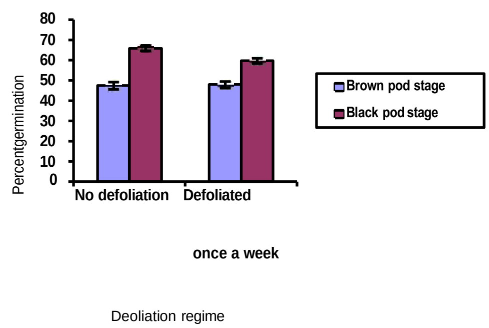


Short rain season

(iii)

(iv)

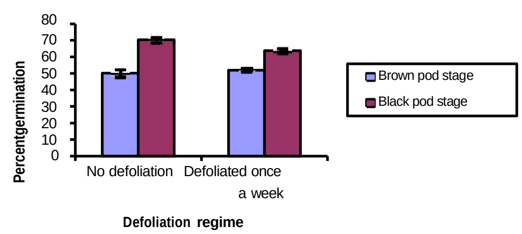
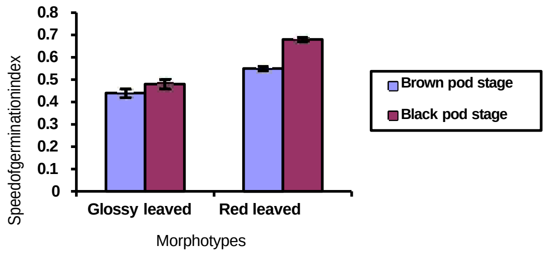


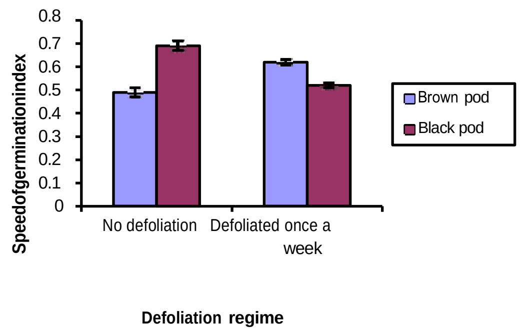
Figure 2 (i) - (iv) Percent germination of significant two way interactions between morphotypes, harvest and post harvest practices for jute mallow seeds in long rain and short rain seasons in Siaya

Seeds from both morphotypes that were harvested at black pod stage had significantly ($P \leq 0.05$) higher percent germination and speed of germination indices compared to those that were harvested at brown pod stage for both the long and short rain seasons (Figure 2 and 3). Seeds from the two morphotypes that were harvested from non defoliated plants at black pod stage had significantly ($P \leq 0.05$) higher percent germination and speed of germination indices than those harvested from plants that were defoliated once a week for both seasons.

Long rain season

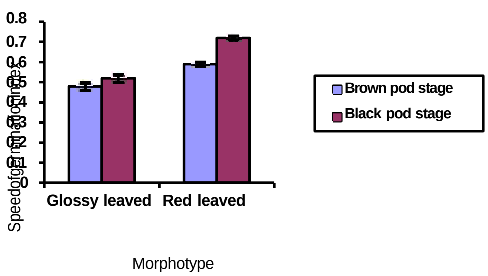


(i)

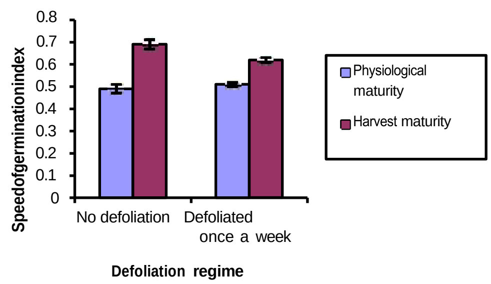


(ii)

Short rain season



(iii)



(iv)

Figure 3 (i) - (iv) Speed of germination index of significant two way interactions between morphotypes, harvest and post harvest practices for jute mallow seeds for the long and short rain seasons in Siaya

Irrespective of the sites and practices seeds produced in the long rain season had significantly (P $\leq$ 0.05) higher germination percentages and speed of germination indices than the short rain season (Table 3).

Table 3 Percent germination (PG) and speed of germination indices (SGI) for long and short rain seasons

Season	PG	SGI	Sites	PG	SGI
Long rain	74.40±1.11a	0.73±0.01a	Kakamemega	87.82±0.29a	0.86±0.01a
Short rain	70.55±1.09b	0.69±0.01b	Siaya	57.14±0.73b	0.55±0.01b

Means with different letters within each column significantly differed at P$\leq$ 0.05

Seeds from Kakamega had significantly (P $\leq$ 0.05) higher percent germination and speed of germination indices than those from Siaya. Means of percent germination and speed of germination indices are shown in Table 3.

Discussion

In Kakamega, seeds harvested at black pod stage from non defoliated plants, which were hand shelled and dried in the sun had higher percent germination and speed of germination indices for both seasons. This is similar to results with crops like canola (*Brassica sp*.) where maximum viability and vigour occurred at harvest maturity or black pod stage (Elias and Copeland, 2001). This has been explained by physical changes in hormonal mechanism that occurs after physiological maturity (brown pod stage) which promotes germination. Farmers should therefore harvest jute mallow seeds should be harvested at black pod stage.

Findings that drying seeds in the sun gave significantly (P≤0.05) better quality seeds differed from those in other studies that indicate that high temperatures associated with sun drying dramatically reduce seed viability and vigour (Walters and Engels 1998). However, a study on spider plant (an ALV) also found that sun drying improved the mean germination time, seedling vigour and overall germination percentage when compared to shade dried seed (K'opondo, et, al., 2005). This may be because sun drying reduces seed moisture levels to 11 - 12% which reduces deterioration of seeds due to moulds and increased respiration in the seed (Kamotho, 2004). Shade drying has been reported to be advantageous only where high temperatures in the sun are capable of damaging seeds with high moisture levels and also where seeds are not fully ripe and therefore require a slow drying process to after ripen and be able to repair mechanical damages (Thomsen and Stubsgaad, 1998). The latter has been observed in tree species and finger millet and does not seem to be the case for the jute mallow seeds.

Jute mallow seeds were not significantly (P≥0.05) affected by threshing methods as far as percent germination and speed of germination is concerned in Kakamega and Siaya. This implies that the jute mallow seeds have a tough seed coat that was not affected by stick threshing.

In Siaya, jute mallow seeds harvested from non defoliated plants had significantly higher percent germination and speed of germination indices than those harvested from defoliated plants. This is because leaf defoliation reduces photosynthetic area hence less food is manufactured in the leaves for the formation of seeds (Bewley and Black, 1994). In addition to this when leaves are harvested; plants concentrate on recovering lost leaf area essential for photosynthesis rather than on reproduction hence reducing the seed quality. Older leaves left on the plant are also less efficient in photosynthesis hence seed quality is negatively affected (Mnzava and Msikita, 1997). However, some plants are able to recover very fast depending on the time and frequency of defoliation as well as inherent qualities. Some studies have found that most farmers obtained their seeds from the remnants of vegetables after defoliating the plants to obtain vegetables throughout the growing season and rarely cultivated plants deliberately to produce seed (Adebooye, *et al*., 2005). However, few farmers in the Kakamega and Siaya seemed to have realised this and grew plants for seeds separately without defoliation. This needs to be encouraged among the farmers.

Level of interaction between morphotype, harvest and post harvest practices in Kakamega and Siaya, varied imply that to obtain high quality seeds farmers need to take relvant factors into account to produce quality seeds. In Kakamega, farmers need to harvest their jute mallow seeds at black pod stage from non defoliated plants and remove the seeds from the pods by hand. In Siaya farmers only need to vary two practices that is defoliation and seed maturity at harvest that is harvest the seeds from non defoliated plants at black pod stage.

T-tests were conducted to find out if seasons and sites significantly affected percent germination and speed of germination indices of jute mallow morphotypes irrespective of harvest and post harvest practices. Seeds produced during the long rain season had significantly higher percent germination and speed of vigour than the short rain season. This is because during the long rain season there was sufficient moisture for vigourous vegetative growth which provided essential assimilates for proper seed formation (Bewley and Black, 1994). It has also been noted that jute mallow is susceptible to moisture stress owing to its shallow rooting system (Ogunrinde and Fasinmirin, 2011)

Jute mallow seeds from Kakamega had greater percent germination and speed of germination indices than those from Siaya. This is because Kakamega receives more rainfall than Siaya hence providing sufficient moisture for plant growth and seed formation. There were greater differences in percent germination and speed of germination indices in Siaya than in Kakamega between long and short rain seasons. This was caused by the greater differences in rainfall amounts between the long and short rain seasons in Siaya (GOK, 1998). Percent germination and speed of germination indices were higher in Kakamega than in Siaya indicating that jute mallow is more adapted to Kakamega than Siaya. This is because it has been noted jute mallow requires fairly high levels of moisture to grow well (Abukutsa- Onyango, 2007).

Conclusion

In conclusion significant interactions between seasons, morphotype/morphotype, harvest and post harvest practices for jute mallow as far as seed quality is concerned in Kakamega and Siaya were observed. Farmers in these two regions need to take seasons, harvest and post harvest practices into account in order to obtain high quality seeds.

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