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Improving Speed of Seed Germination in Vegetable Seeds: A Case of Mrenda (Jews Mallow)

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Abstract—Mrenda (*Jews mallow*) is an important African leafy vegetable in Kenya. It is highly nutritious and has commercial importance. Mrenda seeds exhibit low speed of germination during planting. This reduces the number of seeds that germinate, hence adversely affecting field germination. There is limited research done on appropriate methods of improving speed of seed germination for Mrenda. The study aimed to test, various methods of improving speed of seed germination in Mrenda seeds. Mrenda seeds subjected to the following methods: mechanical scarification, soaking in cold water for 24 hours, soaking in hot water for 5 minutes, soaking in 1% potassium nitrate for 1 minute, leaching, and applying wood ash paste on the seeds. A control experiment was also set up where the seeds were not subjected to any treatment. Four hundred seeds in four replicates of 100 seeds were set in Petri dishes lined with moist filter paper substratum for each method. The Petri dishes were then put in a growth chamber set at a temperature of 23.5°C and 70% relative humidity. The number of seeds that germinated for each method was recorded daily for 14 days. Data obtained analyzed as per ISTA 2025 Protocol by determining the percent number of seeds that germinated and the percentage germination for each methods and the control. Analysis of variance (ANOVA) and Scheffe's multiple comparison procedure were used to identify which methods significantly differed from the control. The most effective treatment was found to be mechanical scarification, followed by leaching and lastly soaking in hot water. In the results it was observed that the number of seeds that germinated by the 3rd day for mechanical scarification, leaching, hot and cold water low speed of germination breaking methods, was significantly higher than the control at $P \leq 0.05$. Likewise, the number of seed that germinated for potassium nitrate method (39.25%) was lower than the control (40%). All Low speed of germination breaking methods differed significantly from the control in terms of the number of seeds that germinated by the 3rd day. There was higher percent seed germination for mechanical scarification, leaching, soaking in hot water and in cold-water methods than the control at $P \leq 0.05$. The study therefore recommended farmers to use mechanical scarification to improving speed of seed germination in Mrenda before sowing.

***Index Terms*—Mrenda, African leafy vegetable, Seed, Germination.**

1. Introduction

African local vegetables (ALVs) play an important role in household nutrition throughout Kenya, especially in rural areas as they are an important source of nutrients (Maundu, et al., 1999; Raymond, 2000; Ndinya, 2005). They have medicinal value, for example, Mrenda roots is used for relieving toothache among the people of Kenya, treatment of abdominal pains, menstrual and pregnancy problems as well as gonorrhea (Kokwaro, 1990; Keller, 2004; Ndinya, 2005). ALVs are also valuable sources of income especially for rural women who are involved in production and sale of these vegetables (Mnzava and Chweya, 1997; Schippers, 2002). Mrenda is an important ALV and there is need to find ways of enhancing its production (Raymond, 2000).

Some authors have identified low speed of seed germination as a major constraint to the production of Mrenda (Schippers, 2002; Palada and Chang, 2003). Low speed of seed germination is the inability of a viable seed to germinate under conditions that are favorable for germination (Basu, 1997; Carvalho and Nakawa, 2000). Mrenda low speed of seed germination shows partly as low final germination percentage (Carvalho and Nakawa, 2000). Low speed of seed germination is a delaying mechanism that prevents germination under favorable condition, which might prove to be unsuitable for establishment, thereby distributing germination in both time and space. This in turn increases the chances that some seeds will successfully germinate to complete the life cycle (Tekrony and Egli, 1997). However, on the farm level low speed of seed germination becomes an obstacle to the establishment of crops. To overcome low germination, Mrenda farmers sow large quantities of seed in order to get good plant stands. However, in most cases low seed quality and high cost of seed limit the use of high amounts of seed. This results in farmers sowing Mrenda in small portions of land and production of Mrenda it quantity.

There are two major causes of low speed of seed germination; coat-imposed impermeability and embryo imposed slow speed of germination. The seed coat-imposed impermeability is caused by a continuous layer of tightly packed palisade cells causing a major barrier to water uptake and gaseous exchange. The seed coat may act as a mechanical restraint to growth of the embryo or as a barrier to photoreception (Basu, 1997). The seed coat can also be a source

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of germination inhibitors. The embryo may have deficiencies in itself that stop germination leading to embryo imposed low speed of germination (Bewley and Black, 1994). Embryo imposed low speed of germination can also be a result of an immature embryo, which requires time to mature and germinate.

Fluctuating temperatures (Proberts, 1992), fire (Mc Donald, 1994), animal ingestion (Adebooye et al,. 2005), abrasion (Gabriel, et al., 1997), soil acids and soil organisms (Bewley and Black, 1994) are responsible for breaking seed coat imposed low speed of germination. Soaking the seeds in water softens the seed coat and allows emergence of the embryo (Bewley and Black, 1994). Soaking seeds in hot water provides a good temperature range for enzymes that catalyze reactions that break down the seed coat.

Breakdown of the seed coat allows the emergence of the embryo, water and gas uptake (Tekrony and Egli, 1997). Leaching washes away germination inhibitors and hence allows germination to occur. Mechanical scarification physically destroys seed coat hence allowing uptake of water and gases for germination to occur (Gabriel, et al., 1997). Potassium nitrate solution acts as an osmoticum causing changes in osmotic pressure within the seeds, which leads to water uptake and germination (Groot, et al., 2012).

The level of low speed of germination varies from species to species (Hampton, 2000). Lack of knowledge on effective methods of breaking low speed of germination among small-scale farmers in Kenya, is a major obstacle to successful production and utilization of Mrenda. This study, therefore, investigated the efficacy of various methods of improving speed of seed germination on Mrenda as well as to identify the low speed of germination breaking methods, for use by small-scale farmers in Kenya.

2. Materials and Methods

A. Mrenda Seed Bulking

Mrenda seed bulking done in December 2024, where seed samples was bulked from farmers in Trans nzoia, Uasin Gishu and Nandi County using scientific germplasm bulking techniques. This first entailed studying the maps of Trans nzoia, Uasin Gishu and Nandi County and selecting 10 seed bulking sites per county along transects made in each county. Possible routes used during bulking noted. Bulking sites selected taking into account the ecological variations in the study area.

Sampling was done in farmers' fields, in farmers' stores and in market centers. Bulking in farmers' fields was done systematically at regular intervals of 3 paces along small transects made at each site. 3 different members of the team walked the 3 different transects and sampled from plants that produced a lot of seeds. Twenty percent of seed available on each plant bulked. 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 not bulked as they may been subjected to deterioration.

Harvesting of pods was done by cutting off the pods using a knife. Seeds bulked put into non-glossy brown paper bags to ensure good aeration for the seeds. The brown paper bags were double packed and stapled at the top. Each brown paper bag labeled using an accession number, species and location bulked. More information recorded on data sheets and included accession number, bulking number (same as bag number), bulking date, name of main collector, institution, other collectors' names and institutions. Country, sub-county, division, location and sub-location, latitude and longitude also recorded. Taxon name, vernacular name(s), number of plants sampled, number of flowers versus fruits, sampling method, sampling area visited (in m^2), slope, soil texture, soil pH, land use and threats to the species were also noted. Site notes (observations or any relevant information), associated species (plants commonly grown alongside the species being studied) and bulking notes (e.g. problems encountered, bulking method, estimate of seed numbers, flower color etc.) were recorded.

Seeds bulked from farmers' stores in the homesteads and market places, bulking were done as randomly as possible (by selecting every 4th farmer/trader) and similar data sheets as the ones for the bulking in the farms filled.

B. Speed of Seed Germination Experiments

Speed of seed germination experiments done during the month of January 2025. Seed samples bulked from farmers' fields, stores and market places in the study area were mixed and a composite sample drawn in order to obtain a representative sample of the seed from the study area. Then sample subjected to improving speed of seed germination methods, which included soaking in cold water, soaking in hot water, mechanical scarification, leaching, dipping in potassium nitrate and coating with wood ash. These methods chosen as they addressed various causes of low speed of germination in seeds. Soaking in cold/hot water and mechanical scarification interferes with a hard seed coat to allow emergence of the embryo, allow gaseous exchange and absorption of water. Soaking in hot water also activates hydrolytic enzymes which breaks down food stored in the seed for use during germination. Leaching washes away enzymes inhibitors found on the seed coat which prevent hydrolytic enzymes from breaking down stored food for germination to occur. Potassium nitrate affects the osmotic relations within the seed allowing absorption of soil water that precedes germination. Wood ash mentioned by a few farmers as a method of breaking low speed of germination during the survey (Chapter 2) hence its inclusion in the study.

Complete Randomized Design (CRD) with 4 replicates for the 7 treatments was used. Each replicate had 100 seeds. For the cold-water treatment, the seeds placed in a beaker and soaked in cold water at room temperature for 24 hours. For the hot water treatment seeds were placed in just boiled water (90°C) for 5 minutes. For mechanical scarification seeds were rubbed between two sand papers for about 3 minutes. Care was taken not to crush the seed. In the leaching treatment seeds were placed in sieves and washed under running water for 3 minutes. In the potassium nitrate solution treatment seeds were soaked for 1 minute in 1% KNO_3 solution. For the ash treatment seeds

were coated with wood ash paste. Seeds from all the treatment were then sown on 3 moist filter papers placed in Petri dishes. Since the seeds used in each treatment were 400 four petridishes were used for each treatment. For the control experiment seeds were directly sowed on moist filter paper substratum. All the petri dishes were then placed in a growth chamber set at 24°C and 70% relative humidity as recommended by ISTA, 2025. The substratum was kept moist by addition of small amount of water every 2 days. Number of seeds that germinated was counted and recorded daily. This was done for 14 days.

Data on number of seeds that germinated done as per ISTA 2025 Protocol and treatment results subjected to Analysis of variance (ANOVA) to find out which methods differed significantly from the control. The percent germination values for the methods were separated using Scheffe's multiple comparison procedure.

3. Results and Discussion

A. Results

It was observed that the number of seeds that germinated by the 3rd day as per ISTA 2025 Protocol, for mechanical scarification, leaching, hot and cold-water low speed of germination breaking methods, was significantly higher than the control at $P \leq 0.05$ (Table 1). Likewise, number of seed that germinated for potassium nitrate (39.25%) was lower than the control (40%) (Table 1).

All Low speed of germination breaking methods differed significantly from the control in terms of the number of seeds that germinated by the 3rd day. There was higher percent seed germination for mechanical scarification, leaching, soaking in hot water and in cold water methods than the control at $P \leq 0.05$ (Table 1).

The number of seeds that had germinated daily for mechanical scarification (88%), leaching (53%), hot water (51%) and soaking in cold (42%) methods was significantly higher than the control (40%) with the difference enhanced for mechanical scarification (double the control). Germination started slower for the potassium nitrate and ash methods compared to the control but slightly rose above the control on the 13th day onwards for the potassium nitrate treatment and on the 12th day onwards for the ash treatment.

B. Discussion

Percent germination of 40% was obtained for control set up (where the seeds were not subjected to any low speed of germination breaking treatment) showing that Mrenda seeds were inactive. This supported by other studies indicating that Mrenda seeds exhibit low speed of germination (Schippers, 2002; Palada and Chang, 2003). Freshly harvested and sometimes old Mrenda seeds have been reported to exhibit low speed of germination (Fondio and Grubben, 2004). This implies that Mrenda seeds experience primary or secondary low speed of germination or both depending on the environmental conditions during plant growth (Fondio and Grubben, 2004).

Abscisic acid (ABA), a plant hormone, has been shown to be a positive regulator of both induction and maintenance of seed inactive state. Mechanism of action of ABA is associated with cell wall properties (Ekpong, 2009). ABA-deficiency during seed development is associated with absence of primary low speed of germination in the mature seed, whereas over-expression of ABA biosynthesis genes can increase seed ABA content and enhance seed low speed of germination or delay germination (Nagel and Borner, 2010). A recent transcriptome analysis with Arabidopsis thaliana strongly supports the view that increased ABA biosynthesis and gibberellic acid (GA) degradation is associated with the inactive state (Taber, 2009). It appears that the ABA/GA ratio, and not the absolute hormone contents, that control germination. Gibberillic acid is associated with germination of seeds. Since Mrenda seeds showed low speed of germination it is possible that this low speed of germination stemmed from the ratio of these hormones in the seeds.

From this study, mechanical scarification was the most effective method of breaking low speed of germination (percent germination of 88%). Mechanical scarification destroys the seed coat allowing absorption of water and gaseous exchange to occur which then allows germination to occur (Bewley and Black, 1994). This implies that the low speed of germination in Mrenda was seed coat imposed.

Percent seed germination for leaching was significantly higher than the control. Leaching washes away enzyme inhibitors found on the seed coat allowing germination to occur (Adebooye, et al., 2005). This implies that low speed of germination in this species is to some extent caused by germination inhibitors attached to the seed coat. This is in line with other studies that have reported that low speed of germination in Mrenda may be due to germination inhibitors on seed coat (Abukutsa-Onyango, 2007).

Percent seed germination slightly increased when the seeds were soaked in hot water. Low speed of germination can be caused by inactive enzymes which are activated when the seeds are placed in hot water (Bewley and Black, 1994). Water also

Table 1
Percent seed germination for various low speed of germination breaking methods

Low speed of germination breaking treatment	Percentage seed germination
Mechanical scarification	88.00 ± 2.00a
Hot water	51.25 ± 1.77b
Leaching	53.00 ± 2.00b
Soaking in cold water	42.00 ± 1.31c
Ash	42.50 ± 1.32c,d
Control	40.00 ± 1.600d,e
Potassium nitrate	39.25 ± 1.895e

Percentages having the same letters are not significantly different at $P \leq 0.05$ (Scheffe's test).

softens the seed coat hence allowing the embryo to emerge. This implies that low speed of germination in Mrenda is caused to some extent by inactive enzymes and as well as hard seed coats. These findings are consistent with other studies that indicate that low speed of germination in Mrenda can be broken by storing seeds for 4 months and then dipping in hot water for 10 seconds (Palada and Chang, 2003). Another study also found that low speed of germination in Mrenda can be broken by par boiling the seeds in simmering water for 5 to 10 seconds (Schippers, 2002). However, in the present study the seeds were soaked in hot water for 5 minutes which may account for the lower percent germination of 51% on the 14th day than would have been expected. The effectiveness of this method may therefore depend on how long the seeds are soaked in hot water and this may not be easy to determine at the farm level.

Soaking in cold water for 24 hours, also gave a higher percent germination (though not statistically significant) than the control but lower than soaking in hot water. It is not a very effective method as shown by the low percent germination of 42% on the 14th day. It still supports the findings that low speed of germination in Mrenda is seed coat imposed as germination improved slightly. Water softens the seed coat hence allowing the embryo to emerge as indicated by Bewley and Black, 1994.

Soaking in 1% KNO_3 and coating with wood ash did not significantly increase germination of Mrenda seeds hence may not be used to break low speed of germination in Mrenda. Low speed of germination in seeds is due to water-salts relations (osmotic potential). If the seeds are low in osmotic potential they may not be able to absorb water required for germination from the surrounding. The use of an osmotic like KNO_3 or ash may remedy the situation. In the present study, use of KNO_3 and ash did not significantly improve germination implying that low osmotic potential in the seeds is not the cause of low speed of germination. This is similar to one study on Cleome sp. (an ALV) where potassium nitrate did not break low speed of germination of the seeds (K'Opondo, et al., 2005). Even though some farmers used ash to try to break low speed of germination, this may be a mistaken notion by the farmers. The benefit of using ash may be its control of storage pests and diseases, which results in better seed germination.

4. Conclusion and Recommendation

A. Conclusion

- The study concluded that seed with low speed of germination exists in Mrenda.
- That low speed of germination was broken by mechanical scarification, leaching and hot water methods, which imply that low speed of germination in Mrenda was due to a combination of factors, which were hard seed coat, presence of enzyme inhibitors and inactive enzymes.
- Although leaching, soaking in hot water and cold water were effective in overcoming low speed of germination in Mrenda, the results were not as good as those from mechanical scarification.

B. Recommendation

- The study recommended farmers to use mechanical scarification to improving speed of seed germination in Mrenda before sowing.
- Study recommended that more studies be done to discern exactly which of the enzyme inhibitors and inactive enzymes are present in the Mrenda seed coat.

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