Influence of Endosperm Types, Seed Moisture Content and Threshing Methods on Germination and Seedling Vigour of Sorghum

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Abstract: Sorghum (Sorghum bicolor L. Moench) is the most important cereal crops in the world. It is adapted to wide agro ecological zones. It has high production compared to most other cereal crops under drought conditions. The study was conducted to determine the effects of endosperm types, seed moisture content and threshing methods on germination percent, mean germination time and seedling vigour of sorghum seeds. Two varieties of sorghum were grown in two diverse locations namely Kiboko and Katumani. One variety Kari-mtama 1 has hard (vitreous) endosperm, while other variety Seredo has soft (non-vitreous) endosperm. After harvesting, sorghum panicles were dried in the sun and using oven before threshing. The panicles were threshed separately for each drying method at two moisture levels namely 18-20% and 13-14%. The three threshing methods used included beating by wooden stick in tied sack, using wooden mortar and pestle as well as using threshing machine. The seeds from various treatments were evaluated for germination percent, mean germination time and vigour using ISTA rules in the University of Nairobi Laboratory. The results showed that, the seeds from panicles that were threshed at low moisture content (13%-14%) (M.C) had significantly higher germination percentage, seedling vigour and took significantly short time to germinate than those which were threshed at high moisture content (18%-20%). Similarly, seeds that were threshed using threshing machine had significantly higher germination percent, seedling vigour and took shorter time to germinate compared to beating with wooden stick and mortar and pestle The results suggested that, sorghum panicles have to be threshed at low moisture content (13%-14%) to obtain high seed quality. Threshing by machine is the best method to be used to avoid poor seed quality followed by beating with wooden stick. Wooden mortar and pestle threshing method should be avoided in threshing sorghum panicles because it results into high seed mechanical damage and hence lowering germination and seedling vigour as compared to beating with wooden stick and threshing by machine. There was no genotype by environment interactions for germination and seedling vigour. This shows that, the results are applicable for sorghum crop across the environments.

Key words: Vitreous variety · Non-vitreous variety · Moisture content · Threshing · Panicles

INTRODUCTION

Sorghum grains can be used to substitute maize and rice because the nutritional content of sorghum is close to that of maize and rice. Sorghum has carbohydrate content of 80.42% as compared to 86.45% in milled rice and 79.95% in maize. Sorghum has slightly higher protein content (10.11%) than milled rice (9.28%), but lower than maize (11.02%). The lipid content in sorghum is (3.65%) which is higher than milled rice (1.88%) although it is lower than that in maize (5.42%) [1]. Although the cultivation of sorghum is important in semi-arid areas, yields are low among the farmers. One of the reasons for low yield is lack of quality seeds due to poor postharvest handling and processing of sorghum seeds. Farmers also lack sufficient knowledge on sorghum processing (threshing, drying, cleaning and storing). All these affect the quality of seeds which results to the low yield of sorghum.
Majority of sorghum farmers in African countries thresh their seed by beating with sticks or rubbing the panicles on a hard surface or by pounding in mortar and pestle and trampling by cattle [2,3]. These methods cause mechanical damage to the seeds. This damage may be higher when the seeds are threshed at unsuitable moisture content [4, 5]. When the seeds are damaged its quality and germination ability is impaired [6]. Seed damage depends on the vitreosity of the sorghum variety. Vitreous variety or hard kernels have better breakage resistance than non-vitreous kernels [7].

There is inadequate knowledge about threshing of sorghum and few studies have been conducted on threshability without focus on quality aspect of threshed seed grains [2,8]. Therefore, this study aims to evaluating the effects of endosperm type, seed moisture contents and threshing methods on germination percent, germination time and seedling vigour of sorghum seeds.

**MATERIALS AND METHODS**

**Study area:** The seed crop was planted at two locations Kiboko and Katuamani which are under Agricultural Mechanization Research Institute (AMRI) in Kenya. Kiboko research sub centre is located in Kiboko, Makindu Division, Makindu Sub-county, Makuene County. It lies within longitudes 37.7235°E and latitudes 2.2172°S. Kiboko is 975 m above sea level and the station receives between 545 and 629 mm of rainfall coming in two seasons. The long rains season is between April and July, while the short rains season is between October and January. This is a hot dry location with a mean annual temperature of 22.6°C, mean annual maximum of 28.6°C and mean annual minimum of 16.5°C.

Katumani is AMRI headquarter and located in Machakos County, on latitude 1° 35'S and longitude 37° 14'E and at an altitude of about 1600 m above sea level. It receives mean annual rainfall of around 655 mm. The average seasonal rainfall for the long rains is 272 mm while that for the short rains is 382 mm. The mean maximum and minimum temperatures at the centre are 24.7°C and 13.7°C, respectively.

**Experimental Design:** The crop was established under split-split plot on Randomized Completely Block (RCB) design with three factors and these are variety (V) as main factor, seed moisture level (M) as sub factor and threshing method (T) as sub-sub factor with three replications. Two varieties used were vitreous (hard) endosperm variety (KARI-Mtama I) as variety 1 and non-vitreous (soft) endosperm (Seredo) as variety 2. The seeds were threshed at two moisture levels namely 18%-20% moisture content one (M1) and 13%-14% moisture content two (M2) using three threshing methods for each moisture content. The threshing methods that were used were beating by wooden stick (T1); threshing by wooden mortar and pestle (T2) and threshing by using machine (T3).

**Seed Harvesting, Panicle Drying and Threshing:** The crop was harvested by hand and panicles were cut using a knife after seed grain had reached the physiological maturity (PM). The panicles from plots that were threshed at higher moisture level (18%-20%) were harvested when the seed was about 25% M.C, while the panicles from the plots that were threshed at lower moisture level (13%-14%) were left in the field. These were harvested when moisture content was about 20%. From each plot, 60 plants were harvested from the inner rows (net plots). The harvesting was done in two batches, each containing 30 randomly selected plants. Therefore, from 60 panicles harvested in each plot, 30 heads/panicles were dried in the sun before threshing and the other 30 were dried in the oven at 36°C before threshing. Extra five heads/panicles were included in each drying method. These were used to regularly monitor the moisture content until the seeds attained the required moisture for threshing. The moisture content of seeds was determined using agraTronix MT-16 grain moisture tester before threshing. Machine threshing was done by one specific bulk machine thresher in both locations which contained rotating rasp bar cylinder. The machine used was from Allan Machine Company (ALMACO 99, M AVE NEVADA 10WA 50201 USA). The mortar hole depth was 22 cm and weight of the pestle and wooden stick was 1.5Kg. After threshing, the seeds were separated from dirt and chaffs by manual winnowing.

**Germination Percentage, Mean Germination Time Test:** Germination test was carried out according to ISTA rules [9] using 200 seeds per sample. Germination final evaluation was done during the tenth day and the count of newly germinated seeds was taken every day from the day of sowing. Seeds were considered to have germinated when radical had emerged and elongated by at least 2 mm. The germination percentage was calculated based on normal seedlings as follows:

\[
\text{Germination percent} = \frac{\text{Number of germinated seeds (Normal seedlings)}}{\text{Total number of seeds}} \times 100
\]
Mean germination time was calculated using the following formula [10, 11].

\[ \text{Germination time} = \frac{\sum (n_d)}{\sum (n)} \]

where:
- \( n \) is number of newly germinated seed counted every day
- \( d \) is number of days from sowing date.
- \( \sum n \) is total number of seeds germinated at the end of the test

Seedling vigour: Seedling vigour was determined from the seedlings that were sown for germination test. After the final count in germination test, 20 normal seedlings from each sample were selected at random and used in measuring seedling length. The measurements were taken using graduated ruler in centimetre (cm). Mean seedling length was calculated by dividing the total seedling length by the number of normal seedlings measured.

Seedling vigour index (SVI) was calculated using the following formula:

\[ \text{SVI} = \frac{\text{Mean seedling length} \times \text{germination percentage}}{100} \]

The seedlings with high SVI value were considered as vigorous seedlings [12].

Table 1: Summary for analysis of variance (ANOVA) for the effects of variety endosperm type, seed moisture content, threshing methods and the interaction

<table>
<thead>
<tr>
<th>SOV</th>
<th>Mean germination (%)</th>
<th>Mean germination time</th>
<th>Seedling vigour index</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Sun dried panicles</td>
<td>oven dried panicles</td>
<td>Sun dried panicles</td>
</tr>
<tr>
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<td>df</td>
<td>MS</td>
<td>df</td>
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<td>Location (L)</td>
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<td>1</td>
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<td>83.99</td>
<td>1</td>
</tr>
<tr>
<td>Variety (v)</td>
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<tr>
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<td>0.28ns</td>
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<tr>
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<td>28.23</td>
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<tr>
<td>Moisture (M)</td>
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<td>1412.46**</td>
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<tr>
<td>L.M</td>
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<td>31.54ns</td>
<td>10.05ns</td>
</tr>
<tr>
<td>V.M</td>
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<td>42.78ns</td>
<td>5.28ns</td>
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<td>L.V.M</td>
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</tr>
<tr>
<td>Residual</td>
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<td>28.85</td>
<td>83.91</td>
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<td>Threshing methods (T)</td>
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<td>3810.39**</td>
<td>5161.58**</td>
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<td>47.18ns</td>
<td>149.07ns</td>
</tr>
<tr>
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<td>42.82ns</td>
<td>167.04ns</td>
</tr>
<tr>
<td>M.T</td>
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<td>25.26ns</td>
<td>63.15ns</td>
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<td>V.M.T</td>
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<tr>
<td>Residual</td>
<td>34</td>
<td>47.18</td>
<td>89.88</td>
</tr>
</tbody>
</table>

SOV- Source of variations ns-non significant *-Significant **-Highly significant MS–mean squares

Data Analysis: All data were subjected to analysis of variance using General Statistical package (GENSTAT) edition 13 for windows and the means separated using least significant difference (LSD) test at 5% and 1% level of significance.

RESULTS AND DISCUSSION

Significant differences were observed between seed moisture content and among the threshing methods for both drying methods. For oven dried panicles, the results showed significance interaction in mean germination time between seed moisture content and threshing methods. However, there were no significant differences in interaction for germination percent and seedling vigour among the various parameters namely location, endosperm type, seed moisture level and threshing methods (Table 1).
seed endosperm or embryo caused during seed processing, may result into blocking of translocation of essential nutrients for the seed growth and this results in poor seedling growth [15].

Influence of Threshing Methods on Germination Percent, Mean Germination Time and Seedling Vigour of Sorghum Seeds from Panicles Dried in the Sun and Oven: There was significant differences in germination percent, seedling vigour and germination time among the threshing methods. Seeds threshed using machine showed significantly higher germination percent (82.69%) when panicles were dried in the sun and (83.2%) when dried in oven, which was significantly different for the seeds threshed by beating with wooden stick (72.04%) when panicles were dried in the sun and (77.6%) when panicles were dried in the oven. Seeds from panicles threshed by using mortar and pestle had significantly lower germination percent at (57.58%) when panicles were dried in the sun and (55.5%) when panicles dried in the oven. Similarly, for the sun dried panicles the seeds that were threshed at high moisture content had significantly less mean germination time which was (2.16 days) compared to those which were threshed using beating with wooden stick (2.31 days) and using mortar and pestle (2.36 days). Mean germination time for the seeds threshed by wooden stick was not significantly different from mortar and pestle. Also seed from panicles that were threshed using machine had significantly higher seedling vigour index followed by beating with stick and mortar and pestle, respectively (Table 3).

The lower germination percent and vigour from the seeds that were threshed using wooden stick as well as mortar and pestle was due to the fact that, these two
methods caused higher mechanical damage compared to threshing machine. The impact of stick or mortar and pestle plus the forces used during threshing caused internal injury to the embryo which resulted into abnormal seedlings and non germinability of some seeds. Machine threshing was done by rotating rasp bar which may have caused little impact in internal injury of the seeds resulting to higher germination percentage and vigour. This confirmed the results reported by Dharmaputra et al. [1], who stated that, sorghum seeds from panicles that were threshed by beating with wooden stick had significantly lower germination percent (91.04%) compared to the seeds threshed by threshing machine (93.33%). These results were strongly correlated with percentage seed damage caused by wooden stick and machine thresher. Similarly, Warzecha et al. [16], who studied the effects of mechanical damage on vigour, physiological parameters and susceptibility of oat (Avenasativa) to Fusarium culmorum infection, reported that, the seeds that were threshed using machine at high speed resulted in severe mechanical damage and consequently seedling vigour decreased by 16% as compared to those threshed at low speed which had low damage. This confirms the results of this study that, mechanical damaged of seeds results to decrease in seedling vigour.

The germination time of the seed from panicles threshed at low moisture content and by using threshing machine was significantly low compared to the seeds from panicles threshed at high moisture content and by beating with stick as well as using mortar and pestle. This could be due to the high quality of the seeds from panicles threshed at low moisture and by using machine because the internal injury to the seeds were minimized compared to the beating with wooden stick as well as mortar and pestle.

**CONCLUSION**

The results suggest that, threshing should be done at low moisture content (13%-14%) for better seed quality. Threshing machine is the best method for threshing sorghum panicles to obtain high quality seeds followed by beating with wooden stick. The germination results were above 70% for seeds from panicles that were threshed at low moisture content (13%-14%) by using machine as well as by beating with wooden stick, which is the minimum percentage accepted in Kenya seed law cap 326 [17]. There was no genotype by environment interaction for germination and seedling vigour. This indicates that germination and seedling vigour tests could be applicable for sorghum grown in different environments.

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**REFERENCES**


