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RESEARCH ARTICLE

SEED QUALITY OF SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH) AS AFFECTED BY SEED PRIMING AND STORAGE

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ABSTRACT

An experimental study was conducted in laboratory and glasshouse to evaluate the effect of seed priming on seed quality parameters of three sorghum varieties:(Muyra-I, Muyra-II and Fendisha) with different storage of one year and two years using different priming agents with different soaking time for each priming agent (1.0mM KNO3, 1mM NaCl and distilled water for 72, 48 and 12 hours respectively) at Haramaya University Seed laboratory. Completely randomized design in 2 x 3 x 4 factorial arrangement with three replications was used to carry out the germination and vigor tests. The priming concentrations and durations were based on previous work, which was effective in hydro and osmo-conditioning of sorghum seed. In the experiment, seed priming increased germination percentage (GP), Mean Germination Time (MGT) and improved seedling shoot (SSL) and root length (SRL), seedling dry weight (SDW) and seedling vigor indices in all varieties of both storage durations compared to their respective control. Priming with NaCl and KNO_3 showed positive response followed by hydro priming for all varieties of different storage duration. When treated with sodium chloride, almost all the varieties of each storage year demonstrated an increase in germination and the degree of increment was higher for Muyra-I (89.33) and Fendisha (88.0), the lowest being for Muyra-II which was significantly lower for both storage year. In case of mean germination time Muyra-II exhibited better with hydro priming for older seeds and with KNO_3 for newer seeds while Muyra-II and Muyra-I showed better with KNO_3 for older seeds and with hydro priming for newer seeds. Responses of varieties for the remaining parameters were intermediate. Therefore, sorghum seed priming with Osmo-media and water can compensate storage deterioration of sorghum seeds in addition to significantly improving the seed germination and vigor quality parameters

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INTRODUCTION

Sorghum *(Sorghum bicolor L. Moench)* had its origin in the northeast quadrant of Africa where wild sorghum still exists today as weed in the domesticated crops. From there it spread throughout Africa and into India between 2100 and 1500 B.C (6). Sorghum grows in a wide range of ecological conditions and can survive frost up to some extent. Sorghum is indispensable food and more important in the diet of poor in arid and semiarid regions where floor grits and whole grain are traditionally used to prepare food.

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Sorghum grains are used for human consumption and beverages such as porridge '*Nefro*' infant food, syrup, '*Tella*' and '*arakie*', in addition to that leaf and stalks are used for animal feed and as the stalks is also used for construction and as fuel wood (18). It ranks 3rd in area under cultivation after teff and maize to cereals total production. The area under sorghum production was estimated to be 1.71 million hectares with a total production and average yield of 3.60 million tones and 2.10 tones/ha, respectively (7). It is grown in 12 of the 18 major agro-ecological zones including the lowland, mid and high-altitude areas of the country (17). Nevertheless, the productivity of the crop is very low, only about 2.10 tones ha^{-1} (7). But experimental result indicated that yield of up to 3.5 tones ha^{-1} is possible on farmers' fields in major sorghum growing regions of the country. This still is very low when compared with the yield of 7 to 9 tones ha^{-1} obtained under intensive management, indicating that drought and factors related to seed and seedling emergence are among the major factors which has reduced sorghum yield in semi-arid regions (11). Therefore, this study was aimed to assess the effect of seed priming on seed quality of sorghum varieties stored for different period of time.

MATERIALS AND METHOD

Experiment: The laboratory work was conducted at seed laboratory of Haramaya University, whereas the glasshouse experiment was carried out at Somali Region Pastoral and Agro-pastoral Research Institute, Jigjiga Research Center. Haramaya University is located 4203' E longitudes and 9026'' N latitude of 1980 meters above sea level and 515 km east of Addis Ababa. The mean annual rainfall of the area amounts to 780 mm and the average minimum and maximum temperatures are 8 and 240 C respectively (5). Jigjiga zone is classified as semi-arid mid highlands and its altitude ranges from 1,200 to 2,950 meters above sea level and it receives an annual rainfall that varies from 500 to 600 mm. The area experience bimodal type of rainfall classified as small and main rain seasons, the short rain season usually occurs from July to September and the main rain season occurs from March to April.

Plant Materials: Three sorghum varieties with different seed colors and sizes, produced during 2009 and 2010 production year, were tested (Table 1). Seeds for the test varieties were obtained from the sorghum research program of Haramaya University.

Experimental Design and Treatments: The experiment was conducted in 2012. Completely randomized design in 2 x 3 x 4 factorial arrangement with three replications was used to carry out the germination and vigor tests for each variety while the priming concentrations and durations were based on previous work (13,14) which was effective in hydro and Osmo-conditioning sorghum seed. Three sorghum varieties with different seed colors and sizes, produced during 2009 and 2010 production year were tested. The treatments consisted of 3 sorghum varieties with different seed colors and sizes, stored for one and two years obtained from Haramaya University Sorghum breeding section store and four seed priming treatments. Prior to the priming treatment, the quality analysis of the seeds were determined according to International Rules for Seed Testing (12).

Treatment details are presented as follows.

- **Factor 1: Storage duration (S);**

S1: Sorghum Seeds stored for one year
S2: Sorghum Seeds stored for two years

- **Factor 2: Sorghum Varieties (V);**

V1: Muyra I,
V2: Muyra II,
V3: Fendisha

- **Factor 3: Priming Treatments (P)**;

P1: Control (unprimed seeds),
P2: Potassium nitrate (KNO HYPERLINK "mailto:T4KNO3@0.2%25"3 HYPERLINK "mailto:T4KNO3@0.2%25") at 2.0 mM (0.2%) concentration for 72 hours,
P3: Sodium chloride (NaCl) at 1.0 mM (0.1%) for 48hours, and
P4: Hydro-priming (Distilled water) for 12 hours

Experimental Procedures

Germination test

Standard Germination Percentage: The top of paper (TP) method was used for the germination test. The three replicates of 100 seeds from each variety samples were arranged on top of absorbent paper moistened with 5 ml distilled water in a 50 mm petridish and were placed in a 25 ^{0}C temperature. The first count was recorded on 3rd day and the final count on 10th day. And germination percentage was calculated as follows: At the end of the germination test period the samples were evaluated and classified into normal seedling, abnormal seedling, fresh ungerminated seed and dead seed to estimate the standard germination (ISTA, 2010)(12).

Rate of germination: Rate of germination was estimated using the formula suggested by (8). For each replicate, the numbers of germinated seeds were counted daily starting from the third day after planting until there was no further germination. Time in days required for germination of 50% of planted seeds (G-50) was determined by applying the following formulae.

$$\text{Mean Germination Time } (D) = \Sigma (dn) / \Sigma n$$

$$RG = 1/\text{Mean Germination Time } (D)$$

Where d is the number of days from the beginning of the germination test and n is the number of seeds germinating on day d.

Vigor tests

Speed of emergence: To determine speed of emergence three replicates of 40 seeds from each sample were sown at a depth of 4 mm in a sandy clay loam soil in 15 x 12 cm plastic boxes. Prior to sowing, the soil was moistened. The boxes were placed or kept for 14 days at a room temperature of about 24^{0}C until no further emergence takes place and the rate of emergence, which is an expression of vigor index, was calculated. Each day normal seedlings were removed at predetermined size and time until all the seeds were capable of producing normal seedling germinated. The speed of emergence was calculated by dividing the number of seedlings removed each day to the number of days in which they were removed (21):

Shoot and root length: The seedlings shoot and root length was measured after the final count in the standard germination test. Ten normal seedlings were selected randomly from each replicate. The shoot length was measured from the point of attachment to the tip of the seedlings while the root length was measured from the tip of the root to the point of attachment of the seedling. Average shoot and root length (cm) was computed by dividing the total shoot and root length to the total number of normal seedlings measured.

Seedling dry weight: Seedling dry weight (mg) was measured after final count in the standard germination test. Ten normal seedlings selected randomly from each replicate were placed in an envelope and oven dried at 80^0C +/- 1^0C for 24 hours. The dried seedlings were weighed to the nearest milligram and the average dry weight was calculated.

Seedling vigor index-I: The seedling vigor index-I was determined by the following formulae

Seedling vigor index-II: The seedling vigor index-II was determined by the following formulae

Field emergence index: Hundred seeds selected at randomly from each treatment in three replications were used for the field emergence studies. The seeds were sown in well prepared sandy clay loam soil at 3.00 cm deep and covered with soil in pot. Field emergence count was taken on from 3^{rd} day to the 10^{th}day after sowing and the emergence index was calculated taking into account the number of seedlings emerged three centimeter above the soil surface.

Statistical Data analysis: All the measured variables were subjected to the analysis of variance using the SAS statistical software in accordance with Factorial experimental Design. Least significance difference (LSD) was used to separate means. Correlation analysis was carried out accordingly for seedling emergence, rate of seedling emergence, standard germination, mean germination time, and rate of emergence.

RESULTS AND DESCUSSION

Germination Percentage: The analysis of variance revealed highly significant differences in germination percentage due to main effects of varieties, priming, storage duration ($P \leq 0.01$), varieties by priming interaction ($P \leq 0.01$), priming by storage interaction ($P \leq 0.01$) and the three factor interactions ($P \leq 0.05$). The interaction of varieties by storage revealed statistically non-significant difference. The highest significant value was recorded for the variety Muyra-I seeds of one year storage primed with sodium chloride (89.33) while the lowest was for untreated Muyra-II sorghum seed of two years storage (45.65) (Table 2). When treated with sodium chloride, all the varieties of each storage year demonstrated an increase in germination compared to their respective control and the degree of increment was highest for Muyra-I seeds of one year storage (89.33) while the lowest was for Muyra-II stored for two years (77.00) (Table 2). This is in line with (10) who concluded that seed priming with sodium chloride showed improved germination and seedling vigor by dormancy breakdown as compared to control. In addition, some previous researchers (4) indicated that some or all process that precede germination are triggered by priming and persist following the re-desiccation of the seed. Thus upon sowing, primed seed can rapidly imbibe and revive the seed metabolism, resulting in higher germination percentage and reduction in the inherent physiological heterogeneity in germination (21).

Standard germination: Abnormal seedlings showed highly significance difference due to main effect of priming, interaction effect of varieties by priming, priming by storage, three factor interaction and significant difference due to varieties by storage. For abnormal seedlings the highest mean value was observed for unprimed Muyra-I stored for two years (13.33) and the lowest was for hydro-primed Muyra-I seeds of two years storage and KNO_3 primed Muyra-II of one year storage (Table 2). Un-germinated seeds showed highly significant difference for all sources of variation except for interaction effect of varieties by storage. The highest mean value of fresh un-germinated seed was observed for hydro primed Muyra-II stored for two years (28.00) and the lowest was forKNO_3 primed Fendisha stored for one year (2.00), Muyra-I primed with NaCl stored for one years (2.00) and Muyra-I primed with KNO_3stored for two years (2.00) (Table 2). Dead seed showed highly significance difference due to varieties, priming, and varieties by priming, priming by storage duration, three way interaction and significance difference due to storage duration and varieties by storage duration. The highest mean value of dead seeds was observed for Muyra-I stored for two years and primed with water (24.00) and the lowest was for unprimed Muyra-II stored for one year and two years (3.50) (Table 2). There was highly significant difference in normal seedling due to all main effects, varieties by priming, priming by storage and significant difference due to varieties by storage but non-significant difference due to three factor interactions. Varieties by priming interaction effect on normal seedlings showed the highest mean values for Fendisha (80.25) and Muyra-I (79.75) primed with sodium chloride and the lowest for unprimed Muyra-II (51.58) (Table 3). Even though there was highly significant interaction effect of variety by priming in this study, most priming treatments except NaCl showed little difference or even sometimes lower number of normal seedlings compared to their respective unprimed control seeds of each variety (Table 3).

This could be because of the increase in fungal infestation after priming (personal observation) and agreed with (22) who pointed out that total external and internal infestation of seeds with both pathogenic and saprophytic fungus did increase after priming. (24) showed that red pericarp was associated with grain mould resistance. The effect of priming treatment on sorghum varieties differently may be due to the chemical composition nature of the priming solutions and the influence of the treatments to suppress or initiate the pathogenic and saprophytic infestations occurring after priming. There was also highly significant difference due to priming by storage interaction on number of normal seedlings. For the priming by storage interaction the highest number of normal seedlings was recorded in sorghum seeds stored for two years primed with NaCl (78.67) and lowest in seeds stored two years primed with water (65.28) (Table 5).

Rate of germination: The analysis of variance showed highly significant differences ($P \leq 0.01$) in germination rate due to varieties, priming and the interaction of varieties by storage duration and the three factor interaction. There was no significance difference due to interaction of variety by priming, priming by storage and main effect of storage duration (Appendix Tables 1). The one year stored Muyra-II variety gave the highest rate of germination when primed with KNO_3 (0.72) while the lowest was for Muyra-I stored two years primed with NaCl (0.39) (Table 2). The germination rate of Muyra-II (white seeded) was higher than the other red seeded (Muyra-I and Fendisha) except for non-primed seeds stored for two years. This is in parallel as suggested by (25), the rate and time to 50% germination of planted seeds might be basically associated with seed color.

Table 1. Description of Sorghum Varieties

No.	Varieties	Variety Type	Seed Color	Seed size	1000 SWt(g)	Year of production
1	Muyra I	Improved	Red	Large	29	2009 & 2010
2	Muyra II	Improved	White	Large	28	2009 & 2010
3	Fandisha	Local	White	Small	22	2009 & 2010

Table 2. Interaction effect of varieties, priming treatments and storage durations on tested standard germination parameters of sorghum

			Germination test parameters				
Varieties	**Storage Duration**	**Priming**	**SG%**	**ABNS**	**FUG**	**DEADS**	**RG (MGT)**
Fendisha	2years	Control	78.33bcdefgh	6.00fgh	7.00dfg	14.50bc	0.60(3.67)cdef
		KNO_3	84.67abcde	7.67cef	5.33dgij	10.00cd	0.48(4.08)hij
		NaCl	87.00abc	7.00fgh	7.00dfg	8.00de	0.45(4.20)ijk
		Water	74.33fgh	4.00hi	6.50dfgi	19.00ab	0.64(3.56)abcd
	1year	Control	85.00abcde	11.50ab	3.00ij	4.00e	0.42(4.38)jk
		KNO_3	77.33cdefgh	5.83fgh	2.00j	20.33a	0.56(3.79)efgh
		NaCl	88.00ab	4.50gh	6.50dfgi	6.50de	0.42(4.38)jk
		Water	82.33abcdefg	9.50bc	3.00ij	14.50bc	0.49(4.04)ghij
Muyra-I	2years	Control	76.33defgh	13.33a	9.67def	14.00bc	0.55(3.82)efgh
		KNO_3	79.00bcdefgh	4.00hi	2.00j	19.00ab	0.60(3.67)cedf
		NaCl	86.33abcd	7.33cefg	8.00dfg	5.67de	0.39(4.56)k
		Water	63.00i	1.00i	13.00de	24.00a	0.54(3.85)fhg
	1year	Control	81.67abcdefgh	6.33fgh	3.67dhij	7.67de	0.57(3.75)defg
		KNO_3	83.00abcdef	9.00bce	8.00dfg	8.33de	0.49(4.04)ghij
		NaCl	89.33a	7.50cefg	2.00j	10.00cd	0.44(4.27)jk
		Water	74.33fgh	7.00fgh	4.00dhij	20.00a	0.58(3.72)fed
Muyra-II	2years	Control	45.67j	9.83bc	17.33bc	3.50e	0.53(3.89)fghi
		KNO_3	72.67ghi	7.17cefg	5.00dgij	22.00a	0.72(3.39a)
		NaCl	77.00cdefgh	7.50cefg	19.00b	4.00e	0.62(3.61)bcde
		Water	72.00hi	8.67bcef	28.00a	6.00de	0.69(3.45)ab
	1year	Control	75.00efgh	10.17bc	19.17b	3.50e	0.68(3.47)abc
		KNO_3	73.33fgh	1.00i	3.50hij	23.00a	0.63(3.59)bcde
		NaCl	82.00abcdefgh	9.00bce	14.00cd	4.00e	0.53(3.89)fghi
		Water	76.00efgh	8.50bcef	18.50b	7.00de	0.71(3.41)a
LSD (5%) CV (%)			9.84 7.90	3.04 25.67	3.79 25.75	5.36 28.12	0.09 9.39

Means followed by the same letter are significantly different from each other at $p \leq 0.05$. SG%=Standard germination percentage; ABNS=Abnormal seedlings; RG=Rate of germination; FUG=Fresh ungerminated seed; DEADS=Dead seeds; Control=unprimed, KNO3= potassium nitrate, NaCl= Sodium chloride, Water= hydropriming.

In addition, (1) stated that white seeded varieties usually have a non-persistent testa and tend to be very palatable; while brown to red seeded varieties usually have a persistent testa. In fact priming had induced a range of biochemical changes in the seed that required initiating the germination process i.e., breaking of dormancy, hydrolysis or metabolism of inhibitors, imbibitions and enzymes activation (2).

Vigour Tests

Seedling shoots length: The analysis of variance revealed highly significant differences due to the main effect of priming, storage durations and interaction effect of variety by storage and priming by storage. There was no significant effect due to varieties, variety by priming interaction and three way interactions for the seedling shoot length (Appendix Table 2). For the interaction effect of varieties by storage Muyra-I stored for one year (10.44) recorded the longest shoot length (10.44) and Muyra-II stored for two years recorded the shortest (8.07) (Table 6). This indicates that seedling shoot length was not affected at one year storage, but it did after two years storage which could be because of the genetically storage quality difference of the varieties. The data in Table 7 showed that there is interaction effect of priming by duration on seedling shoot length; the highest and lowest shoot length was recorded for seeds treated with potassium nitrate of one year storage (11.61) and for hydro primed seeds stored for two years (6.32) respectively. Generally all seeds stored for one year, either primed or unprimed (control) had longer shoot length compared to their older seeds stored for two years. Priming treatment did increase shoot length of all seeds compared to their control for each year except for hydro-primed older seeds which recorded the lowest among all. This indicated that different priming treatments did affect shoot length of sorghum differently depending on the seed age. The improvement in seedling shoot length resulting from priming treatment has been suggested as a result of physiological process and repair mechanism that occur during priming (23).

Seedling root length: All main effects and three factor interaction showed highly significant ($P \leq 0.01$) difference and significantly different ($P \leq 0.05$) for varieties by priming interaction while varieties by storage and priming by storage interaction showed non-significant difference on seedling root length (Appendix Table 2). The longest and shortest seedling root length was recorded for one year stored Muyra-I treated with sodium chloride (14.97) and one year stored Fendisha treated with sodium chloride (5.73) respectively (Table 12).

Seedling dry weight (mg): Seedling dry weight revealed highly significant difference due to varieties and priming ($P \leq 0.01$) and non-significant for all other observations (Appendix Table 2).

Table 3.Interaction effect of varieties x storage duration on seedling shoot length of sorghum varieties

Storage durations			
Varieties	2 years	1 year	Means
Fendisha	9.98ab	9.46abc	9.72
Muyra-I	8.45bc	10.44a	9.45
Muyra-II	8.07c	10.07ab	9.07
Means	8.83	9.99	9.41

Variety x Storage LSD (5%) 1.80 CV (5%) 23.52
Means followed by the same letter are not significantly different from each other at p≤0.05

Table 4. Interaction effect of priming by storage duration on seedling shoot length of sorghum varieties

Priming	Storage Durations		Means
	2 years	1 year	
KNO_3	10.75ab	11.61a	11.18
NaCl	9.43bcd	10.25abc	9.84
Water Control	6.32e 8.84cd	9.75bcd 8.35d	8.04 8.6
Means	8.84	9.99	9.42

Priming x Storage LSD (5%) 1.71 CV (5%) 19.34

Table 5.Main effect of varieties and priming on seedling dry weight of sorghum

Treatments	Parameter
Varieties	Seedling dry weight.
Fendisha	0.28 b
Muyra-I	0.34ab
Muyra-II	0.39a
LSD(0.05)	0.07
CV (%)	35.16
Priming	
Control	0.26 b
KNO3	0.44 a
NaCl	0.41 a
Water	0.25b
LSD (5%)	0.08
CV (%)	35.16

Means followed by the same letter are not significantly different from each other at (p≤0.05) Control=unprimed, $KNO_{3=}$ potassium nitrate, NaCl= Sodium chloride, Water= hydropriming.

Table 6. Interaction effect of varieties x storage duration on seedling vigor index-I of sorghum varieties

Varieties	2 Years	1 Year	Means
Fendisha	12.86b	13.26ab	13.06
Muyra-I	11.51bc	15.96a	13.74
Muyra-II	9.37c	13.89ab	11.63
Means	11.25	14.37	12.81

Variety x Duration LSD (5%) 2.93 CV (5%) 28.04
Means followed by the same letter are not significantly different from each other at p≤0.05

The highest and lowest seedling dry weight was recorded for Muyra-II (0.39) and Fendisha (0.28) respectively (Table 8) and this could be due to seed size (1000 kernel weight) difference of varieties. The seedling dry weight of seeds treated with potassium chloride (0.44) and sodium chloride (0.41) solution was significantly greater than other treatments (Table 8) which did not differ from each other in this respect. These results were as per (14) who stated osmotic priming of seeds generally causes faster germination and faster field emergence (13) which might be resulted in greater mean plant dry weights, leaf areas and ground cover percentages (19); (15).

Table 7. Interaction effect of priming treatment and storage duration on seedling vigor index-II

Priming	2 years	1 year	Means
KNO_3	34.94a	28.59ab	31.77
NaCl	25.91bc	36.85a	31.38
Water Control	12.93d 12.93d	16.78d 18.94cd	14.86 15.94
Means	43.36	25.29	23.49

Priming x Storage LSD (5%) 8.65 CV (5%) 38.27
Means followed by the same letter are not significantly different from each other at p≤0.05. Control=unprimed, $KNO_{3=}$ potassium nitrate, NaCl= Sodium chloride, Water= hydropriming.

Seedling vigor indices

Seedling vigor index I:

There was significant difference for varieties (P≤0.05), highly significant difference for priming, storage duration and varieties by storage interaction (P≤0.01) and non-significant for other variations (Appendix Table 2). For the main effect of priming which revealed highly significant the highest mean value was recorded in KNO_3(15.70) and the lowest was in water priming (11.22) (Table 9). The data in Table 10 shows that there is significant difference due to the interaction effect of varieties by storage, of Muyra-I stored for one year showed the highest seedling vigor index-I (15.96) and Muyra-II stored for two years recorded the lowest (9.37). This clearly shows that vigor depends on varieties of sorghum and in our study Muyra-I was found to be superior in vigor index-I as compared to the other varieties (Table 10). The data also shows that the seedling vigor of seeds stored for one year was higher than that of two years stored. This statement is in agreement (20) seed vigor deterioration in storage is genetically influenced and suggests that within a species there may be at least a 7 fold genotypic variation in seed longevity. Genetic variation within species may occur on different levels, e.g. land races, provenances, individuals and clones.

Seedling vigor index-II: The seedling vigor index-II was found to be highly significant (P≤0.01) for priming treatments and significant (P≤0.05) for the interaction of priming by storage duration (Appendix Table 2). Seeds primed with sodium chloride and potassium nitrate were superior in vigor index-II for both storage compared to the hydroprimed and unprimed control seeds which did not revealed any significant differences among themselves (Table 11). Highest vigor index-II was recorded for seeds stored for one year treated by NaCl (36.85) and seeds stored for two years treated by KNO_3 (34.94) while the lowest was for unprimed (12.93) and hydroprimed seeds (12.93) stored for two years (Table 11).

Speed of emergence: The analysis of variance revealed highly significant (P≤0.01) for main effects of varieties, priming and storage duration on sorghum seed speed of germination. The interaction effects of varieties by priming showed significant difference, while priming by storage and three factor interactions showed highly significant differences. The variety by storage interaction was not significant (Appendix Table 2).The highest speed of emergence was recorded for Muyra-I stored for one year and primed with NaCl (12.96) and the lowest was for Muyra-II stored for two years and primed with KNO_3 (7.41) (Table 12).

Table 8. Interaction effect of varieties, priming treatments and storage duration on seedling shoot length, speed of germination and field emergence of sorghum

Treatments Varieties	Duration	Priming	Vigor Parameters SRL	SPEMG	FEMI
Fendisha	2 years	Control	6.18fg	9.39efghi	5.87j
		KNO3	7.22defg	8.88fghij	3.88l
		NaCl	7.67cdefg	11.00bc	6.78hi
		Water	7.80cdefg	7.63jk	7.64f
	1 year	Control	7.22defg	9.62defgh	7.42fg
		KNO3	11.93ab	8.24ijk	8.60e
		NaCl	5.73g	12.09ab	10.23bc
		Water	6.40efg	10.22cde	10.51ab
Muyra-I	2 years	Control	6.90efg	9.40efghi	6.53i
		KNO3	10.53bcd	9.67defg	5.55jk
		NaCl	7.87cedfg	10.88bcd	8.91e
		Water	6.07g	10.96bc	6.39i
	1 year	Control	7.50cdefg	10.13cdef	9.44d
		KNO3	9.54bcde	10.52cde	9.91cd
		NaCl	14.97a	12.96a	10.95a
		Water	11.30b	9.24efghi	10.53ab
Muyra-II	2 years	Control	6.63efg	9.98cdef	5.87j
		KNO3	10.58bc	7.41k	7.05gh
		NaCl	5.83g	8.63ghijk	7.26fgh
		Water	7.88cedfg	8.33hijk	5.10k
	1 year	Control	7.35cedfg	8.50ghijk	7.71f
		KNO3	12.23ab	8.53ghijk	9.93dc
		NaCl	9.52bcdef	10.48ced	10.99a
		Water	10.67bc	8.17ijk	9.72cd
LSD (5%)			3.34	1.29	0.51
CV (%)			23.73	8.17	3.87

Means followed by the same letter are not significantly different from each other.SRL= Seedling root length; SPEMG= Speed of emergence; FEMI= Field emergence index, Control=unprimed, KNO_3= potassium nitrate, NaCl= Sodium chloride, Water= hydropriming

The speed of germination and emergence were powerful factor because they occur early in the growth of the crop. Early emerging seedlings have a high probability of being larger at stem elongation and of producing more grains than those emerging a few days later. Similarly, (26) observed that it is the rate at which the seeds are germinating and those seedlings with higher index or highest on first count are expected to show rapid germination and seedling emergence and to escape adverse field conditions.

Field emergence index: Highly significant differences in field emergence index has been observed for the main effect of sorghum varieties, priming treatments, storage durations and all their interactions ($P \leq 0.01$), except variety by storage duration (Appendix Table 2). All the three varieties of one year storage showed highest field emergence index when treated with NaCl as compared to other priming treatments except Fendisha stored for one year. In addition, priming enhanced field emergence of older seeds but in different manner from younger seeds of the same varieties; in that Fendisha performed better with the combination of water treatment significantly greater followed by the combination of salt treatment while KNO_3showed even lower than control, for Muyra-I combination with NaCl treatment performed well while other treatments decreased compared to the control and Muyra-II was better with KNO_3followed by NaCl while hydropriming performed even lower than the control for this variety in our study (Table 12).This is probably due to the physiological and/or biochemical difference of varieties, seed size being most probable reason in this study and is in parallel with (3) who studied factors affecting grain sorghum establishment, and found that the size of the seeds showed positive correlation with emergence and vigor. In the field, seed size had effect on speed of emergence. Larger endosperm enhanced emergence ability and large seeds of crops had greater supply of stored energy to support early seedling growth and consequently its plant status. Larger seed not only has greater vigor but emerges faster. Faster emergence and larger seedlings lead to an increase in nutrient access. "Seedlings from large-seeded species would have better access to light and/or to reliable water supply than seedlings from small-seeded species (9).

CONCLUSION

The experiments consisted of 3 factors (2 storage duration: 1 and 2 years; 3 sorghum varieties and 4 priming treatments) arranged in CRD (for laboratory test) and RCBD (glasshouse pot experiment test) with three replications. Data on germination percentage, rate of germination, seedling length, seedling dry weight, vigor indices and field emergence percentage and index were taken. The laboratory results in the experiment indicated that priming sorghum seeds prior to planting have potentials to improve germination, subsequent seedling emergence, root and shoot length and seedling dry weight. All varieties tested showed increased percentage germination, high rate of germination, enhanced rate of emergence when primed regardless of pre-priming seed storage. The varieties by priming by storage duration interaction had showed that when seeds were treated with sodium chloride, almost all the varieties of each storage year demonstrated an increase in germination and the degree of increment was higher for Muyra-I and Fendisha, the lowest being for Muyra-II which was significantly lower for both storage year. In case of mean germination time Fendisha exhibited better with hydro priming for older seeds and with KNO_3 for younger seeds while Muyra-II and Muyra-I showed better with KNO_3 for older seeds and with hydro-priming for newer seeds of sorghum.

Responses for the remaining varieties were intermediate. Thus, the effectiveness of priming treatment might be associated with variety and seed age which indirectly indicates seed quality. Sorghum varieties with bigger sized seeds were superior in their germination and emergence response compared with those having smaller seed sized, although smaller sized seeds had higher relative advantages due to priming. Seed size is one of the principal factors of seed vigor. The beneficial effect of priming was found to be most pronounced in a seed lot with low germination or vigor (i.e. older seeds).In addition, it would appear that red and brown color had enhanced aged seed vigor under this controlled laboratory conditions, though the mechanisms that triggered such responses are not apparent from this study.

Pot experiment data combined with data obtained from laboratory tests showed varieties by priming by seed storage interactions, which suggested that different varieties with different seed age may have varying responses depending on the initial seeds quality, color and size of the seeds. In general there was a consistent pattern of seed priming effects on variables measured from all varieties tested. Osmopriming with NaCl and KNO_3 showed a positive response followed by hydro priming for all varieties of different storage seeds in terms of germination, rate of germination, seedling emergence, rate of seedling emergence and some other measured seed quality characteristics. From the present work it can, therefore, be concluded that priming media is an important element that should be fixed by research for enhanced priming effect on seed germination and seedling emergence of differentially aged sorghum seeds.

Authors Contribution

- **Khalid Ibrahim Omer**: - Corresponding author who conducted the research at Haromaya University in partial fulfillment for the Degree Masters of Science in Seed Science and Technology.
- **Professor Rampal .P.S. Tommer (PhD):-** Major advisor of the research study.
- **Ketema Belete (PhD):-** Co-advisor for the research Study.
- **Awale Degewione Shirdon:-** immediate supervisor and advisor at my employment organization of Somali Region Pastoral and Agro-Pastoral Research Institute and assissted in the collection, analyses, interpretation of data and in the writing of the manuscript

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