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Effect of Seed Age, Size and Moisture Content on Seed Quality of Sorghum (*Sorghum Bicolor*. L. Moench)

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Abstract: A set of laboratory and field experiments were conducted during 2005 to investigated the influence of seed age, size and moisture content on seed quality attributes of sorghum cultivar *Tabat*. Simple correlation coefficients were conducted to determine the degree of association between the different vigor tests and seedling emergence under field conditions. Parameters measured included germination percentage, speed of germination, seedling's shoot length, root length, and shoot to root length ratio, seedling's fresh and dry weight. Results showed that all vigor attributes measured in this study were significantly affected by seed treatment particularly under laboratory condition. In this respect, the new, large seeds (>3.15mm) and seeds with medium moisture content (7.5%) consistently resulted in a better vigor attributes compared to the old, small (<3.15 mm) and seed with either high (10%) or low moisture content (5%).The results also showed that field emergence was positively correlated with the speed of germination (r = 0.91), seedling length (r = 0.67) and seedling dry weight (r = 0.59) suggesting that these vigor attributes could be used to estimate field emergence of sorghum seeds. Therefore, further vigor tests were required to enable ranking of seed lots in a manner that would reflect their stand establishment capabilities under varied field conditions.

Key words:

INTRODUCTION

Grain sorghum (*Sorghum bicolor*. L. Moench) is one of the main stable for the world poorest and more food-insecure people. The crop is genetically suited to hot and dry agro-ecologies, where it is difficult to grow other food grains. It ranks fourth in importance among the cereal crops in the world following rice, wheat and maize [8].

In the Sudan, sorghum ranks first both in total tonnage of grain produced and total acreage cultivated. The average sorghum yield is about 574 kg/ha which is below the world average yield (1386 kg/ha). This low productivity is caused by many constraints among which is the failure in obtaining satisfactory stands, and replanting adds additional cost to an already expensive production programs. Also optimum plant population is a basic requirement for high crop productivity. Thus seed germinability and seedling vigor is a crucial factor in resolving field establishment problem.

One of the main problems observed in the field is poor establishment, which is influenced by seed quality, adverse climatic conditions and poor field management [11]. Seed quality includes several attributes that lead to near maximum germination capacity to produce seedlings, which emerge rapidly from the seedbed and continue to grow uniformly thereafter [5].

Among seed lots with high germination percentage, differences in field emergence can occur due to differences in vigor [19]. The basic requirements of vigor testing include the ability to provide more sensitive index of seed quality than the germination test and to provide consistent ranking of seed lots in terms of potential performance in the field [12]. Previous studies showed that new, large seeds and moisture content had considerable superiority while other studies showed no differences between them. Therefore, the objectives of this study were to investigate the influence of seed age, seed size and seed moisture content on seed quality attributes and to examine the correlation between seed vigor tests and seedling performance under field conditions

MATERIALS AND METHODS

A set of laboratory and field tests were carried out on seed of sorghum (*Sorghum bicolor*. L.Moench) variety Tabat. The objective was to investigate the influence of seed age, seed size and seed moisture content on seed quality attributes and to examine the correlation between seed vigor tests and seedling performance under field condition.

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Two seed lots of sorghum cultivar (Tabat) were provided by Sudanese Arab seed Company. Theyrepresented harvests of 2003 and 2004 and were therefore, presumed to have low and high vigor levels, respectively. Sub samples from each seed lot were graded into two size categories, using electrical mechanical shaker (RetschVibro, Nr.42805). The initial moisture content of two seed sub samples from each seed lot was determined by grain moisture tester. The seeds were then adjusted to two different moisture content above 10% and below 5%, the initial moisture content was 7.5%. The seeds from all the categories were stored in airtight polythene bags and working samples were drawn to perform the following tests:

Laboratory Tests: 200 seeds from each category were distributed in four replications of 50 seeds, and were germinated in double moist filter papers. Seeds were germinated in the dark using incubator set at 27+1°C for ten days according to ISTA rules [1]. At the end of the incubation period, the number of normal seedlings was recorded and the germination percentage, speed of germination, seedling dry weight and seedling shoot and root length was calculated.

Field Tests: Seed sub-samples similar to those described in the laboratory tests were tested under field conditions. The experiment was laid out in split-split plot design with four replicates. Each plot consisted of five ridges five meter in length. The main plots were allowed to seed age, the sub plot to seed size and the sub–sub plots to seed moisture content. On seedling emergence the following tests were performed: Speed of seedling emergence, Seedling fresh weight (mg), Seedling dry weight (mg).

Statistical Analysis: Data were subjected to the analysis of variance appropriate for the design used [4]. Means separation was done according to Duncan's multiple range (DMRT) for different characters. Simple correlation coefficients were calculated to test the association among the laboratory test results and between the laboratory and field emergence tests.

RESULTS AND DISCUSSION

Seed Viability: The overall mean seed viability as represented by germination percentage was relatively higher under the laboratory (56%) conditions compared to the field (44%) conditions (Table 1). Statistical analysis revealed that germination percentage was significantly affected by seed treatments particularly under the laboratory conditions. In this regard, the new, large and medium moisture content seeds resulted in a significantly higher germination percentage compared to the old, small and/or either high or low seed moisture content, respectively (table 1).

Seed Vigor Attributes:

Speed of Germination (Days): Data presented in table (2) indicated that the effect of seed treatments on the speed of germination followed similar pattern to that described for germination percentage. Similar pattern was observed under field condition but the difference between treatments was not significant (Table 2).

Seedling Shoot Length (mm): Statistical analysis showed that seedling shoot length was significantly affected by treatment under both conditions. In this regard, the new, small and higher moisture content seeds resulted in a significantly higher seedling shoot length particularly under laboratory conditions compared to old, large and either medium or low seed moisture content, respectively (Table 3).

Under field conditions the large seeds resulted in a significantly higher seedling shoot length compared to small seed (Table 4). No significant interaction between treatments on seedling shoot length was observed in this study.

Seedling Root Length (mm): Data presented in table (4) indicated that the effect of seed treatments on seedling root length followed similar pattern to that described for seedling shoot length. The new and high moisture content seeds had a significantly taller seedling root length compared to the old and seeds with either low or medium moisture content, respectively (Table 4). Under field condition only the large seed produced taller seedling root length compared to small seeds (Table 4). Differences due to the interactions were not significant under field conditions.

Seedlings Shoot to Root Ratio: Statistical analysis revealed that seedling shoot to root length ratio was significantly affected by seed treatments particularly under laboratory conditions. Under the laboratory condition the old, large and low moisture content seed resulted in a significantly lower seedling shoot to root ratio compared to the new, small and either high or medium seed moisture content, respectively (Table 5). No significant difference between seed treatments was observed under field condition (table 5). No significant interaction between treatments on seedling shoot to root length ratio was recorded in this study.

Seedlings Fresh Weight (mg): Although the effect of seed treatments on seedlings fresh weight followed similar pattern to those described for other vigor tests, there was no significant difference between treatments under both laboratory and field conditions (Table 6).

Seedling Dry Weight (mg): Data presented in Table (7) indicated that the effect of seed treatments on seedlings dry weight followed similar pattern to that described for seedlings fresh weight. Statistical analysis revealed that, seedlings dry weight was only significantly affected by seed age and seed size under laboratory and field conditions, respectively. No significant interaction between treatments on seedling dry weight was observed in thisstudy.

Correlation Analysis Simple correlation coefficients study (Table 8) showed that standard germination percentage was positively correlated only with speed of germination (r = 0.91) among the measured vigor tests. Field emergence was also well correlated with the speed of germination (r = 0.63), shoot length (r = 0.67) and seedling fresh and dry weight (r = 0.59, Table 8). No significant correlation was found between field emergence and the standard germination test (Table 8).

Discussion: In the present study, the influence of seed age, seed size and seed moisture content on seed quality attributes were consistently significant, particularly under laboratory conditions. The lack of significant difference under field conditions may be attributed to the seldom optimal nature of the field conditions and the minor differences between seed quality attributes under laboratory conditions in predicting the planting value of the seed in the field.In the present study, the analysis of the laboratory tests proved that seed age had a highly significant effect on seed viability as monitored by the standard germination test and the highest germination percentage was realized by the new seeds. This result coincided with the findings of Cantliffe [3] in soybean. The low germination percentages of the old seeds may be attributed to seed deterioration during storage. The loss of vigor in aged seed also may be due to impairment of specific biological or physiological function, as reported by Aschermann-Koch *et al,* [2].

Similarly, the highest speed of germination was recorded by the new seeds indicating that seed index in sorghum increases with decreasing seed age. Such results may be ascribed to deterioration with age as reported by Nauliyal *et al* [13] in pearl millet. In addition, significant differences were observed among the two seed lots in the test of shoot and root length and seedling dry weight particularly under laboratory condition. Similar trend was observed by many workers [13,15]. They reported that seed vigor attributes diminished with seed deterioration.

In the present study, seed size affected germination percentage and the highest values were realized by the large seed fraction under laboratory condition. Previous studies revealed that, the greater the seed size the higher would be the germination percentage. This may explain the superiority of the large seed fraction over the small seed fraction on germination percentage test observed in this study. The low germination percentage of the small seeds may partially be attributed to the presence of immature and shriveled seeds. The non significant effect of the seed size on germination percentage under field condition is in accord with the previous findings. They stated that, germination percentage was almost the same in all grades of the seed tested under field conditions. Seed vigor in terms of rapidity of germination was assessed by the speed of germination. Differences between seed sizes were not significant under both laboratory and field conditions. Seed vigor attributes were used to prove a good prediction for seedling vigor and subsequent crop performance. In the present study, the effect of seed size on seedling vigor was investigated as seedling shoot and root length, shoot to root ratio, seedling fresh weight and seedling dry weight. The results showed that seedlings raised from large seeds had significantly better vigor attributes compared to those derived from small seeds. These results support the previous findings of Raveendranth and Singh [14] in sunflower. Moreover, working with Lentil mentioned that large seeds had greater shoot dry weight compared to small ones. Also, Singh and Pai [17] found that shoot and root length increased with increasing seed size in cowpea and attributed this to the large carbohydrate reserve of large seeds.

The superiority of small seeds over the large seeds on some vigor attributes (e.g. shoot length and shoot to root ratio) may be attributed to its high speed of germination. Similar results were reported by Sahoo *et al* [16]. Differences between seed grades in shoot to root ratio may be attributed to the effect of seed size on seedling shoot length.

In the present study the significant effect of seed moisture content on seed viability in terms of germination percentage and speed of germination is in accord with the previous research. In this regard, Ibrahim and Roberts [7] reported that seed viability in lettuce decreased with increases in seed hydration upto 15% moisture content. The effect of seed moisture on seed viability observed in this study may be attributed to the short storage duration between seed treatment and planting (5days) which acted as pre-irrigation to the seed. Supporting evidence was reported by Aziz who showed that the duration of storage had notable effect on seed germination. The significant effect of high and medium moisture content on shoot and root length and on shoot to root ratio observed in this study may be also attributed to short storage duration of seed after moisture treatment.

Since field conditions are rarely optimum and differences in quality between seed lots might not be too wide, the germination percentage test may not always be sufficient to accurately predict the planting value of the seeds. This might explain the non significant correlations between standard germination test and field emergence test measured in this study. Therefore, further vigor tests were required to enable ranking of seed lots in a manner that would reflect their stand establishment capabilities under varied field conditions [6]. In the present study, speed of germination, seedling length and dry weight were positively correlated with field emergence. Similar results were reported by many workers [10,18].

Conclusions: A set of laboratory and field tests were conducted during 2005 to investigate the effect of seed age, seed size and seed moisture content on seed viability and seed vigor attributes of sorghum cultivar Tabat.

The results indicated that seed treatments had significant effects on all measured parameters under laboratory condition only. In this respect, the new, large seeds (>3.15mm) and seeds with medium moisture content consistently resulted in better vigor attributes compared to the old, small and seed with either high or low moisture content.

The results also showed that field emergence was positively correlated with the estimate, under laboratory condition speed of germination, seedling length and seedling dry weight, suggesting that these vigor attributes could be used to estimate field emergence of sorghum seeds. Further study is needed to determine the appropriate seed treatment that leads to better vigor attributes.

Table 1: Effect of seed age, size and moisture content on germination percentage under laboratory and field conditions.

Treatments	Germination percentage	
	Laboratory condition	Field conditions
Seed age		
New(1year)	51.3a	41.6a
Old (2years)	45.6b	40.7a
SE +	1.87	1.38
Seed size		
Small(3.15-2.6mm)	45.6b	38.9a
Large (>3.15mm)	51.3a	43.4a
SE +	1.87	4.11
Seed moisture content		
Low (5%)	45.1b	37.8a
Medium (7.5%)	51.9a	42.4a
High (10%)	48.5b	43.2a
SE+	2.29	3.72

For each treatment, means followed by the same letter (s) within a column are not significantly different ($p \leq 0.05$) according to Duncan Multiple Range Test (DMRT)

Table 2: Effect of seed age, size and moisture content on speed of germination under laboratory and field conditions.

Treatments	Speed of germination	
	Laboratory condition	Field conditions
Seed age		
New(1year)	19.4a	5.8a
Old (2years)	18.1b	6.2a
SE +	0.27	0.31
Seed size		
Small(3.15-2.6mm)	18.6a	5.5a

Table 2: Continue

Large (>3.15mm)	18.9a	6.5a
SE +	0.27	0.62
Seed moisture content		
Low (5%)	18.0b	5.6a
Medium (7.5%)	19.4a	6.3a
High (10%)	18.8b	6.1a
SE+	0.34	0.34

For each treatment, means followed by the same letter (s) within a column are not significantly different ($p \leq 0.05$) according to Duncan Multiple Range Test (DMRT).

Table 3: Effect of seed age, size and moisture content on seedling shoot length (mm) under laboratory and field conditions.

Treatments	Seedling shoot length	
	Laboratory condition	Field conditions
Seed age		
New(1year)	44.3a	196.1a
Old (2years)	36.5b	184.0a
SE +	0.17	0.76
Seed size		
Small(3.15-2.6mm)	43.8a	176.0a
Large (>3.15mm)	37.0b	204.1b
SE +	0.17	0.58
Seed moisture content		
Low (5%)	32.4b	197.9a
Medium (7.5%)	38.3b	192.0a
High (10%)	50.4a	180.3a
SE+	0.21	0.58

For each treatment, means followed by the same letter (s) within a column are not significantly different ($p \leq 0.05$) according to Duncan Multiple Range Test (DMRT).

Table 4: Effect of seed age, size and moisture content on seedling root length (mm) under laboratory and field conditions.

Treatments	Seedling root length	
	Laboratory condition	Field conditions
Seed age		
New(1year)	96.4a	83.8a
Old (2years)	84.1b	82.0a
SE +	0.22	0.10
Seed size		
Small(3.15-2.6mm)	88.3a	74.0b
Large (>3.15mm)	92.1a	91.8a
SE +	0.22	0.30
Seed moisture content		
Low (5%)	83.2b	84.4a
Medium (7.5%)	82.6b	88.6a
High (10%)	104.9a	75.7a
SE+	0.28	0.55

For each treatment, means followed by the same letter (s) within a column are not significantly different ($p \leq 0.05$) according to Duncan Multiple Range Test (DMRT).

Table 5: Effect of seed age, size and moisture content on seedling shoot to root length ratio under laboratory and field conditions.

Treatments	Seedling shoot to root length ratio	
	Laboratory condition	Field conditions
Seed age		
New(1year)	4.6a	24.9a
Old (2years)	4.3a	22.8a
SE +	0.02	0.10
Seed size		
Small(3.15-2.6mm)	4.9a	24.4a
Large (>3.15mm)	4.0b	23.3a
SE +	0.02	0.14
Seed moisture content		
Low (5%)	3.9b	23.1a
Medium (7.5%)	4.7a	23.6a
High (10%)	4.9a	25.0a
SE +	0.03	0.15

For each treatment, means followed by the same letter (s) within a column are not significantly different ($p \leq 0.05$) according to Duncan Multiple Range Test (DMRT).

Table 6: Effect of seed age, size and moisture content on seedling fresh weight (mg) under laboratory and field conditions.

Treatments	Seedling fresh weight	
	Laboratory condition	Field conditions
Seed age		
New(1year)	950a	5570a
Old (2years)	850a	3880a
SE +	0.05	1.51
Seed size		
Small(3.15-2.6mm)	940a	4130a
Large (>3.15mm)	1010a	5320a
SE +	0.05	1.70
Seed moisture content		
Low (5%)	670a	5550a
Medium (7.5%)	870a	6260a
High (10%)	960a	6090a
SE+	0.06	1.35

For each treatment, means followed by the same letter (s) within a column are not significantly different ($p \leq 0.05$) according to Duncan Multiple Range Test (DMRT).

Table 7: Effect of seed age, size and moisture content on seedling dry weight (mg) under laboratory and field conditions.

Treatments	Seedling dry weight	
	Laboratory condition	Field conditions
Seed age		
New(1year)	6.0a	131.0a
Old (2years)	5.0b	108.0a
SE +	0.01	0.01
Seed size		
Small(3.15-2.6mm)	5.0a	96.0b
Large (>3.15mm)	5.0a	143.0a
SE +	0.01	0.01

Table 7: Continue

Seed moisture content		
Low (5%)	4.0a	124.0a
Medium (7.5%)	5.0a	116.0a
High (10%)	6.0a	119.0a
SE+	0.05	0.02

For each treatment, means followed by the same letter (s) within a column are not significantly different (p ≤0.05) according to Duncan Multiple Range Test (DMRT).

Table 8: Correlation among the various vigor tests and between the vigor tests and field emergence.

	1	2	3	4	5	6	.
Standard germination		-					
Speed of germination		0.91*	-				
Seedling shoot length		Ns	Ns	-			
Seedling root length		Ns	Ns	Ns	-		
Shoot to root ratio		Ns	Ns	0.75**	Ns	-	
Seedling fresh weight		Ns	Ns	0.93**	Ns	0.63*	-
Seedling dry weight		Ns	Ns	0.89**	Ns	0.59	0.94**
Field seedling emergence	Ns	0.63*	0.67*	Ns	0.59*	0.59*	

1-germination percentage
2-speed of germination
3- Seedling shoot length
4- Seedling root length
5- seedling shoot to root ratio
6- seedling fresh weight
7- seedling dry weight
8- Field seedling emergence
NS: No significant different
*: Significant at (0.05) level of probability.
**: significant at (0.01) level of probability.

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