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Asian Journal of Plant Science and Research, 2017, 7(3):24-28

ISSN : 2249-7412
CODEN (USA): AJPSKY

# The Effect of Location, Sowing Date and Genotype on Seed Quality Traits in Bread Wheat (*Triticum aestevium*)

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## ABSTRACT

*This research aimed at studying the effect of location, sowing date. The experiment was carried out in the growing season 2012/2013 under Sudan conditions using two sowing dates; optimum sowing date, and late sowing date, at two locations; Shambat in Khartoum state and Hudeiba in the River Nile state. The experimental design was a split-plot with three replications. Seeds were tested for seed moisture content, falling number, seed germination percentage and rate of germination. Results revealed that the effect of location was highly significant for both falling number and rate of germination, and was significant for germination percentage. There was no significant effect of sowing date on all studied seed quality characters. The effect of genotype was highly significant for falling number and non-significant for the other three traits which were positively correlated with rate of germination at the two locations.*

**Keywords:** Sowing, Germination, Genotype

## INTRODUCTION

Wheat as a crop usually needs 110-130 days from sowing up to harvesting, depending upon climate, seed type, and soil conditions. Uniform stand establishment and vigor are the principal determinant of crop performance [1]. Late planting affects the growth, yield and quality of wheat grain, because early sowing produces higher yields than late sowing due to longer duration of grain development. Temperatures below or above normal alter plant functions and productivity. In late planted wheat, low temperature prevailing during germination substantially affects the germination and seedling emergence. Wheat grain is normally harvested at moisture content ranging between 10% and 12%. This moisture content is the most important factor affecting quality of wheat grain; hence it is inversely related to dry matter loss [2]. Ideally, seed should be stored around 10°C, but the availability of such facilities for bulk storage is limited. Generally, wheat seed with a moisture content of 12%, stored at 20°C for a period of 360 days, will retain about 92% germination. However, seed with a moisture content of only three percentage points higher, will result in a mere 27% germination.

α-Amylase is a protein enzyme that hydrolyses alpha bonds of large, alpha-linked polysaccharides, such as starch and glycogen, yielding glucose. It is also present in seeds containing starch as a food reserve. Usually α-Amylase activity in grain is measured by, for instance, the Hagberg-Perten Falling Number, a test to assess sprout damages [3]. Once germination starts an increase in the activity of degradative enzymes takes place within the seeds.

Seed germination and vigor rapidly decreased in seeds exposed to adverse environmental conditions. When parental plants are exposed to high temperature during growth and development the quality of seed is highly influenced [4]. As a consequence, smaller and shriveled grains of low vigor and viability are produced and if used as seed for next crop, they do not perform well. Factors that can affect the performance of seed in germination tests include; diseased seed, old seed, mechanically damaged seed, seed stored under high moisture and excessive heating of seed during storage or drying. Therefore the objective of this study is to assess the effect of location, sowing date and genotype on seed quality traits in bread wheat.

## MATERIALS AND METHODS

### Field experiments

Two field experiments were conducted during winter 2012/2013 for screening of 12 selected genotypes of bread wheat (*Triticum aestivum* L.) at two locations and under two sowing dates. The first location was Shambat at the Faculty of Agriculture Demonstration Farm (Latitude: 15°40'N and longitude: 32°32'E), with soil that consists of Nile alluvium and sandy clay soil. The second location was Hudieba at the research Farm of Hudeiba Research Station (Latitude: 17°34'N and Longitude: 33°56'E), with soil that consists of 51% clay, 1% silt and 48% sand. The two sowing dates were: 1) optimum (on the 28th of November 2012), and 2) late sowing (on the 27th of December 2012). The plant material of this study consisted of a total of twelve genotypes of wheat (*Triticum aestivum* L.), eleven advanced breeding lines and one check cultivar (Imam: code number=95) which were selected and developed for tolerance to heat stress from more than 96 breeding lines that had been provided by the International Center for Agricultural Research in Dry Areas (ICARDA) presented in code numbers.

The experimental design used was split plot design with three replications. The sowing dates were assigned to the main plots, and genotypes to subplots. The seed rate used was 120 Kg/ha. Each genotype was grown in a sub-plot consisted of four rows, each 2.5 m long and 20 cm apart. Both experiments were given eleven irrigations with an irrigation interval of 7-10 days. Fertilizer was applied in form of urea (46% N) before booting stage. All experimental plots were hand-weeded after three weeks and then whenever it was fourth irrigation.

Data was collected on five randomly chosen plants and different agronomical characters were measured during both vegetative and reproductive stages and used for evaluation. After harvesting to achieve the objectives of this study different seed quality traits were measured under the different sowing dates, both locations and for all of screened genotypes. These seed quality traits included the following:

### Seed moisture content

This was determined according to AOAC (1984) and calculated as follows:

$$Moisture\ content\% = \frac{Wt_1 - Wt_2}{Sample\ weight} \times 100$$

where:

$Wt_1$=Weight of sample+dish weight before oven dry

$Wt_2$=Weight of sample+dish weight after oven dry

### Falling number

Alpha-amylase activity was carried out on wheat flour, according to Perten [5].

The required flour sample weight (R.W) was obtained from the correction tables of sample weight to 14% moisture basis (ICC 107/1) [6] and AACC 56-81 B [7], corresponding to 7 g at 14% moisture and quantity of water used is (25 ml).

### Calculations

$$(R.W.)g = 7 \times \frac{(100 - 14)}{(100 - m)}$$

where:

(R.W.)=The required flour sample weight used for determination

M=Actual moisture percentage of the flour sample

### Seed germination test

Four hundred seeds were randomly counted, divided into four replicates (100 seeds for each) and grown in plastic pots. Sand growing media was used. 90% of the particles should pass a sieve having meshes or holes of 0.8 mm width and be retained on a sieve having holes of 0.05 mm width. Seeds were grown in moist sand covered with a layer of 10-20 mm uncompressed moist sand. Seeds were pressed into the surface of the sand. The bottom layer of sand was loosened by raking before sowing. The test was carried out according to ISTA in a cold room adjusted at 20°C [8]. First count was recorded on the 4th day and the final count was on the 8th day from sowing. The germination percentage was calculated based on the following formula:

$$Germination\ \% = \frac{Number\ of\ normal\ seedlings}{Number\ of\ seeds\ planted} \times 100$$

**Rate of germination**

This test is one of the tests used to evaluate seed vigor. After seeds have begun to germinate, they were checked at approximately the same time daily. Normal seedlings were counted when they reached a predetermined size until the seeds that are capable of producing normal seedlings have germinated. An index of germination of the rate quotients of the daily counts divided by the number of days of germination.

Formula as described by Maquire [9]:

$$X = \frac{Number\ of\ normal\ seedlings}{Days\ of\ the\ first\ (count)} + \frac{Number\ of\ normal\ seedlings}{Days\ of\ the\ final\ (count)}$$

**Statistical analysis**

The statistical method was carried out according to the procedure described by Gomez and Gomez for split-plot design to run the analysis of variance and to test the significance of main factors effects (location, sowing date and genotypes) and their interactions (location x genotypes, and sowing date x genotypes) [10]. All possible combinations of correlation coefficients between the seed quality traits were estimated as follows:

Phenotypic correlation coefficient $(rph) = \frac{óph1.2}{\sqrt{(ó^2\ ph1)(ó^2\ ph2)}}$

where:

σph1.2 is the phenotypic covariance between two traits 1 and 2

σ^2 ph1 and σ^2 ph2 are phenotypic variances for trait one and two, respectively.

## RESULTS AND DISCUSSION

Analysis of variance showed that the effect of location was significant for all measured seed quality traits except seed moisture content, and the effect of sowing date was non-significant for all traits. However, genotype effect was significant only for falling number (Table 1). The interaction of S × G was not significant for all of the studied seed quality traits (Table 1). The interaction of L × G was highly significant for seed moisture content and falling number and not significant for other measured traits (Table 1). Mean values for some investigated seed quality characters exhibited some variations between the two locations (Shambat and Hudeiba). The mean values for almost all characters were higher at Hudeiba than Shambat (Table 2). Therefore, this significant interaction between location and genotypes could be attributed to differences in length of winter season at between Hudeiba and Shambat. Also the variability in soil types between the two locations might be of great importance in causing this significant interaction between location and genotypes for moisture content and falling number.

Mean values of genotypes for seed quality characters exhibited large variations between the two sowing dates (S1 and S2). The mean values for almost all characters were higher in the first sowing date than in the second one (Table 3). This is attributed to the adverse effect of the higher terminal temperature that was imposed during the second sowing date. However, the observed non-significant differences for seed moisture content due to treatments may be attributed to the fact that almost all genotypes shortened their life span and reached physiological maturity earlier in the second sowing date at both locations. Also, the seeds were not exposed to enough high temperature during the post-harvesting and pre-testing period. Seed moisture content mainly decreased when seeds are exposed to severe stress that results in shriveled seeds or when stored at elevated degrees of temperature.

The observed highly significant differences among genotypes for falling number could be attributed to differences among genotypes in the grain size. On the other hand the highly significant effect of location for falling number may be ascribed to differences in the environmental and soil nutritional factors between both locations. Those findings are in line with Evers et al. and Evers, who reviewed the evidence for a link between large grain size and high α-amylase activity [11,12]. Results showed that genotype (1) had the highest falling number at both locations which indicates that it has the lowest α-amylase content, while genotype (56) had the lowest falling number at both locations that indicates it has the highest α- amylase content (Table 4).

The non-significant differences between sowing dates for seed germination % and rate of germination may be due to the fact that the difference in temperature between the two sowing dates was not severe enough to affect percentage and rate of germination. On the other hand, Delouche [13], Hasan et al. [4] reported that seed germination and vigor rapidly decreased in seeds exposed to adverse environmental conditions. However, the effect of location was significant for both traits, which could be attributed to the relatively longer winter at Hudieba than at shambat, which consequently would affect the grain filling period, that increase usually germination percentage and seed vigor.

The negative and positive correlations between seed quality traits and yield and its components at Shambat and Hudeiba may be attributed to the differences of environmental conditions during grain filling at both locations, however, falling number was positively correlated with rate of germination at both locations (Table 5). Medcalf et al. found consistent differences among varieties of spring wheat, indicating a definite varietal factor, which affected falling number values, which indicates that this trait although is affected by environment is highly influenced by the genetic factors [14]. The

**Table 1**: Mean squares of different wheat seed quality traits for Location (L), sowing date (S), Genotype (G) and their interactions (S × G) and (L × G)

| No. | Character | Mean squares MS | | | | |
|---|---|---|---|---|---|---|
| | | Location (L) df=(1) | Sowing date (S) df=(1) | Genotype (G) df=(11) | S × G df=(11) | L × G df=(11) |
| **1.** | Seed moisture content% | 0.53 ns | 0.11 ns | 0.2 ns | 0.04 ns | $0.0803^{**}$ |
| **2.** | Falling number | $49368^{**}$ | 297.5 ns | $45417.9^{**}$ | 484 ns | $8506.238^{**}$ |
| **3.** | Seed germination% | $2.4^{*}$ | 1.6 ns | 0.5 ns | 0.3 ns | 0.503 ns |
| **4.** | Rate of germination | $2.2^{**}$ | 1.7 ns | 0.16 ns | 0.14 ns | 0.112 ns |

$^{**}$ Significant at probability p=0.01; $^{*}$ Significant at probability p=0.05; ns not significant

**Table 2:** Means of 12 genotypes for seed quality traits at two locations (Shambat and Hudeiba) during the growing season 2012/2013

| No. | Trait | Shambat | Hudeiba | Mean | LSD |
|---|---|---|---|---|---|
| 1. | Seed moisture content | 6.90 | 7.10 | 7.00 | 0.20 |
| 2. | Falling number | 471.70 | 517.10 | 494.4 | 14.03 |
| 3. | Seed germination% | 99.30 | 99.10 | 99.2 | 0.32 |
| 4. | Rate of germination | 4.80 | 5.10 | 5.00 | 0.14 |

**Table 3:** Means of 12 genotypes for seed quality traits evaluated at two sowing dates (S1, S2) during the growing season 2012/2013

| No. | Trait | S1 | S2 | Mean | LSD |
|---|---|---|---|---|---|
| 1. | Seed moisture content% | 7.10 | 7.10 | 7.10 | 0.20 |
| 2. | Falling number | 496.20 | 492.60 | 494.40 | 14.03 |
| 3. | Seed germination% | 99.30 | 99.01 | 99.20 | 0.30 |
| 4. | Rate of germination | 4.90 | 5.10 | 5.00 | 0.10 |

**Table 4:** Means of seed quality traits for 12 genotypes of wheat, averaged at two different sowing dates (S1 and S2) at two locations (Shambat and Hudeiba) during 2012/2013

| Genotype | Seed Moisture content (%) | | Falling number | | Seed germination (%) | | Germination rate | |
|---|---|---|---|---|---|---|---|---|
| | Shambat | Hudeiba | Shambat | Hudeiba | Shambat | Hudeiba | Shambat | Hudeiba |
| 1 | $6.6^{d}$ | $7.6^{ab}$ | $558.3^{a}$ | $754.0^{a}$ | $99.3^{a}$ | $98.8^{a}$ | $5.0^{a}$ | $5.5^{a}$ |
| 14 | $6.8^{cd}$ | $7.5^{ab}$ | $490.3^{bcde}$ | $546.0^{cd}$ | $99.5^{a}$ | $98.6^{a}$ | $4.8^{a}$ | $5.1^{a}$ |
| 16 | $6.8^{cd}$ | $7.2^{abcd}$ | $536.3^{ab}$ | $573.0^{bc}$ | $99.5^{a}$ | $98.3^{a}$ | $4.8^{a}$ | $5.3^{a}$ |
| 33 | $6.8^{cd}$ | $7.7^{a}$ | $525.3^{abc}$ | $499.0^{de}$ | $99.2^{a}$ | $99.1^{a}$ | $4.7^{a}$ | $5.3^{a}$ |
| 41 | $7.2^{ab}$ | $6.4^{a}$ | $447.3^{de}$ | $462.3^{df}$ | $99.6^{a}$ | $98.7^{a}$ | $4.8^{a}$ | $5.0^{a}$ |
| 53 | $7.0^{bc}$ | $6.6^{ed}$ | $389.3^{f}$ | $430.0^{f}$ | $99.3^{a}$ | $99.5^{a}$ | $5.0^{a}$ | $5.1^{a}$ |
| 56 | $7.3^{a}$ | $6.9^{cde}$ | $364.8^{f}$ | $368.8^{g}$ | $99.3^{a}$ | $99.3^{a}$ | $4.8^{a}$ | $4.7^{a}$ |
| 63 | $7.2^{ab}$ | $6.9^{bcde}$ | $444.3^{e}$ | $460.0^{ef}$ | $99.6^{a}$ | $99.4^{a}$ | $4.8^{a}$ | $4.9^{a}$ |
| 67 | $7.0^{abc}$ | $6.6^{de}$ | $494.5^{bcd}$ | $456.0^{ef}$ | $99.3^{a}$ | $99.3^{a}$ | $5.1^{a}$ | $5.2^{a}$ |
| 83 | $6.7^{cd}$ | $7.5^{abc}$ | $441.8^{e}$ | $493.0^{def}$ | $99.5^{a}$ | $98.7^{a}$ | $4.8^{a}$ | $5.4^{a}$ |
| 86 | $7.1^{abc}$ | $6.6^{de}$ | $482.8^{cde}$ | $541.5^{cd}$ | $99.7^{a}$ | $99.0^{a}$ | $4.7^{a}$ | $5.1^{a}$ |
| 95 | $6.8^{cd}$ | $7.4^{abc}$ | $486.3^{cde}$ | $621.5^{b}$ | $99.2^{a}$ | $99.5^{a}$ | $4.8^{a}$ | $5.0^{a}$ |
| Mean | 6.9 | 7.1 | 471.7 | 517.1 | $99.3^{a}$ | $99.0^{a}$ | 4.9 | 5.1 |
| C.V (%) | 2.7 | 5.7 | 6.3 | 7.7 | 0.6 | 0.9 | 3.9 | 7.7 |

Means within column or row followed by the same letter(s) are not significantly different at 0.05 probability level according to Duncan's Multiple Range test

**Table 5:** Correlation between different seed quality traits of 12 genotypes of wheat averaged over two sowing dates, during the season 2012/2013, at two locations; Shambat (under diagonal) and Hudeiba (above diagonal)

| Traits | Grain yield | Seed moisture content | Falling number | Seed germination | Rate of germination |
|---|---|---|---|---|---|
| **Grain yield** | - | 0.33 | 0.20 | -0.51 | -0.15 |
| **Seed moisture content** | 0.08 | - | 0.56 | -0.30 | 0.50 |
| **Falling number** | 0.34 | $-0.71^{**}$ | - | -0.37 | $0.60^{*}$ |
| **Seed germination** | $0.63^{*}$ | 0.43 | 0.14 | - | -0.52 |
| **Rate of germination** | -0.46 | -0.16 | 0.14 | 0.03 | - |

results also showed that location of growth and environmental conditions at harvest significantly affected the falling number values observed.

## CONCLUSION

It could be concluded that the effect of location on the studied seed quality traits was more prominent than that of sowing date. Moreover, the only significant differences among the genotypes for falling number, indicating its high heritability compared to other the traits. In addition, the significant interaction of location with genotype for only moisture content and falling number, indicating the different the two traits reopened differently with respect to location. The positive correlation of the falling number with rate of germination at both locations, indicating that any increase in falling number will lead to an improvement of rate of germination and thus seed vigor. Nevertheless, more investigations and research studies are needed with other genotypes and under a range of sowing dates.

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