Multi-environmental evaluation of wheat tetraploid genotypes for agronomic traits under rainfed conditions in Syria

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ABSTRACT
This study was conducted at Homs, Al-Swaida and Tartous, General Commission for Scientific Agricultural Research, Syria during 2016/2017 season. Seven wheat genotypes were planted under rainfed conditions in randomized complete block design with three replications. Studied traits were days to maturity, plant height, number of grain per spike, grain weight per spike, 1000 kernel weight and grain yield per plant to evaluate variance between genotypes and locations. Results showed existence of high variance between studied genotypes in all traits especially plant height. It resulted that genotype W 45193 was significantly superior in grain yield per plant with an increasing rate of 69.62% comparing to control Sham 5. Also, it was significantly superior in spike numbers with an increasing rate of 53.53%, 57.24% compared to both controls Sham 3 and Sham 5, respectively. Genotype W 45064 was significantly superior in grain weight per spike and 1000 kernel weight compare to both controls Sham 3 and Sham 5. W 45194 was significantly superior in 1000 kernel weight comparing to control Sham 5 (36.34, 31.16 g), respectively. Furthermore, all studied traits (except spike number per plant) were more significant in Tartous compare to both Homs and Al-Swaida.

KEYWORDS: Genotypes, locations, rainfed, tetraploid wheat, agronomic traits

INTRODUCTION
Durum wheat is considered as the most important crop in the Mediterranean region [1], where the cultivated area is about 40% of the world cultivated area of durum wheat [2]. Durum wheat contributes to the improvement of the food industry like biscuits, pasta and healthy children food [3]. Breeding programs of durum wheat receive remarkable attention from Scientists [4] to develop high-yield new varieties adapted to different environments [5]. Recent varieties of wheat are described on a narrow genetic basis, so it is necessary to evaluate more different genotypes to find out new variations and exploit them in a breeding program [6]. In genetic resources programs, the attention to the first ancient cultivated types of wheat or so-called primitive wheat has increased globally for their importance especially in the aspect of healthy food [7]. Wheat breeders specified Triticum polonicum as a proper genetic resource to enhance nutrition value of modern varieties of wheat, and could be used in genetic bio-fortification of durum wheat and bread wheat [8]. Triticum carthlicum has been recommended as one of the best favorable donors to improve bread wheat [9,10]. The usage of ancient wheat (Triticum polonicum and Triticum carthlicum) in hybridization with new wheat varieties is effective under drought stress environments as mentioned by [11]. Many researchers found significant variations in maturity, plant height and grain weight between durum wheat genotypes [12]. Significant variations were found in grain yield between wheat genotypes and locations and the interaction between them [13]. Results of [14] showed variations in many traits such as grain yield, spike number and plant height between different durum wheat genotypes. After evaluating many wheat genotypes, [15] found that the significant variations in the grain yield and

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1000 kernel weight could be used in a breeding program. [16] studied some agronomic and quantity traits between 21 wheat genotypes, their results referred to significant variations in all studied traits such as spike number, weight and number of grains per spike, 1000 kernel weight and grain yield. Also, [17] and [18] found important variations in spike number, spike length, spike peduncle length and grain number per spike between wheat genotypes which were evaluated in many environments. The objectives of this research were to (i) evaluate the variance in studied traits between local and exotic ancient genotypes and locations, (ii) define the best genotypes (in studied traits) and (iii) broaden the narrow genetic basis in recent cultivated varieties.

**MATERIALS AND METHODS**

**Plant Material**

Seven wheat genotypes (five ancient cultivated wheats) and two improved varieties sham 3 and sham 5 used as controls since they are both high yielded and drought tolerant) originated from different countries were used in this study (Table 1). Genotypes are conserved in the national Syrian genebank at the general commission for scientific agricultural research (GCSAR), Syria.

**Field Experiments**

This study was conducted at the three research centers in Homs (middle of Syria), Al-Swaida (Southern Syria) and Tartous (Western Syria) which all belong to the general commission for scientific agricultural research (GCSAR), Syria during the 2016/2017 growing season under rainfed condition in a randomized complete block design (RCBD), with three replicates, all agronomic practices were applied at each location according to the recommendations of Syrian agrarian ministry.

| No | Genotype name | Scientific name          | Origin          |
|----|---------------|--------------------------|-----------------|
| 1  | W 45049       | *Triticum carthlicum*     | Turkey          |
| 2  | W 45057       | *Triticum carthlicum*     | Turkey          |
| 3  | W 45064       | *Triticum carthlicum*     | Syria           |
| 4  | W 45193       | *Triticum polanicum*      | CIMMYT (unknown orijion) |
| 5  | W 45194       | *Triticum polanicum*      | CIMMYT (unknown orijion) |
| 6  | Sham 3        | *Triticum durum*          | Syria           |
| 7  | Sham 5        | *Triticum durum*          | Syria           |

Table 1: List of wheat genotypes used in this study

| Source of Variation | df | SNP | GNP | TKW | GYP |
|---------------------|----|-----|-----|-----|-----|
| G                   | 6  | 21.482* | 133.29* | 653.08* | 65.86* |
| L                   | 2  | 194.79* | 2635.40* | 1238.67* |
| G × L               | 12 | 21.535* | 177.84* | 107.31* | 58.32* |
| L.S.D G             | 1.757 | 4.244 | 12.467 | 5.998 | 10.113 |
| L.S.D L             | 1.150 | 4.244 | 12.467 | 5.998 | 10.113 |

Table 2: Analysis of variance for studied traits

Each plot contained six rows, 1 m length, 25 cm distance between rows and 5 cm distance between plants in the same row. The depth of planting was 3-5 cm. The following traits were studied at plant maturity: Days to maturity, plant height (cm), spike number per plant, grain number per spike, grain weight per spike (g), 1000 kernel weight (g) and grain yield per plant (g) [19].

**Statistical Analysis**

Results analysis was made using Genstat.12 analytical program using the least significant differences test (LSD) at 0.05 in studied traits for comparison between genotypes and between locations.

**RESULTS**

Analysis of variance at 0.05 revealed significant variations between genotypes and locations and their interaction in all studied traits (Table 2). The mean of studied traits at three locations is recorded in Table 3. Change percent of trait means comparing to both controls are reported in Table 4, in which

\[
\text{Change\%} = \left( \frac{\text{mean of trait} - \text{mean of control}}{\text{mean of control}} \right) \times 100.
\]

**Days to Maturity**

Genotypes ranged from the earliest matured Sham 5 with 141 days to the latest matured W 45064 with 149.9 days, with a grand mean 144.52 day (Table 3). Although significant variation was found between genotypes, none of the ancient wheat was superior compared to both controls Sham 5 and Sham 3 which needed 141.0, 141.3 days, respectively to maturity (Table 4).

Plants were significantly earliest matured at Tartous (130.86 days) compared to Al-Swaida, respectively 139.29 days, and Homs 163.43 days, respectively (Fig. 1).

**Plant Height**

Variation was found between genotypes in plant height which ranged from the shortest plants 68.51 cm in control Sham 3 to the tallest plants 102.01 cm (W 45064), with grand mean 85.79 cm. Three genotypes (W45064, W45193 and W45057) had plant height (102.1, 97.64 and 92.77 cm), respectively afforded significant accumulation in plant height reached to 48.89, 42.52 and 35.41% compare to control Sham 3 which had...
Table 3: Means of studied traits at three locations

| Genotype | MD | PH |
|----------|----|----|
|          | Ho | AIS | Tar | Mean | Ho | AIS | Tar | Mean |
| W45049   | 164.33 | 138.33 | 130.00 | 144.2 | 54.77 | 51.90 | 114.90 | 73.86 |
| W45057   | 162.00 | 136.67 | 130.00 | 142.9 | 94.33 | 55.47 | 128.50 | 92.77 |
| W45064   | 169.00 | 140.67 | 140.00 | 149.9 | 92.33 | 64.80 | 148.90 | 102.01 |
| W45193   | 164.33 | 139.33 | 140.00 | 147.9 | 89.17 | 57.10 | 146.67 | 97.64 |
| W45194   | 162.00 | 141.33 | 130.00 | 144.4 | 62.73 | 58.67 | 130.93 | 84.11 |
| Sham3    | 162.00 | 139.00 | 123.00 | 141.3 | 65.63 | 54.00 | 85.90 | 68.51 |
| Sham5    | 160.33 | 139.67 | 123.00 | 141.0 | 86.43 | 64.33 | 94.10 | 81.62 |
| Mean     | 163.43 | 139.29 | 130.86 | 144.52 | 77.91 | 58.04 | 121.41 | 85.79 |

Where: Ho Homs, AIS AlSwaida, Tar Tartous, MD days to maturity, PH plant height, SNP spike number per plant, GNS grain number per spike, TKW 1000 kernal weight, GYP grain yield per plant

plant height (68.51 cm). The later genotypes also had an increase in plant height in rate of 24.98, 19.63 and 13.66% compared to the second control Sham 5 which its plant height was 81.62 cm. Also, the genotype W45194 with plant height 84.11 cm showed a significant increase rate of 22.77% comparing to Sham 3. Also, results revealed that the mean of plant height at Tartous was significantly the highest, then at Homs and finally at Al-Swaida with 121.41, 77.91 and 58.04 cm, respectively (Figure 1).

**Spike Number per Plant**

This trait varied from the lowest value (5.944 spikes per plant) in the genotype W45064 to the highest value of (10.867 spikes per plant) in the genotype W45193, with a grand mean of 7.70 spike per plant. It resulted that the genotype W45193 was significantly superior in spikes per plant (10.867) with an increased rate of 53.53% compared to control Sham 3 that had (7.078 spikes per plant), and 57.24% compared to control Sham 5 which had (6.911 spikes per plant). Spike number per plant was significantly higher at Homs, followed by Tartous, then Al-Swaida 10.91, 7.33 and 4.86 spike, respectively (Figure 2).

**Grain Number per Spike**

The range of grain number per spike varied from 32.93 grains per spike in the genotype W45194 to 45.00 grains per spike in control

![Figure 1: Variation in days to maturity and plant height between locations.](image)

Where: a, b, c refers to the sort of means at significans level 0.05 (ascending for days to maturity and descending for plant height)

Sham 3, with a grand mean 37.44 grains per spike. Results showed that none of the genotypes were significantly superior compared to both controls. Grain number per spike was higher at both Tartous and Al-Swaida with no significant differences (43.38, 43.43 grains per spike, respectively). However, at Homs 24.52 grain per spike with significant differences compared to other locations (Figure 2).

**1000 Kernal Weight**

Genotypes differed in 1000 kernal weight from the lowest weight of 31.16 g in control Sham 3 to the highest weight of 55.46 g in the
Table 4: Change% of trait means comparing to controls

| Genotype | Mean | Change% comparing to | Mean | Change% comparing to |
|----------|------|----------------------|------|----------------------|
|          | MD   | Sham3 | Sham5 | PH  | Sham3 | Sham5 |
| W45049   | 144.2| 2.05  | 2.27  | 73.86 | 7.81  | -9.51 |
| W45057   | 142.9| 1.13  | 1.35  | 92.77 | 35.41 | 13.66 |
| W45064   | 149.9| 6.09  | 6.31  | 102.01| 48.90 | 24.98 |
| W45193   | 147.9| 4.67  | 4.89  | 97.64 | 42.52 | 19.63 |
| W45194   | 144.4| 2.19  | 2.41  | 84.11 | 22.77 | 3.05  |
| Sham3    | 143.3|       |       | 68.51 |       |       |
| Sham5    | 141.0|       |       | 81.62 |       |       |

| Genotype | SNP | GNS |
|----------|-----|-----|
| W45049   | 31.42| -8.98 | 0.86 | 8.62 | -37.03 | -6.81 |
| W45057   | 36.34| 5.27  | 17.18 | 12.13 | -11.32 | 31.24 |
| W45064   | 55.46| 60.66 | 80.57 | 15.01 | 9.64  | 62.27 |
| W45193   | 33.63| -2.58 | 8.19  | 15.69 | 14.61 | 69.62 |
| W45194   | 40.76| 18.08 | 31.83 | 11.82 | -13.66 | 27.78 |
| Sham3    | 34.52|       |       | 13.69 |       |       |
| Sham5    | 31.16|       |       | 9.25  |       |       |

Where: MD days to maturity, PH plant height, SNP spike number per plant, GNS grain number per spike, TKW 1000 kernal weight, GYP grain yield per plant.

Table 5: Rainfall and temperature at three locations of this study during 2016/2017

| Location | Sept 2016 | Jan 2017 | Feb 2017 | Mar 2017 | Apr 2017 | May 2017 | Sum 2017 |
|----------|-----------|----------|----------|----------|----------|----------|----------|
| Homs     | R 114     | 72.5     | 5.7      | 49.5     | 3.7      | -        | 245.4    |
|          | H-T 10.6  | 10.7     | 14.3     | 17.4     | 23       | 26.9     |          |
|          | L-T 4.4   | 3.2      | 2.8      | 8        | 10.9     | 15.6     |          |
| Tartous  | R 277     | 194.5    | 6.2      | 92       | 18       | 587.5    |          |
|          | H-T 15.45 | 14.4     | 15.24    | 18.7     | 22.7     | 26.16    |          |
|          | L-T 7.8   | 6.58     | 7.33     | 12.45    | 11.2     | 14.83    |          |
| Al-Swaida| R 126.3   | 43.9     | 20.8     | 39.6     | 5.9      | 236.5    |          |
|          | H-T 13.74 | 13.87    | 17.4     | -28.20   | 33.90    |          |          |
|          | L-T 4.55  | 4.35     | 4.86     | -13.20   | 17.71    |          |          |

Where: R Rainfall (mm), H-T Highest temperature, L-T Lowest Temperature

DISCUSSION

Results showed the existence of high variability between genotypes in all studied traits, which agree with the results of many researchers who reported about the presence of high variability between wheat genotypes in many traits such as days to maturity [12], plant height [20], spike number per plant [21], grain number per spike [22], 1000 kernal weight [16] and grain yield per plant [23, 13]. Results revealed that the genotype W45193 was superior in the spike number per plant and this could be a result of having taller plants compared to other genotypes. This is in agreement with other scientist’s results who found that spike number per plant increased when increasing plant height [24]. Regarding 1000 kernal weight, both genotypes W45194 and W45057 were superior compared to controls and this could result in more spikes number per plant and to genetic variation [25]. The genotype W45193 was superior in grain yield as a result of being superior in two yield components which are spike number per plant and 1000 kernal.
weight comparing to controls. All studied traits were significant [26, 27] and The best was at Tartous location because of the high amount of total rainfall which was almost more than the rainfall in both other locations (Table 5), and water, as it is known, is the main reason for plant cell elongation and plant growth [28, 29].

CONCLUSION

In this study, high variability was found between studied genotypes which could be exploited in a breeding program, as the W45193 genotype was superior in the grain yield per plant and three genotypes W45064, W45057 and 45194 were superior in 1000 kernel weight. The genotype W45193 was superior in spike number per plant. Tartous location was the best for most studied traits.

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