Productivity Test of Wheat Genotypes Under Water Stress Conditions

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Abstract

A field experiment was carried out in Dhi Qar Governorate, Iraq, during the agricultural season (2020-2021), with the aim of studying the effect of water stress on the productivity of some genotypes of bread wheat. The experiment included studying the effect of four levels of water depletion from field capacity, which are 25% (W1), 50% (W2) and 75% (W3), in addition to the comparison treatment without water stress (W0), and six genotypes of bread wheat (N29, N12, Aba99, N14, N28, and Bohouth 22). The experiment was applied using the RCBD randomized complete plot design according to the split plot design with three replications. Water stress dish in lining stage. The results showed that water stress (W3) caused a significant decrease in the mean characteristics of the number of grains per spike, weight of 1000 grains, grain yield and biological yield. The compositions differed significantly among themselves if the composition N14 outperformed in the trait and yield of grain (5.390 tons ha⁻¹), biological yield (14.98 tons ha⁻¹) and weight of 1000 grains (48.10 g), while the superiority of the variety Bohouth22 in the number of grains in the spike (36.73 grains spike⁻¹). This study suggests to more cultivation of the genotypes N14, N28 and N12, which gave the best grain yield under water stress conditions in order to adopt them and expand their cultivation in Iraq, and to conduct more studies on the cultivation of genotypes of bread wheat under the influence of water stress, as well as the adoption of the variety Bohouth 22 instead of From the of Apa99 in areas that suffer from water scarcity in Iraq.

Keywords: Wheat, Genotypes, Stress, Water.

1. Introduction

Wheat (Triticum aestivum L.) is one of the important cereal crops in Iraq and the world. It ranks first in terms of economic importance, cultivated area and global production, being the main food for most of the world's population. Its importance comes because it contains gluten in grains, which is the main protein, not an adequate quality product. for the bread industry [1]. Drought is one of the biggest environmental factors facing most agricultural crops during their growth stages, which determines the production of wheat in different parts of the world, and the resulting damage depends on its intensity, duration, and the developmental stage in which the crop is exposed to drought[2]. Water stress is one of the main abiotic stresses and important environmental factors in reducing the production of crops grown in semi-arid agricultural areas. Drought affects the stages of wheat plant development, and the flowering and grain filling stage is one of the most important stages that affect the wheat yield [3]. Their study in Pakistan on genotypes cultivated under water stress conditions, concluded that drought-tolerant genotypes gave the best yield for grain compared with other varieties, and they recommended that they be multiplied in the future to enhance yields in dry areas[4].

Water stress affects the number of grains in the spike, especially in the flowering stage, as it is a critical stage in determining the number of grains in the spike, by decreasing the rate of pollination when stress occurs at this stage, and consequently the number of grains formed in the spike [5,6]. [7] confirmed that the exposure of three varieties of bread wheat to water stress in the flowering stage and the grain fullness led to a significant decrease in the number of grains in the spike, and their averages were 39.6 and 43.6 grains.Spike⁻¹. When [8] studied 3 genotypes of wheat, namely Cham1, Acad65 and Ammon in Jordan under water stress conditions, the water stress applied by irrigation when the soil moisture remained 50% and 75% of the field capacity in the soil led to a significant decrease in the average number of The grains in the spike were 40.7 and 39.98 grains. spike⁻¹ sequentially compared to the control treatment 42.18 grains. Spike⁻¹. The water stress during flowering and in the period of filling the bean reduces its weight because of reducing the representation rates associated with stomata closure and premature aging of the leaf area, shortening the period of filling the bean and decreasing the ability to fill the grains [9]. It was noted [10] that there was a significant difference in the weight of
1000 grains, as the comparison treatment gave the highest average for this trait, which amounted to 37.12 g, with an increase of 11.90% compared to the treatment of water stress by cutting off the water after the flowering stage.

The grain yield is affected by agricultural operations to serve the crop, and the grain yield is determined by three main components interconnected with each other, namely the number of ears produced, the number of grains per spike, and the weight of a single grain, which are affected by water stress [11], [12] confirmed when studied 4 cultivars of bread wheat in Saudi Arabia, namely Yocoro Rojo, Faisalabad 2008, F-10 and L-7096 under the influence of water stress to evaluate the cultivars’ ability to withstand drought when irrigated with 75% and 50% of the water requirement of the varieties, as water stress caused There was a significant decrease in the number of grains in the spike, as the variety L-7096 recorded the lowest grain yield in the spike when stressed by 50%, amounting to 1461 kg.ha\(^{-1}\), while the variety Faisalabad 2008 recorded the highest grain yield among the varieties amounting to 1819 kg.ha\(^{-1}\).

The biological yield of the plant is affected by water stress because it affects its components which are the leaves, stems and seeds [13]. It was found [14] that when the wheat crop was subjected to water stress by adding irrigation water 50% of the value of the field capacity, the biological yield decreased to 13.90 tons. ha\(^{-1}\); comparison in the control treatment without water stress, which recorded 14.30 tons, ha\(^{-1}\).

The research aims to determine and select the genotype most capable of tolerating water stress in Iraq to improve grain yield under water stress conditions.

2. Material and Methods

2.1 Experimental Site and Soil Characteristics

This study was conducted in Dhi Qar Governorate / Iraq by cultivating 6 genotypes of bread wheat (Triticum aestivum L.) during the agricultural season 2020-2021. Some physical and chemical properties were estimated according to standard methods[15]. The soil was Sandy clay loam, having pH 7.90, electrical conductivity (EC) 1.80 dSm\(^{-1}\), organic matter content 6.34 g.kg\(^{-1}\), available P 18.22 mg.kg\(^{-1}\), available K 213.20 mg.kg\(^{-1}\), and available N 32.90 mg.kg\(^{-1}\). The field capacity of the soil is 35% and the wilting point is 15%. A pressure plate device was used, applying a pressure of 0.33 bar and a pressure of 15 bar on the soil samples.

2.2 Experimental Design and Treatments

Six genotypes of bread wheat namely, N29, N12, papa 99, N14, N28, and Bohuth 22, symbolized by the symbols V1, V2, V3, V4, V5 and V6, respectively, are shown in Table 1. Water stress, is denoted by W, if it is divided into four levels of water depletion, namely (W1) 25%, (W2) 50% and (W3) 75% of the field capacity of the soil, and the control treatment W0 without exposing the cultivated structures to water stress, and the treatment is carried out from the lining stage for all the experimental plants. Using a randomized complete block design (RCBD) according to the arrangement of the split panels (Split-plot design) and with three replications, the water stress levels occupied the main panels (Main - plots), While the genotypes secondary panels( Sub - plots ). The six genotypes distributed randomly within each experimental unit.

| Field code | Genotypes name | Processing side | seed source |
|------------|----------------|-----------------|-------------|
| V1         | N29            | Seed Inspection and Certification | Entrance from ICARDA |
| V2         | N12            | Seed Inspection and Certification | Entrance from ICARDA |
| V3         | Apa99          | Seed Inspection and Certification | A certified |
| V4         | N14            | Seed Inspection and Certification | Entrance from ICARDA |
| V5         | N28            | Seed Inspection and Certification | Entrance from ICARDA |
| V6         | buhuth 22      | Seed Inspection and Certification | A certified |

2.3 Field Operations

The land preparation operations were carried out before planting and the plowing of the land allocated for the experiment. The land was leveled and divided into boards according to the design used and the shoulders were made between the boards, leaving a distance of 2 meters between the main boards and between a sector and another to maintain that the levels of water stress did not overlap between the experimental units. The area of the experimental unit was (1.5 * 6 m). Each installation was planted with four lines, as the length of one line is 1.5 m, the distance between one line and another is 20 cm, and the distance between one installation and another is 40 cm, with a seed quantity of 30 kg / acre. The experiment land was fertilized before planting with triple super phosphate fertilizer 46% P\(_2\)O\(_5\) at once with an amount of 100 kg ha\(^{-1}\), and potassium.
fertilizer was added in the form of potassium sulfate (42% K₂O) with an amount of 100 kg ha⁻¹. After planting, two batches in the form of urea 46% with an amount of 200 kg ha⁻¹ [16].

2.4 Irrigation and calculation of added water quantities

Soil samples were taken from different areas of all cultivated experimental panels and placed in aluminum cans and weighed while wet, then placed in a microwave oven for twelve minutes after the drying time was set with the electric oven at 105 degrees according to the method proposed by [17] to dry the samples. The moisture content is extracted according to the equation in [18].

\[ p_w = \frac{(M_{sw} - M_s)}{M_s} \times 100 \]  

Since: \( p_w \) = weight percentage of moisture, and \( M_{sw} \) = mass of wet soil (g), and \( M_s \) = dry soil mass (g). The volumetric moisture content was calculated using the following equation:

\[ Q_v = Q_w \times \frac{\rho_b}{\rho_w} \]  

As \( Q_v \) = volumetric moisture content, \( Q_w \) = moisture content on the basis of weight, and \( \rho_b \) = bulk density (Mg. m⁻³). Irrigation was carried out using plastic tubes connected to an electric pump, and a meter was installed on the tube to measure the water passing through the tube in liters. Equal amounts of water were added to all the panels when planting, then the treated plants were subjected to water stress in the lining stage except for the control treatment, as irrigation is done when (20, 50 and 75)% of the field capacity is depleted, and the added amount to the panel is calculated according to [19] equation.

\[ w = a \times \left( \frac{100}{\frac{\% P_w}{\rho w} - \% P_w} \right) \times D \]  

So: \( W \) = the volume of water to be added during irrigation (m³) and \( a \) = irrigated area (m²) and \( \rho_b \) = bulk density (micgrams. m⁻³) and \( \% P_w \) = percentage of soil moisture on the basis of weight at field capacity (after irrigation) and \( \% P_w \) = Soil moisture percentage before watering and \( D \) = soil depth (m).

2.5 Studied Attributes

The studied traits were; the number of grains per spike was calculated as the average number of grains for ten spikes, which were randomly selected within the harvested plot and then returned to the yield. Taken 1000 grains manually from the quotient of the area previously harvested for each secondary experimental unit and were weighed with a sensitive scale to represent the weight of 1000 grains and then returned to the grain. The grain yield, as it was obtained from the dry matter yield (grain + straw) from the harvested area for each secondary experimental unit, and the weight was converted to a ton ha⁻¹. The biological yield, as it was obtained from the dry matter yield (grain + straw) from the harvested area for each secondary experimental unit, and the weight was converted to a ton ha⁻¹.

2.6 Statistical Analysis

After collecting, reducing and tabulating the data, it was statistically analyzed using the GENESTAT program according to the data analysis tool, and the averages of the coefficients were compared using the Least Significant Difference (LSD) test at the probability level of 0.05.

3. Results

3.1 Number of grains per spike

The results of Table 2 indicate a significant decrease in the average number of grains per spike. The average number of grains in the spike of plants was 30.02 grain spike⁻¹ when water depleted 75% of the field capacity of the soil, while the water depletion 50% and 25% gave an average of 34.43 and 35.99 grain spike⁻¹ respectively. The average number grains for the control treatment (W0) was 38.59 grains of spike⁻¹. The results also indicate in (Table 1) that there is a significant difference between the cultivated structures, as the cultivar Bohouth 22 recorded the highest average for this trait amounting to 36.73 grains of spike⁻¹ and it did not differ significantly from the structure N14 and Apa 99, N28 and N12, while the genotype N29 gave the lowest average of this trait reached 31.24 grains of spike⁻¹. It is clear from (Table 1) that there is no significant interaction between the two factors of the study.
Table 2. Effect of water stress and Genotypes and the interaction between them on the number of grains spike⁻¹.

| Genotypes (G) | W0   | W1   | W2   | W3   | Average (G) |
|---------------|------|------|------|------|-------------|
| N29           | 33.17| 33.30| 32.43| 26.07| 31.24       |
| N12           | 39.57| 34.67| 34.27| 30.23| 34.68       |
| Aba99         | 39.9 | 37.60| 36.57| 28.77| 35.73       |
| N14           | 38.33| 35.23| 34.30| 31.77| 34.91       |
| N28           | 38.57| 37.13| 33.73| 31.67| 35.27       |
| Bohouth22     | 41.97| 38.03| 35.30| 31.60| 36.73       |

Average water stress (w): 38.59 35.99 34.43 30.02
LSD (p < 0.05) for Genotypes (G): 3.294
LSD (p < 0.05) water stress (w): 2.223
LSD (w X G): N.S

3.2 Weight of 1000 grains (g)

The results of Table 3 indicate a significant decrease in the average weight of 1000 grains for the level of water stress 75% of the field capacity in the soil, as the average of this trait was 41.00 g, compared to the levels of moisture depletion 50% and 25%, which gave an average of this trait 43.80 and 44.50 g, respectively, while the comparison treatment recorded the highest average for this trait amounted to 46.08 g. The results in (Table 3) indicated that there was a significant difference in the average weight of 1000 grains for the genotypes of the cultivated treatments. The compositions N14 and N12 recorded the highest average for this trait, which amounted to 48.10 g and 47.59 g, respectively. While The compositions N28 and Aba99 gave the lowest average for this trait amounted to 40.21 g and 40.40 g, respectively. The results showed in (Table 3) that there was a significant difference for the interaction between water stress and the cultivated structures, as the W0W2 treatment recorded the highest weight of 1000 grains amounted to 51.31 g, while the interaction treatment W3V3 recorded the lowest weight for this trait amounted to 37.24 g.

Table 3. Effect of water stress and genotypes and the interaction between them on the weight of 1000 grains (gm).

| Genotypes (G) | W0    | W1    | W2    | W3    | Average (G) |
|---------------|-------|-------|-------|-------|-------------|
| N29           | 49.78 | 47.23 | 47.03 | 39.42 | 45.86       |
| N12           | 51.31 | 47.13 | 46.96 | 44.98 | 47.59       |
| Aba99         | 42.49 | 42.44 | 39.45 | 37.24 | 40.40       |
| N14           | 49.14 | 48.88 | 48.45 | 45.92 | 48.10       |
| N28           | 40.96 | 40.77 | 40.39 | 38.73 | 40.21       |
| Bohouth22     | 42.82 | 40.54 | 40.50 | 39.70 | 40.89       |

Average water stress (w): 46.08 44.50 43.80 41.00
LSD (p < 0.05) for Genotypes (G): 1.548
LSD (p < 0.05) water stress (w): 1.302
LSD (w X G): 3.012

3.3 Grain yield (ton ha⁻¹)

The results of Table 4 indicate a significant decrease in the average grain yield, as the average grain yield was 3.99 tons ha⁻¹ in the treatment of water depletion 75% of the field capacity, while the average for this trait was 4.69 and 5.07 tons ha⁻¹ at The level of depletion is 50% and 25%, respectively, and the comparison treatment recorded the highest average for this trait, as it reached 5.45 tons ha⁻¹. It was found through the results in (Table 4) to a significant difference between the average grain yield of the genotypes grown in the experiment, as the two constructs N29 and Aba99 gave the lowest average grain yield of 4.349 tons ha⁻¹ and 4.463 tons ha⁻¹, respectively. While the combinations N14 and N28 gave the highest mean The grain yield was 5.390 tons ha⁻¹ and 5.11 tons ha⁻¹, respectively. It is clear from the (Table 4) that there is no significant overlap between the two factors of the study.
Table 4. Effect of water stress and genotypes and the interaction between them on grain yield tons ha\(^{-1}\).

| Genotypes (G) | W0   | W1   | W2   | W3   | Average(G) |
|---------------|------|------|------|------|------------|
| N29           | 4.87 | 4.79 | 4.11 | 3.62 | 4.34       |
| N12           | 5.36 | 5.12 | 5.07 | 4.12 | 4.92       |
| Aba99         | 5.37 | 4.76 | 4.19 | 3.52 | 4.46       |
| N14           | 5.97 | 5.49 | 5.46 | 4.63 | 5.39       |
| N28           | 5.82 | 5.55 | 5.06 | 4.03 | 5.11       |
| Bohouth22     | 5.31 | 4.74 | 4.27 | 4.03 | 4.59       |

Average water stress(w) 5.45 5.07 4.69 3.99

LSD (p < 0.05) for Genotypes (G) 0.392

LSD (p < 0.05) water stress(w) 0.58

LSD (w X G) N.S

3.4 Biological yield (ton ha\(^{-1}\))

The results of Table 5 indicate a significant decrease in the biological yield. The average yield was 12.27 tons ha\(^{-1}\) at the water depletion level, 75% of the field capacity of the soil, while the average for this trait was 13.65 and 14.51 tons ha\(^{-1}\) at the depletion level, 50% and 25% water respectively, and the comparison treatment recorded the highest average for this trait, as it reached 15.24 tons ha\(^{-1}\).

The results in Table 5 showed a significant difference between the average biological yield of the genotypes grown in the experiment, as the composition N29 and the variety Aba 99 gave the lowest average for this trait amounting to 12.91 tons ha\(^{-1}\) and 13.23 tons ha\(^{-1}\), respectively. While the formulations N14 and N28 recorded the highest average for this trait amounting to 15.00 tons ha\(^{-1}\) and 14.49 tons ha\(^{-1}\), respectively. It is clear from the (table 5) that there is no significant interaction between the two factors of the study.

Table 5. Effect of water stress and genotypes and the interaction between them on the biological yield tons ha\(^{-1}\).

| Genotypes (G) | W0   | W1   | W2   | W3   | Average(G) |
|---------------|------|------|------|------|------------|
| N29           | 13.75| 13.59| 12.33| 11.99| 12.91      |
| N12           | 15.29| 14.94| 14.78| 12.49| 14.37      |
| Aba99         | 15.16| 13.81| 12.28| 11.67| 13.23      |
| N14           | 16.11| 15.24| 15.14| 13.52| 15.00      |
| N28           | 16.04| 15.42| 14.67| 11.84| 14.49      |
| Bohouth22     | 15.09| 14.39| 12.78| 12.11| 13.59      |

Average water stress(w) 15.24 14.56 13.66 12.27

LSD (p < 0.05) for Genotypes (G) 0.697

LSD (p < 0.05) water stress(w) 0.874

LSD (w X G) N.S

4. Discussion

The current study showed a significant decrease in the number of grains in the spike under the influence of water stress in (Table 2). The reason may be due to water stress in the flowering stage, which led to a decrease in the number of fertile florets and the percentage of pollination, and thus a decrease in the number of grains in the spike [20]. Studies have indicated that the effect of water stress leads to a reduction in the number of grains in the wheat plant [21]. The cultivated genotypes differed among themselves with the number of grains in the spike, and the reason may be due to the difference in the structures between them in the growth characteristics and their difference in the number of spikes in the spike and their impact on water stress [22].

There was a significant decrease in the weight of 1000 grains under the influence of water stress (Table 3). This may be because the increase in water stress during the flowering stage and during the grain’s filling period led to a decrease in the efficiency of photosynthesis resulting from closing the stomata, a decrease in the area of the flag leaf and premature aging of the leaves, thus reducing the filling time bean [23,24]. The varieties differed morally among themselves in the weight of 1000 grains, and the reason may be due to the difference in the compositions in this trait [25]. As these genotypes that resisted drought reduced the loss of water from the leaves through evaporation, and thus were able to retain water and improve their yield by increasing the period needed to fill the grains and increasing their weight [26].
The study showed a significant decrease in the grain yield under the influence of water stress (Table 4). This may be due to the fact that water stress led to a decrease in the weight and number of grains [27], as it was found that the relationship between water stress and the number and weight of grains is an inverse relationship in the results (Table 2 and 3) the moral decrease in the number of grains and the weight of a thousand grains, Studies have indicated that water stress reduces grain yield, and the higher the intensity of stress, the lower grain yield [28]. The compositions differed significantly in the grain yield, and the reason may be due to the differences among the varieties in growth characteristics and yield [29]. As the structures sensitive to drought close the stomata, the absorption of water and nutrients from the soil solution decreases, photosynthesis decreases and leads to a decrease in yield [30], while the drought-resistant compositions, photosynthesis continues and increases the yield of the crop [31]. The study showed a significant decrease in biological yield under the influence of water stress (Table 5). The reason may be that water stress had a significant effect on plant growth and grain yield as shown in (Table 4), which led to a decrease in biological yield [32]. The compositions also differed significantly among themselves in the biological yield. The reason may be for difference in plant height and grain yield [33].

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