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# EVALUATION OF BREAD WHEAT CULTIVARS IN TERMS OF SPIKE AND YIELD PROPERTIES UNDER VARIOUS CONCENTRATIONS OF SOIL AND FOLIAR FERTILIZATION

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**Abstract**

This study was carried out at the farms of Field Crops department, College of Agricultural Engineering Sciences, University of Duhok during the growing season 2021/2022 season. Three bread wheat (*Triticum aestivum* L.); Ceyhan-99, Adana-99 and Tamuz-2 varieties were used sown under four levels (Control, Low, recommended and high) of soil and foliar fertilization. The experiment was designed as Split Plots and arranged in Randomized Complete Block Designs (RCBD) with four replications. Wheat cultivars considered the main plots, fertilization methods the sub-plots and the fertilizer concentrations the sub-sub-plots.

The results of this study revealed significant differences of the wheat cultivars in most of the spike characteristics and mainly spike length and spike biomass; Ceyhan-99 and Tamuz-2 cultivars were superior and produced highest spike biomass; 10.82 and 10.68 $g.spike^{-1}$ respectively compared to the inferior cultivar in this trait (Adana-99). On the other hand, the effect of foliar fertilization was non-significant on most of spike characters. The application of soil fertilization surpassed foliar fertilization for producing higher number of tillers per unit area; 399 spikes compared to 375 tillers per square meter respectively. The effect of fertilization method and their concentrations were significant on final biomass per unit area; soil fertilizer recorded highest biomass yield than foliar fertilizer and each produced 5.70 $t.ha^{-1}$ and 5.01 $t.ha^{-1}$ respectively. Also, both

recommended (5.36 $t.ha^{-1}$) and high concentrations of fertilization (5.63 $t.ha^{-1}$) recorded higher yield of biomass compared to control (4.74 $t.ha^{-1}$) and low concentrations (4.78 $t.ha^{-1}$) of fertilization. Ceyhan-99 cultivar in soil fertilization recorded highest final grain yield (1.69 $t.ha^{-1}$) compared to Tamuz-2 in soil fertilizer which recorded lowest final grain yield (1.15 $t.ha^{-1}$). Based on the obtained results in this study, the cultivar Ceyhan-99 and soil form of fertilization is recommended under similar conditions of this study and further study under different rainfall or irrigation regimes are suggested to have more convenient results for foliar fertilization.

**Keywords:** Wheat, Soil fertilization, Foliar fertilization, Spike, Yield.

# تقييم اصناف حنطة الخبز لصفات السنبلة والحاصل تحت مستويات مختلفة من التسميد والورقي والأرضي

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**الخلاصة**

نفذت هذه الدراسة في حقول كلية علوم الهندسة الزراعية/جامعة دهوك للموسم الزراعي 2022/2021 بهدف دراسة تأثير مستويات مختلفة من التسميد الورقي والارضي (الموصى، اقل من الموصى، اعلى من الموصى بالإضافة الى معاملة المقارنة) لعدة اصناف من حنطة الخبز (ادنة–99، جيهان–99 وتموز–2) قي تصميم القطع المنشقة ضمن القطاعات العشوائية الكاملة وبأربع مكررات حيث رتبت اصناف الحنطة في الالواح الاساسية وطرق التسميد الثانوية ومستويات التسميد تحت الثانوية.

اظهرت نتائج هذه الدراسة فروقات معنوية بين الاصناف الداخلة في الدراسة وخاصة في معظم صفات السنبلة، تفوق الصنفان جيهان–99 وتموز–2 في صفة الوزن الحيوي للسنبلة وأنتجا 10.82 و10.68 غرام للسنبلة على التوالي بالمقارنة مع الصنف ادنة–99، ومن جانب اخر فان تأثير التسميد الورقي لم يكن معنويا على صفات السنبلة. تفوق التسميد الارضي معنويا في انتاج أكبر عدد من الاشطاء او عدد السنابل في المساحة حيث اعطى 399 سنبلة بالمقارنة مع 375 سنبلة بالنسبة للسماد الورقي في المتر المربع الواحد وعلى التوالي. وكذلك تفوق طريقة التسميد الارضي معنويا على التسميد الورقي في انتاج الوزن الحيوي النهائي واعطت كل

منهما 5.7 و5.01 طن للهكتار على التوالي ولنفس الصفة تفوقت كل من التركيز الموصى والعالي بالمقارنة مع التركيز الواطئ او معاملة المقارنة.

بالنسبة لحاصل البذور النهائي، تفوق الصنف جيهان مع التسميد الورقي في صفة الحاصل النهائي واعطت 1.69 طن للهكتار بالمقارنة مع الصنف تموز-2 مع نفس طريقة التسميد حيث اعطى 1.15 طن للهكتار. وبناءً على النتائج التي تم الحصول عليها من هذه الدراسة فيمكن توصية الصنف جيهان-99 والتسميد الارضي في مثل اجواء هذه الدراسة وخاصة تحت ظروف قلة الامطار وايضا اجراء المزيد من الدراسات تحت الظروف الديمية والمواقع المختلفة وادخال الاسمدة الورقية لدعم هذه النتائج.

**كلمات مفتاحية:** السماد الورقي، السماد الارضي، الحنطة، السنبلة، الحاصل.

## Introduction

By releasing good varieties with higher yield performance and the ability to withstand drought and heat stress and pests, as well as having relatively higher efficiency of water and nutrient uptake for microclimate areas (20). Crop scientists are simultaneously addressing several cultural practices such as fertilization relating to all crops in general and wheat crop in particular in the particular region (5). (6) reported that following the green revolution, improvements in management practices, such as fertilization and breeding of new cultivars have mostly been responsible for advances in wheat production. Also, (16) discovered that in both 2015 and 2016 seasons, there were substantial differences in wheat cultivars and locations for most of growth and yield related traits of wheat. The variety evaluation and performance under rainfed circumstances was the most important study parameter in terms of yield and yield features. In this regards, (1) found significant differences amongst new varieties when compared to the locally historically grown variety. (15) recorded differences in spike counts ($m^{-2}$), spike weights (g), and grain yields (g) as a result of sowing dates of various wheat cultivars.

According to studies conducted in the Mediterranean region (12), the variety phenology is one of the key characteristics that promote agronomic adaptation. This attribute is typically correlated with earliness in terms of time to heading and anthesis. On the other hand, (2) demonstrated that using good and robust seeds in accordance with appropriate phenotyping techniques is the only method to improve breeding efficiency to face of climate-change challenges. (10). Illustrated that the variety Prodip had the highest levels of effective tillers $plant^{-1}$, spike length, number of spikelets $spike^{-1}$, fertile spikelets $spike^{-1}$, grains $spike^{-1}$, 1000-grain weight, grain yield, straw yield, and biological yield, whereas the variety Shotabdi had the highest levels of plant height and total tillers $plant^{-1}$. The variety Prodip had the highest grain yield (3.05 $t.ha^{-1}$) whereas variety Bijoy had the lowest (2.58 $t.ha^{-1}$).

According to a study of (21), wheat (*Triticum aestivum* L.) is the second most common crop in India and its leading cereals in the north-western region; it is a significant staple crop. The collected data revealed notable differences in the number of spikes/$m^2$, spike length, number of kernels per spike, weight of 1000 kernels, and

grain and straw yields/fad between the studied wheat cultivars in the two seasons. (7) investigated the effect of fertilization on wheat cultivars in a field experiment; with the increase in fertilizer levels, spike population and grain production significantly increased linearly. Fertilizer amounts had little effect on grain weight. The spike population, number of grains, and 1000 grain weight were not significantly impacted by the fertilizer types (ammonium sulphate and ammonium nitrate). The number of productive tillers per unit area considerably increased when fertilizer was applied (50 kg N $ha^{-1}$) during the vegetative and booting stages (S2+S3) or at the vegetative and sowing stages (S1+S2). Generally, applying 50 kg N $ha^{-1}$ during the booting stage enhanced grain weight while decreased the number of grains per spike.

The combined impact of NPK on the growth and yield of wheat cultivar Sahar-2006 was investigated in a field experiment by (11); the findings showed that NPK fertilizers considerably affected maximum growth traits. The application of 175-150-125 NPK $Kg.ha^{-1}$ resulted in the maximum grain yield, which was 5168 Kg $ha^{-1}$; comparing the increase in yield to the control unit (2502 $Kg.ha^{-1}$), revealed a 51.58% greater difference. A study by (13) revealed that the application of 120: 60: 60 NPK + 300 kg/ha and at compression with the application of 120: 60: 60 NPK + 300 kg/ha resulted in significant improvements in dry weight production, and productive tillers. (9) demonstrated in study of winter wheat yield and biomass of four types during three consecutive growing seasons as well as four site-year trails. Grain yield and biomass production were greatly impacted by the fertilization. Application of DAP had a considerable impact on the number of spikes per square meter and the grain production, but has no impact on the length of the spike, number of grains per spike, or the weight of 1000 grains for wheat cultivars (14). (22) reported that Sustainable wheat production and environmental safety might benefit from the incorporation of the regional diversity of achievable yield and fertilizer requirements into wheat production practices.

(3) reported that foliar treatment ensure that nutrients are available to crops for a higher yield. (8) reported that foliar fertilization of urea significantly enhanced spike length, spike weight, biological yield and grain production. (19) findings showed that there was a significant impact of foliar fertilization on the production of dry weight, there was a noticeable increase in the number of effective tillers ($m^{-2}$), spikelets, grains per spiklets, thousand-grain weight, and grain yield. (4) investigated those foliar fertilizers significantly enhanced plant height, spike length, $spike^{-1}$ grain weight, and grain production when compared to the control treatment. (18) illustrated in field research conducted under Duhok Governorate conditions that the supplementary application of Foliar EcoZink alone or with DAP fertilizer is highly recommended for the farmers based on the results of his study for different varieties of wheat under rainfall environments. Accordingly, this study aimed to assist and evaluate the spike and yield properties of several wheat cultivars under various levels of soil and foliar fertilization.

## Materials and Methods

This field trail was carried out at farms of Field Crops Department, College of Agricultural Engineering Sciences, University of Duhok during the growing season 2021/2022 season. Three bread wheat (*Triticum aestivum* L.); Ceyhan-99, Adana-99 Tamuz-2 varieties were used in this study. Due to the delaying of first active rainfall, the land was plowed with disc plow and soil softening applied with Rotavator before sowing date at first week of December. The experiment was designed as Split Plots and arranged in Randomized Complete Block Designs (RCBD) with four replications. Wheat cultivars considered the main plots, fertilization methods (soil and foliar) the sub-plots and the fertilizer concentrations the sub-sub-plots. Sowing date was at 11/12/2021 the land was divided into four blocks, one meter among them, each experimental unit was of 2.5 m length and 1.2 m width with half meter between the plots. The block split into 24 plots of $3m^2$ (2.5 x 1.2 meter), and include 6 rows, 20 cm between the rows. Sowing density for the wheat cultivars were adjusted correspondingly considering their germination percentages and 1000 seed weight taking into account the target number of seedling per meter square is 400 (17 and 18) and as follow:

$Kg.ha^{-1}$ = (target number of seedlings×1000 seeds)×100/germination × establishment (17).

**Table 1 Information for wheat cultivars.**

| Varieties | 1000 Seed Weight (g) | Germination (%) |
|---|---|---|
| **Ceyhan-99** | 26.16 | 98 |
| **Adana-99** | 23 | 93 |
| **Tamuz 2** | 23.96 | 98 |

Soil fertilizer (NPK Soil Treatment; 15:15:15 +25 $SO_3$) in four concentrations (low; 60g, recommended; 90g and high;120g per experimental unit ($3m^2$)) and this match 200, 300 and 400 $kg.ha^{-1}$. The three levels of soil NPK fertilizers (low, recommended and high) were applied directly after sowing in the middle of December 2021. Each plot was incorporated with the fertilizer according to the experimental layout plan. Also, the controls plots were left without fertilizer treatment. After that, the treated plots separated to six straight lines and sowed. For each line, the prepared weights for each particular variety were used. Also, the foliar fertilizer (Triplex Amino 20-20-20) made in Mexico which is prepared according to the foliar fertilizer treatments (low, recommended, high foliar) was applied at the end of April after heading stage in addition to the control treatment. Climatic data were collected from the meteorological station at experimental site (College of Agricultura Engineering Sciences Station (Table 2). Due to the severe drought and rain breaking at the end of the season during May, two supplementary irrigations were applied through sprinkler system 10 days interval and each for two and half hours.

**Table 2 The average rate of humidity, temperature and rainfall during the experiment period.**

| Months | Duhok | | | |
|---|---|---|---|---|
| | Relative Humidity (%) | Temperature (ºC) Max. | Min. | Rainfall (mm) |
| **October, 2021** | 34.796 | 30.05 | 12.61 | 2.5 |
| **November, 2021** | 45.606 | 23.15 | 7.49 | 2.6 |
| **December, 2021** | 66.935 | 15.30 | 3.27 | 53.4 |
| **January, 2022** | 78.9032 | 10.15 | 1.42 | 73.2 |
| **February, 2022** | 66.375 | 17.24 | 3.24 | 16.5 |
| **March, 2022** | 66.9032 | 16.13 | 2.95 | 41.8 |
| **April, 2022** | 55.0366 | 27.97 | 10.98 | 19.5 |
| **May, 2022** | 45.0838 | 30.81 | 14.32 | 52.5 |
| **June, 2022** | 34.796 | 30.051 | 12.61 | 2.5 |
| **Total Rainfall** | | | | 262 |

At maturity two central rows (1 $m^2$) from each plot was harvested manually at beginning of June. The harvested crops were kept in polypropylene bags for the measurement. Ten spikes were randomly selected for the determination of spike measurement such as length, spike biomass, number and weight of seeds per spike, seed yield per spike and thousand grain weight. Threshing and cleaning were carried out manually in the laboratories of the College of Agricultural Engineering Sciences, Field crops Department of the University of Duhok. Also, thousand grain weight. Also, Number of spikes (reproductive tillers) was counted for the harvested central row (1 $m^2$). Final grain yield and air-dried biomass yield (above ground biomass) was determined for the one square meter sample. The data were statistical analyzed using SAS 9.4 software (SAS Institute, Inc., Cary, NC). Duncan Multiple Range Test was used for means verification and for discussion of the result under probability level of 0.05.

## Results and Discussion

Spike Characteristics:

Spike length (cm): Data in table 3 describe non-significant differences between soil and foliar fertilization methods and fertilizer concentrations effect on spike length trait; while the effect of wheat cultivars was significant. Tamuz-2 cultivar was superior and produced highest spike length value (8.58 cm) compared to other cultivars.

The interaction of fertilization methods and wheat cultivars was also significant; Tamuz-2 cultivars in soil fertilization recorded highest spike length (8.66 cm) while Ceyhan-99 cultivars in foliar fertilization recorded lowest spike length (7.82 cm). The interaction of fertilization method and fertilizer concentration was significant as well; the recommended concentration of soil fertilizer recorded highest spike length (8.45 cm) compared to the lowest spike length which recorded in the interaction between the recommended concentration of foliar fertilization (7.90 cm). The impact of fertilizers concentration and cultivars interaction was also significant; Tamuz-2 cultivar in low concentrations recorded highest spike length (9.32 cm), on the other hand, Ceyhan-99 cultivar in low concentrations and recommended concentrations of fertilization recorded lowest spike length (7.78 cm).

The second order interaction of fertilization method for wheat cultivars effect with fertilizers concentration was significant; Tamuz-2 cultivar in low concentration of foliar fertilizer verified highest spike length (9.52 cm) compared to lowest value of spike length of Ceyhan-99 cultivar in recommended dose of foliar fertilization (7.25 cm). the results of spike length characteristic showed that this trait is mostly varietal concern as wheat cultivars exhibit differences in spike length (17).

**Table 3 Effect of soil and foliar fertilization on spike length (cm) for different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 7.87cd | 8.44abcd | 8.24bcd | 8.18ab | 8.30a |
| | low | 7.39d | 9.13ab | 8.45abcd | 8.32ab | |
| | Recommended | 8.30bcd | 8.64abc | 8.40abcd | 8.45ab | |
| | High | 8.09bcd | 8.43abcd | 8.23bcd | 8.25ab | |
| **Foliar** | Control | 7.87cd | 8.44abcd | 8.24bcd | 8.18ab | 8.27a |
| | low | 8.16bcd | 9.52a | 8.67abc | 8.78a | |
| | Recommended | 7.25d | 8.14bcd | 8.32bcd | 7.90b | |
| | High | 7.99bcd | 7.91bcd | 8.72abc | 8.21ab | |
| **Fertilization *Cultivars** | Soil | 7.91b | 8.66a | 8.33ab | Fertilizer Conc. effect | |
| | Foliar | 7.82b | 8.50a | 8.49a | | |
| **Conc. *Cultivars** | Control | 7.87b | 8.44b | 8.24b | 8.18a | |
| | low | 7.78b | 9.32a | 8.56b | 8.55a | |
| | Recommended | 7.78b | 8.39b | 8.36b | 8.17a | |
| | High | 8.04b | 8.17b | 8.48b | 8.23a | |
| **Cultivars effect** | | 7.87b | 8.58a | 8.41a | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05.

Number of spikelets per spike: Non-significant differences were observed between wheat cultivars, fertilization, concentration of fertilizers and their interaction on the number of spikelets per spike (Table 4). This can be attributed to the stress of environmental conditions in which restricted the effect of the studied factors to be appear under such abnormal environment (Table 2). The percentage of infertile, mainly basal spikelets is highly associated with stress conditions and therefore can be used as in indirect selection criterion in a physiology-based wheat breeding program. Considering a somewhat higher number of spikes in Tanuz-2 cultivar (12.80 spikelets. spike$^{-1}$).

**Table 4 Effect of soil and foliar fertilization Number of spikelets per spike content with different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 11.60a | 11.80a | 12.07a | 11.82a | 12.05a |
| | Low | 12.00a | 12.70a | 10.93a | 11.88a | |
| | Recommended | 12.20a | 12.83a | 12.00a | 12.34a | |
| | High | 12.27a | 12.52a | 11.73a | 12.17a | |
| **Foliar** | Control | 11.60a | 11.80a | 12.07a | 11.82a | 12.11a |
| | Low | 11.70a | 13.33a | 12.03a | 12.36a | |
| | Recommended | 11.63a | 11.47a | 12.53a | 11.88a | |
| | High | 13.33a | 11.13a | 12.70a | 12.39a | |
| **Fertilization *Cultivars** | Soil | 12.02a | 12.46a | 11.68a | Fertilizer Conc. effect | |
| | Foliar | 12.07a | 11.93a | 12.33a | | |
| **Conc. *Cultivar** | Control | 11.60a | 11.80a | 12.07a | 11.82a | |
| | Low | 11.85a | 13.02a | 11.48a | 12.12a | |
| | Recommended | 11.92a | 12.15a | 12.27a | 12.11a | |
| | High | 12.80a | 11.83a | 12.22a | 12.28a | |
| **Cultivars effect** | | 12.04a | 12.80a | 12.01a | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05.

Spike biomass (g. spike$^{-1}$): The results in table 5 show non- significant differences between soil and foliar fertilization methods and also effect of fertilizer concentration on spike biomass trait, while the effect of wheat cultivars was significant on the same trait; Ceyhan-99 and Tamuz-2 cultivars were superior and produced highest spike biomass (10.82 and 10.68 g.spike$^{-1}$ respectively) compared to the inferior cultivar in this trait (Adana-99) which produced only 9.32 g of spike biomass.

On the other hand, the interaction of fertilization methods and wheat cultivars was significant, Ceyhan-99 cultivar with foliar fertilization recorded highest spike biomass (11.07 gspike$^{-1}$) while Adana-99 cultivar in soil fertilization recorded lowest spike biomass (9.08 g.spike$^{-1}$). Also, the interaction of fertilization method and fertilizer concentrations was significant, the high concentration of foliar fertilizer recorded highest spike biomass (10.91 g.spike$^{-1}$) compared to the recommended concentration of the same fertilizer which recorded lowest spike biomass (9.24 g.spike$^{-1}$). The impact of fertilizer concentrations interaction and wheat cultivars was also significant, Tamuz-2 cultivar in low fertilizer concentrations recorded highest spike biomass (11.85 g.spike$^{-1}$) compared the lowest spike biomass which recorded in Adana-99 cultivars interaction with recommended concentration of fertilizers (9.09 g.spike$^{-1}$).

The second interaction of fertilization methods with wheat cultivars and fertilizer concentrations was also significant; Ceyhan-99 cultivar in low concentration of foliar fertilizer showed highest spike biomass (12.70 g.spike$^{-1}$) while Adana-99 cultivar in recommended concentration of soil fertilizer recorded lowest spike biomass (8.23 g.spike$^{-1}$). the effect of foliar fertilization was noted within the interaction with wheat cultivars as it enhanced the spike biomass of Ceyhan-99 (11.02 g.spike$^{-1}$) compared to other treatments. Also, most other interactions with foliar fertilization somehow improved this characteristic value.

**Table 5 Effect of soil and foliar fertilization on spike biomass (g.spike$^{-1}$) character for different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 10.87abc | 10.10abc | 9.33abc | 10.10ab | 10.13a |
| | Low | 10.09abc | 11.25abc | 10.10abc | 10.48ab | |
| | Recommended | 12.16ab | 10.53abc | 8.23c | 10.31ab | |
| | High | 9.16abc | 11.03abc | 8.65bc | 9.61ab | |
| **Foliar** | Control | 10.87abc | 10.10abc | 9.33abc | 10.10ab | 10.42a |
| | Low | 12.70a | 12.45ab | 9.18abc | 11.44a | |
| | Recommended | 8.61bc | 9.17abc | 9.94abc | 9.24b | |
| | High | 12.10abc | 10.80abc | 9.83abc | 10.91ab | |
| **Fertilization *Cultivars** | Soil | 10.57ab | 10.73ab | 9.08b | Fertilizer Conc. effect | |
| | Foliar | 11.07a | 10.63ab | 9.57ab | | |
| **Conc. *Cultivar** | Control | 10.87ab | 10.10ab | 9.33ab | 10.10a | |
| | Low | 11.39ab | 11.85a | 9.64ab | 10.96a | |
| | Recommended | 10.38ab | 9.85ab | 9.09b | 10.97a | |
| | High | 10.63ab | 10.92ab | 9.24ab | 10.26a | |
| **Cultivars effect** | | 10.82a | 10.68a | 9.32b | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05.

Number of seeds per spike: The results in table 6 reflect non- significant differences between soil and foliar fertilization method and also effect of fertilizer concentrations trait as well as the effect of wheat cultivars. On the other hand, the effect of the interaction between fertilization methods and wheat cultivars and also the interaction of Fertilization method with fertilizer concentrations, and the second order interaction of fertilization methods with the wheat cultivars and fertilizer concentrations were non-significant on the number of seeds per spike under the conditions of this study.

On the other hand, the impact of the interaction of fertilizer concentrations with wheat cultivars was significant; Ceyhan-99 cultivar non fertilization treatment (control) concentration recorded highest number of seeds per spike 22.83 and the interaction of Adana-99 cultivars in recommended concentration recorded lowest number of seeds per spike 15.72

**Table 6 Effect of soil and foliar fertilization on number of seed per spike for different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 22.83a | 20.53a | 20.57a | 21.31a | 20.23a |
| | Low | 19.53a | 20.67a | 19.87a | 20.02a | |
| | Recommended | 23.20a | 19.07a | 15.73a | 19.33a | |
| | High | 21.40a | 21.30a | 18.07a | 20.26a | |
| **Foliar** | Control | 22.83a | 20.53a | 20.57a | 21.31a | 20.54a |
| | Low | 22.93a | 20.17a | 22.80a | 21.97a | |
| | Recommended | 21.30a | 15.53a | 15.70a | 17.51a | |
| | High | 22.10a | 23.37a | 18.70a | 21.39a | |
| **Fertilization *Cultivars** | Soil | 21.74a | 20.39a | 18.56a | Fertilizer Conc. effect | |
| | Foliar | 22.29a | 19.9a | 19.44a | | |
| **Conc. *Cultivar** | Control | 22.83a | 20.53ab | 20.57ab | 21.31a | |
| | Low | 21.23ab | 20.42ab | 21.33ab | 20.99a | |
| | Recommended | 22.25ab | 17.30ab | 15.72b | 18.42a | |
| | High | 21.75ab | 22.33ab | 18.38ab | 20.82a | |
| **Cultivars effect** | | 22.02a | 20.15a | 19.00a | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05.

Seed yield per spike (g): The results in table 7 show non-significant differences between the fertilization methods (soil and foliar) and effect also for wheat cultivars, the interaction of fertilization methods and wheat cultivars and fertilizer methods with fertilizer concentration on seed yield per spike.

On the other hand, the effect of fertilizer concentration was significant; the recommended concentration of fertilization recorded highest seed yield per spike compared to (0.73 g.spike$^{-1}$) for control concentration which recorded lowest seed yield per spike (0.56 g).

Also, the interaction of fertilizer concentration with wheat cultivars was significant; Adana-99 cultivars with non-treated of control concentration recorded seed highest seed yield per spike (0.89 g) while Adana-99 cultivars in recommended concentration recorded lowest seed yield per spike (0.53 g).

The second order interaction of fertilization methods with wheat cultivars and fertilizer concentration was significant, Adana-99 cultivars in control concentration of soil fertilizer recorded highest seed yield per spike (0.89 g) and the same cultivar (Adana-99) in recommended concertation of soil fertilizer recorded lowest seed yield per spike (0.43 g). the recommended concentration improved the yield of spike with somehow remarkable notification of foliar contribution for enhancing the spike biomass (Table 5) but still not significant.

**Table 7 Effect of soil and foliar fertilization on seed yield per spike (g) for different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 0.68ab | 0.62ab | 0.89a | 0.73a | 0.64a |
| | Low | 0.62ab | 0.74ab | 0.58ab | 0.64a | |
| | Recommended | 0.64ab | 0.57ab | 0.43b | 0.55a | |
| | High | 0.57ab | 0.71ab | 0.59ab | 0.63a | |
| **Foliar** | Control | 0.68ab | 0.62ab | 0.89a | 0.73a | 0.67a |
| | Low | 0.76ab | 0.65ab | 0.64ab | 0.68a | |
| | Recommended | 0.60ab | 0.50ab | 0.62ab | 0.57a | |
| | High | 0.77ab | 0.79ab | 0.57ab | 0.71a | |
| **Fertilization *Cultivars** | Soil | 0.63a | 0.66a | 0.62a | Fertilizer Conc. effect | |
| | Foliar | 0.70a | 0.64a | 0.68a | | |
| **Conc. *Cultivar** | Control | 0.68ab | 0.62ab | 0.89a | 0.56b | |
| | Low | 0.69ab | 0.69ab | 0.61b | 0.66ab | |
| | Recommended | 0.62ab | 0.54b | 0.53b | 0.73 a | |
| | High | 0.67ab | 0.75ab | 0.58b | 0.67ab | |
| **Cultivars effect** | | 0.66a | 0.65a | 0.65a | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05

Yield and Yield Component Characteristics:

Number of Spike (Tillers.m$^{-2}$): The results in table 8 display significant differences between soil and foliar fertilization methods, the application of soil fertilization surpassed foliar fertilization for producing higher number of tillers (spikes) per square meter 399 spikes compared to 375 tillers respectively. Superiority of soil over foliar fertilization may due to the earlier influence of NPK at the beginning of sowing

which reflect their impact soon at the stage of tiller development compared to the late application of foliar fertilizers beyond tillering stage.

The same table (table 8) showed non-signification of the wheat cultivars on the number of tillers. However, Tamuz-2 cultivar showed somehow higher number of tillers (398 spikes.m$^{-2}$) followed by Adana-99 (390 spikes.m$^{-2}$) cultivar. On the other hand, the effect of fertilizer concentration on the number of tillers per square meter was not significant. Also, the effect the interaction of fertilization methods and wheat cultivars and also the interaction of fertilization methods with fertilizer concentration was significant on number of spikes (tillers) per meter square. Similarly, the he interaction of fertilizers concentration with wheat cultivars was significant on the mentioned yield component characteristic. The effect of soil fertilization in all interaction was clearly observed compared to the foliar form of fertilization on number of tillers per unit area and this may due to the same reanimation above.

Also, the second order interaction of fertilization methods with the wheat cultivars and fertilizer concentration was also significant, Tamuz-2 cultivar in the recommended concentration of soil fertilizer recorded highest number of spikes (472.67 spikes.m$^{-2}$) while Ceyhan-99 cultivar in low concertation of foliar fertilizer recorded lowest number of spikes per square meter 289.67.

**Table 8 Effect of soil and foliar fertilization Number of spikes per unit area (tillers.m$^2$) for different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 385.00abc | 376.0abc | 414.33abc | 391.78ab | 398.78a |
| | low | 369.00abc | 389.3abc | 380.00abc | 379.44ab | |
| | Recommended | 397.67abc | 472.6a | 401.00abc | 423.78a | |
| | High | 409.67abc | 390.6abc | 400.00abc | 400.11a | |
| **Foliar** | Control | 385.00abc | 376.0abc | 414.33abc | 391.78ab | 374.69b |
| | low | 289.67c | 434.33ab | 397.33abc | 373.78ab | |
| | Recommended | 360.33abc | 359.3abc | 325.67bc | 348.44b | |
| | High | 441.67ab | 391.0abc | 321.67bc | 384.78ab | |
| **Fertilization *Cultivars** | Soil | 391.33ab | 407.17a | 398.83ab | Fertilizer Conc. effect | |
| | Foliar | 369.17b | 390.17ab | 364.75b | | |
| **Conc. *Cultivar** | Control | 385.00ab | 376.00ab | 414.33a | 391.78a | |
| | Low | 329.33cb | 411.83a | 388.67ab | 376.61a | |
| | Recommended | 379.00b | 416.00a | 363.33b | 386.11a | |
| | High | 425.67a | 390.83ab | 360.83bc | 392.44a | |
| **Cultivars effect** | | 379.75a | 398.67a | 381.79a | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05.

Weight of 1000 grains: Table 9 shows non-significant differences between soil and foliar fertilization method, their concentrations and their interactions for different bread wheat cultivars on the weight of 1000 seeds. Non affecting the weight of seeds by the fertilization treatments can be returned to the negative impact of the environments and mainly low rainfall and soil moisture during the study period (Table 2) and during the grain filling stage in particular. (17 and 18) referred to the importance and sensitivity of grain filling stage to the water stress at the grain filling stage of wheat crop.

**Table 9 Effect of soil and foliar fertilization on the weight of 1000 seeds for different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 25.99a | 26.17a | 25.11a | 25.76a | 26.25a |
| | low | 27.53a | 24.81a | 26.51a | 26.28a | |
| | Recommended | 28.24a | 25.39a | 25.46a | 26.36a | |
| | High | 26.98a | 26.37a | 26.46a | 26.60a | |
| **Foliar** | Control | 25.99a | 26.17a | 25.11a | 25.76a | 26.64a |
| | low | 27.73a | 27.97a | 25.49a | 27.06a | |
| | Recommended | 27.85a | 27.59a | 28.37a | 27.93a | |
| | High | 28.18a | 24.05a | 25.15a | 25.79a | |
| **Fertilization *Cultivars** | Soil | 27.19a | 25.68a | 25.89a | Fertilizer Conc. effect | |
| | Foliar | 27.44a | 26.44a | 26.03a | | |
| **Conc. *Cultivar** | Control | 25.99a | 26.17a | 25.11a | 25.76a | |
| | Low | 27.63a | 26.39a | 26.00a | 26.67a | |
| | Recommended | 28.05a | 26.49a | 26.91a | 27.15a | |
| | High | 27.58a | 25.21a | 25.80a | 26.20a | |
| **Cultivars effect** | | 27.31a | 26.06a | 25.96a | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05

Biomass yield (t.ha$^{-1}$): Table 10 display non-significant differences between wheat cultivars on the final biomass production per unit area. On the other hand, the effect of fertilization method and fertilizer concentrations were significant; soil fertilizer recorded highest biomass yield than foliar fertilizer and produced (5.70 t.ha$^{-1}$) and (5.01 t.ha$^{-1}$) respectively. Regarding the fertilizers concentrations, both recommended (5.36 t.ha$^{-1}$) and high concentration (5.63 t.ha$^{-1}$) of fertilizers recorded higher yield of biomass compared to control (4.74 t.ha$^{-1}$) and low concentrations (4.78 t.ha$^{-1}$) of fertilizers.

The interaction of fertilization methods with wheat cultivars was also significant, Ceyhan-99 cultivar in soil fertilization recorded highest biomass yield (6.29 t.ha$^{-1}$) while Tamuz-2 cultivar in foliar fertilization recorded lowest biomass yield (4. 87 t.ha$^{-1}$). Also, the interaction of fertilization methods with fertilizer concentration was significant; the recommended concentration of soil fertilizers recorded highest biomass yield (6.16 t.ha$^{-1}$) while the recommended concentration of foliar fertilizer recorded lowest biomass yield (4.55 t.ha$^{-1}$). The impact of fertilizers concentration interaction with wheat cultivars was also significant; Ceyhan-99 cultivar in high concentration of fertilization recorded highest biomass yield (6.29 t.ha$^{-1}$) but the interaction of Adana-99 cultivar with low concentration of fertilization recorded lowest biomass yield (4.68 t. ha$^{-1}$).

The second order interaction of fertilization methods with wheat cultivars and fertilizers concentration was also significant; Ceyhan-99 cultivar with high concentration of soil fertilizer recorded highest biomass yield (7.2 t.ha$^{-1}$) while Tamuz-2 cultivar in recommended concentration of foliar fertilizer recorded lowest biomass yield (4.10 t. ha$^{-1}$). On the other hand, superiority of soil fertilization can be attributed to the higher number of tillers produced per unit area (Table 8).

**Table 10 Effect of soil and foliar fertilization on biomass yield (t.ha$^{-1}$) for different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 5.68abc | 5.55abc | 5.80abc | 5.68ab | 5.70a |
| | low | 5.47abc | 4.50bc | 4.64bc | 4.87bc | |
| | Recommended | 7.00a | 5.43abc | 6.04abc | 6.16a | |
| | High | 7.02a | 5.15abc | 6.15ab | 6.10a | |
| **Foliar** | Control | 5.68abc | 5.55abc | 5.80abc | 5.68ab | 5.01b |
| | low | 4.34bc | 4.93bc | 4.72bc | 4.66bc | |
| | Recommended | 4.63bc | 4.10c | 4.93bc | 4.55c | |
| | High | 5.39abc | 4.91bc | 5.14abc | 5.15abc | |
| **Fertilization *Cultivars** | Soil | 6.29a | 5.16b | 5.66ab | Fertilizer Conc. effect | |
| | Foliar | 5.01b | 4.87b | 5.15b | | |
| **Conc. *Cultivar** | Control | 5.68ab | 5.55ab | 5.80ab | 4.74b | |
| | Low | 4.91ab | 4.72b | 4.68b | 4.77b | |
| | Recommended | 5.81ab | 4.77b | 5.49ab | 5.36ab | |
| | High | 6.20a | 5.03ab | 5.64ab | 5.63a | |
| **Cultivars effect** | | 5.65a | 5.02a | 5.40a | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05.

Final Grain yield (t.ha$^{-1}$): The results in table 11 demonstrate non-significant differences between the single effects of the studied factors, soil and foliar fertilization methods; effect of wheat cultivars, and the effect of fertilizer concentration on the final grain yield of the wheat cultivars under the experiment conditions; with somehow superiority but not significant of Ceyhan-99 cultivar (1.60 t.ha$^{-1}$) over other two cultivars and both produced (1.19 t.ha$^{-1}$). This increasing con be connected to the superiority of Ceyhan-99 cultivar in both number of seeds per spike (Table 6) and weight of 1000 seeds (Table 9).

On the other hand, the effect of the interaction of fertilization methods with wheat cultivars was significant; Ceyhan-99 cultivar in soil fertilization recorded highest final grain yield (1.69 t.ha$^{-1}$) compared to Tamuz-2 cultivar interaction with soil fertilizer which recorded lowest final grain yield (1.15 t.ha$^{-1}$). The interaction of fertilization method and fertilizer concentration was also significant; high concentration of soil fertilization recorded highest final grain yield (1.42 t.ha$^{-1}$), compared to low concentration of the same fertilization which recorded lowest final grain yield (1.03 t.ha$^{-1}$). The interaction of fertilizer concentration and wheat cultivars was also significant, Ceyhan-99 cultivar in recommended concentration of fertilization recorded highest final grain yield (1.93 t.ha$^{-1}$) and Adana-99 cultivar in low concentrations recorded lowest final grain yield (0.99 t.ha$^{-1}$).

The second order interaction of fertilization methods and wheat cultivars with fertilizer concentration was also significant; Ceyhan-99 cultivar in recommended concentration of soil fertilizer recorded highest final grain yield (2.29 t.ha$^{-1}$), while Adana-99 cultivar in low concertation of soil fertilizer recorded lowest final grain yield (0.85 t.ha$^{-1}$).

**Table 11 Effect of soil and foliar fertilization on final grain yield (t.ha$^{-1}$) for different bread wheat cultivars.**

| Fertilization Method | Concentration | Cultivars | | | Fertilization method * conc. | Fertilizer Method effect |
|---|---|---|---|---|---|---|
| | | Ceyhan-99 | Tamuz-2 | Adana-99 | | |
| **Soil** | Control | 1.24bc | 1.49abc | 1.22bc | 1.31ab | 1.35a |
| | low | 1.33bc | 0.90c | 0.85c | 1.03b | |
| | Recommended | 2.29a | 1.32bc | 1.28bc | 1.63a | |
| | High | 1.89ab | 0.89c | 1.48abc | 1.42ab | |
| **Foliar** | Control | 1.24bc | 1.49abc | 1.22bc | 1.31ab | 1.30a |
| | low | 1.59abc | 1.27bc | 1.14bc | 1.33ab | |
| | Recommended | 1.58abc | 0.95c | 1.36bc | 1.29ab | |
| | High | 1.62abc | 1.23bc | 0.96c | 1.27ab | |
| **Fertilization *Cultivars** | Soil | 1.69a | 1.15b | 1.21b | Fertilizer Conc. effect | |
| | Foliar | 1.51ab | 1.23b | 1.17b | | |
| **Conc. *Cultivar** | Control | 1.24bc | 1.49abc | 1.22bc | 1.31a | |
| | Low | 1.46abc | 1.08c | 0.99c | 1.18a | |
| | Recommended | 1.93a | 1.13c | 1.32bc | 1.46a | |
| | High | 1.76ab | 1.06c | 1.22bc | 1.35a | |
| **Cultivars effect** | | 1.60a | 1.19a | 1.19a | | |

* Within each column or rows, numbers sharing the same letters are not significantly differ according to Duncan Multiple Range Test at probability 0.05.

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