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Response of two winter soft wheat varieties to moisture deficiency under several levels of nitrogen fertilization

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ABSTRACT

The research was conducted in the Natural Resources Research Department/Homs Research Center, for three consecutive seasons 2015/2016, 2016/2017, 2017/2018, with the aim of knowing the response of two soft wheat cultivars to several levels of supplementary irrigation and several levels of nitrogen fertilizer. Two soft wheat cultivars (Bohouth10 and Douma6) were planted in a split-split-plot design experiment, with three irrigation treatments (100%, 66%, 33%) of the water requirement with a control without irrigation (rainfed), and five nitrogen fertilization treatments (N0: fertilizer recommendation, N1, N2: 25% and 50% higher than fertilizer recommendation respectively, N3, N4: 25% and 50% lower than fertilizer recommendation respectively), with three replicates for each treatment. The results showed that the 100% irrigation treatment was superior in terms of water requirement with a grain yield of 5.67 tons/ha over the other treatments, while the differences were apparent between the varieties, with a grain yield of 4.18 and 4.13 tons/ha for the Douma6 and Bohouth10 varieties, respectively. As for the differences between the fertilizer treatments, they were apparent with a grain yield of (4.14, 4.22, 4.29, 4.14, 3.99) tons/ha for the N0, N1, N2, N3, and N4 fertilizer treatments, respectively.

KEYWORDS: soft wheat, fertilizer recommendation, water requirement, nitrogen fertilization, grain yield.

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1. Introduction

development and stability, improving economic returns, Since Syria is one of the countries with limited water resources compared to the size of the increasing demand for all sectors (agriculture, domestic purposes, industry), it will not be easy to achieve any qualitative leap in increasing and stabilizing production without rationalizing water use and achieving sustainable water security. The first strategies to achieve food security are determined by setting the necessary standards and controls for this use, introducing irrigation technologies suitable for the climatic and social conditions of the Syrian farmer and the size of agricultural holdings, and setting mechanisms, policies, and procedures to achieve this according to a programmed plan in terms of material and time.

Nitrogen is one of the major nutrients that plants need in large quantities during their growth stages, and therefore it is considered one of the most expensive fertilizers and the most widely used in increasing crop production [11]. Nitrogen fertilization of wheat crops is an important and determining factor for growth, as high-yielding wheat varieties need large and regular amounts of nitrogen, in order to secure the energy needed for photosynthesis [13]. Nitrogen has a positive effect on increasing the percentage of productive spikes at the expense of unproductive ones, and increases the number of grains in spikes, which contributes to increasing grain yield more than the contribution of grain weight [17], [12], [15], and increases the percentage of protein, by encouraging good vegetative growth and forming a strong root system, in addition to its effect on the photosynthesis process that produces the energy needed for enzymes to work, and its role in forming amino acids that form proteins [10].

Wheat ranks first among cereal food crops in the world in terms of production and cultivated area, and its cultivation is becoming increasingly important as a result of population growth, which is why food security in any country depends on it. About 60% of the world's wheat production is used for human nutrition [9].

2. Literature Review

- **Sakellariou (1988)** indicated in a study on supplementary irrigation of wheat in a number of regions in the Syrian Arab Republic that the irrigation treatment at 70% of the field capacity was superior to the other treatments, with an average production of 5.77 tons/ha and a water consumption rate of 5489 m^3/ha.
- **Oweis and Zhang (1998)** conducted supplementary irrigation experiments on durum wheat in different ecological zones of Syria. Grain production in irrigated agriculture ranged between 2.9 and 6.3 tons/ha, while in rainfed agriculture it ranged between 2.4 and 3.4 tons/ha. Thus, supplementary irrigation led to a significant increase in grain production, achieving the highest water use efficiency values of 25 kg/m^3.
- Bassam et al. (2015) reported in a study conducted at the Agricultural Research Center in Homs on wheat crop irrigation methods that the average total water consumption of durum wheat, Buhuth 5 variety, when irrigated by sprinkling with sprinkler spacing (9 × 9 m), was the lowest among the irrigation treatments, reaching 3243 m^3/ha. This treatment also produced the highest yield, reaching 5.90 tons/ha, with a 97% increase over the rainfed control, and achieved the

highest water saving, at 48%, compared with surface irrigation using long strips.

- **Ahmed et al. (2019)** conducted a field experiment at the Sarbaia Research Station in Aleppo to study the effect of supplementary irrigation levels on some production traits of the durum wheat variety Sham 7 at rates of 33%, 66%, and 95% of available water. The results showed that supplementary irrigation contributed to increasing grain yield by 23.7%, 40.7%, and 49.2%, respectively.
- **Yan et al. (2019)** showed that the response of winter wheat to irrigation and fertilization was clear in terms of grain filling, average grain weight, and grain yield during the three years of the study. The grain filling rate decreased with increasing water deficit, whereas moderate irrigation gave the highest grain filling rate. Grain weight and spike moisture content were closely related, and spike moisture decreased with increasing water stress. Moderate irrigation and balanced fertilization improved winter wheat yield and enhanced grain filling.
- **Zain et al. (2021)** conducted an experiment for two consecutive seasons to evaluate the effect of irrigation scheduling and nitrogen application pattern on winter wheat growth, productivity, and water use efficiency. Three irrigation scheduling treatments were applied at 20, 35, and 50 mm of soil water consumption (SWC), together with three nitrogen treatments: N50:50, N25:75, and N0:100. The results showed that irrigation at 35 mm SWC combined with N25:75 gave the best grain yield compared with the other irrigation and fertilization treatments, reaching 8.62 and 9.4 tons/ha in the 2017–2018 and 2018–2019 seasons, respectively.
- **Al Areej et al. (2022)** showed in an experiment conducted at the Agricultural Scientific Research Center in Rif Damascus that, for the soft wheat variety Sham 10, the addition of 160 or 200 kg N/ha gave yields of more than 7 tons/ha compared with the control treatment (5.33 tons/ha). For the durum variety Sham 7, the addition of 120 or 160 kg N/ha increased productivity to 6.57 and 6.77 tons/ha, respectively, compared with the control treatment (4.37 tons/ha).

3. Materials and Methods

The research was carried out in the Natural Resources Research Department of Homs Agricultural Research Center, located at the northern entrance to Homs city, at an altitude of 490 meters, and 36:43 longitude and 34:45 latitude, with a rainfall rate about 439 mm annually. Table No. (1) Shows some of the chemical and physical properties of the soil in study site. The table shows that the soil is clayey in texture; its pH is almost neutral; medium in organic matter content; and rich in potassium.

TABLE (1): SOME CHEMICAL AND PHYSICAL SOIL PROPERTIES AT STUDY SITE

Mechanical analysis %			**OM %**	**N total%**	**K_2O**	**P_2O_5**	**N mineral**	**EC**	**pH**
clay	silt	sand			mg/kg				
59.2	13.2	27.6	1.48	0.02	315.2	17.4	16.2	0.84	7.37

The experiment planted at the beginning of December using an automatic seed drill, Phosphorus fertilizer (superphosphate fertilizer) was added before the last plowing before planting in one batch over the entire experimental land according to the fertilizer recommendation. Nitrogen fertilizer was added according to the coefficients specified in the questionnaire, spread in two batches: the first at planting and the second at the tillage stage. A sprinkler irrigation network was installed to irrigate the experiment with a spacing of 6x6 m between sprinklers. A germination irrigation was given after planting. Soil moisture was measured with a nitrogen probe, and plants were watered when the soil moisture reached the levels specified in the experimental design. The rate of each irrigation was calculated based on the following equation:

$$M=10000*H*(B1-B2)$$

Where:
M: Irrigation rate (m^3/ha)
10000: Conversion factor for calculations based on hectare area (m^3/ha)
H: Effective root depth (m), which varies depending on the growth stage
B1: Field capacity of the soil.
B2: Current soil moisture (immediately before irrigation), or the minimum soil moisture suitable for the crop.
The water share of each treatment was then calculated as stated in the experimental design (100%, 66%, 33% of the calculated irrigation rate), in addition to the control without irrigation.

3.1. Experimental design and layout

The experiment was carried out in a split-split plot design as follows (Figure (1) shows the experimental design diagram):

3.1.1. Main Blocks (varieties): Douma6, Bohouth10

3.1.2. Split plots (irrigation levels R): R0 depends on rainwater (rainfed), 33% of water requirement (R1), 66% of water requirement (R2), 100% of water requirement (R3).

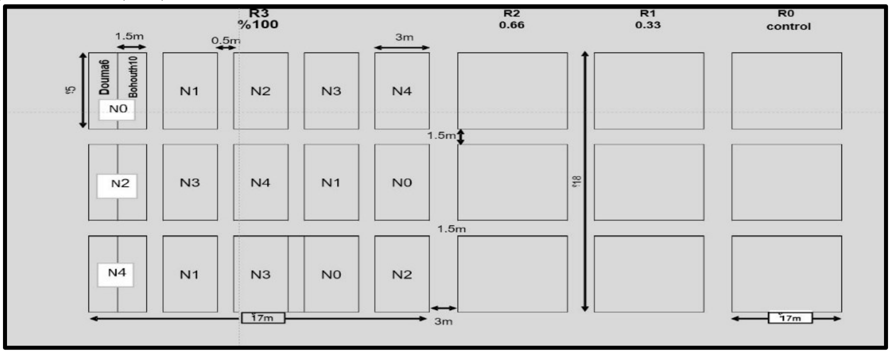

FIGURE (1): DISTRIBUTION OF COEFFICIENTS OF THE EXPERIMENT

3.1.3. Split-split plots (nitrogen fertilizer levels N):

Fertilization according to the recommended fertilizer equation (N0), fertilization 25% more than the recommendation (N1), fertilization 50% more than the recommendation (N2), fertilization 25% less than the recommendation (N3), fertilization 50% less than the recommendation (N4).

FIGURE (2): THE PROCESS OF IRRIGATING WHEAT WITH SPRINKLERS.

- Experimental plot area: 7.5 m^2 (5 x 1.5 m) and number of plots 120, each variety 60 plots.
- Each plot has six lines planted for each variety and the distance between the lines is (25) cm
- Net experimental area: 7.5 * 120 = 900 m^2

The phonological stages of wheat were monitored and all necessary agricultural services were provided, including irrigation, weed and pest control, until the harvest date in June. The necessary readings were taken, and statistical analysis was conducted using the GenStat program.
Figure (2) Show one of the stages of wheat growth and the sprinkler irrigation process.

4. Results and Discussion

The statistical analysis of the data was carried out using the Genstat analysis program, version (7), where the data to be analyzed was initially entered into an Excel file (here the yield data), and then the file was imported through the analysis program. Within the program, the variable factors whose effect on the yield was required to be analyzed (water and fertilizer) were determined. After that, the split-plot analysis was chosen, the analysis was carried out, the result was extracted, the least significant difference value was determined for each variable factor L.S.D at an accuracy level of 5%, and the value of the coefficient of variation CV% was determined.

4.1. Results of the three agricultural seasons (2018/2017, 2017/2016, 2016/2015)

The average net consumption for the three years was 3606 m^3/ha for the treatment of 100% of the water requirement, 3108.3 m^3/ha for the treatment of 66% of the water requirement, and 2756 m^3/ha for the treatment of 33% of the water requirement. The number of irrigations for the three treatments was (3) irrigations, while the theoretical average rate of irrigation was 675 m^3/ha for the first treatment, 446 m^3/ha for the second treatment, and 223 m^3/ha for the third treatment.
Tables (2), (3) and (4) show the result of the least significant difference (LSD 5%) for wheat grain yield for the three seasons 2015/2016, 2016/2017, 2017/2018, and for each season alone, according to the irrigation levels and fertilization levels applied.
The following is noted from the tables:
The wheat variety Doma6 gave better grain yield than the variety Buhuth10 in the three seasons, with a significant difference in the first and third seasons, and an apparent difference in the second season. This may be due to some drought-related crop and morph physiological traits that are more abundant in the Doma6 variety compared to the Buhouth10 variety.

The nitrogen fertilization treatment, to which 50% more than the fertilizer recommendation was added, gave the best wheat grain yield compared to the rest of the fertilization treatments, although the difference between these treatments was apparent.
The wheat grain yield in the 100% irrigation treatment of the water requirement was the best, with a significant difference from the rest of the treatments, followed by the 66% treatment, with a significant difference from the rest of the irrigation treatments, while the difference between them was apparent in the 33% irrigation treatment and the control, This is consistent with (5) that supplementary irrigation at a rate of 95% of available water gave the highest value in grain yield compared to other treatments.
In the case of the three intersections (irrigation-fertilization-variety), it was noted that the variety Douma6 gave the best productivity in the seasons 2015/2016 and 2017/2018 when treated with 100% irrigation and nitrogen fertilization treatment which was 50% more than the fertilizer recommendation, This may be due to the fact that the sufficient amount of water in the root zone helped in the decomposition of the nutrients present in the soil, which were easily absorbed by the plant roots and had a positive impact on productivity. This is consistent with the researcher (12) that supplementary irrigation with the addition of fertilizers leads to an increase in grain yield. While the yield of the variety Bohouth10 was the best in the season 2016/2017 when treated with 100% irrigation and nitrogen fertilization treatment which was 25% less than the fertilizer recommendation.

TABLE (2): STATISTICAL ANALYSIS FOR THE 2015-2016 SEASON AND L.S.D 5% DIFFERENCE IN GRAIN YIELD, TONS/HA

Fertilizer av.	Varieties av.	Irrigation level				fertilizer	variety	
		Cont.	% 33	% 66	% 100			
4.24 AB	4.45 A	4.02	3.69	4.9	5.19	N0	Douma6	Yield tons/ha
4.41 AB		3.84	4.21	4.83	5.6	N1		
4.57 A		4.43	3.84	5.08	6.29	N2		
4.09 BC		3.52	4.1	3.59	5.99	N3		
3.71 C		3.16	3.4	4.25	5.14	N4		
	3.96 B	3.22	3.77	4.72	4.45	N0	Bohouth10	
		3.55	3.76	4.40	5.09	N1		
		3.26	3.76	4.42	5.51	N2		
		3.21	3.63	4.05	4.66	N3		
		2.48	3.22	3.31	4.73	N4		
Total av.:4.21		3.47 C	3.74 C	4.35 B	5.26 A	Irrigation levels av.		

0.44	fertilizer	0.53	Irrig.	0.11	Var.	L.S.D 5%
1.25	Triple	0.56	Ferti×Var	0.65	IR×Var	
18					C.V %	

TABLE (3): STATISTICAL ANALYSIS FOR THE 2016-2017 SEASON AND L.S.D 5% DIFFERENCE IN GRAIN YIELD, TONS/HA

Fertilizer av.	Varieties av.	Irrigation level				fertilizer	variety	
		Cont.	% 33	% 66	% 100			
4.53 A	4.76 A	2.95	4.18	4.94	5.75	N0	Douma6	Yield tons/ha
4.85 A		2.61	5.28	5.60	6.88	N1		
4.61 A		3.12	4.93	5.11	5.74	N2		
4.75 A		2.58	5.07	5.62	6.13	N3		
4.78 A		3.44	4.03	5.13	6.06	N4		
	4.65 A	3.16	3.90	4.60	6.78	N0	Bohouth10	
		2.57	4.64	4.19	7.04	N1		
		2.48	3.65	5.14	6.75	N2		
		2.63	4.33	4.94	6.96	N3		
		2.48	4.16	6.34	6.60	N4		
Total Av. 4.71		2.80 D	4.42 C	5.16 B	6.44 A	Irrigation levels av.		

0.47	Ferti.	0.43	Irrig.	0.91	Var.	L.S.D 5%
1.36	Triple	0.78	Ferti×Var	0.74	Irrig×Var	
17.5					C.V %	

TABLE (4): STATISTICAL ANALYSIS FOR THE 2017-2018 SEASON AND L.S.D 5% DIFFERENCE IN GRAIN YIELD, TONS/HA

Fertilizer av.	Varieties av.	Irrigation level				fertilizer	variety	
		Cont.	% 33	% 66	100 %			
3.66A	3.84A	0.88	4.02	5.19	5.4	N0	Douma6	Yield tons/ha
3.39A		0.86	3.93	4.52	4.94	N1		
3.69A		1.13	4.14	5.23	6.37	N2		
3.58A		0.91	3.8	4.36	5.8	N3		
3.49A		1.05	4.12	4.53	5.52	N4		
	3.29B	0.78	3.07	4.69	5.21	N0	Bohouth10	
		0.66	3.49	4.05	4.68	N1		
		0.67	3.5	3.75	4.75	N2		
		0.64	3.54	4.17	5.39	N3		
		0.69	3.48	3.67	4.89	N4		
Total Av. 3.56		0.83 D	3.71 C	4.42 B	5.30 A	Irrigation levels av.		

0.385	Ferti.	0.448	Irrig.	0.132	Var.	L.S.D 5%
1.189	Triple	0.531	Ferti×Var	0.604	Irrig×Var	
20.3					C.V %	

4.2. Average of the three seasons

Table (5) Shows the result of the least significant difference (L.S.D 5%) for wheat grain yield of the average of three seasons according to the irrigation levels and applied fertilization levels. The following is noted from the tables:

TABLE (5): THE RESULT OF L.S.D 5% OF GRAIN YIELD, TONS/HA

Fertilizer av.	Varieties av.	Irrigation level: Cont.	% 33	% 66	% 100	fertilizer	variety	
4.14AB	4.18 A	2.35	3.99	4.95	5.20	N0	Douma6	Yield tons/ha
4.22AB		2.34	4.32	4.84	5.64	N1		
4.29A		2.50	4.28	4.92	5.88	N2		
4.14AB		2.23	4.17	4.67	5.53	N3		
3.99B		2.32	3.79	4.33	5.44	N4		
	4.13 A	2.65	3.55	4.73	5.28	N0	Bohouth10	
		2.36	4.12	4.36	5.77	N1		
		2.53	3.66	4.65	5.93	N2		
		2.27	3.99	4.23	6.02	N3		
		2.11	3.68	4.75	5.54	N4		
Total Av. 4.16		2.37 D	3.95 C	4.64 B	5.67 A	Irrigation levels av.		

0.243	Ferti.	0.278	Irrig.	0.326	Var.	L.S.D 5%
0.733	Triple	0.368	Ferti×Var	0.345	IR×Var	L.S.D 5%
10.9					C.V %	

The wheat varieties Douma6 and Bohouth10 were close in terms of grain yield (4.18 and 4.13 tons/ha, respectively) with an apparent difference in favor of Douma6.
The nitrogen fertilization treatment, to which 50% more than the fertilizer recommendation was added, gave the best wheat grain yield (4.29 tons/ha) compared to the rest of the fertilization treatments, although the difference was apparent between these treatments, It is consistent with (4) that moderate irrigation and balanced fertilization lead to improved winter wheat yield and increased grain filling.
The wheat grain yield in the 100% irrigation treatment of the water requirement was the best and with a significant difference from the rest of the treatments, followed by the 66% treatment, then the 33% treatment, and finally the control treatment (5.67, 4.64, 3.95, 2.37 tons/ha, respectively). In the case of the three intersections (irrigation-fertilization-variety), it was noted that the yield of the Bohouth10 variety are the best when treated with 100% irrigation and nitrogen fertilization, which was 25% less than the fertilizer recommendation.
Figures (3) and (4) show the change in wheat grain yield for the two studied varieties, Douma6 and Bohouth10, according to the change in irrigation level (Figure 3) and the change in nitrogen fertilization level (Figure 4).

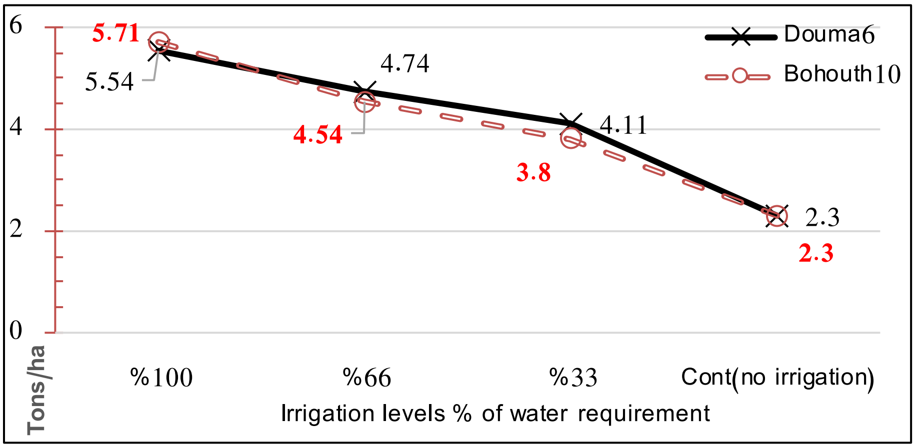

FIGURE (3): GRAIN YIELD (TONS/HA) FOR THE TWO WHEAT VARIETIES, DOUMA6 AND BOHOUTH10, ACCORDING TO IRRIGATION LEVEL CHANGE

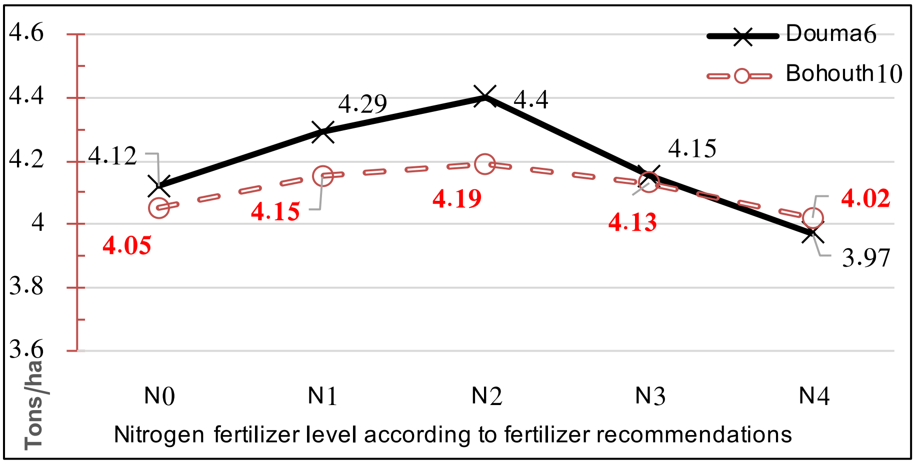

FIGURE (4): GRAIN YIELD (TONS/HA) FOR THE TWO WHEAT VARIETIES, DOUMA6 AND BOHOUTH10, ACCORDING TO NITROGEN FERTILIZATION (N) LEVEL CHANGE

5. Conclusions and recommendations

By reviewing the experimental data, the following can be concluded:

- The effect of irrigation on wheat grain yield was clear, as it led to an increase in yield for both varieties, Douma6 and Bohouth10, with a direct increase with the increase in the amount of irrigation water. The rain-fed control was the least productive, and the 100% irrigation treatment was the highest productive.
- Increasing or decreasing the amounts of nitrogen fertilization from the fertilizer recommendation for the wheat crop did not lead to a significant change in grain yield, although a slight increase in yield occurred with an increase in the amount of nitrogen fertilizer by 25% and 50% from the recommendation.

- Both wheat varieties gave similar grain yields without any difference when irrigated with different water requirements and fertilized with varying amounts of nitrogen fertilizer. The Douma6 wheat variety was distinguished by its better yield than the Bohouth10 variety in the case of applying water stress.

Based on previous conclusions, the following could be recommended:

When planting soft winter wheat varieties in conditions of water shortage, the variety Douma6 can be relied upon, because this variety tolerates drought and its grain yield is better in conditions of water shortage according to the results of the experiment, in addition to the fact that this variety showed a greater response to increasing the amount of nitrogen fertilizer compared to the other variety (Bohouth10).

- It is recommended to conduct a study of the genetic relationships between some drought-related crop and morph physiological traits in soft wheat of the Doma 6 and Buhuth 10 cultivars over more than one growing season.

Continue conducting such experiments on all crop varieties approved by the General Authority for Scientific Agricultural Research.

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