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Physiological impact of water deficit during growth stages of the wheat crop

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Abstract

To know the physiological impact of water deficit during the growth stages of the wheat crop, this study was conducted using plastic pots through the growing season 2023-2024. A split plot design was used. The primary lot comprised water deficit periods (ID) (26/11–25/12 ID1), (26/12–24/1 ID2), (25/1–24/2 ID3), and (25/2–25/3 ID4)) while the sub plots included five wheat varieties (C) (Al-Rashid (C1), Bohouth 22 (C2), Ibaa 99 (C3), Abu Ghraib (C4), and Bora (C5)) on three replicates. The deficit period (ID2) produced the lowest averages for height of plant, amount of chlorophyll, area of flag leaves, tillers number, grain spike number, and the total grain yield (96.07 cm, 0.6780, 44.62 cm^2, 320.9 tiller.m^2, 61.80 grain.$spike^{-1}$, 5.757 ton.ha^{-1}) respectively. The water deficit period (ID4) gave the lowest average weight of 1000 grains, which amounted to 39.09 g. Al-Rasheed variety achieved greatness by providing the highest average height of plant, content of chlorophyll , and flag leaf area (108.50 cm, 0.7475, 58.32 cm^2), respectively. Bohouth variety gave the highest averages for the number of tillers, the number of grains per spike, and grain yield (406.2 tiller.m^2, 66.58 grain.$spike^{-1}$, 7.464 ton.ha^{-1}). The Ibaa variety provided the greatest average weight of 1000 grains (44.17 g). The interaction treatment ID2C4 provided the least mean of grain yield 5,100 ton.ha^{-1}, while ID1C2 provided the greatest average, this was not very different from ID1C1 (8.847 - 8.463) ton.ha^{-1}. Attention must be paid to the growth periods of the wheat crop that are most affected by water deficit (ID2, ID4) and try to provide water needs for them compared to the periods (ID1, ID3) because they have a significant impact on the overall production.

Keywords: production, physiological impact, water deficit, varieties

Introduction

The wheat crop, especially in the central and southern regions of Iraq, is exposed to periods of water deficit, which may be due to the lack of water reaching Iraq, lack of rainfall, or increased demand during the developmental stages of the plant's life, or the lack of correct irrigation scheduling, which exposes the crop to water stresses that may cause harmful effects on the stages of growth or affect the potential limit that each organ and component of the crop can reach (Zaban and Alsajri, 2022). Wheat varieties are among the main factors that affect the overall production process of the wheat crop due to its ability to adapt to the environmental conditions in which it is grown. The growth of the crop and its arrival at certain stages differ according to the varieties, which is reflected in its growth and production (Mohammed et al. 2020). The gap between consumption and production of wheat in Iraq seems large, even though this country is one of the main places for the emergence of this crop. The decline in wheat crop production may be due to not using the appropriate variety for the region, not following good management to serve the crop, not applying modern technologies, the problem of climate change, salinity and drought, in addition to how to exploit water sources scientifically and thoughtfully to reduce waste resulting from misuse through accurate estimation for the water needs of the crop and irrigation in the critical stages of plant growth (Al-Sammak and Al-Huhairi, 2017), therefore this study aimed to know the physiological impact of water deficit (lack of irrigation) and the critical stages during the crop growth stages and the extent of resistance and tolerance of wheat varieties to water deficit.

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MATERIALS AND METHODS

Study location

To know the physiological impact of water deficit (lack of irrigation) during the growth stages of the wheat crop, this study was conducted using plastic pots (Dhi Qar Governorate's Al-Fadhiliya region) through the growing season 2023-2024.

Experiment design

A split-plot design was used. The primary lot comprised water deficit periods (ID) (26/11 – 25/12 ID1), (26/12 – 24/1 ID2), (25/1 – 24/2 ID3), (25/2 – 25/3 ID4))(Table 1), while the sub plots included five wheat varieties (C)(Al-Rashid (C1), Bohouth 22 (C2), Ibaa 99 (C3), Abu Ghraib (C4), Bora (C5)) on three replicates.

Table 1. Periods of water deficit during the growth stages of wheat crop

No:	The period for water deficit periods	Water deficit period Code	Growth stage	Period for the growth stage	Date of the growth stage
1	**-**	**-**	**Plant emergence**	7 - 10	11 /26 – 11 /16
2	**/25 – 11 /26 12**	**ID1**	**Seedlings**		
			- From one to two leaves - From two to three leaves	10 12	12/ 11 – 5 /26 12/ 12 – 16 /5
3	**1 /24 - 12 /26**	**ID2**	**Tillering**		
			- From completing the leaflets to completing the tillering	21	1 /5 – 12 /16
			Elongation		
			- From tillering to complete elongation	19	1 /23 – 1 /5
4	**2 /24 – 1 /25**	**ID3**	**Booting**		
			- From completion of elongation to booting	20	2 /11 – 1 /23
			Emergency inforescene	15	2 /25 – 2 /11
5	**3 /25 – 2 /25**	**ID4**	**Anthesis**	7	3 /3 - 2 /25
			Physiological maturity	27	4 /1 – 3 /3

Water deficit treatments were applied when the plants reached the growth stage required in Table (1) and for 30 days. After the end of the period, irrigation was repeated normally and according to the

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plant's needs. Seeds of wheat varieties were planted on 11/16/2023 in the soil of plastic pots 5 kg , with 10 seeds in each pot. Fertilizer recommendations for nitrogen, phosphorus and potassium were applied according to publications prepared by the Ministry of Agriculture (Education leaflet, 2012) at three stages of plant growth (ZGs21, ZGs32, ZGs49) (Zadoks et al., 1974).

Studied traits

Data were recorded for the studied traits (height of plant, content ofchlorophyll , area of flag leaf , tillers number, grain spike number, the weight of one thousand grains, yield of grains). The plants were harvested on 17/4/2024. The data were analysed according to the design used and LSD was used to compare the averages at the probability level of 0.05.

RESULTS

Plant height

Table 2's findings demonstrate the considerable effects of both wheat varieties and water deficiency periods, as well as their interactions. Water deficit period (ID2) provided the poorest mean 96.07 cm compared to the period of water deficit (ID1) which provided the greatest average 104.87 cm. Al-Rasheed variety (C1) excelled by giving the provided the greatest average 108.50 cm, whilst Bohouth 22 (C2) provided the poorest mean 88.50 cm. The outcomes also showed that the treatment of interactions ID2C2 provided the poorest mean 85.67 cm. In comparison, the treatment of interactions ID1C1 provided the greatest average 111.33 cm, This was not very different from the intervention treatment ID1C3, that provided 111.00 cm.

Table 2. Impact of water deficit and varieties on plant height (cm)

Type Irrigation	**Cultivars**					**Mean**
	C_1	**C_2**	**C_3**	**C_4**	**C_5**	
ID_1	111.33	91.67	111.00	109.33	101.00	**104.87**
ID_2	105.33	85.67	99.00	97.00	93.33	**96.07**
ID_3	110.33	89.67	105.67	104.67	97.00	**101.47**
ID_4	107.00	87.00	101.00	98.00	94.33	**97.47**
Means	**108.50**	**88.50**	**104.17**	**102.25**	**96.42**	
$L.S.D_{0.05}$	**Irrigation Deficiency**	**Cultivars**	**Interaction**			
	0.621	**1.169**	**2.146**			

Chlorophyll content

The findings presented in Table (3) demonstrated that the factors under investigation and their interactions had a noteworthy influence, as the period (ID2) provided the poorest mean in this characteristic, amounting to 0.6780. In contrast, the period (ID1) provided the greatest average 0.7713. Al-Rasheed variety (C1) provided the greatest average.0.7474, whilst Bohouth 22 (C2) provided the poorest mean 0.6833. The interaction treatment ID2C2 gave the lowest average of 0.6567, while the interaction treatment ID1C5 gave the highest average of 0.8167, This was not very different from ID1C1, that provided 0.7833.

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Table 3. Impact of water deficit and varieties on chlorophyll content

Type Irrigation	Cultivars					Mean
	C_1	C_2	C_3	C_4	C_5	
ID_1	0.7833	0.7200	0.7600	0.7767	0.8167	**0.7713**
ID_2	0.7000	0.6567	0.6933	0.6600	0.6800	**0.6780**
ID_3	0.7767	0.6700	0.7200	0.7433	0.7200	**0.7260**
ID_4	0.7300	0.6867	0.7033	0.6967	0.7000	**0.7033**
Means	**0.7475**	**0.6833**	**0.7192**	**0.7192**	**0.7292**	
$L.S.D_{0.05}$	**Irrigation Deficiency**	**Cultivars**	**Interaction**			
	0.021	**0.019**	**0.037**			

Area of flag leaf

The outcomes displayed in Table (4) the significant impact of water deficit periods and wheat varieties and the interaction between them. The results indicated that the period (ID2) provided the poorest mean 43.14 cm^2, this was not very different from (ID4) that provided 44.60 cm^2, while the period (ID1) gave the highest average was 50.46 cm^2. Al-Rasheed variety (C1) also excelled by providing the greatest average 58.32 cm^2, whilst Bora (C5) provided the poorest mean 34.24 cm^2. Treatment of interaction ID2C5 provided the poorest mean 30.14 cm^2, this was not very different from ID4C5, that provided 31.57 cm^2. In comparison, the interaction treatment ID1C1 provided the greatest average 62.56 cm^2, this was not very different from ID3C1, that provided 60.80 cm^2.

Table 4. Impact of water deficit and varieties on flag leaf area (cm^2)

Type Irrigation	Cultivars					Mean
	C_1	C_2	C_3	C_4	C_5	
ID_1	62.56	51.29	54.11	44.20	40.12	**50.46**
ID_2	54.85	46.42	50.10	34.18	30.14	**43.14**
ID_3	60.80	50.12	52.60	38.12	35.12	**47.35**
ID_4	55.06	48.14	51.37	36.97	31.57	**44.62**
Means	**58.32**	**48.99**	**52.05**	**38.37**	**34.24**	
$L.S.D_{0.05}$	**Irrigation Deficiency**	**Cultivars**	**Interaction**			
	2.308	**2.815**	**5.358**			

Number of Tillers

The results of Table (5) show how the study elements and their interactions have a substantial impact. It was also noted that the period (ID2) gave the lowest average of 320.9 tiller.m^2 in contrast to (ID1) that provided the greatest mean 437.6 tiller.m^2. It was also noted that Bohouth 22 (C2) outperformed by assigning it the greatest average 406.2 tiller.m^2 in contrast to Abu Ghraib (C4), that provided the minimum mean, was 350.5 tiller.m^2, which did not differ significantly from Ibaa 99 variety (C3) and Bora variety (C4), which both gave (357.2, 359.2) tiller.m^2. Treatment of interaction ID2C4 provided the poorest mean 287.3 tiller.m^2, this was not very different from the interference treatment ID4C4,that provided 297.3 tiller.m^2, while the interference treatment ID1C2 gave the highest average, amounting to 477.0 tiller.m^2, this was not very different from the interference treatment ID1C4, that provided 472.3 tiller.m^2.

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Table 5. Impact of water deficit and varieties on the number of tillers (tiller.m^2)

Type Irrigation	Cultivars					Mean
	C_1	C_2	C_3	C_4	C_5	
ID₁	412.7	477.0	390.0	472.3	436.0	**437.6**
ID₂	341.0	344.7	320.0	287.3	311.3	**320.9**
ID₃	390.7	435.0	375.0	345.0	355.0	**380.1**
ID₄	355.7	368.0	343.7	297.3	334.3	**339.8**
Means	**375.0**	**406.2**	**357.2**	**350.5**	**359.2**	
L.S.D$_{0.05}$	**Irrigation Deficiency**	**Cultivars**	**Interaction**			
	11.39	**16.73**	**31.23**			

Grain Spike Number

Table 6 findings show a noteworthy influence of water deficit periods, wheat varieties, and the interaction between them. The water deficit period (ID2) continued to give the lowest average of 59.07 grain per spike, this was not very different from (ID4), that provided 61.80 grain per spike, whilst period (ID1) provided the greatest average 64.53 grain per spike this was not very different from period (ID3), that provided 63.33 grain per spike. Bohouth 22 (C2) variety confirmed its superiority in this characteristic and gave the highest average of 66.58 grain per spike, which did not differ significantly from Al-Rashid variety (C1), which gave 65.75 grain per spike, whilst Ibaa 99 (C3) provided the poorest mean 56.92 grain per spike, which did not differ significantly from the variety Abu Ghraib (C4), which gave 58.50 grain per spike. Treatment of interaction ID3C3 provided the poorest mean 50.00 grain per spike, this was not very different from ID4C4, that provided 55.00 grain per spike, whilst the interaction treatment ID3C5 provided the greatest average 70.00 grain per spike, this was not very different from ID3C2, ID4C1, that provided 69.00 grain per spike-.

Table 6. Impact of water deficit and varieties on Grain Spike Number (grain per spike)

Type Irrigation	Cultivars					Mean
	C_1	C_2	C_3	C_4	C_5	
ID₁	66.33	65.33	66.00	60.00	65.00	**64.53**
ID₂	65.00	65.00	53.67	54.00	57.67	**59.07**
ID₃	62.67	69.00	50.00	65.00	70.00	**63.33**
ID₄	69.00	67.00	58.00	55.00	60.00	**61.80**
Means	**65.75**	**66.58**	**56.92**	**58.50**	**63.17**	
L.S.D$_{0.05}$	**Irrigation Deficiency**	**Cultivars**	**Interaction**			
	2.899	**3.052**	**5.932**			

The weight of one thousand grains

Table (7) results demonstrated that the study parameters and their interactions had a substantial impact, as the period (ID4) provided the poorest mean 39.09 g compared to the period (ID2) provided the greatest average 42.24 g, which did not differ significantly from the period (ID1, ID3) that both gave (42.19, 41.69) g. Ibaa 99 variety (C3) excelled by giving provided the greatest average 44.17 g, this was not very different from Al-Rasheed variety (C1), which gave 43.80 g, while Abu Ghraib variety (C4) provided the poorest mean 36.48 g. Treatment of interaction ID4C4 gave the lowest average, amounting to 32.97 g, this was not very different from ID2C4, that provided 35.33 g. In contrast, the interaction treatment ID2C3 gave the highest average, amounting to 49.74 g.

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Table 7. Impact of water deficit and varieties on the weight of (1000 g)

Type Irrigation	Cultivars					Mean
	C_1	C_2	C_3	C_4	C_5	
ID_1	44.67	43.15	40.25	40.48	42.39	**42.19**
ID_2	45.66	42.03	49.74	35.33	38.44	**42.24**
ID_3	43.80	43.21	44.11	37.16	40.16	**41.69**
ID_4	41.07	41.23	42.60	32.97	37.57	**39.09**
Means	**43.80**	**42.41**	**44.17**	**36.48**	**39.64**	
$L.S.D_{0.05}$	**Irrigation Deficiency**	**Cultivars**	**Interaction**			
	2.730	**1.470**	**3.517**			

Grain Yield

The results in Table (8) show the presence of a significant impact of water deficit periods and wheat varieties and the interaction between them. The results indicated that the period (ID2) gave the lowest average, amounting to 5,757 $ton.ha^{-1}$, while the period (ID1) produced the greatest average 8,162 $ton.ha^{-1}$. Bohouth 22 (C2) variety achieved greatness by providing the highest average 7,464 $ton.ha^{-1}$, this was not very different from Al-Rasheed (C1), that provided 7,402 $ton.ha^{-1}$, whilst Abu Ghraib (C4) provided the poorest mean 6,192 $ton.ha^{-1}$. Treatment of interaction ID2C4 provided the poorest mean 5,100 $ton.ha^{-1}$, whilst ID1C2 produced the greatest average 8,847 $ton.ha^{-1}$, this was not very different from the two treatments ID1C1, ID1C5, which gave (8,463, 8,300) $ton.ha^{-1}$.

Table 8. Impact of water deficit and varieties on grain yield ($ton.ha^{-1}$)

Type Irrigation	Cultivars					Mean
	C_1	C_2	C_3	C_4	C_5	
ID_1	8.463	8.847	8.000	7.200	8.300	**8.162**
ID_2	6.197	5.720	6.000	5.100	5.767	**5.757**
ID_3	8.323	8.690	7.900	6.700	8.033	**7.929**
ID_4	6.627	6.600	6.500	5.767	6.167	**6.332**
Means	**7.402**	**7.464**	**7.100**	**6.192**	**7.067**	
$L.S.D_{0.05}$	**Irrigation Deficiency**	**Cultivars**	**Interaction**			
	0.223	**0.301**	**0.566**			

DISCUSSION

Water deficiency has much damage during every stage of wheat crop growth because it is included in the name of water stress, especially since the wheat crop is not resistant to water stress. Wheat needs (5 - 7) % of the water needs in the germination and seedling stage and (15 - 20) %. In the tiller stage, (50-60) % of the total amount of water in the elongation, spike, and anthesis stage (Al-Tahir et al., 2023). The water needs of the wheat crop vary according to the stages of growth. There may be a water surplus during the first stages of growth, especially in the months (December, January, and even February), due to low water needs, low rates of evaporation-transpiration (beginning of plant growth, moderate climate, and low rates of the temperature and wind speed rise, while water needs increase, and the water deficit begins in March and continues until April (Thanoon, 2013). Giving the period (ID2) the lowest average for plant height may be attributed to the fact that water deficit affects the performance of physiological processes and leads to a reduction in growth, elongation, and unfolding, and thus plant tissues accelerate toward maturity, particularly in the initial phases of the plant's existence, and it is an adaptive process carried out by the plant to compete for the products of photosynthesis between the stem, which begins to elongate, the leaves that begin to grow and expand, and the remaining organs of the plant, and the height

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of the plant decreases accordingly, or it may be attributed to the lack of division, expansion, and elongation of the stem cells as a result of the decrease in the water potential of the structural cells associated with the lack of water readiness. Water stress also leads to this. The stage coinciding with the rise in temperature leads to a decrease in the length of the internodes, especially the upper internodes, and consequently causes the plant's height to decrease. This outcome was consistent with Zabn and Alsajri (2022).

Exposure of wheat plants during their growth stages, especially during the period (ID2) to water deficit leads to a reduction in all physiological processes due to their connection to the presence of water, such as photosynthesis and transpiration, which contributes to a decrease in the level of development of plant organs, including the leaves and their chlorophyll content. This result agreed with Wasaya et al., (2021).

The explanation for the flag leaf's decreased area may be that water deficit in the period (ID2) contributed to reducing the amount of chlorophyll (Table 3), and thus this decrease contributed to reducing the effectiveness of the photosynthesis process, which affected the growth and expansion of the flag leaf. Likewise, these processes of leaf coincide with period (ID2) (a period of low water content), in addition to the competition that occurs between meristematic plant tissues for water and nutrients, which decreases with increasing water stress, which accelerates growth processes towards maturity in response to water stress, This has a negative reflection in the flag leaf's area. This outcome was consistent with Zabn and Alsajri (2022).

The cause for the decrease in tillers number in the period (ID2) could be linked to the scarcity of water, which to a decline in chlorophyll, which to a decline in the results of photosynthesis and an increase in competition between the stem, which is going through the elongation stage, and the growth of tillers, which consequently resulted in less resources being ready for the freshly created tillers to continue growing and forming, which does not help most of them to continue in life, and thus produces a smaller tillers number. This outcome was consistent with Khadka et al., (2020).

Cause for the decrease in the grain number in period (ID2) possibly as a result of the maximum number of spikelets coinciding with the beginning of stem elongation, in which competition occurred as a result of a lack of water and nutrients, causing miscarriage and death of the spikelets due to insufficient materials prepared for the completion of the formation of the spikelets. Also, the decrease in the formation of chlorophyll has caused a decrease in photosynthesis, which increased the competition between the stem, tillers, spikelet's, and thus the effect of the number of grains in the spike. This result agreed with Mohammed et al., (2020).

The resulting differences in the character of the weight of 1000 grains and giving the period (ID2) the lowest average are attributed to the impact of the water deficit accompanying the high temperature and wind speed, This result in the grain filling time being shortened, which causes it to contract and become smaller, besides the reduction of photosynthetic products from the source to the sink (decrease in area of flag leaf, Table 4) and hence its decrease in weight, because the effectiveness and length of the duration of photosynthesis of the flag leaf are related to the weight of the grain, as well as the reduction in the duration of photosynthesis and the speed towards maturity harms the accumulation of total dry matter that will later be transferred to the grain, as well as a decrease in the height of the plant (Table 2) will reduce its contribution to filling the grains and increasing their weight. In addition, high temperatures and high respiration rates at the plant level as a whole reduce the rate of net stored metabolism in the plant towards the grains, that was also returned in weight of grain. This outcome was consistent with Mohammed et al., (2020).

The decrease in grain yield in the period (ID2) was due to the impact of water deficit on growth characteristics: plant height, chlorophyll content, and flag leaf area (Tables (2, 3, 4)) and then its impact on the yield components, tillers number, grains number (Tables (5, 6) thus, grain yield (Table 8).

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The genetic makeup of the variants and the degree to which they react and adjust to environmental factors and water deficit in this study affected their ability to grow, adapt and compete for water needs and nutrients, which was reflected in the growth characteristics and yield components (the varieties varied by giving the highest averages for the studied traits) which is the reason for the superiority of Bohouth 22 (C2) variety. Compared with other varieties, this is due to its genetic ability to excel in two components of yield (tillers number, grain number) (Tables (5,6)) its high ability to adapt to periods of water deficit and the study area's surrounding environmental conditions, and thus its superiority in grain yield. This result agreed with Pandey et al., (2022).

CONCLUSION

The study showed that the growth stages of wheat varieties occurring in periods of water deficit (ID2, ID4) are more sensitive to water, they had a significantly effects on studied traits and yield components. Bohouth 22 variety (C2) and Al-Rasheed variety (C1) also confirmed their ability to adapt and tolerate water deficit during the growth stages giving them the highest grain yield compared to the rest of the varieties included in the study.

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REFERENCES

Al-Sammak, Q.H.A., and Al-Hujairi, J.K.O. (2017). The effect of Potassium application on some yield traits of wheat plant (*Triticum aestivum* L.) exposed to different levels of water stress. Journal of Kerbala University. V 15 (2) P: 262-272.

Al-Tahir, F.M.M., Al-Refai, SH. M., Al-Sadain, KH.J.Y. (2023). Cereal Crops. Ministry of Higher Education and Scientific Research. University of Al-Muthanna. College of Agriculture.

Education Leaflet.2012. Agricultural Extension Service. P 36 . Baghdad, Iraq.

Khadka, K., Earl, H. J., Raizada, M. N., and Navabi, A. (2020). A physio-morphological trait-based approach for breeding drought tolerant wheat. Frontiers in plant science, 11, 715.

https://doi.org/10.3389/fpls.2020.00715

Mohammed, A.K.S., Swaid, A.H., Neama, A.S., Abd Majeed, M.M., and Jaber, T.N. (2020). Effect of Irrigation Period on the Growth and Yield of Cultivars of Bread Wheat. Journal of Education and Scientific Studies. 3(15) P: 199-212.

Pandey, A., Khobra, R., Mamrutha, H. M., Wadhwa, Z., Krishnappa, G., Singh, G., & Singh, G. P. (2022). Elucidating the drought responsiveness in wheat genotypes. Sustainability, 14(7), 3957.

https://doi.org/10.3390/su14073957

Thanoon, A.A. (2013). Gross Irrigation Water Requirement for Durum Wheat Crop (Sham 3) At Mosul Area in Season 2009/2010. AL-Rafidain Engineering Journal (AREJ), V 21 (2) P: 64-72.

https://doi : 10.33899/rengj.2013.72800

Wasaya, A., Manzoor, S., Yasir, T. A., Sarwar, N., Mubeen, K., Ismail, I. A., and El-Sabagh, A. (2021). Evaluation of Fourteen Bread Wheat (*Triticum aestivum* L.) Genotypes by Observing Gas Exchange

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Parameters, Relative Water and Chlorophyll Content, and Yield Attributes under Drought Stress. Sustainability, 13(9).

https://doi.org/10.3390/su13094799

Zabn, KH.M., and Alsajri, F.A. (2022). Effect of Stopping Irrigation at Different Growth Stages in Wheat Growth and Dry Matter Accumulation. Iraqi Journal of Desert Studies. V 12 (2) P: 18-30.

https://doi : 10.36531/ijds.2022.176691

Zadoks, J. C., Chang, T. T., and Konzak, C. F. (1974). A decimal code for the growth stages of cereals. Weed Research, 14, 415-421.

https://doi.org/10.1111/j.1365-3180.1974.tb01084.