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WATER REQUIREMENTS IN RELATION TO GROWTH STAGES IN WHEAT

El-Batal, M.A.*; M.H. Abdel -Gawad*; Mona, A. M. Soliman;**
and El-Set A. Abdel-Aziz*
***Field crops Res. Inst., Agric. Res. Center, Giza., Egypt**
****Botany Dept. N.R.C. , Giza , Egypt**

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ABSTRACT: Pot experiments were carried out at the green-house of crop Physiology Department in the Experimental Farm of Giza 168 wheat Giza Agricultural Research Station, ARC. variety was grown during 1999/2000 and 2000/2001 seasons to determine the water requirements for wheat plants at different sandy loam soil. All pots received 3.5L as water growth stages in sowing and 0.5L at germination stage. Then, six water treatments were applied in 43 irrigations 1L each 3 days, i.e., (1) control-43L in equal doses, (2) 43L in differ distribution as 4.65% at emergence, 9% at the next 10 growth stages and as 2.33%at maturity as growth stage need, [(3) withholding 10%, (4) withholding 20%, (5) withholding 30% and (6) withholding 40%,] from treatment No.2 with 45 reputations.

In light of the obtained results, there were significant differences among water treatments tested for all characters studied. It is clear that the second water treatment 43L in different distributions at 12 growth stages surpassed the other water treatments in dry matter accumulation and rate, number of tillers and spikes per plant, spike length, number of spikelets and kernels number per spike, kernels weight per spike, 100-kenel weight, yields per plant (biological, grains and straw), harvest index and water widely use efficiency for grains weight per plant.

Plants in control treatment had the highest values of phenological stages duration and plant height. While, withholding 10% (of water amount) gave higher values of the other characters than those of the control, without significant differences in most traits. Increasing

water stress reduced the values of all studied characters. Changing irrigation systems lead to better water use efficiency. So, the 2^nd^ treatment of this study can be used by moved and/or fixed sprinkler irrigation systems which are adapted in most new lands.

INTRODUCTION

In Egypt, wheat has been considered the first strategic food crop for making bread and wheat straw is an important for hay making . Availability of irrigated water at different growth stages would be one of the obstacles in increasing the total acreage of wheat. **Hagras et al (1993)** found that application of 2130 m^3 water/fed. scored the highest plant height and dry weight, number of tillers and spikes per plant, grain index, grain and straw yields per fed. **Ghadekar et al (1994)** indicated that water requirements varied with growth stage and weather conditions with 255.4 mm as a weekly mean. Irrigation at late jointing or anthesis significantly increased number of spikes, grains and grain weight per plant **(Mc Master et al, 1994).** The highest grain or straw yield per fed. was obtained when irrigation was practiced at 30% depletion of available soil moisture **(Yousef and Eid, 1994).** Irrigation at 35% water depletion produced the highest values of plant height, tillers or spikes number per plant, shoot dry weight, grains weight per plant and grain index **(Imam et al, 1995).** The crop irrigated at crown-root initiation, maximum tillering, boot and milk stages produced high grain yield **(Pal et al, 1996). Garabet et al (1998)** stated that supplemental irrigation, applied at a sensitive growth stage, would be a valuable management practice for improving yield and water use efficiency under the dry conditions of a Mediterranean climate. **Siddique et al (1999)** demonstrated that plants subjected to drought at the early vegetative stage displayed similar physiological characters subsequently under well-watered conditions when compared with control plants.

The effects of water stress on yield were mainly due to decrease in number of grains per spike **(Wang et al, 1993).** Exposing of wheat plants to drought conditions at booting and dough stages caused a significant reduction in number of days to heading, plant height, number of tillers or spikes per plant, spike length, number of grains per spike, grain weight per plant and yields of grain or straw per fed. as mentioned by **Abdel-Gawad et al (1994)**. Single plant yield as recorded by **Sieling et al (1994)** was decreased under water stress between anthesis to early milk development, mainly caused by lower number of spikes per plant and by a reduction of grains number per spike. **Abo-Shetaia and Abdel-Gawad (1995-a)** found that plant height, number of tillers per plant, shoot fresh and dry weight, 1000- grain weight, grains number per spike and both straw and grain yields per fed. showed a considerable reduction by prolonging the period between first and second irrigation. **Abo-Shetaia and Abdel-Gawad (1995-b)** added that grain yield was more decreased when irrigation was skipped at tillering than at heading, milk or dough stages. **Christen et al (1995)** indicated that the largest relative effect of a temporary water stress on crop accrued after the flag leaf stage. While, **Singh and Patel (1995)** pointed out that water stress at tillering reduced number of tillers or spikes, at flowering reduced number of grains per spike and at grain filling reduced grain weight. Early water deficits can alter the timing of phonological development, reduce fertile tillers and grain yield **(Armstrong et al, 1996)**. **Muhammad et al (1996-a)** noted that grain yield and harvest index were reduced by water stress at all growth stages particularly at anthesis. However, straw yield was reduced only when water stress occurred at jointing. Therefore, water stress at anthesis was most critical for grain formation as reported by **Muhammad et al (1996-b)**. Father, flowering was the most sensitive stage to water stress **(Ravichandran and Mungse, 1997)**.

Asseng et al (1998) showed that total root growth was reduced under water deficit. Crop subjected to early water deficit could compensate for some of the reductions in root growth during subsequent rewetting, but the impact of the mid-season water deficit treatment was more severe and permanent. Application of water stress decreased the number of days required to reach physiological maturity **(Ravichandran and Mungse, 1998-b)**. **Abayomi and Wright (1999)** concluded that water stress had smaller effects on growth, yield and recovery better when the stress was applied in the early vegetative phase than when applied in late vegetative and post-anthesis stages. Overall, water stress had a greater effect on yield when it occurred during the reproductive stage, suggesting that screening for water stress tolerant genotypes should be done at this stage. On the other hand, moisture stress at tillering caused maximum reduction in total dry matter **(Pal et al, 2000).**

Drought and/or water stress resistance and heat tolerance are major constraints. Environments with drought, water and heat stress encompass about 80.000 hectares at Northwest Coast, about 6000 hectares at the new valley and about 220,000 hectares at upper Egypt governorates **(Gomaa, 1999)** . So the present study aimed to determine the amount of water for wheat plants at different growth stages to improve water use efficiency.

MATERIALS AND METHODS

Pot experiments were conducted at the green-house of crop Physiology Department in Giza Experimental Station, ARC, during 1999/2000 and 2000/20001 seasons. The main objective of this study was to determine the water requirements for wheat plants at different growth stages to increase plant productivity and improve the water use efficiency. Sandy loam soil with the mechanical analysis of 8.5% clay, 13.7% silt, 48.6% fine sand and 29.2% coarse sand collected from Northwest Coast was used. Six treatments of water amount were applied in 43 irrigations 1L each 3 days, i.e., (1)control-43Lin equal doses, (2) 43L in differ distribution as 4.65% at emergence ,9% at the next 10 growth stages and 2.33% at maturity as growth stage need [(3)withholding 10% , (4) withholding 20%, (5)withholding 30% and (6)withholding 40%] from treatment No.2 as shown in Table (1) using completely random design with 45 pots for each treatment.

On Nov. 11, 1999 and Nov. 8, 2000, Giza 168 cultivar was sown by 12 kernels per pot and irrigated with 3.5L. After ten days, seedlings in each pot were thinned to 6 plants and irrigated with 0.5L. Afterwords the irrigation regime of the six treatments was regulated as presented in Table (2). Each pot received basal fertilization of 11.5g calcium supper phosphate (15.5% P_2O_5) and 3.3g potassium sulfate (50% K_2O) before sowing. One month later, ammonium nitrate (33.5% N) was added at the rate of 1.7g/pot, then every two weeks one gram of urea (46% N) was applied five times. A mixture of chelated

Table (1): Water distribution (L/pot) for all growth stages:

Growth stages (GS)	Treatments							
	Control 1		2	3	4	5	6	%
	L	%						
Sowing	3.5	-	3.5	3.5	3.5	3.5	3.5	-
1- Germination	0.5	-	0.5	0.5	0.5	0.5	0.5	
2- Leaf-emergence	2	4.65	1	0.9	0.8	0.7	0.6	2.33
3- Tillering	4	9.30	1	0.9	0.8	0.7	0.6	2.33
4- Elongation	4	9.30	1.5	1.35	1.2	1.05	0.9	3.49
5- Jointing	4	9.30	1.5	1.35	1.2	1.05	0.9	3.49
6- Flag-leaf	4	9.30	2	1.8	1.6	1.4	1.2	4.65
7- Booting	4	9.30	3	2.7	2.4	2.1	1.8	6.98
8- Heading	4	9.30	5	4.5	4	3.5	3	11.63
9- Anthesis	4	9.30	8	7.2	6.4	5.6	4.8	18.60
10- Kernel-formation	4	9.30	8.5	7.65	6.8	5.95	5.1	19.77
11- Milk-ripe	4	9.30	7	6.3	5.6	4.9	4.2	16.28
12- Dough-ripe	4	9.30	4	3.6	3.2	2.8	2.4	9.30
13- Maturity	1	2.33	0.5	0.45	0.4	0.35	0.3	1.16
Total from: L GS2 to GS13	43.0	-	43.0	38.7	34.4	30.1	25.8	-
%	100	-	100	90	80	70	60	-
Total (L/pot)	47.0	-	47.0	42.7	38.4	34.1	29.8	-
m^3/feddan	2791.5	-	2791.5	2536.1	2280.7	2025.3	1769.9	-
mm	665	-	665	604	543	482	421	-

Pot diameter = 30 cm
One feddan = 0.42 ha.

Table (2): Data of irrigation and water amount(L/pot) in both

Growth stages	Treatments											
	1999/2000						2000/2001					
	1	2	3	4	5	6	1	2	3	4	5	6
Sowing	11/11 3.5L for all treatments						8/11 3.5L for all treatments					
1- Germination	21/11 0.5L for all treatments						18/11 0.5L for all treatments					
2- Leaf-emergence	1L 27/11 2/12	0.5 27/11 3/12	0.45 27/11 3/12	0.4 27/11 3/12	0.35 27/11 3/12	0.3 27/11 3/12	1L 24/11 29/11	0.5 24/11 30/11	0.45 24/11 30/11	0.4 24/11 30/11	0.35 24/11 30/11	0.3 24/11 30/11
3- Tillering	1L 7/12 10/12 13/12 16/12	0.5 9/12 14/12	0.45 9/12 14/12	0.4 9/12 14/12	0.35 9/12 14/12	0.3 9/12 14/12	1L 4/12 7/12 10/12 13/12	0.5 6/12 11/12	0.45 6/12 11/12	0.4 6/12 11/12	0.35 6/12 11/12	0.3 6/12 11/12
4- Elongation	1L 19/12 22/12 25/12 28/12	0.5 19/12 23/12 27/12	0.45 19/12 23/12 27/12	0.4 19/12 23/12 27/12	0.35 19/12 23/12 27/12	0.3 19/12 23/12 27/12	1L 16/12 19/12 22/12 25/12	0.5 16/12 20/12 24/12	0.45 16/12 20/12 24/12	0.4 16/12 20/12 24/12	0.35 16/12 20/12 24/12	0.3 16/12 20/12 24/12
5- Jointing	1L 31/12 3/1 6/1 9/1	0.5 31/12 4/1 8/1	0.45 31/12 4/1 8/1	0.4 31/12 4/1 8/1	0.35 31/12 4/1 8/1	0.3 31/12 4/1 8/1	1L 28/12 31/12 3/1 6/1	0.5 28/12 1/1 5/1	0.45 28/12 1/1 5/1	0.4 28/12 1/1 5/1	0.35 28/12 1/1 5/1	0.3 28/12 1/1 5/1
6- Flag-leaf	1L 12/1 15/1 18/1 21/1	0.65 12/1 16/1 0.7 20/1	0.6 12/1 16/1 20/1	0.5 12/1 0.55 16/1 20/1	0.45 12/1 16/1 0.5 20/1	0.4 12/1 16/1 20/1	1L 9/1 12/1 15/1 18/1	0.65 9/1 13/1 0.7 17/1	0.6 9/1 13/1 17/1	0.5 9/1 0.55 13/1 17/1	0.45 9/1 13/1 0.5 17/1	0.4 9/1 13/1 17/1
7- Booting	1L 24/1 27/1 30/1 2/2	1L 24/1 28/1 1/2	0.9 24/1 27/1 30/1	0.8 24/1 27/1 30/1	0.7 24/1 27/1 30/1	0.6 24/1 27/1 30/1	1L 21/1 24/1 27/1 30/1	1L 21/1 25/1 29/1	0.9 21/1 24/1 27/1	0.8 21/1 24/1 27/1	0.7 21/1 24/1 27/1	0.6 21/1 24/1 27/1
8- Heading	1L 5/2 8/2 11/2 14/2	1L 4/2 6/2 8/2 10/2 12/2	0.9 3/2 5/2 7/2 9/2 11/2	0.8 2/2 4/2 6/2 8/2 10/2	0.7 2/2 4/2 6/2 8/2 10/2	0.6 2/2 4/2 6/2 8/2 10/2	1L 2/2 5/2 8/2 11/2	1L 1/2 3/2 5/2 7/2 9/2	0.9 31/1 2/2 4/2 6/2 10/2	0.8 30/1 1/2 3/2 5/2 7/2	0.7 30/1 1/2 3/2 5/2 7/2	0.6 30/1 1/2 3/2 5/2 7/2

Table (2) "contin.": Data of irrigation and water amount(L/pot) in both seasons

Growth stages	Treatments											
	1999/2000						2000/2001					
	1	2	3	4	5	6	1	2	3	4	5	6
9- Anthesis	11.	1.3	1.2	1.05	0.9	0.8	11.	1.3	1.2	1.05	0.9	0.8
	17/2	14/2	13/2	12/2	12/2	12/2	14/2	11/2	10/2	9/2	9/2	9/2
	20/2	16/2	15/2	14/2	14/2	14/2	17/2	13/2	12/2	11/2	11/2	11/2
	23/2	1.35	17/2	16/2	0.95	16/2	20/2	1.35	14/2	13/2	0.95	13/2
	26/2	18/2	19/2	18/2	16/2	18/2	23/2	15/2	16/2	15/2	13/2	15/2
		20/2	21/2	1.1	18/2	20/2		17/2	18/2	1.1	15/2	17/2
		22/2	23/2	20/2	20/2	22/2		19/2	20/2	17/2	17/2	19/2
		24/2		22/2	22/2			21/2		19/2	19/2	
10- Kernel formation	11.	1.4	1.25	1.1	0.95	0.85	11.	1.4	1.25	1.1	0.95	0.85
	29/2	26/2	25/2	24/2	24/2	24/2	26/2	23/2	22/2	21/2	21/2	21/2
	3/3	28/2	27/2	26/2	11.	26/2	1/3	25/2	24/2	23/2	11.	23/2
	6/3	1/3	29/2	1.15	26/2	28/2	4/3	27/2	26/2	1.15	23/2	25/2
	9/3	3/3	1.3	28/2	28/2	1.3	7/3	1/3	1.3	25/2	25/2	27/2
		1.45	2/3	1/3	1/3	1/3		1.45	28/2	27/2	27/2	1/3
		5/3	4/3	3/3	3/3	5/3		3/3	2/3	1/3	1/3	3/3
		7/3	6/3	5/3	5/3			5/3	4/3	3/3	3/3	
11- Milk-ripe	11.	1.4	1.3	1.15	11.	0.85	11.	1.4	1.3	1.15	11.	0.85
	12/3	9/3	8/3	7/3	7/3	7/3	10/3	7/3	6/3	5/3	5/3	5/3
	15/3	11/3	1.25	9/3	9/3	9/3	13/3	9/3	1.25	7/3	7/3	7/3
	18/3	13/3	10/3	1.1	11/3	11/3	16/3	11/3	8/3	1.1	9/1	9/1
	21/3	15/3	12/3	11/3	0.95	13/3	19/3	13/3	10/3	9/3	0.95	11/3
		17/3	14/3	13/3	13/3	0.8		15/3	12/3	11/3	11/3	0.8
			16/3	15/3	15/3	15/3			14/3	13/3	13/3	13/3
12- Dough-ripe	11.	11.	0.9	0.8	0.7	0.6	11.	11.	0.9	0.8	0.7	0.6
	24/3	20/3	19/3	18/3	18/3	18/3	22/3	18/3-	17/3	16/3	16/3	16/3
	27/3	23/3	22/3	21/3	21/3	21/3	25/3	21/3	20/3	19/3	19/3	19/3
	30/3	26/3	25/3	24/3	24/3	24/3	28/3	24/3	23/3	22/3	22/3	22/3
	2/4	29/3	28/3	27/3	27/3	27/3	31/3	27/3	26/3	25/3	25/3	25/3
13- Maturity	11.	0.5	0.45	0.4	0.35	0.3	11.	0.5	0.45	0.4	0.35	0.3
	9/4	5/4	3/4	2/4	1/4	31/3	6/4	3/4	1/4	31/3	30/3	29/3

The bold letters monished to water amount liter per each pot copper (14% Cu), manganese (13% Mn), iron (13% Fe) and zinc (13% Zn) in the form of EADTA at the rate of one gram from each material per two liter water for all pots was sprayed twice at 60 and 90 days age. Harvest took place after one week from the last irrigation, i.e. 156, 153,151,150,149 and 148 days after sowing for the six irrigation treatments, respectively, in both seasons.

All characters studied were recorded as an average of the six plants in each pot using five repetitions (pots) of each treatment for the analysis of variance.

To determine shoot, root and total plant dry matter, seven samples ware taken during plant growth. The first one was after 52 days from sowing and at two weeks interval up to 136 days age. Plants in every pot were carefully deracinated and roots were washed, then air dried over night and descicted into shoots and roots (6 plants together) and oven dried at 75 ^{0}C until constant weight. Daily dry matter accumulation in shoot per plant through the periods between samples was calculated too. The developmental stages were determined as described by **Waddington et al (1983)** upon five pots and was considered to be attained when at least 60% of the plants were at the desired stage.

At harvest time the following characters were measured:

- Plant height (cm) .
- Number of tillers per plant.
- Number of spikes per plant.
- Spike length (cm).
- Number of spikelets per spike.
- Number of kernels per spike.
- Kernels weight per spike (g).
- 100-kernel weight (g).
- Biological weight per plant (g).
- Grains weight per plant (g).
- Straw weight per plant (g).
- Harvest index (%).
- Water use efficiency for grains weight per plant (mg/L).

Data were statistically analyzed according to the procedure outlined by **Steel and Torrie (1984).** Means were compared using least significant difference (LSD) test at 0.05 level probability.

RESULTS AND DISCUSSION

Dry matter accumulation:

Root dry matter per plant at different samples are presented in Table (3). The results showed that there were significant differences in root dry weight among water treatments under study in both

Table (3):Effect of date and water amount treatments on root dry matter per plant (g) of wheat.

Treatments	Number of days from sowing						
	52	66	80	94	108	122	136
	1999/2000						
(1)Control	0.270	0.442	0.736	1.064	1.360	1.620	1.837
(2) 100%	0.239	0.533	0.867	1.245	1.570	1.847	2.066
(3) 90%	0.342	0.546	0.898	1.255	1.554	1.812	2.012
(4) 80%	0.311	0.479	0.789	1.073	1.299	1.502	1.666
(5) 70%	0.281	0.440	0.701	0.934	1.105	1.243	1.340
(6) 60%	0.244	0.382	0.579	0.724	0.857	0.979	1.061
LSD 0.05	0.024	0.037	0.059	0.082	0.103	0.118	0.133
	2000/2001						
(1)Control	0.292	0.473	0.775	1.108	1.409	1.676	1.898
(2) 100%	0.345	0.547	0.889	1.286	1.620	1.904	2.130
(3) 90%	0.358	0.568	0.932	1.297	1.602	1.866	2.069
(4) 80%	0.323	0.517	0.817	1.108	1.340	1.548	1.718
(5) 70%	0.301	0.468	0.737	0.980	1.158	1.303	1.405
(6) 60%	0.263	0.406	0.607	0.758	0.898	1.075	1.161
LSD 0.05	0.026	0.040	0.064	0.088	0.109	0.124	0.140
	Combined						
(1)Control	0.281	0.458	0.756	1.086	1.385	1.648	1.868
(2) 100%	0.337	0.540	0.878	1.266	1.595	1.876	2.098
(3) 90%	0.350	0.557	0.915	1.276	1.578	1.839	2.041
(4) 80%	0.317	0.507	0.803	1.090	1.320	1.525	1.692
(5) 70%	0.291	0.454	0.719	0.957	1.131	1.273	1.372
(6) 60%	0.254	0.394	0.593	0.741	0.877	1.027	1.111
LSD 0.05	0.017	0.027	0.042	0.059	0.074	0.084	0.094

seasons and combined analysis. Root dry weight gradually increased with increasing plant age. It could be mentioned that dry weight of root per plant in third water treatment was the highest value up to 94 days age, then the second water treatment surpassed the others in root dry matter accumulation without significant difference between the two treatments. Root dry weight per plant was decreased with increasing water stress as shown in all samples. It this respect, **Asseng et al (1998)** reported that total root growth was reduced under water deficit and crop subjected to early water deficit could compensate for some of the reductions in root growth during subsequent rewatering, but the impact of the mid-season water deficit treatment was more severe and permanent.

Shoot dry matter per plant at different samples are listed in Table (4). The results indicated that there were significant differences among water treatments under study in both seasons and combined analysis. Shoot dry weight gradually increased as plant age increased. Shoot with the system irrigation of the second treatment accumulated the highest dry matter over all other water treatments at every ages. Shoot of the third water treatment had higher dry weight than control treatment without significant difference. While, shoot of the fourth water treatment had lower dry weight than control treatment without significant differ up to 108 days age. Shoot of the sixth water treatment had the lowest dry weight compared to all the other water treatments at every ages. Generally, dry matter which accumulated in shoot was gradually decreased with increasing water stress in both seasons and combine analysis as shown in every samples under study. These results are in harmony with reported by **Imam et al (1995) and Abo-Shetaia and Abdel-Gawad (1995-a).**

Total plant dry matter accumulation at different samples are given in Table (5). There were significant differences in this trait between water treatments under study in both seasons and combined analysis. Plant dry weight gradually increased with increasing plant age. Dry weight per plant with the system irrigation of the second treatment was the highest value compared to other treatments at every plant ages. Plants of the third water treatment accumulated higher dry matter than control treatment without significant difference

Table (4): Effect of date and water amount treatments on shoot dry matter per plant (g) of wheat.

Treatments	Number of days from sowing						
	52	66	80	94	108	122	136
	1999/2000						
(1)Control	1.013	2.116	4.316	7.114	9.428	11.582	13.546
(2) 100%	1.222	2.566	5.094	8.290	10.997	13.477	15.683
(3) 90%	1.090	2.219	4.491	7.364	9.790	12.019	14.008
(4) 80%	0.954	1.997	4.017	6.530	8.654	10.534	12.152
(5) 70%	0.754	1.596	3.278	5.387	7.135	8.657	9.935
(6) 60%	0.530	1.093	2.444	4.185	5.579	6.785	7.772
LSD 0.05	0.085	0.172	0.359	0.600	0.802	0.963	1.105
	2000/2001						
(1)Control	1.025	2.138	4.351	7.166	9.498	11.660	13.632
(2) 100%	1.234	2.586	5.130	8.352	11.088	13.593	15.819
(3) 90%	1.096	2.240	4.523	7.403	9.845	12.092	14.107
(4) 80%	0.977	2.030	4.062	6.599	8.736	10.628	12.250
(5) 70%	0.764	1.628	3.332	5.456	7.211	8.759	10.051
(6) 60%	0.537	1.122	2.491	4.248	5.654	6.874	7.872
LSD 0.05	0.086	0.178	0.368	0.602	0.803	0.980	1.107
	Combined						
(1)Control	1.019	2.127	4.334	7.140	9.463	11.621	13.583
(2) 100%	1.228	2.576	5.112	8.321	11.043	13.535	15.751
(3) 90%	1.093	2.230	4.507	7.384	9.818	12.056	14.058
(4) 80%	0.966	2.014	4.040	6.565	8.695	10.581	12.201
(5) 70%	0.759	1.612	3.305	5.421	7.173	8.708	9.993
(6) 60%	0.533	1.107	2.767	4.216	5.616	6.829	7.822
LSD 0.05	0.059	0.121	0.252	0.417	0.556	0.674	0.766

Table (5): Effect of date and water amount treatments on total plant dry matter(g) of wheat.

Treatments	Number of days from sowing						
	52	66	80	94	108	122	136
	1999/2000						
(1)Control	1.283	2.558	5.052	8.178	10.788	13.202	15.383
(2) 100%	1.551	3.089	5.951	9.535	12.567	15.324	17.749
(3) 90%	1.432	2.765	5.389	8.619	11.344	13.831	16.020
(4) 80%	1.265	2.494	4.806	7.603	9.953	12.036	13.818
(5) 70%	1.035	2.036	3.979	6.321	8.240	9.900	11.275
(6) 60%	0.774	1.475	3.023	4.909	6.436	7.764	8.833
LSD 0.05	0.106	0.203	0.396	0.642	0.858	1.021	1.180
	2000/2001						
(1)Control	1.317	2.611	5.126	8.274	10.907	13.336	15.530
(2) 100%	1.579	3.133	6.019	9.638	12.708	15.497	17.949
(3) 90%	1.454	2.808	5.455	8.700	11.447	13.958	16.176
(4) 80%	1.300	2.547	4.879	7.707	10.076	12.176	13.968
(5) 70%	1.065	2.096	4.069	6.436	8.369	10.062	11.456
(6) 60%	0.800	1.528	3.098	5.006	6.552	7.949	9.033
LSD 0.05	0.109	0.209	0.411	0.658	0.872	1.045	1.198
	Combined						
(1)Control	1.300	2.585	5.089	8.226	10.848	13.269	15.457
(2) 100%	1.565	3.111	5.985	9.587	12.638	15.411	17.849
(3) 90%	1.443	2.787	5.422	8.660	11.396	13.895	16.098
(4) 80%	1.283	2.521	4.843	7.655	10.015	12.106	13.893
(5) 70%	1.050	2.066	4.024	6.378	8.304	9.981	11.365
(6) 60%	0.787	1.501	3.060	4.957	6.494	7.856	8.933
LSD 0.05	0.074	0.143	0.280	0.450	0.599	0.715	0.824

especially after 80 days age. While, plants of the fourth water treatment had lower dry weight than control treatment without significant difference up to 108 days age. Plants with the system irrigation of the sixth treatment had the lowest value of dry matter accumulation compared to other treatments at every ages. Generally, dry matter accumulation in wheat plants was gradually decreased with increasing water stress in both seasons and combine analysis for all samples. In this connection, similar results are observed by **Hagras et al (1993) and Pal et al (2000).**

Daily dry matter accumulates in shoot per plant at different periods between samples are shown in Table (6). The results indicated that there were significant differences in this character among water treatments under study in both seasons and combine analysis. It is clear that the third period (80 to 94 days) had the highest dry matter accumulation rate over both seasons compared to other periods for all water treatments under study. Regarding water treatments, shoot per plant which received the second system irrigation had the highest dry matter accumulation rate over all other water treatments at every ages. While, shoot of the sixth water treatment had the lowest value of daily dry weight. Other water treatments were inbetween. Dry matter accumulation rate in shoot of the third water treatment was higher than that of control without significant difference. On the other hand, daily dry matter accumulation in shoot of the fourth water treatment was lower than that of control without significant difference up to the fourth period. Furthermore, dry matter accumulation rate was gradually decreased with increasing water stress. Similar results are recorded by **Hagras et al (1993), Imam et al (1995), Abayomi and Wright (1999) and Pal et al (2000).**

Phenological stages:

It is rather of interest to note that wheat plant growth stages were 13 stages namely: germination, leaf-emergence, tillering, elongation, jointing, flag-leaf, booting, heading, anthesis, kernel-formation, milk ripe, dough ripe and physiological maturity. All growth stages needed about156, 153, 151, 150, 149 and 148 days in control, second, third, fourth, fifth and sixth treatments, respectively to complete plants life cycle. Number of days from sowing to physiological maturity were

Table (6): Effect of date and water amount treatments on daily dry matter accumulation of shoot per plant (mg/day) of wheat.

Treatments	Number of days from sowing					
	52 to 66	66 to 80	80 to 94	94 to 108	108 to 122	122 to 136
	1999/2000					
(1)Control	78.786	157.143	199.857	165.286	153.857	140.286
(2) 100%	96.000	180.571	228.286	193.357	177.143	157.571
(3) 90%	80.643	162.286	205.214	173.286	159.214	142.071
(4) 80%	74.500	144.286	179.500	151.714	134.286	115.571
(5) 70%	60.143	120.143	150.643	124.857	108.714	91.286
(6) 60%	40.214	96.500	124.357	99.571	86.143	70.500
LSD 0.05	9.114	17.610	22.166	19.056	16.937	14.940
	2000/2001					
(1)Control	79.500	158.071	201.071	166.571	154.429	140.857
(2) 100%	96.571	181.714	230.143	195.429	178.929	159.000
(3) 90%	81.714	163.071	205.714	174.429	160.500	143.929
(4) 80%	75.214	145.143	181.214	152.643	135.143	115.857
(5) 70%	61.714	121.714	151.714	126.071	109.857	92.28
(6) 60%	41.786	97.786	125.286	100.643	87.143	71.286
LSD 0.05	9.203	18.102	22.509	19.380	17.155	14.964
	Combined					
(1)Control	79.143	157.607	200.464	165.929	154.143	140.572
(2) 100%	96.286	181.143	229.215	194.393	178.036	158.285
(3) 90%	81.178	162.678	205.464	173.857	159.857	143.000
(4) 80%	74.857	144.715	180.357	152.179	134.715	115.714
(5) 70%	60.929	120.928	151.179	125.464	109.285	91.786
(6) 60%	41.000	97.143	124.821	100.107	86.643	70.893
LSD 0.05	6.346	12.372	15.477	12.943	11.811	10.360

almost constant irrespective of both seasons under study (data not given). Every growth stage of plants in control treatment needed about 12 days or less in other water treatments.

Number of days from sowing to 60% heading, anthesis and physiological maturity are presented in Table (7). Data showed significant differences among the tested water treatments in number of days during these stages in both seasons and combine analysis. Control treatment had the longest period from planting to heading, anthesis or maturity followed by the second water treatments without significant difference between them. Increasing water stress caused a reduction in number of days for the above mentioned phases. Plants in the sixth water treatment had the shortest period of these phenological stages. On the same line, several investigators reached similar results among them, for the relationships between water stress and the reduction in number of days to heading as reported by **Abdel-Gawad et al (1994)**. **Armstrong et al (1996)** showed that early water deficits can alter the timing of phenological stages. **Ravichandran and Mungse (1998-b)** found that application of water stress decreased the number of days required to reach physiological maturity. The decrease in the duration to heading is rather expected as it was reported by **Friend (1965)** to be caused by an increase of apical dominance of nutrient or water stressed wheat.

Yield and yield attributes at harvest:

From the results in Table (7), there were significant differences among water treatments in plant characters under study, i.e., plant height, number of tillers and spikes per plant, spike length, number of spikelets and kernels per spike, kernels weight per spike, 100-kernel weight, yields per plant (biological, grains and straw), harvest index and water use efficiency for grains weight per plant in both seasons and combined analysis. The mean of the two seasons was used for discussion of results of these traits.

With respect to plant height, control plants surpassed plants in other water treatments in plant height. The value of plant height was decreased by increasing water stress. Then, the shortest plants were obtained from the sixth water treatment. In this respect, similar results were recorded by **Hagras et al (1993), Abdel-Gawad et al**

Table (7): Effect of date and water amount treatments on phonological stages, yield and yield attributes at harvest of wheat.

Trt.	Number of days to			Plant height (cm)	No. of Tillers /plant	No. of spikes /plant	Spike length (cm)	No. of spikelets /spike	No. of Kernels /spike	Kernels weight /spike	100 kernel weight	Yield per plant (g)			Harvest index %	Grain water use efficiency (mg/L)
	Heading	Anthises	Maturity									Biological	Grain	Straw		
	1999/2000															
Cont.	89.0	100.8	150.3	80.3	5.9	4.8	11.7	20.8	39.7	1.6	3.9	18.9	7.6	11.4	40.0	160.7
100%	87.8	98.7	147.2	76.4	6.5	5.8	12.5	22.1	42.1	1.7	4.1	23.6	10.2	13.4	43.1	216.5
90%	86.5	97.67	145.5	72.0	6.1	5.0	11.9	21.0	40.2	1.6	4.1	19.9	8.2	11.8	40.9	190.9
80%	85.7	97.00	144.7	66.7	5.4	4.4	11.2	19.7	37.7	1.5	3.9	16.2	6.5	9.7	40.0	168.2
70%	85.0	96.5	143.8	63.1	4.8	3.9	10.3	18.3	35.0	1.3	3.8	13.3	5.1	8.1	38.7	150.7
60%	84.8	95.5	142.3	59.3	4.3	3.4	9.5	16.9	32.2	1.2	3.6	10.6	4.0	6.5	37.5	133.0
LSD 0.05	2.18	2.91	4.77	4.20	0.48	0.44	0.51	1.08	2.78	0.10	0.15	2.04	0.69	1.12	2.75	15.25
	2000/2001															
Cont.	89.3	101.0	150.5	79.9	6.0	5.0	11.8	20.8	39.7	1.6	4.0	19.4	7.8	11.6	40.4	166.6
100%	88.0	98.7	147.0	77.0	6.5	5.9	12.5	22.2	42.3	1.8	4.2	24.0	10.4	13.6	43.5	222.2
90%	86.7	97.8	145.7	72.8	6.1	5.1	11.9	21.1	40.3	1.7	4.1	20.3	8.4	11.9	41.4	196.5
80%	85.5	96.8	144.3	67.4	5.5	4.5	11.1	19.7	37.7	1.5	3.9	16.4	6.6	9.8	40.3	172.3
70%	84.8	96.2	143.3	63.5	4.9	4.0	10.4	18.3	35.0	1.3	3.8	13.4	5.3	8.2	39.2	154.0
60%	84.7	95.3	142.0	59.7	4.4	3.5	9.6	16.9	32.3	1.1	3.6	10.8	4.1	6.5	37.9	136.9
LSD 0.05	2.20	2.89	4.72	4.10	0.49	0.45	0.52	1.09	2.80	0.10	0.15	2.11	0.72	1.14	2.80	15.92
	Combine															
Cont.	89.2	100.9	150.4	80.1	5.9	4.9	11.8	20.8	39.7	1.6	4.0	19.1	7.7	11.4	40.2	163.6
100%	87.9	98.7	147.1	76.7	6.5	5.9	12.5	22.1	42.2	1.8	4.2	23.8	10.3	13.5	43.3	219.3
90%	86.6	97.8	145.6	72.2	6.1	5.0	11.9	21.1	40.2	1.6	4.1	20.1	8.3	11.8	41.2	193.7
80%	85.6	96.9	144.5	67.0	5.4	4.5	11.2	19.7	37.7	1.5	3.9	16.3	6.5	9.8	40.1	170.2
70%	84.9	96.3	143.6	63.3	4.8	3.9	10.4	18.3	35.0	1.3	3.8	13.4	5.2	8.1	39.0	152.4
60%	84.8	95.4	142.2	59.5	4.3	3.5	9.5	16.9	32.3	1.2	3.6	10.7	4.0	6.5	37.7	135.0
LSD 0.05	1.52	2.01	3.29	2.90	0.34	0.31	0.35	0.75	1.93	0.07	0.10	1.44	0.49	0.78	1.92	10.79

(1994), and Abo-Shetaia and Abdel-Gawad (1995-a).

Regarding number of tillers per plant, the second water treatment give the highest plant tillers compared to other water treatments. Plants of the third water treatment had higher number of tillers per plant than those of control treatment without significant difference between them. While, control plants were superior to the other water stress treatments. Water stress decreased number of tillers per plant. These result are in agreement with those reported by **Imam et al (1995), Singh and Patel (1995), Armstrong et al (1996) and Pal et al (1996).** Respecting number of spikes per plant, the ranking of water treatments under study was the same as the number of tillers plant. However, fertile tillers percentage was higher in plants received the second system of irrigation (over 90%) than those in the other water treatments (about 82% as a mean). Similar findings were abstained by **Abdel-Gawad et al (1994), Mc Master et al (1994), Sieling et al (1994), and Singh and Patel (1995).**

With regard to spike characters, the second system of irrigation surpassed the other in spike length number of spikelets and kernels per spike, kernels weight per spike and100-kernel weight. Water stress reduced the values of these traits and the same trend was observed. Similar results were recorded by **Abdel-Gawad et al (1994)** for spike length and number of spikelests per spike, **Wang et al (1993), and Singh and Patel (1995),** for spike weight, **Abo-Shetaia and Abdel-Gawad (1995-a)and Imam et al (1995)** for 100-kernel weight.

Respecting yield characters, the highest values of biological, grains and straw weights per plant, harvest index and water use efficiency for grains weight per plant were obtained from plants treated with the second treatment of irrigation followed by those of third water treatment. Increasing water stress reduced the values of these characters. In this connection, similar results were reported by **Yousef and Eid (1994), and Muhammad et al (1996 a and b)** for biological and straw yields, **Christen et al (1995), Armstrong et al (1996),Garabet et al (1998), and Abayomi and Wright (1999),**for grain yield, **Muhammad et al (1996-a)** for harvest index, and **Garabet et al (1998)** for water use efficiency in yield.

It is clear that the second water

treatment surpassed the other water treatments in biological and straw weight per plant, attributing to its superiority in dry matter accumulation per plant and number of tillers. Also, the second water treatment surpassed the other in grain weight per plant, harvest index and water use efficiency, due to its superiority in number of spikes per plant and spike characters, i.e., spike length, number of spikelets and kernels per spike, kernels weight per spike and 100-kernel weight. These superiority of the second water treatment in the above mentioned traits may be due to the well-watered conditions of plants at the most sensitive stages to water stress which were anthesis, kernel-formation and milk-ripe stages (five weeks duration and needed about 55% from water irrigation). In this connection, **Muhammad et al (1996-b)** reported that water stress at anthesis was most critical for grain formation. **Ravichandran and Mungse (1997)** revealed that flowering was the most sensitive stage to water stress.

Plants received the third water treatment had significant higher values of kernels weight per spike, 100-kernel weight, kernels weight per plant and water use efficiency than those of control treatment, suggesting that plants subjected to drought at the early vegetative stage displayed similar physiological characters subsequently under well-watered conditions **(Siddique et al, 1999)**. In addition, **Abayomi and Wright (1999)** concluded that water stress had smaller effects on growth and yield and recovery better when stress was applied in early vegetative phase than when applied in late vegetative and post-anthesis stages. So, selection for yield and its components under stress conditions may result in decreased susceptibility to stress . In other words, screening for water stress tolerant genotypes should be done at the reproductive stage.

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الاحتياجات المائية و علاقتها بمراحل النمو فى القمح

مسعد عبد العاطى البطل* - محمد حافظ عبد الجواد* - منى احمد محمد سليمان**
- الست عبد الفتاح عبد العزيز*
* معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية بالجيزة - مصر
**قسم النبات - المركز القومي للبحوث - الجيزة - مصر

أقيمت تجارب أصص فى صوبة قسم بحوث فسيولوجيا المحاصيل بمحطة التجارب الزراعية بالجيزة، مركز البحوث الزراعية، و زرع صنف القمح جيزة 168 فى موسمى الزراعة 200/1999 ، 2001/2000 لدراسة تأثير توزيع كميات مختلفة من مياه الرى على أطوار النمو المختلفة على نمو وإنتاجية صنف من القمح (جيزة 168) . و أضيف لكل أصيص 3.5 لتر ماء عند الزراعة و نصف لتر فى مرحلة الإنبات ، ثم بعد ذلك رويت النباتات بمعدل 43 رية فى جميع المعاملات كما يلى:

1- مقارنة بإضافة 43 لتر لكل رية لتر واحد.
2- إضافة 43 لتر مع توزيع كمية الماء تبعا لمرحلة النمو (واحد لتر لكل ثلاث أيام).
3- إضافة 90% من كمية الماء فى كل رية من المعاملة (2).
4- إضافة 80% من كمية الماء فى كل رية من المعاملة (2).
5- إضافة 70% من كمية الماء فى كل رية من المعاملة (2).
6- إضافة 60% من كمية الماء فى كل رية من المعاملة (2).

أظهرت النتائج المتحصل عليها وجود فروق معنوية بين المعاملات المختبرة فى جميع الصفات المدروسة ، و تفوقت المعاملة الثانية على جميع المعاملات فى الوزن الجاف و معدل تراكم المادة الجافة فى جميع العينات المدروسة ، و كذلك فى عدد الفروع و عدد السنابل للنبات و طول السنبلة و عدد السنيبلات و الحبوب بالسنبلة و وزن حبوب السنبلة و وزن 100حبة و المحصول البيولوجى و محصول الحبوب و القش للنبات و دليل الحصاد و كفاءة استخدام الماء بالنسبة لوزن حبوب النبات.

أدت معاملة المقارنة الى زيادة مدة المراحل الفينولوجية للنبات و زيادة ارتفاع النبات ، بينما تفوقت المعاملة الثانية على معاملة المقارنة فى باقى الصفات بدون فروق معنوية بينهما مع توفير 10% من كمية ماء الرى ، كما ظهر نقص قيم جميع الصفات مع زيادة الإجهاد الرطوبى فى المعاملات الأخرى ، أدى تغيير نظام الرى الى تحسين كفاءة استخدام الماء وعلى ذلك يمكن اتباع هذا النظام فى طرق الى بالرش المتحرك أو الثابت و التى اتسع استخدامها فى معظم الأراضى الجديدة.