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Interrelationship Between Drought Stress and Hydrogel on Productivity of Two Barley Cultivars under Sandy Soil Conditions

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Abstract: Field experiment was conducted at researches and production station of National Research Centre (NRC), Al Emam Malek village, Al-Nubaria district, Al Behaira Governorate, Egypt. Sowing date was 17 November 2019. Two barley cultivars Giza 123 and Giza 2000 were sown by broadcast method in the seeding rate of 144kg/ha under sprinkler irrigation system, distance between valves (sub line) was 8 m and between sprinklers was 10 m, sprinkler 3/4 inch. Area irrigated by each valve contained 5 sprinklers (8x50) = 400 m^2. The experiment included two factors:

- Cultivars were two (Giza 123 and Giza 2000).
- Irrigation quantity were five treatments:- 100% Recommended Irrigation Quantity RIQ Without hydrogel (Control) – 25% RIQ + hydrogel – 50% RIQ + hydrogel – 75% RIQ + hydrogel – 100% RIQ + hydrogel.

The results showed that Giza 2000 cultivar surpassed Giza 123 in plant height (cm); no. spikes/m^2; biological yield/ tiller (g); straw yield (ton/h);biological yield (ton/h). Giza 123 recorded taller spikes; greater number of spikelet's/spike; and higher harvest index than Giza 2000. Data revealed that treatment of 75% of the recommended irrigation quantity RIQ with hydrogel produced the tallest plants (76.67 cm); tallest spikes (8.84 cm); highest No. spikes/m^2(362.00); highest grain yield(2.045 ton/ha); highest straw yield (6.600ton/ha) and the highest biological yield (9.120 ton/ha). In other words, including hydrogel as a soil conditioner could effectively save 25% of recommended irrigation requirement for barley without affecting yield. The interaction between Giza-123 cultivar and 75% RIQ recorded the best results in most studied characters and it was more pronounced in Giza 2000.

Key words: Barley · Hydrogel · Water Irrigation Quantity WIQ

INTRODUCTION

Barley (*Hordum vulgare*) is a member of grass family. It was one of the first cultivated grains, particularly in Eurasia. Barley was ranked fourth among grains in quantity produced 141 million tons in 2016 behind maize, rice and wheat [1]. Area harvested in Egypt was constant from 2014 to 2018 (83 000 ha) also, constant yield/area 1 MT/ha although domestic consumption increased from 152 (1000 MT) in 2014 to 188 (1000 MT) in 2018 [1] so, increasing harvested area and yield quantity of barley is important target in Egyptian agriculture. It has many effective uses like barley bread of various cultures, as animal fodder, source of fermentable material for beer and

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certain distilled beverages and as a component of various health foods. Barley is more tolerant to soil salinity than wheat, with shorter growing season [2]. Drought is one of the most important environmental stresses that reduces barley grain yield [3, 4], depending not only on the duration and intensity of water stress, but also on the developmental phase at which the stress was imposed [5]. During grain filling, drought stress reduces barley grain yield by decreasing individual grain weight [6]. Drought stress during the early grain filling period negatively impacts grain weight and yield more than during late grain filling [3, 7, 8]. The negative effect of drought on grain weight was due to a reduction in grain filling duration of barley by 5 days [3, 7, 9]. Drought stress during late grain f illing reduced net photosynthetic rate of barley as a result of the increase in stomata closure [9, 10, 11] stomata resistance [6, 12, 7, 13, 14], Barley grain filling rate decreased by 40 % under drought stress during the grain filling period [9]. Samarah [15] reported that drought during the grain filling period decreased grain filling duration, but had no effect on the grain filling rate.

Nowadays water management is considered one of the major challenges for all countries in arid and semi-arid regions. In fact, by 2030, global water demand is probable to be 50% higher than today, resulting in water scarcity, in the same time agricultural sector used over 70% of fresh water in most regions of the world. Hydrogel polymer have the ability to absorb water is quite a hundred times its original weight within short period of time and desorbs the absorbed water under stress condition [16]. Research evidence suggests that when the soil is treated with water hydrogel composite the water volumetric content of the soil increases significantly and when the surrounding soil dries, the stored water is released back slowly into the soil [17].

Increasing water use efficiency by roots at early and late growing stages of plant in sandy soil came one of the main objectives aim to tolerate drought stress because the arable land around the world suffers from low water availability which causes reductions in yield of many crops [18, 19]. Wang and Boogher [20] indicated effect of a medium incorporated hydrogel on plant growth and water use of two foliage species also, Woodhouse and Johnson [21] reported that the best effect of a gel forming polymer on seed germination and establishment. Hydrogel is effective tool to insure soil moisture profile in the root zone which in turn in reducing fertilizers leaching from soil. Hydrogel amendments may improve seedling growth and establishment by increasing water retention capacity of soils and regulating the plants available water supplies, particularly under arid environments. Akhter *et al*. [22] reported that the addition of 0.1, 0.2 and 0.3% hydrogel increased the moisture retention at field capacity linearly and amount of plant available water significantly in sandy and sandy loam soils and seeding growth of wheat and barley was improved by the hydrogel amendment also, hydrogel amendment caused a delay by 4-5 days in wilting of seedlings growth. Excellent benefits of hydrogel by many crops under Egyptian condition reported by [23] on rice and barley; [24] on sunflower and wheat; [25] on sugar beet; [26] on potato and [27] on sunflower and [28] on mungbean.

The aim of the work was to determine effect of drought stress by reducing water irrigation quantity 25 ; 50 and 75% from recommended by using hydrogel 4 g/m^2 on two barley cultivars growing in sandy soil.

MATERIALS AND METHODS

Field experiment was conducted at research and production station of National Research Centre (NRC), Al Emam Malek village, Al-Nubaria district, Al Behaira Governorate, Egypt, this experimental farm (latitude 30°30'1.4"N and longitude 30°19'10.9"E and mean altitude 21 m above sea level). Sowing date was 17 November 2019. Two barley cultivars Giza 123 and Giza 2000sown by broadcast method in the seeding rate of 144 kg/ha under sprinkler irrigation system, distance between valves (sub line) was 8 m and between sprinklers was 10 m, sprinkler 3/4 inch. Area irrigated by each valve contain from 5 sprinklers was 8 x 50 = 400 m^2. The experiment included two factors:

- Two Cultivars: (Giza-123 and Giza-2000).

Giza-123 is a local cultivar recommended for newly reclaimed sandy soil and salty soil, Giza-2000 local cultivar has wide adaptation range in new sandy new cultivated lands and rainy lands.

- Five Irrigation quantities treatments:

Percentage of recommended irrigation quantity (%)	25 % + hydrogel (4 g/m^2)	50 % + hydrogel (4 g/m^2)	75 % + hydrogel (4 g/m^2)	100 % + hydrogel (4 g/m^2)	100 % without hydrogel
Water amount (m^3) Valve read	50	100	150	200	200
Water amount (m^3) per hectare	1260	2520	3780	5040	5040

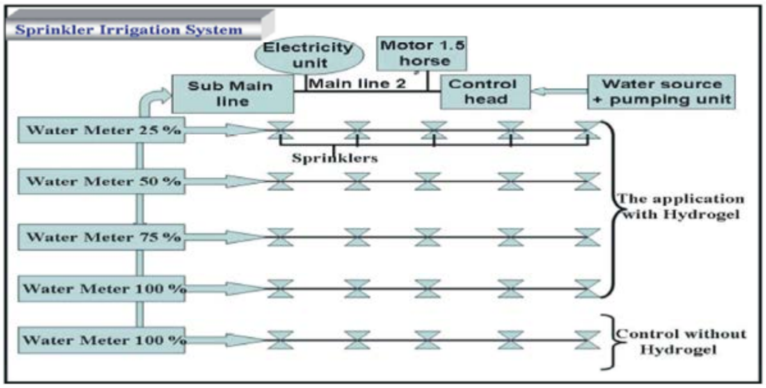

Fig. 1: Automatically sprinkler irrigation system

Table 1: Mechanical and chemical analysis of soil before hydrogel addition

Sand (%)	Silt (%)	Clay (%)	pH	O.M (%)	Ca Co$_3$	E.c Dsm^{-1}	N (ppm)	P (ppm)	K (ppm)
92.3	3.1	4.6	7.4	0.3	1.3	0.3	8.0	3.0	19.8

Treatments were 10 treatments in 3 replicates; experimental design was split-plot design, where irrigation treatments were distributed in main plots and cultivars were randomly arranged in sub plots. Irrigation automatically system IAS was used as shown in Figure (1), it contains the following items:

- Main water pumping unit (20 hp)
- Main line 4 inch
- Main line of IAS was 2 inch – 6 bar.
- Control head 1.5 inch.
- Motor 1.5 horse – 220 volt – Calbida NGM 32E
- Electricity unit (5 control key 220 volt)
- Water meter.
- Sub main line (1.5 inch – 10 bar)
- Sprinklers 3/4 inch.

In duple jacketed of a capacity 60 litter equipped with condenser, variable speed motor temperature controller adjusted at 30°C was reactor charged with 4 kg starch slurred in 40 litter water followed by addition of 2 g emulsifier after 10 minutes acrylonitrile (AN) 4 kg added during 20 minutes with continues stirring for three hours. The obtained product was saponified in isopropanol (40 litters) with continues stirring with the addition of 0.65 equivalent sodium hydroxyl tell the color of the product changed from deep brown to yellowish color. The obtained hydrogel was filtered, dried and milled.

Materials Used Commercial Product Without Purification: Acrylonitrile (AN), Corn starch, sodium hydroxyl, emulsifier.

Harvest date was done 140 days after sowing DAS. Ten plants were harvested randomly from each treatment and the following characters were determined 1- plant height (cm) 2- spike length (cm) 3-No. of spikelet's/spike 5- Biological yield/ tiller (g), one m2 was harvested randomly from each treatment and determined No. of spikes/m^2. The whole area of each treatment was harvested to determine 6- grain yield/ ha. 7- Straw yield/ ha. 8- Biological yield/ ha. 9- Harvest index was determined as a ratio of grain yield/biological yield per hectare %.

Statistical Analysis: The analysis of variance procedure of split-plot design according to [29]. For means comparison Least Significant Difference (LSD) at 5% level was applied.

RESULTS AND DISCCUSION

Effect of Varieties: Data presented in Table (1) and Figure (2) show the cultivars differences and their effect on yield and yield components of barley. It's clear from data that Giza 2000 cultivar surpassed Giza 123 cultivar in characters of plant height (cm) by 1, 00%; no. spikes/m^2 by 21, 54%; biological yield/ tiller (g) by 11, 20%; grain

Table 1: Cultivars differences in yield and yield components of barley under sandy soil condition. (Winter season of 2019/2020)

Varieties	Plant height cm	Spike length cm	No. spikes/m^2	No. spikelet's /spike	Biological yield/ tiller (g)	Grain yield (ton/h)	Straw yield (ton/h)	Biological yield (ton/h)	Harvest Index
Giza 123	69.74	7.87	264.11	12.33	12.17	2.045	6.600	8.640	23.66
Giza 2000	70.07	7.13	321.02	10.20	13.64	2.061	6.672	8.712	23.44
LSD5%	0.35	0.56	4.32	0.67	0.43	0.04	0.02	0.01	0.03

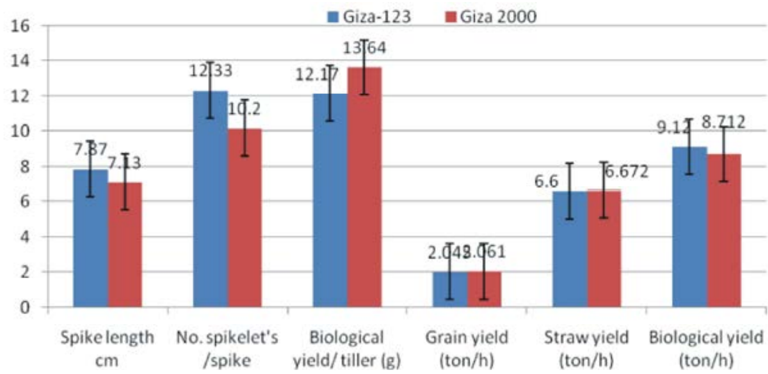

Fig. 2: Comparison between Giza 123 and Giza 2000 in yield and yield components

yield (ton/ ha) by 10, 07%; straw yield (ton/ ha) by 10, 10%; biological yield (ton/ ha) by 4, 68%. Giza 123 recorded taller spikes (cm) by 15.48%; greater number of spikelet's/spike by 11.20%; and higher harvest index% than Giza 2000 by 1.00%. Data revealed that Giza 123 surpassed Giza 2000 in characters of spike length and No. of spikelet's/spike but Giza 2000 had superiority in characters measured by unit area. Egyptian varieties differed in many characters reported by [30] also, significant differences for standard germination, seedlings vigor and green fodder production. Samah *et al*., [31] reported the Excellency of Giza 123 barley variety in grain, straw and biological yields under salt stress in comparative study among 19 local varieties under Egyptian condition. Such variability could be attributed to the genetic effect.

Effect of Hydrogel: Table (2) shows the effect of different recommended irrigation quantity on yield and yield components of barley. Data revealed that treatment of 75% recommended irrigation quantity with hydrogel had superiority on all treatments for most studied characters produced the tallest plants (76.67 cm); tallest spikes (8.84 cm); highest No. spikes/m^2 ‘362.00); highest biological yield/ tiller (15.66 g); highest grain yield(2.522 ton /ha.); highest straw yield(7.824ton/ha.) and the highest biological yield (10.344 ton/ha.)

The treatment of 100% recommended irrigation quantity combined with hydrogel produced the highest no. spikelet's/spike (12.0) and the highest harvest index (27.04 %).

Superiority of treatment 75% recommended irrigation quantity with hydrogel in most studied characters indicated the excellence of hydrogel in drought stress mitigation .In other words, including hydrogel as a soil conditioner could effectively save 25% of recommended irrigation requirement for barley without affecting yield. This beneficial effect of hydrogel may be due to its mode of action by absorb water quite a hundred times its original weight within short period of time and desorbs the absorbed water under stress condition, which reflected on yield characters of barley . The obtained results were are in accordance with obtained by [16] also, [17], they suggested that when the soil is treated with water hydrogel composite the water volumetric content of the soil increases significantly and when the surrounding soil dries, the stored water is released back slowly into the soil.

The slow release of water through hydrogel seems to be effective in avoiding or mitigation drought stress on barley plants during grain filling stage which reduced net photosynthetic rate of barley as a result of the increase in stomata closure [9, 10, 11], stomata resistance [6, 12, 7, 13]. Mitigation drought effect led to the superiority of treatment 75% recommended irrigation quantity + hydrogel may be due to the excellence of treatment on characters of spikes as No. of spikes/m^2; spike length (cm) and plant height (cm) which in turn on economic characters of barley grain; straw and biological yields per unit area (hectare) also, these treatment clear that barley plants can tolerate effect of drought stress by decreasing irrigation quantity to 75% from recommended amount without decrease in economic yields.

Table 2 Effect of irrigation quantities on yield and yield components of barley under sandy soil condition. (Winter season of2019/2020).

Irrigation	Plant height cm	Spike length(cm)	No. spikes/m^2	No. spikelet's /spike	Biological yield/ tiller (g)	Grain yield (ton/h)	Straw yield (ton/h)	Biological yield (ton/h)	Harvest Index
Cont 100	68.50	6.75	278.49	10.00	12.17	1.927	6.384	8.304	23.21
25	57.34	6.50	244.10	11.33	10.25	1.370	5.952	7.320	18.79
50	72.84	7.84	294.19	11.67	13.31	2.113	6.696	8.808	24.00
75	76.67	8.84	362.00	11.33	15.66	2.522	7.824	10.344	24.40
100	74.17	7.59	284.06	12.00	13.16	2.332	6.312	8.640	27.04
LSD 5%	1.47	0.33	3.19	0.11	0.27	0.01	0.13	0.14	0.31

Table 3: Interaction between cultivars and irrigation quantities on yield and yield components of barley under sandy soil condition. (Winter season of 2019/2020).

Varieties	Irrigation	Plant height cm	Spike length cm	No. spikes/m^2	Bio-yield/ tiller (g)	Grain yield (ton/ha)	Straw yield (ton/ha)	Biological yield (ton/ha)	Harvest Index
Giza 123	Cont 100	66.67	7.17	248.54	10.22	2.094	2.69	8.544	24.51
	25	60.00	6.33	203.96	9.15	1.363	2.30	6.888	19.80
	50	75.67	8.00	264.05	12.16	2.153	2.75	8.760	24.58
	75	81.67	9.67	336.03	16.25	2.387	3.27	10.224	23.35
	100	71.67	8.17	267.96	13.08	2.227	2.72	8.760	25.43
Giza 2000	Cont 100	70.33	6.33	308.44	14.11	1.761	2.62	8.040	21.90
	25	61.67	6.67	284.24	11.35	1.378	2.66	7.752	17.78
	50	70.00	7.67	324.33	14.45	2.072	2.83	8.856	23.41
	75	71.67	8.00	387.96	15.07	2.657	3.24	10.440	25.45
	100	76.67	7.00	300.15	13.24	2.439	2.53	8.520	28.64
LSD 5%	2.14	0.33	3.13	0.37	22.03	0.12	0.21	0.19	

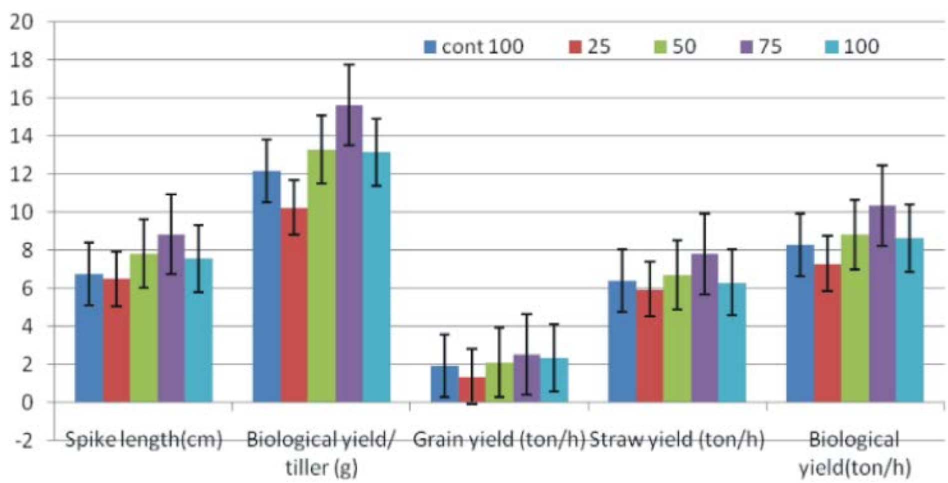

Fig. 3: Comparison between treatments of irrigation quantity and hydrogel in yield and yield components

Interaction of Varieties X Hydrogel: It's clear from data in Table (3) that interaction between Giza-123 cultivar and 75% recommended irrigation quantity recorded the best result in most studied characters; it produced tallest plants (81.67 cm); tallest spikes (9.67 cm) and highest biological yield/tiller (16.25 g). Interaction of Giza 2000 x 75% recommended irrigation quantity recorded the best result in highest number of spikes/m^2 (387.96); highest grain yield (2.657 ton/ha.); highest straw yield (3.24 ton/ha.) and highest biological yield/ha. (10.44 ton) and the. Interaction of Giza-2000 x 100% recommended irrigation quantity with hydrogel gave the highest harvest index (28.64%).Superiority of interaction of Giza 2000 x 75% recommended irrigation quantity recorded the same trend recorded by Giza 2000 variety and 75% RIQ so, interaction collect the best effect of both factors.

CONCLUSION

Addition of hydrogel in the rate of 4 g/m^2 in sandy soil can be effective tool for increasing most important economic characters (grain and straw yields per hectare) of barley with different ratios besides saving 25 or 50 % from recommended irrigation quantity under sprinkler irrigation method. Superiority of interaction of Giza 2000 x 75% recommended irrigation quantity recorded the same trend recorded by Giza 2000 variety and 75% RIQ so, interaction collect the best effect of both factors.

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