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Correlation Between Barley Yield and Yield Attributes as Affected by Hydrogel for Reducing Irrigation Amounts under Drip Irrigation System

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Abstract: Field experiment was conducted at Experimental Farm of National Research Centre NRC, Al-Nubaria District, Al Behaira Governorate, Egypt. Barley cultivar Giza-126 sown in mid November 2019 at seeding rate of 100 kg/hectare under drip irrigation system, grains in holes under surface drip irrigation system (SDIS). Five irrigation treatments were 1- (Control) 100% recommended irrigation quantity (RIQ) (4838 m^3/H.) without hydrogel. 2- 25% RIQ (1210m^3/H.)+ hydrogel. 3- 50% RIQ (2420 m^3/H.)+ hydrogel. 4- 75% RIQ (3628 m^3/H.)+ hydrogel. 5- 100% recommended irrigation quantity (RIQ) (4838m^3/H.) + hydrogel. Results indicated significance between treatments in all studied characters, superiority of 75% RIQ+hydrogel in all studied characters followed by treatment of 50% RIQ+hydrogel recorded the second order in all characters except for grain yield per hectare and harvest index treatment of 100% RIQ+hydrogel came in second order. Correlation coefficient between studied characters cleat that the important two economic yield characters of barley (grain yield and straw yield per hectare) had highly significant correlation with characters grain yiels/spike in gram and biological yield per unit area hectare.

Key words: Barley · Hydrogel · Correlation · Water Irrigation Quantity (RIQ)

INTRODUCTION

Barley (*Hordum vulgare*) considered one of crops of grass family; it was fourth behind maize, rice and wheat among grains in quantity production [1]. Area harvested in Egypt was 29307 hectare and production was 104092 ton in 2o2o [1]. Increasing area harvested and yield quantity of barley is important object in Egypt agriculture for many utilities for human consumption and animal feeding as well as a component of various health foods. Barley is more tolerant of soil drought and salinity than wheat, also, has short growing season and low requirements irrigation quantity than other winter crops. [2] clear many harmful effects of drought on barley especially under sandy soil conditions, under drought stress during grain filling period, early grain filling rate decreased by 40% [3].

There were big shortage by 2030 in global water requirements; it is probable to be 50% higher than the current situation, resulting in water scarcity. Agricultural sector consume over 70% of fresh water in most regions of the world, therefore, water management is considered one of the major challenges for all countries in arid and semi arid regions. Polymer such as hydrogel has the ability to absorb water hundred times it's original weight within short period of time and desorbs the absorbed water under stress conditions [4]. Double effect of hydrogel and irrigation reported by [5] who clear that

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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. [6, 7] revealed medium incorporated hydrogel on plant growth and water use of two foliage species. The best effect of gel forming polymer on seed germination and establishment reported by [8]. Under Egyptian conditions many researchers clear the best effect of hydrogel in reducing water irrigation quantity either with sprinkler or drip irrigation systems in sandy soil on many summer and winter crops, [9] on rice in summer and barley in winter; [10] on sunflower followed by wheat [11] on sugar beet revealed that hydrogel is effective tool to insure soil moisture profile in the root zone which reflect on reducing irrigation quantity requirements and fertilizers leaching from soil; [12]; on potato; [13] on sunflower revealed the same results; [14] in long term trial revealed positive effect of hydrogel in reducing irrigation quantity, increasing water-holding capacity, water use efficiency, preventing nutrient leaching and fertilizers use efficiency also, decrease nutrients lost from rooting zone in sandy soil; [15] on two wheat cultivars; [16] on two barley verities irrigated by sprinkler system; [17] on flax; [18] on wheat under drip irrigation system; [19] on cotton; [20] on barley under drip irrigation system also [21] and [22] revealed that hydrogel at different percentage can be replacement part of agar in tissue culture explants production. The aim of this work was to study correlation between barley yield characters irrigated by drip irrigation system and treated by hydrogel to reduce irrigation quantity.

MATERIALS AND METHODS

Field experiment was conducted at Experimental farm of National Research Centre NRC, Al Emam Malek village, Al-Nubaria district, Al Behaira Governorate, Egypt. Sowing date was 17 November 2014. Barley cultivar Giza-126 sown in the seeding rate of 100 kg/hectare under drip irrigation system, grains in holes under surface drip irrigation system (SDIS) and diameter of the lateral line was 16 mm with dripper discharge of 4 L/hour with 30 cm miters spacing. Distance between lines (sub line) was 0.5 m and between drippers was 0.30 m. Area irrigated by each valve contained 10 lines was 10x0.50x25 = 125 m^2.

Mechanical and chemical analysis of experimental soil before addition of hydrogel according to [24] were: Sand (92.3%) - Silt (3.1%) – Clay (4.6%) – pH (7.4) – O.M (0.3%) – Ca Co^3 (1.3) – Ec mmhos/cm^3 (0.3) – N (8.0 ppm) – P (3.0 ppm) – K (19.8 ppm).

Preparing and Finishing Hydrogel: In double jacketed of a capacity 60 litre equipped with condense, 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 stirring for three hours. The obtained product was saponified in isopropanol (40 liters) 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). Recommended hydrogel addition amount was 4 g/m^2 from dry hydrogel.

Five irrigation treatments were1- (Control) 100% recommended irrigation quantity (RIQ) without hydrogel. 2- 25% RIQ + hydrogel. 3- 50% RIQ + hydrogel. 4- 75% RIQ + hydrogel. 5- 100% recommended irrigation quantity (RIQ) + hydrogel.

Harvest date was carried out 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 4- biological yield/tiller(g) 5- grain yield/spike (g). One meter harvested to determine 6- grain yield/spike (g). The whole area of each treatment was harvested to determine characters measured per hectare 7- biological yield/H. 8- grain yield/h. 9- straw yield/H. 10- harvest index (%) determined as a ratio of grain yield/biological yield per hectare

Table 1: Treatments of Recommended Irrigation Quantity percentages and hydrogel under drip irrigation system

Recommended Irrigation Quantity (RIQ) %	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 (control)
Water Irrigation Quantity (M^3/H)	1210	2420	3628	4838	4838

Correlation coefficient was done between all studied characters due to [24].

RESULTS AND DISCUSSION

Plant Height (cm): Data presented in Figure 1 show that the tallest plants produced by treatment of 75% Recommended Irrigation Quantity RIQ + hydrogel and 50% RIQ + hydrogel recorded the second order and 100% RIQ + hydrogel was third; control was fourth and 25% RIQ + hydrogel was fifth.

Spike Length (cm): Figure 2 revealed superiority of treatment of 75% RIQ + hydrogel in spike length (9.33 cm) followed by 50% RIQ + hydrogel (8.17 cm) and 100% RIQ + hydrogel (7.83 cm); control (7.33 cm) and 25% RIQ + hydrogel (7.07 cm) , arrangement of treatments was same in both characters plant height and spike length.

No. of spikes/m^2: Treatment of 75% RIQ + hydrogel produced the highest number of spikes per unit area m2 (456.09), treatment of 50% RIQ + hydrogel (427.96) came in the second order followed by 100% RIQ + hydrogel (384.33), control(375.96) and 25% RIQ + hydrogel in the fifth order (Figure 3).

No. of Spiklets/spike: The same trend recorded in plant height, spike length and no. of spikes/m^2 was recorded in no. of spikelets/ spike as showen in figure 4 , it can be arranged treatments in descending order from the best 75% RIQ + hydrogel (23.00) - (21.67) - (19.67) - (17.67) and the lowest 25% RIQ + hydrogel (16.33).

Biological Yield/ Tiller (g): Data presented in figure 5 revealed the same trend recorded in all characters studied for a single plant or area meter as m^2 treatment of 75% RIQ + hydrogel was the best (12.60 g), 50% RIQ + hydrogel was second (11.60 g), 100% RIQ + hydrogel was third (11.30 g), control was fourth (10.50 g) and 25% RIQ + hydrogel was the fifth (10.00 g). The trend was logical due to the superiority of treatment of 75 % + RIQ followed by 50% RIQ and 100 % RIQ + hydrogel in important attributes measured of spikes such as spike length (cm); number of spikelets/spike and number of spikes per unit area (m^2) also plant height (cm).

Grain Yield/spike (g): The same trend was recorded in plant height, spike length; no. of spikes/m^2; no. of spikelets/ spike and biological yield/tiller was recorded in grain yield/ spike (Figure 6), it can be arranged treatments in descending order from the best 75% RIQ + hydrogel (4.83) - (4.42) - (4.30) - (4.25) and the lowest 25% RIQ + hydrogel (3.51).

Biological Yield (ton/H.): Figure 7 show biological yield per unit area (hectare) as affected by percentage of recommended irrigation quantity and hydrogel. The same trend recorded in biological yield/ tiller (g) and all characters studied for single plant or area meter as m^2 was recorded as logic result which revealed the similarity between characters studied by single plant and unit area (hectare).

Grain Yield (ton/H.): Data in Figure 8 revealed trend near from trend recorded in most characters, 75% RIQ + hydrogel was the best (2.798), 100% RIQ + hydrogel was second (2.357), 50% RIQ + hydrogel was third (2.328), control was fourth (2.163) and 25% RIQ + hydrogel was the fifth (1.593).

Straw Yield (ton/H.): Figure 9 show that treatment of 75% RIQ + hydrogel produced the highest straw yield (ton/H.) (7.152), treatment of 50% RIQ + hydrogel (6.648) came in the second order followed by 100% RIQ + hydrogel (6.480), control(6.120) and 25% RIQ + hydrogel in the fifth order (4.776).

Harvest Index (%): Results which shown in Figure 10 treatments can be arranged in descending order from the best 75% RIQ + hydrogel (28.90) - 100% RIQ + hydrogel (26.69) - control (26.12) – 50% RIQ + hydrogel (25.93) and the lowest 25% RIQ + hydrogel (25.04).

It can be concluded that superiority of 75% and 50% RIQ + hydrogel may be due to effect of hydrogel in saving the amount of water irrigation quantity in root growth zoon, then the water volumetric content of the soil increases and when the surrounding soil dries, the stored water is released back slowly into the soil also, decrease leaching of fertilizers through big holes between sandy soil particles which in turn on the growth rate, spikelets per spike and no. of spikes per unit area also, biological yield/tiller as result of these attributes. Results were in accordance with those obtained by Waly *et al*., [9] on rice in summer and barley in winter; Waly *et al*. [10] on sunflower followed by wheat Elkaramany *et al*. [11] on sugar beet revealed that hydrogel is an effective tool to

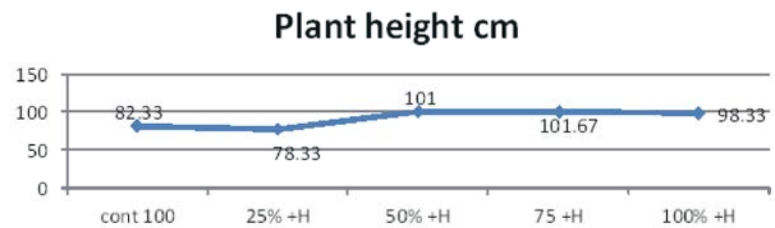

Fig. 1: Effect of RIQ+ hydrogel on plant height

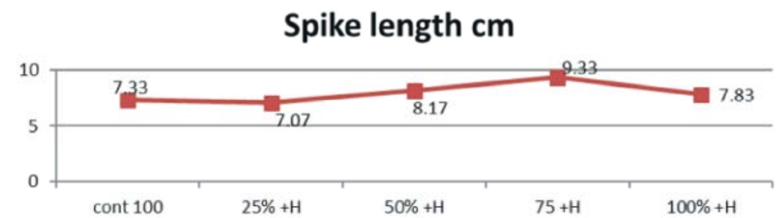

Fig. 2: Effect of RIQ and hydrogel on spike length (cm)

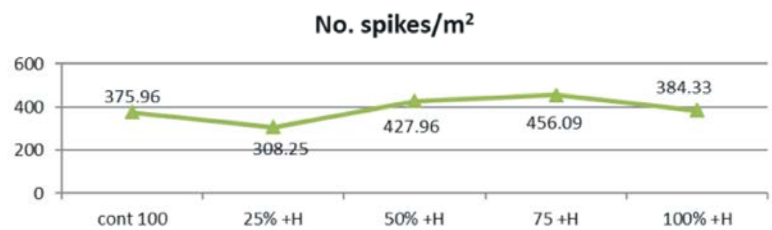

Fig. 3: Effect of RIQ and hydrogel on No. of spikes/m^2

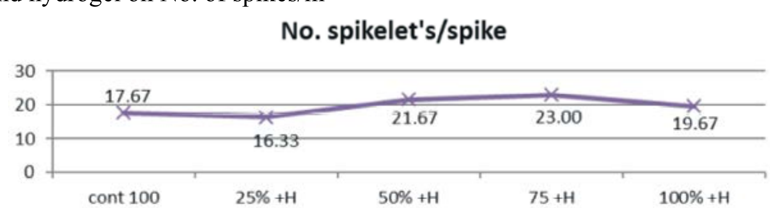

Fig. 4: Effect of RIQ and hydrogel on No. spikelets/spike

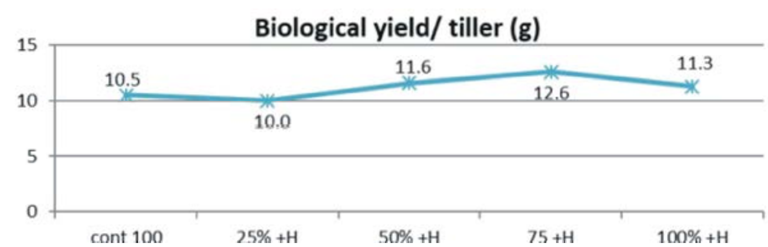

Fig. 5: Effect of RIQ and hydrogel on biological yield/tiller (g)

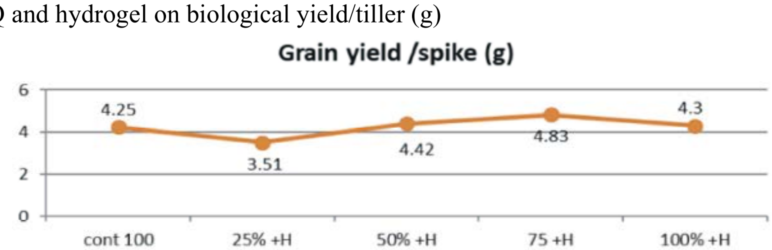

Fig. 6: Effect of RIQ and hydrogel on grain yield/spike (g).

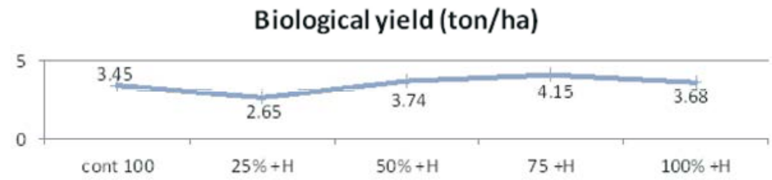

Fig. 7: Effect of RIQ and hydrogel on biological yield (ton/ha)

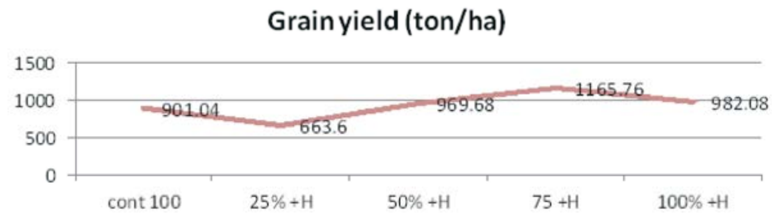

Fig. 8: Effect of RIQ and hydrogel on grain yield (ton/ha)

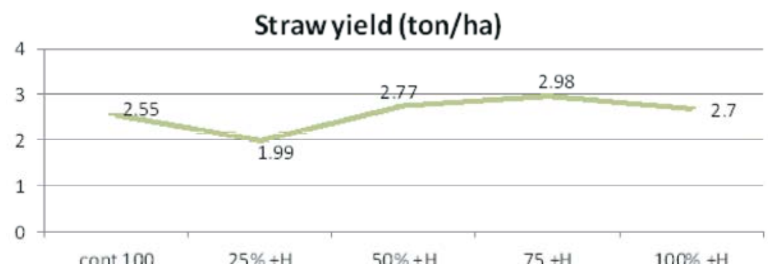

Fig. 9: Effect of RIQ and hydrogel on straw yield (ton/ha)

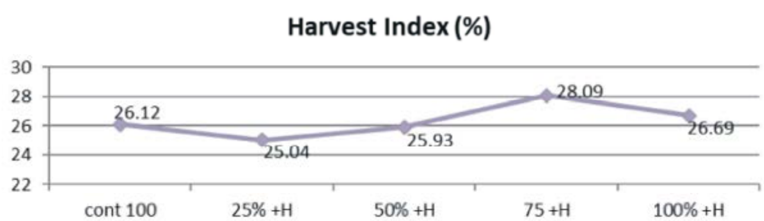

Fig. 10: Effect of RIQ and hydrogel on harvest index (%)

insure soil moisture profile in the root zone; Waly *et al*. [12]; on potato Elkaramany *et al*. [13] on sunflower; Elkaramany *et al*. [14] in long term trial on mungbean in seventh season with the same addition; Elkaramany *et al*. [15] on two wheat cultivars; Elkaramany *et al*. [16] on two barley verities irrigated by sprinkler system; Bakry *et al*. [17] on flax; Bakry *et al*. [18] on wheat under drip irrigation system; Elkaramany *et al*. [19] on cotton.

Correlation Study: Behavior of barley plants may be affected due to drought stress in treatments of study thus, a correlation study was done to test relations between yield characteristics of barley plants under reducing recommended irrigation quantities with utilize of 4 g/m^2 hydrogel as soil addition under soil surface irrigated by drip irrigation system in sandy soil.

The first economic character of barley yield is grain yield per unit area (hectare) had high significant correlation with grain yield/spike in gram (0.9932); biological yield per unit area ton/hectare (0.9916); biological yield/ tiller in gram(0.9864), characters were arranged in descending order.

The second economic character of barley yield is straw yield per unit area (hectare) had high significant correlation with most characters studied under trial condition. It can be arranged correlated characters with straw yield per unit area in descending order as follow biological yield ton/hectare (0.9978); grain yield per spike in gram (0.9897); plant height in centimeter (0.9822); grain yield ton/hectare (0.9811); number of spikes per square meter (0.9706); number of spikelet's per spike (0.9676); biological yield per tiller (0.9651).

Table 2: Correlation between yield components of wheat Misr-1 variety under different recommended irrigation quantity and hydrogel

	Spike length cm	No. spikes/m^2	No. spikelet's /spike	Biological yield/ tiller (g)	Grain yield /spike (g)	Biological yield (ton/H)	Grain yield (ton/H)	Straw yield (ton/H)	Harvest Index
Plant height cm	0.7954	0.9395*	0.9341*	0.9021*	0.9468*	0.9683**	0.9291*	0.9822**	0.7469
Spike length cm		0.9337*	0.9380*	0.9834**	0.9465*	0.9125*	0.9424*	0.8907	0.9245*
No. spikes/m^2			0.9980**	0.9764**	0.9814**	0.9692**	0.9527*	0.9706**	0.8121
No. spikelet's /spike				0.9775**	0.9807**	0.9670**	0.9519*	0.9676**	0.8143
Biological yield/ tiller (g)					0.9926**	0.9767**	0.9864**	0.9651**	0.9178*
Grain yield /spike (g)						0.9952**	0.9932**	0.9897**	0.8969*
Biological yield (ton/H)							0.9916**	0.9978**	0.8834*
Grain yield (ton/H)								0.9811**	0.9360*
Straw yield (ton/H)									0.8516

It is clear from data in Table 2 that grain yield per spike in gram and biological yield per unit area hectar had highly significant correlation with the two important barley yield production grain yield per unit area hectare and straw yield per unit area hectare.

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