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Utilization of hydrogel for reducing water irrigation under sandy soil condition 4-Yield and yield components of sunflower as affected by hydrogel and drought stress in sandy soil.

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ABSTRACT

Field experiment was carried out during summer season of 2014 in research and production station of National Research Centre NRC, Al emamMalek village, Al Nubarie district, Al Behaira Governorate, Egypt. Effect of hydrogel at rate of 8 g/m^2 and control (without) on yield, yield components of sunflower (*Helianthus annuus* L.) Variety (Sakha-53). Effect of hydrogel in two rates (8 g/m^2 -control without) and four irrigation quantity (100%, 75%, 50% and 25% from recommended dose) on yield, yield components of sunflower (*Helianthus annuus* L.) under newly reclaimed sandy soil. Super absorption hydrogel based on corn starch was produced using ceric ammonium nitrate as initiator for graft copolymerization of acrylonitrile (AN) onto starch at room temperature with ratio 1:1 acrylonitrile to starch for three hours with liquor ratio of 1 starch to 10 water grafted starch was separated by centrifuge follow by saponification in isopropanol at 80 – 85 °C using 0.65 equivalent sodium hydroxyl solution. The obtained hydrogel was dried and milled, the holding capacity reached 450 ml/g hydrogel.Data clear that hydrogel at the rate of 8g/m^2 recorded higher values than control. Treatment of 75% recommended irrigation quantity recorded values ranged from 80% in seed yield/plant to 95% in seed yield/feddan compared to the best 100% recommended quantity. Interaction of hydrogel and 50% recommended irrigation quantity recorded values ranged from 48% to 99% from the best and save 50% from recommended irrigation quantity.Interaction between hydrogel and 50%recommended irrigation quantity recorded the best seed yield/fed. and oil yield/fed.

Keywords: hydrogel - sunflower - sandy soil - drought stress

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INTRODUCTION

Sunflower (*Helianthus annuus* L.) is the fourth oil seed crops after seed cotton, sesame and soybean under Egyptian condition, its cultivated area was 9000 hectare, its production 22000 tons in 2013 season. FAOSTAT (2014). Sunflower seeds are more commonly eaten as snack, sprout, can be used as biomass fuel. Over the past decades sunflower oil has become popular worldwide. The oil may be used as is, or may be processed into polyunsaturated margarines. The protein-rich cake remaining after the seeds have been processed for oil is used as a livestock feed.

A possible approach to minimize drought stress that induces crop losses is moisture in root growth zone. Irrigation is used to maintain the soil moisture profile in the root zone to field capacity and satisfied evapotranspiration requirement of each crop on any area.

The uses of alternative water holding amendments and irrigation methods will become more important over time, especially in regions of reduced water availability. Hydrogels are super absorbents that absorb and store water hundreds of times their own weight, i.e. 400-1500 g water per dry gram of hydrogel (Johnson 1984; Bowman and Evans 1999). Their performance is determined by the chemical properties of the hydrogel, such as molecular weight, formation conditions of the hydrogel, as well as the chemical composition of the soil solution or irrigation water. Water held in the expanded hydrogel is intended as a soil reservoir for maximizing the efficiency of plant water uptake. Commonly used hydrogels can be generally divided into three classes: natural polymers, synthetic hydrogels usually consist of polyacrylamides (PAM) and polyvinyl alcohols. Fully synthetic polymers are chemically cross-linked to prevent them from dissolving in solution (Mikkelsen 1994). The non-cross-linked PAM form is effectively used for soil erosion control, sediment reduction in surface waters and earthen canal bed stabilization (Woodhouse and Johnson 1991).

Hydrogels have been used to establish tree seedlings and transplants in the arid regions of Africa and Australia to increase plant survival (Specht and Harvey-Jones 2000; Save *et al*. 1995; Callaghan *et al*. 1988, 1989).

Callaghan *et al*. (1988, 1989) found that hydrogel amendments in sandy soils promoted seedlings survival and growth under arid conditions, while Viero *et al*., (2000) under similar conditions found only an increase in seedling growth when hydrogel was applied in combination with irrigation. Contrasting results may be related to the soil texture, thus hydrogel application in sandy soil promotes an increase in water retention capacity and plant water potential (Huttermann *et al*., 1999, Abedi-kaoupai and Sohrab 2004) while in loamy and clay soils the effect may be negligible. Jahangir *et al*., 2008 revealed that application of hydrogels can result in significant reduction in the required irrigation frequency particularly for coarse-textured soils. (Waly *et al*., 2015 b) concluded that treatment of (0.2 % hydrogel to soil) weight / weight may be effective tool to reduce water leaching from soil and recorded 93.4 % in seed yield, 95.3 % in biological yield, 92.9 % in 100 seed weight and 98.3 % in oil % in seeds compared to the treatment of recommended dose of irrigation in sunflower grown in greenhouse. (Waly *et al*., 2015 a) conducted trial with two crops rice in summer and barley in winter they revealed that treatment of 1% hydrogel to soil weight/ weight in rice crop had superiority on other treatments in all yield attributes, it produced the tallest plants, the highest number of tillers/pot, the highest number of grains/panicle, the heaviest panicle, the highest grain yield/pot, the highest biological yield/pot, the highest harvest index and the highest protein % in grains. Due to barley data revealed the superiority of treatment of 1 % hydrogel produced plants have highest leaf area (cm^2) and highest total chlorophyll (SPAD). Treatment of 1% produced the tallest plants. Treatment of 0.2 % hydrogel revealed the superiority in all other studied characters, it produced highest number of spikes/pot; the heaviest 1000-grains; the highest grain yield; highest biological yield and the highest harvest index. (El-karamany *et al*., 2015) in field trial on sugar beet clear that treatment of watering hydrogel for 48 hours at 90 DAS produced the highest fresh biological, fresh shoot and fresh root yields per plant also, leaf area and total chlorophyll, at harvest it produced highest fresh biological yield; fresh shoot weight; fresh root yield ton/fed. and root diameter but control (without hydrogel) recorded the highest root/shoot and root length. Due to technological characters of sugar beet roots treatment of watering hydrogel for 48 hours recorded the highest impurities and highest quality but recorded the lowest amino N; Na and near the lowest in K. Due to fertilizers use efficiency treatment of watering hydrogel 48 hours raised N, P and K use efficiency by sugar beet plants to the (36.6 ; 45.9 and 33.5 %) higher than that of control treatment by biological, shoots and roots yields. Irrigation water in (liter) needed to produce (1 kg.) of sugar beet yield grown on sandy soil decrease the amounts of irrigation water by 7.4, 18.5 and 25.9 % for producing the fresh bio-yield 12.1, 21.2 and 30 % for producing the fresh shoots yield 9.1, 18.2 and 27.3 % for producing the fresh roots yield.

Thus the aim of this work was to examine effect of hydrogel in two rates (8 g/m^2 -control without) and four irrigation quantity (100%, 75%, 50% and 25% from recommended dose) on yield, yield components of sunflower (*Helianthus annuus* L.) under newly reclaimed sandy soil.

MATERIALS AND METHODS

Field experiment was carried out during summer of 2014 in Researches and Production Station of National Research Centre (NRC), Al-Nubaria District, Al Behaira Governorate, Egypt. The experimental soil before added hydrogel treatments was analyzed according to Chapman & Pratt 1978. Soil texture was sandy and its characteristics are shown in Table (1)

Location and climate of experimental site: this experimental farm (latitude 30˚30'1.4''N, and longitude 30˚19'10.9''E, and mean altitude 21 m above sea level). The data of temperature and relative humidity were obtained from "Local Weather Station inside Researches and Production Station of National Research Centre (NRC)

Table (1): Mechanical and chemical analysis of experimental soil

Sand %	Silt %	Clay %	pH	Organic matter, %	CaCO3 %	E.C. dS/m	Soluble N, ppm	Available P, ppm	Exchangeable K, ppm
91.2	3.7	5.1	7.3	0.3	1.4	0.3	8.1	3.2	20

Temperature averages (^{o}c) during trial period were May (25.0) – June (25.5) – July (25.6) – August (26.2). Humidity average (%) were May (67.0) – June (75.8) – July (76.0) – August (76.5) respectively.

The experiment design was complete randomized block design in three replicates (Gomez and Gomez, 1984). Area of each plot was 45 m^2 (6 rows x 0.50m width x 15m length). Ditches 0.5 m in width were done and hydrogel treatments were added in the ditches then covered with soil to make rows. Seeds of sunflower variety (Sakha-53) were hand seeded in hills 0.30 m between on the 15 April 2014. The soil was immediately irrigated after sowing using drip irrigation system. Plants were thinned to one plant per hill 35 days after sowing (DAS). Fertilization of NPK at rate of (45:32:48)/feddan (4200m^2) in the form of ammonium nitrate 33%N ; superphosphate 15.5%$P_2O_5$and potassium sulfate 48%K_2O. Other cultural practices were done due to those recommended for sunflower.

At 120 DAS total yield of each plot (45 m^2) was harvested and then the following characters were determined:-1-Plant height(cm.) 2-Stem diameter(cm.) 3-Head diameter (cm.) 4-Bio-yield/plant (g) 5-Head weight/plant(g) 6-Seed yield/plant (g) 7-Seed yield (kg/fed.) 8-Oil % in seeds.

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

Treatments were:

A-1- Control without (hydrogel) addition. 2- Hydrogel at the rate of 8g/m^2.
B- Irrigation quantity (100%, 75%, 50% and 25% from recommended dose which were 2000; 1500; 1000 and 500 m^3/feddan)

At harvest the obtained data were statistically analyzed according to Snedecor and Cochran (1990), treatments means were compared using least significant differences LSD at probability level of 5 %.

RESULTS AND DISCUSSION

Effect of hydrogel

Data presented in Table (2) and figure (1) show significant differences between treatment of hydrogel at the rate of 8 $g/m^2$and control (without hydrogel) in all studied characters except for oil % in seeds. It produced taller plants with increase 24% than control; stem diameter higher by 84%; head diameter higher by 69%; biological yield higher by 320%; head weight 306%; seed yield/plant 329%; seed yield kg/fed. 280% and oil yield kg/fed. 304 % higher than control. Results were in accordance with those obtained by Callaghan *et al.* (1988, 1989) who found that hydrogel amendments in sandy soils promoted seedlings survival and growth under arid conditions. Contrasting results may be related to the soil texture, thus hydrogel application in sandy soil promotes an increase in water retention capacity and plant water potential (Huttermann *et al.*, 1999, Abedi-kaoupai and Sohrab 2004). (Viero *et al.*, 2000) under similar conditions found only an increase in seedling growth when hydrogel was applied in combination with irrigation. (Jahangir *et al.*, 2008) revealed that application of hydrogels can result in significant reduction in the required irrigation frequency particularly for coarse-textured soils. (Waly*et al.*, 2015a) concluded that treatment of (0.2 % hydrogel to soil) weight / weight may be effective tool to reduce water leaching from soil and recorded increase by 93.4 % in seed yield, 95.3 % in biological yield, 92.9 % in 100 seed weight and 98.3 % in oil % in seeds compared to the treatment of recommended dose of irrigation in sunflower grown in greenhouse.

Table (2): Effect of hydrogel on yield and yield components of sunflower in sandy soil (summer season of 2014).

Hydrogel	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	Biological yield/plant (g)	Head weight (g)	Seed yield /plant (g)	Oil %	Seed yield (kg/fed.)	Oil yield (Kg/fed.)
without	123.59	0.98	9.05	178.53	85.13	18.39	33.11	351.08	116.20
with	153.50	1.81	15.31	572.18	260.59	60.57	33.39	1011.34	353.64
LSD 5%	8.6	0.24	1.66	101.32	48.41	13.95	n.s	105.45	25.33

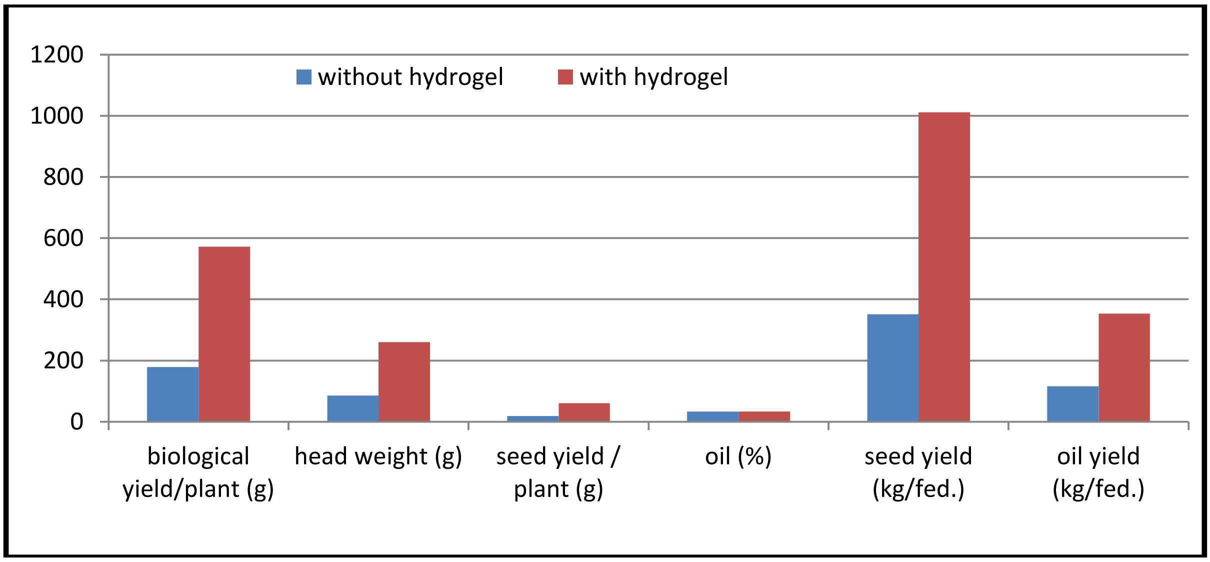

Figure (1) Effect of hydrogel on yield and yield components of sunflower.

Effect of irrigation quantity.

It is clear from data in table 3 and figure 2 that there were significant differences between treatments of irrigation quantity in all studied characters. Data revealed that treatment 100% recommended irrigation quantity had superiority on other treatments in all studied characters except for oil% in seeds it came in second order after 75% from recommended, and in oil yield kg/fed. came in the third order after 75% and %50% from recommended irrigation quantity.

Data revealed that treatment decrease the irrigation to 75% from recommended quantity produce the highest both oil% in seeds and oil yield kg/fed.also, it came in the second order in all other characters. Treatment of 75% recommended irrigation quantity recorded second order and identify from the best treatment 94% in plant height; 93% in stem diameter; 84% in head diameter; 86% in biological yield/plant; 59% in head weight; 80% in seed yield/plant and 95% in seed yield/fed. Viero *et al.*, (2000) under similar conditions found an increase in seedling growth when hydrogel was applied in combination with irrigation. (Huttermann *et al.*, 1999, Abedi- Kaoupai and Sohrab 2004) concluded that hydrogel application in sandy soil promotes an increase in water retention capacity and plant water potential. Jahangir *et al.*, 2008 revealed that application of hydrogel can result in significant reduction in the required irrigation frequency particularly for coarse-textured soils. (Waly*et al.*, 2015a) presented contrasting results on sunflower in greenhouse trial.

Table (3): Effect of irrigation quantityon yield and yield components of sunflower in sandy soil (summer season of 2014)

Water requirements %	plant height (cm)	stem diameter (cm)	head diameter (cm)	biological yield/ plant (g)	head weight (g)	seed yield /plant (g)	oil (%)	Seed yield (kg/fed.)	oil yield (Kg/fed.)
100	226.17	2.19	19.66	694.68	328.76	62.94	42.89	1048.67	305.60
75	213.51	2.04	16.50	431.11	194.27	50.83	56.02	999.67	379.04
50	197.34	1.84	15.78	403.21	188.52	49.24	55.14	974.67	367.74
25	164.33	1.47	14.89	329.47	150.14	31.70	45.17	404.00	119.72
LSD 5%	12.16	0.35	2.34	143.29	68.47	19.73	1.98	88.97	13.15

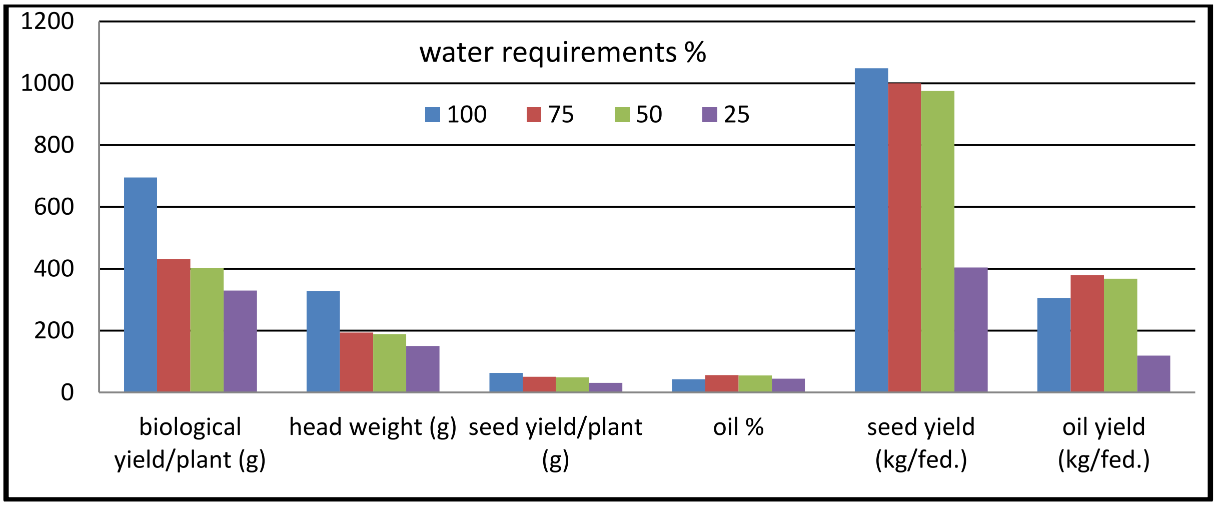

Figure (2) Effect of water requirements on yield and yield components of sunflower.

Interaction of hydrogel and irrigation quantity.

Data presented in table 4 show significant differences between interactions in all studied characters. It is clear from table 4 and figure 3 that interaction of hydrogel and 100% recommended irrigation quantity had superiority in stem diameter; head diameter; biological yield/plant and head weight. Interaction of hydrogel and 50% recommended irrigation quantity produced the tallest plants 177.33 cm; highest seed yield/fed. 1290 kg/fed. and the highest oil yield 499.88 kg/fed. Interaction of hydrogel and 75% recommended irrigation quantity recorded the highest oil% in seeds 38.93%.

Table (4) Effectof Interaction between hydrogel and irrigation quantity onyield and yield components of sunflower in sandy soil (summer season of 2014).

Hydrogel	Water requirements %	plant height (cm)	stem diameter (cm)	head diameter (cm)	biological yield/ plant (g)	head weight (g)	seed yield /plant (g)	oil (%)	Seed yield (kg/fed.)	oil yield (Kg/fed.)
without	100	151.67	0.97	10.07	236.63	104.57	21.07	27.92	411.33	114.84
	75	134.67	1.27	9.83	209.17	94.40	22.13	36.55	425.67	155.58
	50	108.67	0.93	8.63	144.87	79.23	16.97	35.77	329.33	117.80
	25	99.33	0.73	7.67	123.43	62.30	13.40	32.18	238.00	76.59
with	100	149.00	2.43	19.17	916.10	448.37	83.73	29.93	1274.67	381.51
	75	157.67	1.53	13.33	443.87	199.73	57.40	38.93	1148.00	446.92
	50	177.33	1.82	14.30	516.67	218.57	64.53	38.73	1290.67	499.88
	25	130.00	1.47	14.43	412.07	175.67	36.60	25.98	332.00	86.25
LSD 5%		25.52	0.72	1.02	33.68	113.67	21.4	2.69	119.47	19.96

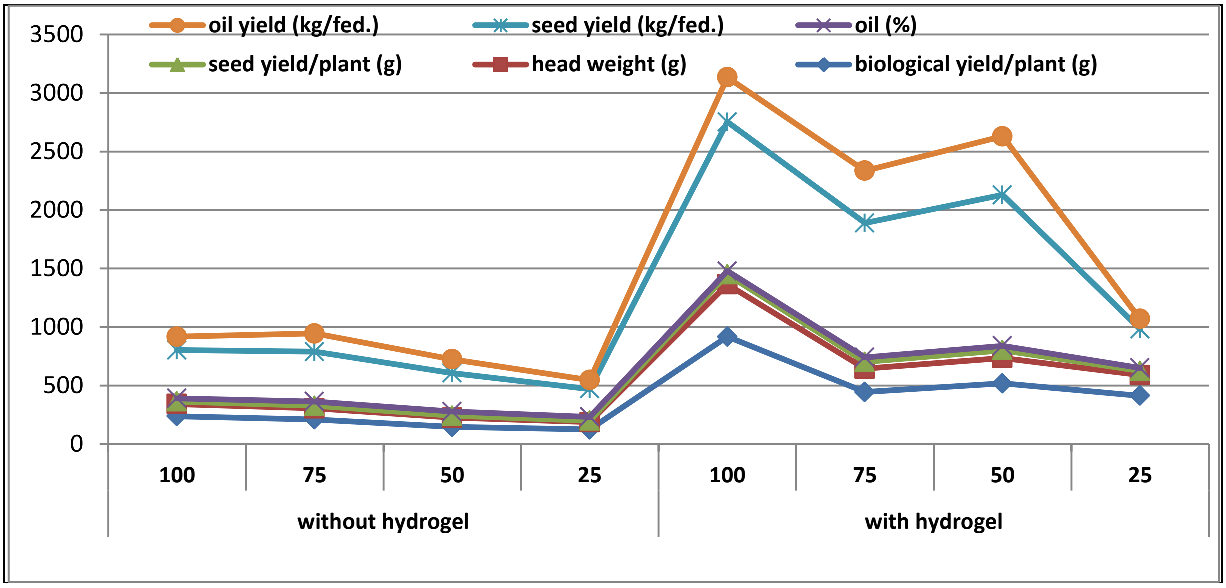

Figure (3) Effect of interaction between hydrogel and water requirements on yield and yield components of sunflower.

It can be concluded that interaction of hydrogel and 50% recommended irrigation quantitymay be promise interaction for producing highest plants, highest seed yield (kg/fed.) and oil yield (kg/fed.) also, it recorded the second order in most other characters with ratio to the best treatment identify 74% in stem diameter, head diameter; 56% in biological yield/plant; 48% in head weight; 77% in seed yield/plant and 99% in oil% in seeds.

It can be concluded that interaction of hydrogel at the rate of 8 g/m^2 and 50% recommended irrigation quantity may be effective tool to reduce water leaching from soil and recorded results near the best treatment and reducing irrigation rates to the half amount of recommended quantity without high lost in seed yield and oil yield per feddan.

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