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Utilization of hydrogel for reducing water irrigation under sandy soil condition.
1- Preliminary study on the effect of hydrogel on yield and yield components of sunflower and wheat under newly reclaimed sandy soil.

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ABSTRACT

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. Effect of hydrogel in three rates (0.2%, 0.5%, 1%) and control (without) on yield, yield components of sunflower (*Helianthus annuus* L.) followed by wheat (*Triticum aestivum* L.) For reducing irrigation quantity to 75% from recommended amount under newly reclaimed sandy soil. Two greenhouse experiments were conducted during summer season of 2013 and winter season 2013/2014 in research and production station of National Research Centre, Al Emam Malek village, Al Nubarie district, Al Behaira Governorate, Egypt. Due to sunflower experiment data clear that control (without hydrogel) had superiority on other treatments in most yield attributes. Control produced the tallest plants; the highest plant dry weight; the heaviest seed yield/plant; the highest harvest index; the heaviest 100 seeds, also, its seed contain highest oil%. Treatment of (0.2 %) recorded the second order in all studied character except for head diameter came in the first order. Treatments of (0.5 %) and (1 %) recorded the third and fourth order in all studied character. Due to wheat experiment data revealed the superiority of treatment 0.2 % which produced plants have highest leaf area 131.40 cm^2 and highest total chlorophyll 46.36 SPAD at 90 DAS. There were significant differences between treatments in all studied characters, treatment of 0.2 % hydrogel had superiority in all studied characters, it produced the tallest plants (82 cm) ; highest number of spikes/pot (27.2) ; the heaviest 1000-grains (39.8 g) ; highest biological yield (156.8 g/pot) ; highest grain yield (32.4 g/pot) and the highest harvest index (20.66 %). Treatment of 0.5 % recorded the second order in all studied characters, control was third and 1 % was the fourth in all studied characters.

Keywords: hydrogel - sunflower – wheat - newly reclaimed sandy soil

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INTRODUCTION

The uses of alternative water holding amendments and irrigation methods will become more important over time, especially in regions of reduced water availability such as most Middle East and African countries. 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). Hydrogel 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 and 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.

Sunflower (*Helianthus annuus* L.) is the fourth oil seed crops after seed cotton, sesame and soybean under Egyptian condition, its cultivated area was 7552 and 10^3 hectare in 2011 and 2012 seasons. FAOSTAT (2012). 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.

Increasing cultivated of wheat production of unit area are the most important national objectives in Egypt for decreasing the gap between the production and population consumption. That could be achieved by improving agricultural practices especially in desert area such as irrigation and fertilizers. Wheat (*Triticum aestivium* L.) is considered the main cereal crop in the world as well as in Egypt. Therefore, increasing grain yield production is considered one of the most important national aims to face the great demand of the highly

Increasing human population, Wheat is considered the first strategic food crop in Egypt. It has maintained its position during that time as the basic staple food in urban areas and mixed with maize in rural areas for bread making. In Egypt wheat plants are sometimes exposed to drought stress at different periods of growth. 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. Hussein (2004), Mousa and Abdel-Maksoud (2004), El-Afandy (2006) and Fang *et al*., (2006) found that subjecting wheat plants to drought –stress resulted in a significant reduction in grain yield and its components of wheat.

Thus the aim of this work was to examine effect of three rates of hydrogel on yield and yield components of sunflower and wheat with reducing irrigation to 75% from recommended.

MATERIALS AND METHODS

Two green house experiments were carried out during summer of 2013 and winter season 2013/2014 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) is reported in **Table 2**.

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

Table (2a). Meteorological data for AL-Nubaria region in summer growing season 2013.

Month	Temperature (average)	Humidity (average)
June 2013	250.50	66.93
July 2013	25.46	75.47
August 2013	26.06	76.30
September 2013	24.71	73.26

Table (2b). Meteorological data for AL-Nubaria region in winter season 2013/2014.

Month	Temperature (average)	Humidity (average)
November 2013	18.6	78.77
December 2013	12.89	80.98
January 2014	12.45	84.54
February 2014	13.49	81.83
Mars 2014	16.11	72.90
April 2014	19.08	70.56

Sandy soil from wild zone in NRC station was used in sunflower experiment. Sowing date was 18 June 2013, earthenware pots 40 cm diameter and 30 cm in depth each one filled with 10 kg sandy soil then, treatment was done in 8 pots (replicates).

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- Control without (hydrogel) addition in 8 replicates
B- 0.2% (hydrogel) - C- 0.5% (hydrogel) - D- 1% (hydrogel
* Treatments were 4, replicates were 8 and experimental design was complete randomize design.

Five seeds of sunflower local variety (Sakha-53) taken from oil crops research department, Agricultural Research Centre – Agriculture Ministry – Egypt. Were sown in each pot.

Fertilization of NPK at rate of (45:32:48)/feddan (4200 m^2) equal 2.76 g/pot ammonium nitrate 33 % N + 3.37 g/pot superphosphate 15.5 % P_2O_5 + 1.69 g/pot potassium sulfate 48 % K_2O. Irrigation by drip method was used at rate of 0.016 m^3/pot during season which identifies 75% from recommended dose. Hand hoeing of weeds was done at 21 and 35 days after sowing then, take two sunflower plants/pot.

At harvest the following parameters were recorded:-

Plant height (cm) – stem diameter (cm) – head diameter (cm) – plant dry weight (g)– seed yield (g/plant) – biological yield (g/plant) – harvest index = seed yield/biological yield – seed index = 1000 seeds weight (g) – oil % in seeds.

Due to wheat experiment sown date was 16 November 2013, the experimental variety was Misr-1 (local), its source was Ministry of Agriculture, Egypt. The same pots which used in sunflower experiment were used in wheat experiment. Irrigation by drip method was used at rate of 0.020 m^3/pot during season which identifies 75% from recommended dose. Hand hoeing of weeds was done at 21 and 35 days after sowing then, take three wheat plants/pot.

Fertilization of NPK at rate of (90:32:48)/feddan (4200 m^2) equal 5.52 g/pot ammonium nitrate 33 % N + 3.37 g/pot superphosphate 15.5 % P_2O_5 + 1.69 g/pot potassium sulfate 48 % K_2O.

At 90 days after sowing (DAS) leaf area (cm^2) and total chlorophyll (SPAD) were determined.

At Harvest the following parameters were recorded:-

Plant height (cm) – Number of spikes/pot – 1000-grains weight (g) – Grain yield (g/pot)– Biological yield (g/pot) – harvest index = Grain yield /biological yield.

Statistical analysis:

The experimental design was complete randomize design in eight replicates in both experiments (sunflower – wheat). At harvest t he 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

A- Sunflower:

Table (3): Effect of (hydrogel) rates on yield and yield components of sunflower in sandy soil (summer season of 2013)

Characters / Treatments	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)	Plant dry weight (g)	Seed yield/plant (g)	Biological yield/plant (g)	Harvest index (%)	Seed index (g)	Oil in seed (%)
Control	152.80	1.01	10.03	38.50	24.50	125.40	19.53	2.85	41.60
0.2%	150.75	0.94	12.71	34.00	22.90	130.00	17.61	2.65	40.90
0.5%	120.08	0.96	10.78	24.00	18.30	136.40	13.41	2.50	40.70
1%	116.33	1.07	10.19	20.50	18.00	144.40	12.46	2.40	40.60
LSD (0.05)	2.28	n.s	0.66	1.44	0.88	1.24	1.36	0.12	N,s

Data presented in Table (3) clear that control (without hydrogel) had superiority on other treatments in most yield attributes. Control produced the tallest plants (152.8 cm), the highest plant dry weight (38.5 g) the heaviest seed yield/plant (24.5 g) , the highest harvest index (19.53 %), the heaviest 100 seeds (2.85 g) , also, its seed contain highest oil 41.60%.

Treatment of (0.2 %) recorded the second order in all studied character except for head diameter came in the first order (12.71 cm). Treatments of (0.5 %) and (1 %) recorded the third and fourth order in all studied character. It can be concluded that superiority of control and (0.2 %) may be due to high distribution of roots in sunflower plants through deep depth of soil which reflect on yield and yield components but high rates of (0.5 % and 1%) affected on surface layer of soil only, results were in accordance with those obtained by Vieeo *et al*., 2000, who reported that hydrogel amendments in sandy soil promoted seedlings survival and growth when hydrogel was applied in combination with irrigation. Contrasting results may be related to the soil texture, thus hydrogel application in sandy soils promotes an increase in water retention capacity and plant water potential in trial had different concentrations of the hydrogel were added to sandy soils at 0.04, 0.08, 0.12, 0.20 and 0.40 % weight by weight (Huttermann *et al*., 1999; Abedi-Koupai and Sohrab 2004), also, they reported that the hydrogel allowed for 19 days tolerating drought.

Jahangir *et al*., 2008, stated that application of hydrogels can result in significant reduction in the required irrigation frequency particularly for coarse-textured soils and it is important in arid and semi-arid regions of the world for enhancing the water management of coarse-textured soils.

It can be concluded that treatment of (0.2 %) 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 best treatment. Results indicated that supplement study is needed under field condition with reducing irrigation rates to 90, 80, 70, 60, and 50 % from recommended to test effect of hydrogel on reducing irrigation amount and show clear show of hydrogel under field condition.

B- Wheat:

Table (4) Effect of hydrogel rates on leaf area and total chlorophyll of wheat plants at 90 DAS during winter season of 2013/2014 season.

Characters / Treatments	Leaf area (cm^2)	Total chlorophyll (SPAD)
Control (without hydrogel)	100.80	44.06
0.2 %	131.40	46.36
0.5 %	103.10	40.00
1 %	97.45	39.16
LSD at 0.05 % level	0.64	0.42

Table 4 shows the differences between treatments in leaf area index (cm^2) and total chlorophyll (SPAD) at 90 days after sowing DAS. Data revealed the superiority of treatment 0.2 % which produced plants have highest leaf area 131.40 cm^2 and highest total chlorophyll 46.36 SPAD. Treatment of 0.5% came in the second order, control the third and 1 % was the fourth in leaf area. Due to total chlorophyll control recorded the second 44.06 followed by 0.5 % (40.0) and 1 % (39.16).

It can be concluded that treatment of 0.2 % hydrogel saving more moisture in root elongation zoon of wheat plants than other treatments which reflect on wheat leaves growth rate and contents of chlorophyll. Results are near with those obtained by Jahangir Abedi Koupai *et al*., 2008, who reported that the maximum effect of polymer addition on the leaf area is related to control, 6 and 4 kg^{-1}, respectively, also, indicated that there is a significant effect of 66 % evapotranspiration Etc on the leaf area compared with the 33 % Etc.

Data presented in table 5 show the effect of hydrogel treatments on yield and yield components of wheat plants sown in sandy soil. There were significant differences between treatments in all studied characters. It is clear from data that treatment of 0.2 % hydrogel had superiority in all studied characters, it produced the tallest plants (82 cm) ; highest number of spikes/pot (27.2) ; the heaviest 100-grains (39.8 g) ; highest biological yield (156.8 g/pot) ; highest grain yield (32.4 g/pot) and the highest harvest index (20.66 %. Treatment of 0.5 % recorded the second order in all studied characters, control was the third and 1 % was the fourth in all studied characters.

It can be concluded that superiority of 0.2 % treatment may be due to saving balanced moisture compared to other treatments and/or control in root elongation zone of wheat plants during growth stage which pointed in leaf area and total chlorophyll and during maturity which reflect on wheat yield and yield components. Results are in harmony with those obtained by Jahangir Abedi Koupai *et al*., 2008, who reported that application of 4 and 6 g/kg^{-1} of Superab A200 (polymer) addition in sandy loam soil enhanced the available water content by 2.2 and 2.3 times as compared to the control, also, Allahdadi *et al*., 2005, who studied the impact of Superab A200 (polymer) on *Zea mays* yield and yield components.

Table (5) Effect of hydrogel rates on yield and yield components of wheat plants at winter season of 2013/2014 season.

Characters / Treatments	Plant Height (cm)	No. of Spikes/ pot	1000 Grains Weight (g)	Grain Yield (g/pot)	Bio-Yield (g/pot)	Harvest Index (%)
Control (without hydrogel)	66.20	16.40	35.20	25.20	139.60	18.05
0.2 %	82.00	27.20	39.80	32.40	156.80	20.66
0.5 %	78.40	23.00	36.00	28.20	140.00	20.14
1 %	60.20	14.80	32.00	22.00	128.20	17.18
LSD at 0.05 % level	1.20	0.82	0.44	0.64	1.08	0.42

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