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Effect of Hydrogels and Irrigation Frequency on Yield and Water Use Efficiency in the Coastal North-Eastern Part of Sinai

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TOW FIELD experiments were conducted to study the effect of the hydrogels (0, 57 kg of superhydro and 2.4 rolls of DWAL/ha. at El-Arish, and 0, 57 kg of superhydro, 2.4, 4.8 and 7.1 rolls of DWAL/ha. at Rafah and irrigation for one hour (one hour irrigation = 47.12 m^3/ ha.) 1, 2, 3 and 6 times per week on yield and water use efficiency. The indicator plants were squash (at El-Arish and Rafah) and okra and squash (at Rafah).

The hydrogels increased the yield, water use efficiency and saved irrigation water. The highest yield of okra and squash was obtained with 57 kg superhydro and 7.1 rolls DWAL/ha., respectively in Rafah. Also, the squash yield of the 57 kg of superhydro/ha. exceeded that of 2.4 rolls DWAL /ha. in the two locations.

In Rafah location, okra yield and its water use efficiency decreased with increasing DWAL from 2.4-7.1 rolls/ha. An opposite trend was noticed in the case of squash. From water economy point of view, El-Arish is preferred for squash than Rafah, and squash is preferred than okra at Rafah.

Keywords : Hydrogels, irrigation, frequency, yield, water use efficiency.

Agriculture in the coastal North-Eastern part of Sinai depends mainly on rainfall. According to Frer and Popov (1964) the mean rainfall varied from 175 mm in El-Arish to 200 mm in Rafah. This small amount of rain and its distribution pattern during the growing season do not meet the full water requirements of many crops and water stress develops frequently in plants under such conditions affecting crops growth and yield.

Several authors have reported the beneficial effects of using the hydrogels on soil physical characteristics, water retention, evaporation plant growth, yield and water use efficiency (Al-Omran *et al.*, 1987, Diab *et al.*, 1992, El-Hady and Azzam, 1983, El-Hady *et al.*, 1981, El-Hady *et al.*, 1990, Henderson and Hensly, 1986 and Tayel and El-Hady, 1981).

The ultimate objective of this research is to study the effect of hydrogels application and drip irrigation frequency on yield of okra and squash grown in El-Arish and Rafah and on their water use efficiency.

Material and Methods

Soils

The soils of the experimental field in both El-Arish and Rafah are sandy in texture; their characteristics are given in Table 1. The soil of El-Arish and Rafah have been classified according to Soil Survey Staff (1990) as a Typic torrifluevent and Typic Toriorthent, respectively.

Irrigation water

Groundwater was used in irrigation. Table 2 shows the chemical analysis of the irrigation water.

Hydrogels

Superhydro

Its chemical composition is polyacrylamide-sodium polyacrylate (active material 90%). It contains 20% N and can absorb 300 -700 gram of water per gram depending on water salinity. It is a Swiss product in a crystalline form.

DWAL

The gel is a product of the American Co. (DOW) in sheet form. The active material is 90%. It contains 50% cellulose and 50% polymer and can absorb 150-200 gm of water per gram depending upon water salinity. One roll contains 14.67 kg of the polymer.

Irrigation system

Drip irrigation system was used. Distances between laterals and between drippers were 1.5 and 0.5m, respectively. Drippers discharge water at the rate of 3.3 L/h (one hour irrigation = 47.12 m^3/ha).

Experiment I

The 1*st* experiment was conducted at both El-Arish and Rafah using squash as an indicator plant. Soil in plant pits only was treated with the hydrogels at the rates of 0, 57 kg superhydro or with 2.4 rolls of DWAL/ha., then seeds were seeded.

Experiment II

The 2*nd* experiment was carried out at Rafah only using both squash and okra as indicator plants. Plant seeds were seeded after treating plant pits with gels at the following rates: 0, 57 kg of superhydro, 2.4, 4.7 and 7.1 rolls of DWAL/ha.

In both of the two experiments, plants were irrigated for one hour 1, 2, 3 and 6 times per week. All the other normal practices of growing squash and okra plants in the two locations were followed. At the end of the growing season, the yield was weighed and water use efficiency was calculated (marketable yield in kg/seasonal irrigation water in liter).

Results and Discussion

The soil characteristics in both El-Arish and Rafah locations are presented in Table 1.

Although soils are sandy in texture yet the clay content in Rafah location is higher than that in El-Arish (1.5 to 3 times) according to the depth. Also, while the clay content was constant with depth, in El-Arish soil (3.6%), it increased from 5.6% in the surface layer to 9.6% in the subsurface one in Rafah soil. Calcium carbonate, P and Mg^{++} decreased with depth but organic matter, EC x 10^3 and Mg^{++} increased in El-Arish soil. On the other hand, $CaCO_3$, EC x 10^3 and Mg^{++} increased with depth while organic matter, K^+ and Na^+ decreased with depth in Rafah.

Concerning salinity, water of both locations can cause a severe problem (Ayers and Westeot, 1976). In fact, salinity problem is relieved due to the winter rainfall and the coarse texture of the soil. Because soils are sandy and the EC x $10^3 > 0.5$ mmhos/cm no problem is expected in soil permeability. Crops sensitive to both Na^+ and Cl^- are not recommended under El-Arish conditions.

TABLE 1. Soil characteristics in the experimental fields.

Location	El-Arish		Rafah	
	0 - 15 cm	15 - 30 cm	0 - 15 cm	15 - 30 cm
M-analysis %				
Sand	87.60	87.60	85.6	81.60
Silt	8.80	8.80	8.80	8.80
Clay	3.60	3.60	5.60	9.60
Soil texture	Sandy	Sandy	Sandy	Sandy
$CaCO_3$ %	7.38	3.28	3.69	8.20
O. matter %	1.75	2.10	2.28	2.20
EC x 10^3 (mmhos/cm)	0.34	0.39	0.21	1.22
Macro elements mg/100 g soil	8.41	8.42	8.32	8.28
P	1.32	0.48	0.48	0.48
K	8.68	8.68	6.20	4.96
Mg	9.80	5.60	5.60	12.60
Na	15.20	30.20	30.40	22.80

TABLE 2. Chemical analysis of irrigation water.

Location	EC x 10^3 mmhos/cm	pH	Soluble cations meq/L				Soluble anions meq/L				SAR adjus.
			Mg^{++}	Ca^{++}	K^+	Na^+	SO_4^{--}	Cl^-	HCO_3^-	CO_3^{--}	
El-Arish	6.42	7.4	1.72	4.92	0.30	12.10	7.45	10.15	1.67	0.23	11.96
Rafah	2.95	8.3	0.90	4.06	0.35	6.59	4.53	6.11	1.11	0.15	6.69

TABLE 3. Effect of the hydrogels and irrigation frequency on water use efficiency of squash and okra at Rafah (g/L).

No. of irrigat. per week	Water use efficiency (g/L of water)				
	Control	Superhydro 57 kg/ha.	DWAL (Rolls/ha.)		
			2.38	4.76	7.14
Squash					
1	1.230	6.130	5.110	6.640	7.150
2	1.750	4.090	3.790	4.380	5.250
3	2.010	3.620	3.320	4.020	4.420
6	1.310	2.520	2.190	2.630	3.060
Okra					
1	0.511	1.532	1.487	1.430	1.277
2	0.627	1.571	1.414	1.257	1.100
3	0.899	1.574	1.484	1.349	1.282
6	0.290	0.639	0.678	0.755	0.670

One hour irrigation = 47.12 m3/ha.
*One roll of DWAL (600 x 0.6 m) contains 14.67 kg of the polymer.

The response of squash yield grown in the two locations (Rafah and El-Arish) to gel treatments and irrigation frequency is illustrated in Fig. 1. It is obvious that squash yield (ton/ha.) increased with gels application and with increasing the number of irrigation per week. This could be attributed to the higher evapotranspiration of squash. The yield in El-Arish exceeded that in Rafah. Also 57 kg of superhydro/ha. was superior than 2.4 rolls of DWAL. This may be due to the nitrogen content and the higher ability for water absorption in the case of the superhydro.

The yield of squash for different gels and irrigation treatments relative to the control irrigated for one hour 6 times weekly (regular irrigation) was calculated. This relative yield increased with using gels and with increasing irrigation number from 1 to 6 per week. Again, the positive effect of superhydro exceed that of DWAL. Reasons for this have been discussed before. It is worthy to mention that squash yield in the case of using gels and 3 irrigations per week ranged from 115 to 150% of that of the control with 6 irrigations per week. In other wards, using gels gave a better yield and save 50% of the irrigation water.

Figure 2 indicates that water use efficiency decreased with increasing irrigation frequency and increased with using gels. This may be explained on the basis that gels increased the yield and at the same time decreased irrigation requirement through decreasing water losses via evaporation and percolation. Although, water use efficiency was the highest with one irrigation per week in all cases, this irrigation treatment can not be recommended because the yield is not economic.

On tonnage basis, squash yield was higher than that of okra in Rafah regardless of gel treatments (Fig. 3). It is obvious that squash yield increased with increasing irrigation frequency from 1 to 6 times per week, but okra yield decreased after 3 irrigations. Also, it worths to mention that an increase in squash yield and a decrease in okra yield were noticed with increasing the application rate of DWAL. This may be attributed to the higher evapotranspiration rate from the bigger areas of squash leaves relative to the smaller ones of okra.

Squash plant made a better use of irrigation water than okra in Rafah location (Table 3). The response of water use efficiency to the hydrogels and irrigation treatments was similar to that of the yield.

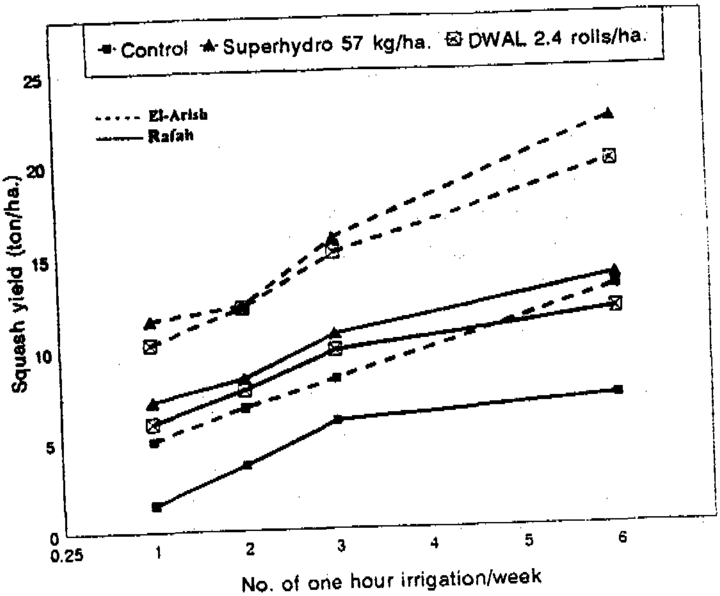

Fig. 1. Effect of the hydrogels and irrigation frequency on squash yield.

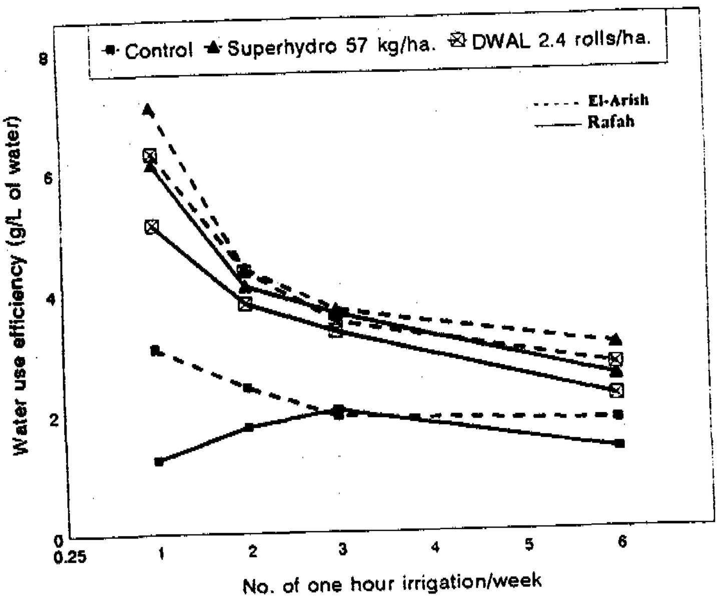

Fig. 2. Effect of the hydrogels and irrigation frequency on water use efficiency of squash.

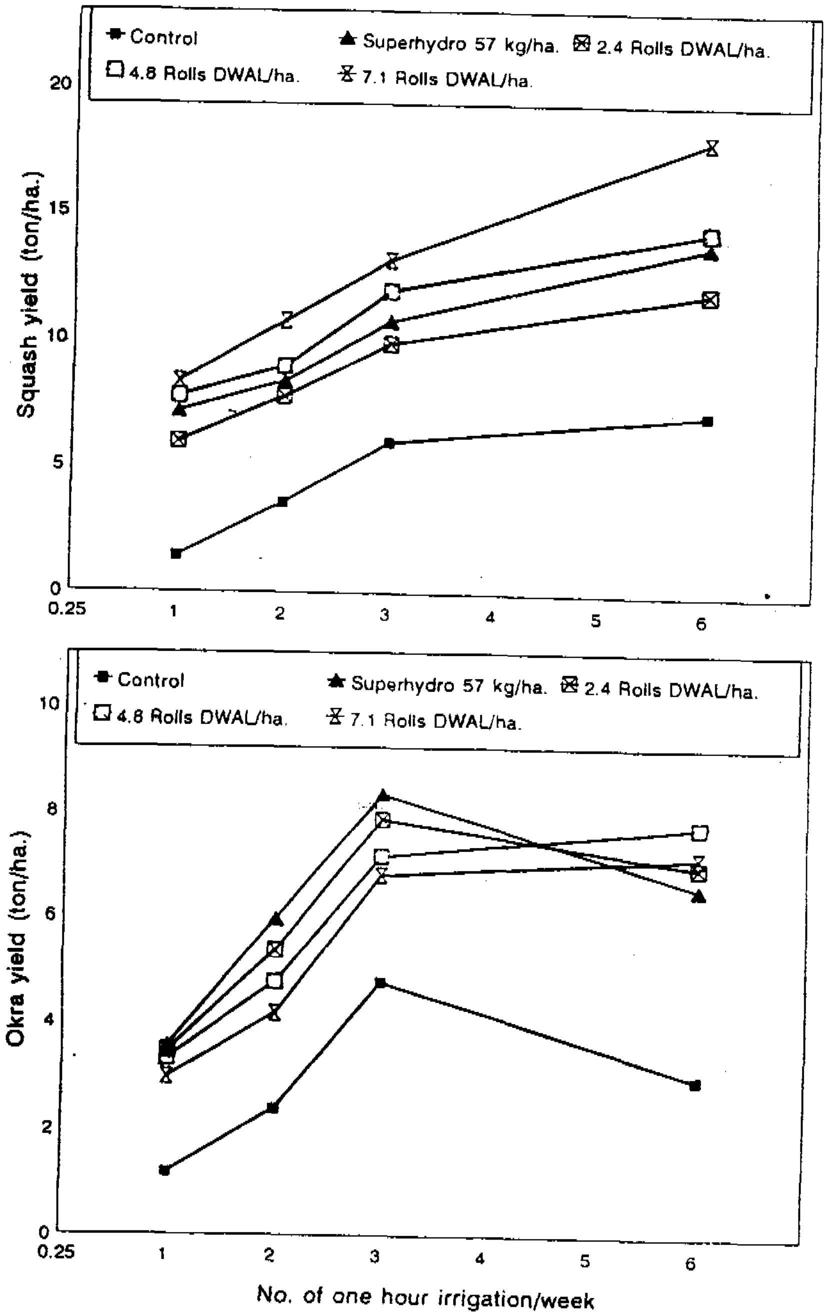

Fig. 3. Effect of the hydrogels and irrigation frequency on the yield of squash and okra at Rafah.

Conclusion

It could be concluded that:

1- Squash plants needed more irrigation water than okra plant.

2- The yield and water use efficiency of squash exceeded that of okra.

3- Using the hydrogels increased the yield and water use efficiency and cut down the irrigation requirement.

4- From the water economy point of view, El-Arish is preferred for squash than Rafah and squash is preferred than okra in Rafah.

5- Under Rafah conditions, the highest yield was obtained using 57 kg superhydro/ha. and 3 irrigations weekly for okra, and 7.1 rolls of DAWL/ha. and 6 irrigations per week for squash.

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تأثير الهيدروجيل والفترة بين الريات على الانتاج وكفاءة استعمال الماء فى الجزء الشمالى الشرقى من سيناء

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لدراسة تأثير استعمال الهيدروجيل والفترة بين الريات أقيمت تجربتان احدهما في العريش حيث زرعت الكوسة في جور معاملة بـ (صفر ، ٧٥ كجم سوبر هيدرو ، ٢,٤ رول دوال / هكتار) والثانية في رفح حيث زرعت كل من الكوسة والبامية في جور تحت ظروف المعاملات (صفر، ٧٥ كجم سوبر هيدرو ، ٢,٤ ، ٤,٨ ، ٧,١ رول دوال / هكتار) - ونظام الري في الموقعين هو التنقيط وكانت معاملات الري هي ١، ٢ ، ٣، ٤ ، ٥ ، ٦ ريات/اسبوع .

وتشير نتائج الدراسة الى :

- تحتاج الكوسة كمية مياه أكثر من البامية.
- الانتاج وكفاءة استعمال الماء للكوسة أكبر منه للبامية.
- استعمال الهيروجيل أدى الى زيادة الإنتاج وكفاءة استعمال الماء مع تقليل مياه الري.
- من وجهة نظر الاقتصاد في مياه الري يفضل زراعة الكوسة عن البامية في الموقعين .