Improving Nitrogen Utilization Efficiency by Potato (*Solanum tuberosum* L.)

B. Effect of Irrigation Intervals, Nitrogen Rates and Veterra Hydrogel on Growth, Yield, Quality, Nutrient Uptake and Storability

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ABSTRACT: A complete randomized field experiment with four replications was conducted at Baramoon Research Station, Mansoura, Dakahlia Governorate, Egypt, using furrow irrigated potato (*Solanum tuberosum* L. cv. Cara). The effect of two irrigation intervals (15 and 26 days, starting after 1st irrigation) and three nitrogen fertilizer rates (120, 150, and 180 kg fed^{-1}) with or without veterra hydrogel VH (soil conditioner) on growth, yield, quality, nutritional status and plant water relationships on potato were studied in a clay loam soil. Obtained results could be summarized as follows: 1. Applied conditioners VH and irrigation every 26 days with 150 kg N fed^{-1} positively affect vegetative growth characters. These include, plant height, relative growth rate and net assimilation rate in 1st season only. On the other hand, no significant differences in these traits were evident among the treatments in 2nd season of study. 2. The increases in total and marketable tuber yields as well as tuber grade No. 1 & 2 and decreases in grade No. 3 for soil application of VH and fertilized potatoes with 150 kg fed^{-1} under irrigation every 26 days condition treatment over the other treatments, in both seasons. 3. The highest values of macro (NPK) and micro-nutrients (Fe, Mn and Zn) as well as tuber quality (DM, specific gravity and starch content), plant water relations (free water, total water) and total chlorophyll was obtained from potato receiving 150 kg N fed^{-1} and soil amending with VH under 26 days irrigation intervals. 4. The highest values of NO_3 and NO_2 as well as storage behavior characters were recorded under the treatment received 180 kg N fed^{-1} for both irrigation intervals without application of VH. As regard to residual NH_4^+ and NO_3^- in soil after harvesting, the greatest values were obtained in the treatments of 150 kg N fed^{-1} for both irrigation intervals with application of VH. Generally, it could be concluded that application of veterra hydrogel as soil conditioner and irrigation every 26 days (4 times for growing season) with moderate N-fertilizers (150 kg fed^{-1}) to winter potatoes cv. Cara fields might gave the chance for efficient management of soil moisture and increasing nitrogen use efficiency and produce satisfactory and good marketable tuber yield with minimizing environmental impact of over-fertilization.

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INTRODUCTION

Soil physical condition is one factor that can limit crop production. Poor soil physical condition can restrict water intake into the soil and subsequent movement, plant root development, and aeration of the soil. Optimal irrigation and nitrogen management remain a major challenge for improving water use efficiency, nitrogen use efficiency and vegetables yield in Egypt. Producers and researchers alike are interested in improving the physical condition of the soil and water use efficiency and, thus, enhance crop production. These goals can be accomplished in part through the use of good management techniques. In addition, there are amending materials that claim to improve the soil physical condition. Such materials are called soil conditioners (i.e., veterra hydrogel). Previous experiments on soil conditioning showed that polyacrylamide (PAM) solution was more effective in improving hydrophysical conditions (Williams *et al.*, 1967); increased the vegetative growth (Wallace *et al.*, 1986); reduced furrow runoff losses (Lentz *et al.*, 1998); reduced nitrogen losses (Bres and Watson, 1993) and increased a germinating plant's chance of survival (Lehrsch *et al.* 1996). Polyacrylamide applied to the irrigation water in small quantities has been shown to decrease the amount of sediment loss, as well as increase water infiltration into the soil in furrow-irrigated fields (Trout *et al.* 1993, Shock *et al.* 1994).

The use of hydrogels leads to increased water-holding capacity; increased availability of water to plants; improved soil structure and aeration; reduced compaction and hardpan conditions; improved tile drainage effectiveness; alkali soil reclamation; release of "locked" nutrients; better chemical incorporation; better root development; and higher yields and quality (Jhurry, 1997; Hickman and Whitney, 1998; El-Hady and

Abo-Sedera, 2006). Orts *et al.* (2000) found that application of biopolymers to furrow irrigation water reduced suspended solids by more than 80% and exhibited the >90% runoff sediment reduction of some clay-rich soils. In Ontario, Shock *et al.*, (2009) reported that Stockosorb® is a soil conditioner that is designed to enhance the water retention capability of soils, produced higher total and marketable yield, and yield of U.S. No. 1 tubers of potatoes. In another study, Agaba *et al.* (2010) mentioned that soil amendment with super absorbent polyacrylate (SAP) hydrogel amendment decreased the hydraulic soil conductivity that might reduce plant transpiration and soil evaporation. Therefore, this investigation carried out to illustrate the effect of veterra hydrogel as a soil conditioner, irrigation intervals and nitrogen fertilizer rates on potato growth, yield, quality, water-plant relationships and nutrient uptake.

MATERIALS AND METHODS

Trials were conducted at Baramoon Research Station, Mansoura, Dakahlia Governorate, Egypt, using potato (*Solanum tuberosum* L. cv. Cara). The potatoes were grown on clay loam soil and irrigated with furrow system (Fig. 1). Analyses of the soil are presented in Table 1 (Page, 1982; El-Hady and El-Sherif, 1988).

Table 1: Analytical data of El-Baramoon clay loam soil

(a) Mechanical analysis

Sand		Silt	Clay	Soil Texture
Coarse	Fine	20-2 µ%	< 2 µ %	
>200 µ %	200-20 µ %			
4.4	28.8	28.5	38.3	Clay loam

(b) Chemical analysis

pH 1:2.5	EC 1:5 dSm^{-1}	CaCO3 (%)	CEC Meq/100 g	cmol OM (%)	Macro-nutrients (ppm)					
					Total			Available		
					N	P	K	N	P	K
8.1	0.9	3.1	35.2	1.4	415	738	1015	32	6	55

(c) Hydrophysical analysis

Real density g/cm^3	Total porosity %	Water holding capacity* %	Field capacity* %	Wilting percentage*	Available water	Hydraulic conductivity mmh^{-1}	Mean diameter of soil pores µ
2.66	2.97	48.97	40.2	16.4	18.6	12.3	2.35

*on weight basis

The experimental design was a randomized complete block with four replicates. The treatments were: 1) irrigation intervals (Ir.) every 15 days + 180 kg N fed^{-1}; 2) Ir. every 15 days + 150 kg N fed^{-1} + veterra hydrogel (VH); 3) Ir. every 15 days + 120 kg N fed^{-1} + VH; 4) Ir. every 26 days + 180 kg N fed^{-1}; 5) Ir. every 26 days + 150 kg N fed^{-1} + VH, and finally 6) Ir. every 26 days + 120 kg N fed^{-1} + VH. Each plot was 11.25 m^2 and contained 3 rows; 75 cm wide and 5 m long. Potato seed pieces were planted manually on October 15 using a hand tool to dig holes at 25 cm intervals. Veterra hydrogel (Shering Co., Germany) medium dry granular was applied manually over the row at 37.3 kg/feddan (= 4200 m^2). After planting, the beds were reformed manually with an axe. All agronomic practices were conducted by the Ministry of Agriculture, Egypt.

Emergence started after 21 days from planting. Irrigation intervals were applied at 15 and 26 days after the first irrigation which was 21 days after planting, from October 30 to January 12. The number of irrigation events was 7 and 4 for both irrigation treatments, i. e., 15 and 26 days, respectively.

Nitrogen treatments in the form of ammonium nitrate (33.5% N) were applied at three equal doses, i. e. the first after emergence, and second and third doses with 2nd and 3rd irrigation, respectively. Single superphosphate (15.5% P_2O_5) was applied before planting at the rate of 75 kg P_2O_5 fed^{-1}. Potassium sulphate (48% K_2O) at the rate of 96 kg K_2O fed^{-1} was added in two equal doses with the 2nd and 3rd doses of ammonium nitrate.

Five plants from each plot were randomly taken after 70 and 90 days from planting for measuring the vegetative growth parameters, i. e., plant height (70 DAP), relative growth rate (R.G.R), net assimilation rate (N.A.R). R.G.R was estimated using the following equation (Richards, 1969):

$$R.G.R = \frac{\text{Ln } W2 - \text{Ln } W1}{T2 - T1}$$

Where, W1 and W2 are the shoot dry weight at the timing of sampling T1 and T2, respectively. N.A.R.; the method of McCollum (1978) was used to determine Net assimilation rate (N.A.R.) at the period of 70 and 90 days. The following formula was used:

$$N.A.R = \frac{W2 - W1}{L2 - L1} \times \frac{\log L2 - \log L1}{T2 - T1}$$

Where, W1 and W2 are shoot dry weight, L2 and L1 are the leaf area plant^{-1} (Koller, 1972), but T1 and T2 refer to timing of sampling.

Total, free and bound water in the fourth upper leaf of potato plants were determined at 70 days after planting according to the method described by Gosev (1960). Also, at the same time, total chlorophyll was determined according to Wettestein (1957).

At the harvesting time (130 DAP), the tuber yield and yield grading per feddan were recorded. Tubers were graded according to their diameter (grade 1, > 60 mm; grade 2, 30: 60 mm and grade 3, < 30 mm). Marketable tubers if any of the following conditions occurred: growth cracks, bottleneck shape, abnormally curved shape, or two or more knobs.

A 20-tuber sample from each plot was selected from the largest sizes to evaluate tuber quality (dry matter, specific gravity, starch, and nitrate and nitrite content) according to the methods described by (AOAC, 1990). N, P and K concentrations in the digested dry weight of tubers were determined according to the methods described by Olsen and Sommers (1982). Fe, Mn and Zn contents in dry matter of tubers were determined by atomic absorption according to Rangana (1979). Residual available nitrogen in soil samples after harvesting the plants was determined by Mg O-Devarda alloy method (Black, 1965).

Data from all trials were analyzed according to the procedure described by Snedecor and Cochran (1982). Comparisons among means of treatments were tested using the last significant differences (LSD) at 5 % level of probability.

Potato tubers 35: 55 mm in diameter were used for storage investigation. The tubers were cured for 15 days, before storage, i. e., **heaped** under a thick layer of rice straw for healing wounds and bruises. The cured was stored at ambient temperature (average 20/10° C day/night and 90% RH) for four months. Tubers were packed in wid-mesh cotton sacks at the rate of 10 kg and were distributed in 3 replicate for determining: weight loss, sprouting, decay and N content. The randomized complete blocks design was used.

RESULTS AND DISCUSSION

1. Vegetative growth:

The conditioning effect of hydrogel with irrigation intervals and N-rates on vegetative growth was estimated at 70 and 90 days after planting (Table 2; Fig 2 & 3). In 1st season (2007/08), plant height, relative growth rate and net assimilation rate tended to increase significantly due to application of veterra hydrogel VH plus irrigation every 26 days and 150 kg N fed-1. Meanwhile, no significant differences in these traits were evident among the treatments in 2nd season.

Also, it is evident from the data in Table 2 the effect of VH plus irrigation intervals and nitrogen rates on total chlorophyll of potato leaves were significant in both season. The highest values and healthy plants were obtained from adding VH plus 150 or 120 kg N Fed-1 and irrigation every 26 days intervals (Fig. 3).

These results could be attributed to the great role of hydrogel to reduce watering requirements of container grown plants (Taylor and Halfacre, 1986), enhance plant growth (Wallace et al., 1986), reduce nitrogen losses (Bres and Watson, 1993; Jhurry, 1997), increase nutrient retention of media (Henderson and Hensley, 1985), and increase the shelf-life of pot crops (Ferrazza, 1974; Gehring and Lewis, 1980).

El-Sayed *et al.* (1990) reported that, generally, dry weight, leaf area, succulence, chloroplast pigments (chlorophyll a, chlorophyll b, and carotenoids), photosynthetic activity, total amino acids, proline, and protein contents were increased with polymer incorporation compared with pure sand of all species (i. e., tomato, lettuce and cucumber) under saline conditions.

Table 2: Vegetative growth characters of potato plants as affected by irrigation intervals, nitrogen rates and veterra hydrogel in 2007/08 and 2008/09 seasons.

Characters	Plant height (cm)		Relative growth rate (mg/gm/day)		Net assimilation rate (mg/cm^2/day)		Total chlorophyll (mg/g F. W.)	
Treatments	**2007/08**	**2008/09**	**2007/08**	**2008/09**	**2007/08**	**2008/09**	**2007/08**	**2008/09**
T1.	50.00	49.67	47.839	48.735	0.11382	0.11460	25.88	25.00
T2.	49.33	49.33	47.019	47.834	0.11252	0.11323	25.62	25.08
T3.	49.67	49.00	49.258	49.802	0.11488	0.11508	24.14	24.13
T4.	48.00	48.67	45.466	47.638	0.10662	0.11297	24.60	24.22
T5.	51.33	50.00	50.424	49.415	0.11783	0.11540	27.93	26.60
T6.	51.67	49.67	48.883	48.953	0.11392	0.11483	26.81	26.16
LSD at 5%	1.49	N.S	0.640	N.S	0.00527	N.S	2.15	0.78

T1. Ir. every 15 Ds + N 180 kg; T2. Ir. 15 Ds + N 150kg + VH; T3. Ir. 15 Ds + N 120 kg + VH; T4. Ir. 26 Ds + N 180 kg; T5. Ir. 26 Ds + N 150 kg + VH, and T6. Ir. 26 Ds + N 120 kg + VH.
Ir.: Irrigation; Ds: Days intervals; VH: veterra hydrogel; All N-rates per Feddan=4200 m^2.

2. Yield and yield components:

Values of total tuber yield and yield grading influenced by treating the soil with hydrogel and/or irrigation intervals as well as N-rates as illustrated in Table 3 reveal that soil conditioner VH, irrigation every 26 days and 150 kg N fed^{-1} significantly ($p < 0.05$) increase total tuber yield, marketable yield and grade 1 & 2. On the other hand, it significantly decreased tuber grade 3.

Also, it was evident that, these treatments considerably differed among them in their effect and that, application hydrogel VH to the soil and fertilized with 150 kg N fed^{-1} showed satisfactory yield increment of 15.28 and 15.48% (for both seasons, respectively; Fig 4) over non application one with 180 kg fed^{-1} (in case of irrigation every 26 days intervals). Moreover, the percentage increases of superior treatment over the control (irrigation every 15 days + 150 kg N fed^{-1}) reached to 8.67 and 6.67%, in both seasons, respectively. Yield increases were due to the increases of vegetative growth traits, chlorophyll content (Table 2) and tuber macro and micronutrients (Table 4).

These yield enhancements as a result of hydrogel application are in agreement with the results obtained by Eiasu *et al.* (2007) who found that the pure gel polymer, especially at higher fertilizer rate, improved total and marketable tuber yield.

These results were accordance to those obtained by Shock *et al.*, (2009). They found that application of Stockosorb® (soil conditioner), produced higher total and marketable yield, and yield of U.S. No. 1 tubers of potatoes.

In another study, Yangyuoru *et al.* (2006) found that increases in maize yields over the control were due to the improved water retention ability of the soils (sandy/clay/loam) amended with the natural or synthetic soil conditioner.

Table 3: Total tuber yield and yield components of potato plants as affected by irrigation intervals, nitrogen rates and veterra hydrogel in 2007/08 and 2008/09 seasons.

Characters / Treatments	Tuber yield (ton fed^{-1})											
	Grade 1		Grade 2		Grade 3		Marketable		Total		Relative yield (%)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
T1.	5.92	5.95	7.10	7.15	0.52	0.61	13.02	13.10	13.54	13.71	106.6	108.8
T2.	5.55	5.60	7.05	6.90	0.58	0.68	12.60	12.50	13.18	13.18	103.8	104.6
T3.	5.20	5.30	6.90	6.75	0.62	0.73	12.10	12.05	12.72	12.78	100.2	101.4
T4.	5.10	5.15	6.90	6.60	0.70	0.85	12.00	11.75	12.70	12.60	100.0	100.0
T5.	6.45	6.45	7.71	7.60	0.48	0.50	14.16	14.05	14.64	14.50	115.3	115.5
T6.	6.15	6.20	7.36	7.45	0.50	0.56	13.51	13.65	14.01	14.21	110.3	112.8
LSD at 5%	0.24	0.19	0.12	0.19	0.09	0.09	0.32	0.38	0.41	0.43	---	---

T1. Ir. every 15 Ds + N 180 kg; T2. Ir. 15 Ds + N 150kg + VH; T3. Ir. 15 Ds + N 120 kg + VH; T4. Ir. 26 Ds + N 180 kg; T5. Ir. 26 Ds + N 150 kg + VH, and T6. Ir. 26 Ds + N 120 kg + VH.
Ir.: Irrigation; Ds: Days intervals; VH: veterra hydrogel; All N-rates per Feddan=4200 m^2; S1: 1st season; 2nd season.

3. Macro and micronutrients content in tubers:

From such data in Table 4, it is evident that the treatments had a significant effect on chemical constituents of potato tubers. All tested chemical constituents were significantly increased with application of VH, in two seasons. The highest values of NPK as well as micronutrients (Fe, Mn and Zn) were obtained from 26 days intervals and fertilized potato plants with 150 kg fed^{-1} in the presence of VH, while, the lowest values were recorded with 26 days irrigation intervals + 180 kg N fed^{-1} in the absence of VH. In this respect, Doering and Gericke (1984) indicated that soil conditioner application was effective in supplying nutrients to plants. The increase in macro- and micro-nutrients uptake may be due to the effect of veterra hydrogel in improving hydrophysical conditions as reported by Awad (1990) and El-Hady and Abo-Sedera (2006).

4. Tuber quality:

Data presented in Table 5 show that, there were significant differences in tuber quality parameters, and nitrate as well as nitrite content in potato tuber, in both seasons. Highest tuber dry matter (1st season), specific gravity (2nd season) and starch content (1st season) was obtained under the treatment received VH with 150 kg N fed^{-1} and irrigated every 26 days.

It could be attributed that application of VH maintain the nutrients supply to the plants during growth period more than non application one. These increases in dry matter, starch and specific gravity may be attributed to the effect of VH on increasing the availability of certain elements and their supply to plant (Table 4). These results were confirmed with those of Eiasu *et al.* (2007) and Shock *et al.* (2009).

Regarding, nitrate and nitrite content in tuber, the highest values were recorded under the treatment received 180 kg N fed^{-1} for both irrigation intervals in the absence of VH. On the other hand, the lowest values were found in treatments amended with the lowest dose of N (120 kg fed^{-1}) with VH, in both seasons. Similarly, Walker (1975) found a close correlation between application of N-fertilizer and accumulation of nitrate. This results may be attributed to regulate the release of nitrogen due to application of VH and making it as a slow-acting nitrogen fertilizer, as conducted by Awad (1990).

Table 4: Macro and micronutrients content of potato tubers as affected by irrigation intervals, nitrogen rates and veterra hydrogel in 2007/08 and 2008/09 seasons.

Characters / Treatments	N uptake (mg/100 g)		P uptake (mg/100 g)		K uptake (mg/100 g)		Fe (mg/1 kg)		Mn (mg/1 kg)		Zn (mg/1 kg)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
T1.	810.9	792.1	86.9	91.2	1336.2	1282.1	42.6	40.1	16.5	16.8	13.32	13.17
T2.	825.5	813.1	88.2	90.7	1329.1	1098.0	40.8	38.2	15.4	15.9	12.76	13.00
T3.	692.5	709.3	84.9	84.0	1257.1	1018.1	38.6	36.1	14.8	15.1	11.85	12.76
T4.	701.5	698.8	83.1	82.5	1115.5	1211.3	36.7	36.0	14.0	14.9	11.80	12.58
T5.	870.5	890.2	93.6	95.2	1412.4	1390.2	43.8	42.6	17.3	18.0	14.08	14.00
T6.	862.3	886.1	92.9	94.9	1408.2	1362.4	44.2	43.5	18.8	18.1	14.11	14.20
LSD at 5%	79.7	78.8	1.9	3.5	76.2	102.9	4.7	4.7	2.9	1.9	1.99	N.S

T1. Ir. every 15 Ds + N 180 kg; T2. Ir. 15 Ds + N 150kg + VH; T3. Ir. 15 Ds + N 120 kg + VH; T4. Ir. 26 Ds + N 180 kg; T5. Ir. 26 Ds + N 150 kg + VH, and T6. Ir. 26 Ds + N 120 kg + VH.
Ir.: Irrigation; Ds: Days intervals; VH: veterra hydrogel; All N-rates per Feddan=4200 m^2; S1: 1st season; 2nd season.

Table 5: Tuber quality of potato as affected by irrigation intervals, nitrogen rates and veterra hydrogel in 2007/08 and 2008/09 seasons.

Characters / Treatments	Tuber dry matter (%)		Specific gravity of tuber		Starch (%)		NO_3^- accumulation (ppm) in tuber		NO_2^- accumulation (ppm) in tuber	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
T1.	21.162	22.418	1.0850	1.0810	14.40	14.34	69.30	67.62	0.60	0.58
T2.	21.312	22.538	1.0848	1.0832	14.65	14.73	55.14	51.74	0.58	0.54
T3.	21.278	22.520	1.0872	1.0798	14.03	14.46	49.08	42.32	0.36	0.32
T4.	21.498	22.622	1.0853	1.0841	14.80	14.55	65.38	63.40	0.52	0.50
T5.	22.830	22.716	1.0883	1.0890	15.70	14.78	62.18	60.92	0.48	0.48
T6.	22.512	22.318	1.0862	1.0885	15.52	14.62	58.72	55.37	0.40	0.40
LSD at 5%	0.370	N.S	N.S	0.002	0.26	N.S	9.96	8.03	0.09	0.08

T1. Ir. every 15 Ds + N 180 kg; T2. Ir. 15 Ds + N 150kg + VH; T3. Ir. 15 Ds + N 120 kg + VH; T4. Ir. 26 Ds + N 180 kg; T5. Ir. 26 Ds + N 150 kg + VH, and T6. Ir. 26 Ds + N 120 kg + VH.
Ir.: Irrigation; Ds: Days intervals; VH: veterra hydrogel; All N-rates per Feddan=4200 m^2; S1: 1st season; 2nd season.

5. Plant water relations & residual N-sources in soil:

As for the effect of veterra hydrogel, N-rates and irrigation intervals, it is obvious from the data in Table 6 that application of VH with 150 kg N fed^{-1} and 26 days irrigation intervals significantly increased both free and total water (%) in potato leaf tissues, in both seasons, compared with other treatments.

Concerning bound water (%), maximum values were obtained under water stress or irrigation (26 days) with high rates of N-applied (180 kg fed^{-1}) and this trend was opposite to that of free or total water percentages. In this context, Agaba *et al.* (2010) mentioned that the 0.4% hydrogel amendment significantly ($p < 0.05$) increased the plant available water PAW by a factor of about three in sand, two fold in silt loam and one fold in sandy loam, loam and clay soils compared to the control. Similarly, the addition of either 0.2 or 0.4% hydrogel to the five soil types resulted in prolonged tree survival compared to the controls.

As regard to residual ammonium and nitrate in soil after harvesting, data in Table 6 indicate that the greatest residual available N was obtained in the treatments of 150 kg N fed^{-1} for both irrigation intervals with application of VH. This result may be attributed to the effect of conditioners (VH) on increasing residual N-sources in soil samples as indicated by El-Hady and Abo-Sedera (2006).

6. Storability:

The effect of veterra hydrogel with N-rates and irrigation intervals on weight loss, sprouting, decay and N content are shown in Table 7. Significant differences in storage behavior were noticed among treatments. Applying N at 180 kg fed-1 with 15 or 26 days intervals recorded maximum weight loss, sprouting, decay and N content at 120 DAS in both seasons of study. The increases in N supply lead to increased transpiration rate per unit of tuber area and subsequently increased water loss in tuber tissue (Augustin et al., 1977). Storage tuber was significantly lower under low rate N. This indicated substantial effect of N supply on dry matter (Table 5) and N content (Table 7) partitioning between storage tubers and water loss (Kelm *et al*., 2002).

Data collected from this study suggest that improper irrigation, especially with high nitrogen fertilizer rates, results in a dramatic increase in N content in the tubers (Table 7).

These results are in accordance with those obtained by Stalin and Enzmann (1992), who found that weight loss were enhanced after N application at the rate of 180 kg fed^{-1}. Furthermore, Marghitas *et al.* (1997) found that the main weight loss of potato tubers were recorded at low NPK rates.

Table 6: Plant water relations and residual N sources in soil as affected by irrigation intervals, nitrogen rates and veterra hydrogel in 2007/08 and 2008/09 seasons.

Characters / Treatments	Free water (%)		Bound water (%)		Total water (%)		Residual NH_4-N (mg/100 g soil)		Residual NO_3-N (mg/100 g soil)	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
T1.	42.15	41.86	48.28	47.36	90.43	89.22	3.12	3.30	3.58	3.68
T2.	38.08	38.12	51.90	50.87	89.98	88.99	5.10	5.80	4.18	4.31
T3.	36.60	35.95	52.13	51.36	88.73	87.31	4.60	4.75	2.47	2.50
T4.	33.72	32.86	3.88	52.76	87.60	85.62	4.80	4.92	2.32	2.50
T5.	47.32	45.82	46.62	46.78	93.94	92.60	5.50	5.62	4.20	4.03
T6.	43.67	42.18	47.36	47.30	91.03	89.48	5.08	5.00	3.50	3.52
LSD at 5%	1.91	1.99	1.85	3.93	1.92	2.41	0.46	0.40	0.39	0.38

T1. Ir. every 15 Ds + N 180 kg; T2. Ir. 15 Ds + N 150kg + VH; T3. Ir. 15 Ds + N 120 kg + VH; T4. Ir. 26 Ds + N 180 kg; T5. Ir. 26 Ds + N 150 kg + VH, and T6. Ir. 26 Ds + N 120 kg + VH.
Ir.: Irrigation; Ds: Days intervals; VH: veterra hydrogel; All N-rates per Feddan=4200 m^2; S1: 1st season; 2nd season.

Table 7: Storage behavior at 120 DAS as affected by irrigation intervals, nitrogen rates and veterra hydrogel in 2007/08 and 2008/09 seasons.

Characters / Treatments	Sprouting (%)		Weight loss (%)		Decay (%)		N (%) at 130 DAS*	
	S1	S2	S1	S2	S1	S2	S1	S2
T1.	35.20	40.70	7.20	7.76	10.12	11.30	1.74	1.64
T2.	26.70	27.13	5.12	5.22	6.65	7.36	1.55	1.51
T3.	23.11	21.00	6.30	6.15	6.37	7.26	1.51	1.47
T4.	36.18	38.35	7.22	7.33	8.03	9.11	1.68	1.60
T5.	18.60	18.10	4.18	4.00	4.11	3.80	1.43	1.40
T6.	15.80	16.18	4.20	4.32	5.20	5.60	1.21	1.18
LSD at 5%	5.07	0.94	0.25	1.99	1.99	2.74	0.03	0.05

T1. Ir. every 15 Ds + N 180 kg; T2. Ir. 15 Ds + N 150kg + VH; T3. Ir. 15 Ds + N 120 kg + VH; T4. Ir. 26 Ds + N 180 kg; T5. Ir. 26 Ds + N 150 kg + VH, and T6. Ir. 26 Ds + N 120 kg + VH
Ir.: Irrigation; Ds: Days intervals; VH: veterra hydrogel; All N-rates per Feddan=4200 m^2; S1: 1st season; 2nd season. DAS: days after storage

.

Fig 1: Furrow irrigation management

Fig 2: Potato plants irrigated every 15 days intervals without application VH

Fig 3: Potato plants irrigated every 26 days intervals with application VH

Fig 4: Potato yield of treatments irrigated every 26 days with application VH

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تحسين كفاءة النتروجين المستفادة بواسطة نباتات البطاطس
ب. تأثيرفترات الري ومعدل النتروجين ومركب فيترا هيدروجيل علي النمو والمحصول والجودة والحالة الغذائية والقدرة التخزينية

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تمثل الأدارة المزرعية المثلي لمياه الري، والسماد النيتروجيني تحديا رئيسيا لتحسين كفاءة استخدام المياه والأستفادة من عنصر النيتروجين، وزيادة غلة محاصيل الخضر في مصر، نظرا لمحدودية مياه الري وزياد التوسع في استصلاح الأراضي. وتعتبر البطاطس من محاصيل الخضر التي ينخفض محصولها وتقل جودتها عند التعرض للإجهاد المائي أو نقص التسميد الأزوتي، لذلك نفذت تجربتان حقليتان في تربة طميية طينية بالمزرعة البحثية بالبرامون- المنصورة- محافظة الدقهلية خلال الموسمين الشتويين ٢٠٠٨/٢٠٠٧و ٢٠٠٩/٢٠٠٨ لدراسة تأثير فترتين من فترات الري (كل ١٥ و ٢٦يوم، تبدأ بعد أول رية) مع ثلاث معدلات من التسميد الأزوتي (١٢٠، ١٥٠ و ١٨٠ كجم ن للفدان) مع أو بدون أضافة محسنات التربة الصناعية مادة فتيرا هيدروجيل، بوليمرات الهيدروجيل (veterra hydrogel; VH) علي النمو والمحصول والجودة والحالة الغذائية والعلاقات المائية لنباتات البطاطس (صنف كارا). استخدم تصميم القطاعات كاملة العشوائية في ٤ مكررات.

أوضحت النتائج أن أضافة محسنات التربة VH مع الري كل ٢٦ يوم مع التسميد بمعدل ١٥٠ كجم ن/فدان أدي إلي حدوث زيادة معنوية في كل من صفات النمو الخضري، والتي تشمل طول النبات ومعدل النمو النسبي ومعدل التمثيل الصافي، وذلك في الموسم الأول من الدراسة، بينما لم تكن هناك أي فروق معنوية بين المعاملات بالنسبة لهذه الصفات في الموسم الثاني من الدراسة، وكذلك في صفات المحصول الكلي والمحصول القابل للتسويق وتدريج الدرنات ١ & ٢ في موسمي الدراسة.

وكذلك أدي استخدام هذه المعاملة إلي الحصول علي أعلي القيم بالنسبة للمحتوي الغذائي للدرنات من العناصر الكبري (ن، فو، بو) والعناصر الصغري (حديد، زنك، منجنيز)، وكذلك صفات الجودة (المادة الجافة، الكثافة النوعية، نسبة النشا) والسلوك التخزيني والعلاقات المائية (الماء الحر، الماء المرتبط) في الأنسجة النباتية، وكذلك المحتوي من الكلوروفيل الكلي.

بينما سجلت أعلي القيم بالنسبة لتراكم النترات والنيتريت في الدرنات في معاملات إضافة ١٨٠ كجم /فدان سواء مع الري كل ١٥ أو ٢٦ يوم وبدون أضافة محسنات التربة.. أما بالنسبة لقيم النتروجين المتبقي في التربة سواء في الصورة الأمونيومية أو النتراتية فقد أعطت المعاملات السمادية بأضافة ١٥٠ كجم ن/فدان مع الري بفاصل ١٥ أو ٢٦ يوما مع أضافة محسنات التربة أعلي القيم في هذا الأطار.

بصفة عامة.. توصي هذه الدراسة باستخدام محسنات التربة (فيترا هيدروجيل) في الأراضي الطميية الطينية مع الري كل ٢٦ يوم (٤ مرات خلال موسم النمو مقارنة بالمعدل الشائع الاستخدام في هذه الأراضي وهو ٧ مرات) مع التسميد بمعدل ١٥٠ كجم ن/فدان (مقارنة بالمعدل الموصي به وهو ١٨٠ كجم ن/فدان) وذلك في حقول البطاطس صنف كارا لزيادة كفاءة رطوبة التربة وزيادة كفاءة استخدام النتروجين، مع تحسين الأنتاجية والمحصول القابل للتسويق والقدرة التخزينية، مع التقليل لأدنى حد من الأثر البيئي للتسميد المفرط، وذلك تحت ظروف هذه الدراسة.