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EFFECT OF IRRIGATION WATER AMOUNTS AND NITROGEN RATES, ON CUCUMBER OPTIMUM YIELD AND NET RETURN, UNDER DRIP IRRIGATION AT NORTHWEST DELTA, EGYPT

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ABSTRACT

Two field experiments were carried out at Wady Elnatron, El-Behera Governorate, during 2007 and 2008 seasons, to study the effect of irrigation water amounts and nitrogen rates, on cucumber yield and the net return from these treatments, under drip irrigation system. Split-plot design was used with four replicates. The main plots were assigned by four irrigation water amounts (100%, 90%, 80% and 70%) of evapotranspiration (ETc). The sub-plots were randomly assigned by four nitrogen rates (0 addition (N_0), 50 (N_1), 100 (N_2) and 150 (N_3) kg N fed.$^{-1}$.) as ammonium nitrate. The other recommended agriculture practices were done.

Four polynomial quadratic equations were established to show the following results:

1. The maximum and optimum N rates (X_m and X_{opt}) were increased as irrigation water amounts decreased in the two seasons.
2. The maximum and optimum cucumber yields (Y_m and Y_{opt}) were decreased as irrigation water amounts decreased in the two seasons.
3. The highest maximum yield (23.01 ton fed^{-1}), (1 feddan = 0.42 hectar), the highest total value of yield (27605 L.E. fed^{-1}) and the highest return of N fertilizer (13864 L.E. fed^{-1}) were obtained as irrigation water amount 100% of ETc used in the two seasons.
4. The efficiencies of N rates (eX) were decreased as N rates increased from N_0 to N_1, N_2 and N_3, respectively, with different irrigation water amounts .
5. The efficiency average ($e\overline{X}$), the relative efficiency (EX) and the efficiency of nitrogen fertilizer at optimum rate (eX_{opt}), were decreased as irrigation water amounts decreased.
6. The soil nitrogen content during plant growth (X_s) was increased as irrigation water amounts decreased.
7. The contribution of soil N was decreased as irrigation water amounts decreased in the two seasons.
8. The contribution of N fertilizer was increased as N levels increased in the two seasons.

Keywords: Cucumber, drip irrigation, N fertilization, irrigation water amounts, maximum and optimum N rates.

INTRODUCTION

Cucumber *(Cucumis sativus* L.) is the fourth most important vegetable crop after tomato, cabbage and onion as favorite crops in Egypt. It is taken not only for fresh eating but also for salad and pickling (sites from El-Atawy, 2010). It is a primary source of vitamins and minerals in human diet.

Cucumber can highly be useful for both high and low blood pressure, due to its high content of potassium (50 - 60 mg/100 g), (Kadans, 1979).

Management of irrigation water is one of the most important factors which influence the yield and quality of crops. It is very useful for high yield and saving both of irrigation water and fertilizer (Knany *et al*., 2005). Bao-Zhong *et al*. (2006) reported that amount of irrigation water significantly affected cucumber plant growth and fruit production.

Fertilizer application is one of the quickest and easiest way of increasing yield per unit area. Nitrogen is considered as one of the major nutrients required for growth, development and yield (Singh *et al*., 2003, Watcharasak and Thammasak, 2005 and Jilani *et al*., 2009).

It would be very useful to have adequate information on the probabilities of the various yield outcome that would aid in determine a fertilization program. This would then enable researchers to calculate the economical optimum rate of fertilizer application. The expected yield when this optimum rate is applied, and the obtainable yield at specified rate of fertilizer application can also be predicted (Balba, 1987). Many investigators have used the quantitative approach to evaluate and quantitatively express the response of crops yield to nitrogen fertilizer, Thabet and Balba (1994), El-Shebiny and Badr (1998), Atia (2005), Atia *et al*. (2009).

The objectives of the present study were to assess the influence of nitrogen fertilization under different irrigation water amounts on cucumber yield and achieve both the high and optimum net return from the studied treatments.

MATERIALS AND METHODS

Two field experiments were carried out at Wady Elnatron (30° 25' N latitude and 30° 20' E longitude), El-Behera Governorate, during 2007 and 2008 seasons, to study the effect of irrigation water amounts and nitrogen rates, on cucumber yield and the net return from the studied treatments. The experimental field was fertilized by 10 m^3 of chicken manure and 15 kg P_2O_5 as superphosphate per feddan under cucumber rows throw soil preparation. Surface drip irrigation system used was consisted of normal polyethylene pipes of 16 mm diameter as laterals with line dripper of 4.0 L/h at 50 cm apart. The laterals were located 150 cm apart, one lateral for each plant row. The EC of irrigation water was 1.1 dSm^{-1}. Some physical and chemical properties of the experimental soils were determined according to the methods described by Page *et al*. (1984) and presented in Table 1.

Table (1): Some physical and chemical properties of the experimental soils.

Seasons	Sand %	Silt %	Clay %	Texture	EC dSm^{-1} soil paste	pH 1:2.5	Available nutrients ($mg\ kg^{-1}$)		
							N	P	K
2007	74.4	13.65	11.95	Sandy loam	3.8	7.4	28.0	7.0	377
2008	74.5	13.70	11.80	Sandy loam	3.9	7.6	27.0	6.0	380

Split plot design was used with four replicates. The main plots were assigned by four irrigation water amounts (100%, 90%, 80% and 70%) of evapotranspiration (ETc). The sub-plots were randomly assigned by four nitrogen rates (0 addition (N_0), 50 (N_1), 100 (N_2) and 150(N_3) kg N fed^{-1}) as ammonium nitrate (33.5% N) in ten doses. The first dose was added after 15 days from planting, while the later doses were applied on weekly bases. Cucumber seeds *(cucumis sativus L. var. Prince*) were manually planted in one row in 11 and 18 July in the first and second seasons, respectively. The distance between hills was 50 cm and two plants/hill. All field practices were done as usually recommended for cucumber cultivation. Harvesting was began after 30 days from planting. Central area of 45 m^2 in each plot was kept for determining cucumber yield to eliminate any border effect.

The amount of water applied at each irrigation was measured by flow meter and calculated according to Keller and Karmeli (1974). The crop evapotranspiration (ETc) values of growing months (July, Aug., Sep. and Oct.) were 3.70, 5.57, 5.37 and 3.76 mm day^{-1}. The obtained data were statistically analyzed according to Snedecor and Cochran (1980). Combined analysis conducted for the data of the two growing seasons according to Cochran and Cox (1957).

Quantitative analysis:

The quadratic polynomial equation has been used to describe the cucumber yield response to nitrogen rates, its general form is:

$$Y = B_0 + B_1 X_i \pm B_2 X^2_i$$

Where, the term (Y) is the yield corresponding to nutrient rates X_i, the term B_0 is the intercept and B_1 and B_2 are the linear and quadratic coefficients, respectively. The constraints B_0, B_1 and B_2 were calculated using the least squares method.

The maximum addition of fertilizer (X_m), the maximum yield (Y_m), the optimum rate of fertilizer (X_{opt}), the optimum yield (Y_{opt}), the efficiencies of N rates (N_0, N_1, N_2 and N_3) (eX), the average of efficiency ($e\overline{X}$) of the fertilizer application rate (X) along the range from X= 0 to X= i, the efficiency of fertilizer at optimum rate (eX_{opt}), the relative efficiency (EX), the efficiency of soil nitrogen (eX_s), the soil nitrogen content (X_s) and standard error (SE) can be calculated from the following equations, respectively.

1. $X_m = -\frac{B_1}{2B_2}$ Balba (1961).

2. $Y_m = B_0 - \frac{B_1^2}{4B_2}$ Capurro and Voss (1981).

3. $X_{opt} = \frac{P_r - B_1}{2B_2}$ Balba (1964).

4. $Y_{opt} = B_0 + \frac{Pr^2 - B_1^2}{4B_2}$ Balba (1964).

Where the (Pr) = $\frac{\text{Price of fertilizer unit}}{\text{Price of one ton of crop}}$

5. $eX = B_1 + 2 B_2 X_i$ Thabet and Balba (1994).

6. $e\overline{X} = B_1 + B_2 X_i$ …at X_i = 3 units Thabet and Balba (1994).

7. $eX_{opt} = B_1 + B_2 X_{opt}$ …at X=optimum rate,Hassanein and El-Shebiny (2000).

8. $EX = 0.1\sqrt{B_1^2 - 4B_0B_2}$ Capurro and Voss (1981).

9. $eX_s = \frac{B_0}{X_s}$ Thabet and Balba (1994).

10. $X_s = \frac{-B \pm \sqrt{B_1^2 - 4B_0B_2}}{2B_2}$ at y = 0

11. $SE = \sqrt{\frac{(\text{Observed - Calcualted})^2}{n-2}}$

12. The contribution of soil N = $\frac{X_s}{X_f + X_s}$ x calculated yield.

13. The contribution of fertilizer = $\frac{X_f}{X_f + X_s}$ x calculated yield.

RESULTS AND DISCUSSION

In the present study, cucumber yields were increased successively and significantly with N increments. The polynomial quadratic equations were established to express the cucumber response to N application are presented in Table 2.

Table 2:The polynomial equations expressing yield of cucumber and irrigation water amounts of seasons (2007 and 2008).

Treatments	The polynomial equations	X_s N unit fed-1
100 % of ETc	$Y = 11.451 + 7.839 X - 1.329 X^2$	1.212
90% of ETc	$Y = 10.76 1+ 7.333 X - 1.225 X^2$	1.219
80 % of ETc	$Y = 8.978 + 6.312 X - 1.082 X^2$	1.183
70 % of ETc	$Y = 7.870 + 5.315 X - 0.863 X^2$	1.234

The experimental and calculated cucumber yield values obtained from the polynomial equations 1-4 are presented in Table 2. The calculated yields closely approximate experimental yield as shown from the values of standard error (SE) of estimates and determination coefficient (R^2). The chi square test showed that the calculated yield values from each equations do not significantly differ from the experimental values for each treatment (Table 3).

Table 3: Observed and calculated cucumber yield (ton fed.$^{-1}$) under rates of nitrogen fertilizer and irrigation water amounts of 2007 and 2008 seasons.

Treatments	100 of ETc		90% of ETc		80% of ETc		70% of ETc	
	observed	Calculated	observed	calculated	observed	calculated	observed	calculated
N_0	11.234	11.451	10.717	10.761	9.006	8.978	8.003	7.870
N_1	18.611	17.960	17.001	16.869	14.123	14.208	11.921	12.321
N_2	21.161	21.812	20.396	20.528	17.360	17.275	15.446	15.046
N_3	23.221	23.004	21.780	21.736	18.151	18.179	15.911	16.044

Maximum and optimum N rates:

Values of maximum and optimum N rates (X_m and X_{opt}) for each treatment were calculated and presented in Table 4.

Table 4: The maximum N rate (X_m), optimum N rate (X_{opt}), maximum yield (Y_m), optimum yield (Y_{opt}) and the returns of cucumber yield under irrigation water amounts.

Treatments	X_m unit N fed^{-1}	X_{opt} unit N fed^{-1}	Y_m ton fed^{-1}	Y_{opt} Ton fed^{-1}	Total values of yield LE fed^{-1}	Total values of yield at control L.E fed^{-1}	Return of N fert. L.E fed^{-1}	Fert. cost L.E fed.$^{-1}$	Net return of fert. L.E fed.$^{-1}$	Return L.E./1L.E. fed^{-1}	Fer./ control Ratio.
100%ETc	2.949	2.878	23.010	22.975	27605	13741	13864	647.6	13216	20.41	1.009
90% ETc	2.993	2.916	21.728	21.696	26074	12913	13161	656.1	12505	19.06	1.019
80% ETc	2.917	2.829	18.175	18.140	21810	10774	11036	636.5	10400	16.34	1.024
70% ETc	3.079	2.969	16.043	15.998	19252	9444	9808	668.0	9140	13.68	1.039

Price of cucumber = 1200 L.E. ton^{-1}
Fertilizer price = 225 L.E unit^{-1}
Fertilizer unit = 50 kg

The maximum and optimum N rates (X_m & X_{opt}) are the values of fertilizer required to give the maximum and optimum yields (Y_m & Y_{opt}). The maximum N rates (X_m) increased from 2.949 unit N fed^{-1} to 3.079 unit N fed^{-1} as irrigation water amounts decreased from 100% of ETc to 70% of ETc as the mean of the two seasons. The values of the optimum N rates (X_{opt}) also show the same trend, where it increased from 2.878 unit N fed^{-1} to 2.969 unit N fed^{-1} as irrigation water amounts decreased from 100% of ETc to 70% of ETc as the mean of the two seasons. On the other hand, the values of X_{opt} were less than the values of X_m, whereas the X_{opt} were calculated by differentiating (y) in the polynomial equations from 1- 4 with regard to X (dy/dx) and equating with the ratio (Pr) of the price of fertilizer unit and the price of cucumber unit (ton). The increase of X_m and X_{opt} added may be attributed to one or more of the three reasons. The first reason is the effect role of irrigation water amounts on the decomposition of chicken manure. The second is decreasing translocation of the nitrogen to the plant roots, where the main way of the nitrogen translocation is by mass flow with water distribution. The third is the decrease of fertilizer efficiency where the average efficiencies ($e\overline{X}$) decreased from 3.852 ton unit^{-1} fed^{-1} to 2.726 ton unit^{-1} fed^{-1} as irrigation water amounts decreased from 100% of ETc to 70% of ETc (Table 5). This results are in agreement with those obtained by Simsek *et al*. (2005).

Maximum and optimum yields:

Data presented in Table 4 showed that the Y_m decreased as irrigation water amounts decreased from 100% of ETc to 70% of ETc. The Y_m decreased from 23.004 ton fed^{-1} to 16.053 ton fed^{-1} as the average of the two seasons. The highest Y_m value (23.010 ton fed^{-1}) was obtained when 100% of ETc used. The decrease of Y_m was more than 30% as 70% of ETc used. This difference between 100% of ETc and 70% of ETc values reflect the importance of irrigation water amounts to plant growth and nutrients uptake where increasing irrigation water amounts lead to increase the wet root zone, decrease salts and osmotic effects and increasing fertilizer translocation to the plant roots. These results are encouraged by those reported by Ahmet *et al*. (2006), Bao Zhong *et al*.(2006) and Ayotamuno *et al*. (2007).

As shown in Table 4 the values of Y_{opt} were less than the values of Y_m, where the values of Y_{opt} were obtained by substitution of "X" by corresponding values of X_{opt} in equations 1-4 found in Table 3. Values of Y_{opt} show the same trend of Y_m , where it decreased from 22.975 ton fed^{-1} to 15.998 ton fed $^{-1}$ as ETc decreased from 100% of ETc to 70% of ETc (Table 4).

The returns from applied optimum rates

The returns from applied optimum N rates are found in Table 4. The total values of the yield decreased from 27605 L.E fed.$^{-1}$ to 19252 L.E fed.$^{-1}$ as irrigation water amount (ETc) decreased from 100% of ETc to 70% of ETc. This decrease was more than 30% of the returns from applied optimum rates as 100% of ETc used. Data in Table 4 also, show the returns of N fertilizer and the returns per each Egyptian pound (L.E) spent for each of the applied optimum rate of N fertilizer. The highest value of L.E/1 L.E was 20.41 when 100% of ETc applied and the lowest one was 13.68 as 70% of ETc used. Data presented in Table 4 also, show that fertilizer/control ratio which increased as ETc decreased from 100% of ETc to 70% of ETc. This means that the losses of fertilizer increases as irrigation water amount decreases and increase the osmotic pressure in the root zone, as well as, salts which causes less root growth and less utilization of fertilizer. These results are in agreement with those obtained by El- Hady and Wanas (2006) and El-Atawy (2007).

Efficiencies of nitrogen fertilizer and soil nitrogen:

The efficiencies of N rates (N_0, N_1, N_2 and N_3), the average efficiencies ($e\overline{X}$), the relative efficiency EX, the efficiency of soil nitrogen (eXs) and, the efficiency of optimum N rate (eX_{opt}) are presented in Table 5 .

Table 5: Efficiencies of N rates eX, $e\overline{X}$, EX, eXs and eX_{opt} (ton unit^{-1} fed^{1}) under irrigation water amounts.

Treatments	eX (ton unit^{-1} fed^{-1})				$e\overline{X}$	EX	eXs	eXopt
	N_0	N_1	N_2	N_3	ton unit^{-1} fed^{-1}			
100 % ETc	7.839	5.181	2.523	-0.135	3.852	1.106	9.448	4.014
90 % ETc	7.333	4.883	2.433	-0.017	3.658	1.032	8.828	3.761
80 % ETc	6.312	4.148	1.984	-0.180	3.066	0.887	7.589	3.251
70 % ETc	5.315	3.589	1.863	0.137	2.726	0.744	6.378	2.753

The efficiencies of N rates (eX) decreased as N rates increased from N_0 to N_1, N_2 and N_3, respectively under the different irrigation water amounts. It can be stated that the eX values changed from maximum at the beginning at N_0 then decreased till it reached zero at the maximum yield and turned to negative at further increments. Values of $e\overline{X}$ decreased as irrigation water amounts decreased from 100% of ETc to 90%, 80% and 70% of ETc respectively. The $e\overline{X}$ values decreased from 3.852 ton unit^{-1} fed^{-1} to 3.658, 3.066 and 2.726 ton unit^{-1} fed^{-1} as irrigation water amounts decreased from 100% of ETc to 90%, 80% and 70% of ETc, respectively.

The relative efficiency (EX) decreased from 1.106 ton unit^{-1} fed^{-1} to 1.032, 0.887 and 0.744 ton unit^{-1} fed^{-1} as irrigation water amounts decreased from 100% of ETc to 90%, 80% and 70% of ETc, respectively (Table 5). The soil nitrogen efficiency (eXs) and the efficiency of optimum N rate (eX_{opt}) showed the same trend of EX.

It is clear from above mentioned results that the different efficiencies of fertilizer (Table 5) decreased as irrigation water amounts decreased. These results reflect the effect of irrigation water amount on plant growth, where its increase increased the surface area per unit root length and enhanced root hair branching with an eventual increase in the uptake of nutrients from the soil and vice versa. The results are in agreement with those obtained by Thabet and Balba (1994), Atia (2005) , Atia *et al*. (2007) and Atia *et al*. (2009) who stated that the efficiency of nitrogen fertilizer had decreased with increasing N fertilizer levels.

Contribution of soil and fertilizer N to yield:

In fact, the roots absorb the plant needs of N from two available sources of N, the soil source and the fertilizer source. Accordingly, the contribution of the soil source in yield would be equal to $\frac{X_s}{X_f + X_s}$ x

calculated yield, and the contribution of fertilizer source = $\frac{X_f}{X_f + X_s}$ x calculated yield.
The results obtained by using this method are presented in Table 6.

Table 6:Contribution of soil N and added fertilizer N to cucumber yield at different irrigation water amounts as average of two seasons (2007 and 2008).

Treatments	100% of ETc		90% of ETc		80% of ETc		70% of ETc	
	Soil N ton fed.$^{-1}$	Fert. N ton fed.$^{-1}$	Soil N ton fed.$^{-1}$	Fert. N ton fed.$^{-1}$	Soil N ton fed.$^{-1}$	Fert. N ton fed.$^{-1}$	Soil N ton fed.$^{-1}$	Fert. N ton fed.$^{-1}$
N_0	11.451	0.000	10.761	0.000	8.979	0.000	7.870	0.000
N_1	9.878	8.082	9.278	7.591	7.672	7.536	6.777	5.544
N_2	8.289	13.523	7.801	12.727	6.392	10.883	5.717	9.329
N_4	6.671	16.333	6.303	15.433	5.090	13.089	4.653	11.391

Results showed that the contribution of N fertilizer increased as N rates increased from N_0 to N_1, N_2 and N_3 with the different irrigation water amounts. For example the values of 100% of ETc increased from 0.0 ton fed^{-1} to 8.082, 13.523 and 16.333 ton fed^{-1}, respectively as N rates increased from N_0 to N_1, N_2 and N_3. On contrast, the contribution of soil N decreased as N rates increased from N_0 to N_1, N_2 and N_3, respectively. Other irrigation water amounts 90%,80% and 70% of ETc gave the same trend. Thabet and Balba (1994) obtained similar results, where they stated that the contribution of N fertilizer to the rice grain yields increased with the increase of fertilizer N application under different levels of tillage, and the contribution of soil N to the rice grain yields decreased with the increase in the fertilizer N application under different levels of tillage. The results are in agreement with those obtained by Atia (2005), Atia *et al*. (2007) and Atia *et al*. (2009).

Data presented in Table 7 showed that the contribution fraction of N fertilizer increased as N rates increased, it increased from 0.00 to 0.45, 0.62 and 0.71 as N fertilizer increased from N_0 to N_1, N_2 and N_3 as 100% of ETc used. The other irrigation water amounts (90%, 80% and 70% of ETc) gave the same trend. The contribution fraction of soil N deceased with increasing N rates.

Table 7: Contribution fraction of soil N and added fertilizer to cucumber yield at different irrigation water amount as average of two seasons (2007 and 2008).

Treatments	100% of ETc		90% of ETc		80% of ETc		70% of ETc	
	Soil N ton fed.$^{-1}$	Fert .N ton fed.$^{-1}$	Soil N ton fed.$^{-1}$	Fert. N ton fed.$^{-1}$	Soil N ton fed.$^{-1}$	Fert. N ton fed.$^{-1}$	Soil N ton fed.^{1}	Fert .N ton fed.$^{-1}$
N_0	1.00	0.00	1.00	0.00	1.00	0.00	1.00	0.00
N_1	0.55	0.45	0.55	0.45	0.54	0.46	0.55	0.45
N_2	0.38	0.62	0.38	0.62	0.37	0.63	0.38	0.62
N_3	0.29	0.71	0.29	0.71	0.28	0.72	0.29	0.71

The values of contribution fraction of soil N decreased from 1.0 to 0.55, 0.38 and 0.29 as N rates increased from N_0 to N_1, N_2 and N_3, respectively with 100% of ETc. The same trend was observed as other irrigation water amounts used, where increasing nitrogen fertilizer application led to increase soil available nitrogen from the fertilizer source and causes inhibition of the soil microorganisms and mineralization process and reverse is right.

Conculusion

It could concluded from calculated equation that the optimum and high quality of cucumber yield achieved by the addition of 144 kg N fed^{-1} with 100% of ETc

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تأثير كميات مياه الري ومعدلات التسميد النتروجيني علي محصول الخيار والعائد الاقتصادي تحت الري بالتنقيط بشمال غرب الدلتا، مصر

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أقيمت تجربتان حقليتان خلال موسمي الزراعة ٢٠٠٧ و٢٠٠٨ بمنطقة وادي النطرون بمحافظة البحيرة وذلك بهدف دراسة أثر كميات مياه الري المضافة بالتنقيط ومعدلات التسميد النيتروجيني التي تحقق أعلى عائد اقتصادي وأعلى محصول من نبات الخيار.
كان التصميم المستخدم هو تصميم القطع المنشقة في أربع مكررات وكانت المعاملات تحت الدراسة هي:
أولا: القطع الرئيسية وكانت لمعاملات الري كما يلي:
١- تروي يومياً وبكمية مياه تعادل ١٠٠% من جهد البخر نتح اليومي للمحصول.
٢- تروي يومياً وبكمية مياه تعادل ٩٠ % من جهد البخر نتح اليومي للمحصول.
٣- تروي يومياً وبكمية مياه تعادل ٨٠ % من جهد البخر نتح اليومي للمحصول.
٤- تروي يومياً وبكمية مياه تعادل ٧٠ % من جهد البخر نتح اليومي للمحصول.

ثانيا:كانت القطع المنشقة لأربعة مستويات نيتروجينية هي: صفر ، ٥٠، ١٠٠ و ١٥٠ كجم نيتروجين للفدان،
وتم إضافة ١٠ م^{٣} سماد دواجن + ١٥ كجم سوبر فوسفات للفدان في خطوط الخيار قبل الزراعة.
وقد استخدمت أربع معادلات من معادلات الدرجة الثانية للحصول على النتائج التالية:
١- تناقص المحصول الأعظم كلما تناقصت كميات مياه الري المستخدمة.
٢- كان أعلى محصول أعظم (٢٣.٠١ طن للفدان) مع المعاملة الأولي ١٠٠% من جهد البخر نتح اليومي للمحصول.
٣- كان أعلى عائد اقتصادي ٢٧٦٠٥ جنيه مصري للفدان) وأعلى عائد صافى من السماد (١٣٨٦٤ جنيه مصري للفدان) مع المعاملة الأولي ١٠٠% من جهد البخر نتح اليومي للمحصول.
٤- تناقصت كفاءة السماد المضاف مع تناقص كميات مياه الري المضافة.
٥- ازداد محتوى الأرض من النيتروجين مع تناقص كميات المياه المضافة.
٦- ازدادت مساهمة النتروجين السمادي في المحصول الناتج مع زيادة معدلات السماد المضاف.
٧- تناقصت مساهمة النتروجين الأرضي في المحصول الناتج مع زيادة معدلات السماد المضاف.

قام بتحكيم البحث

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