IRRIGATION MANAGEMENT OF DRIP-IRRIGATED POTATO PLANT GROWN IN SANDY SOIL

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ABSTRACT

This study was carried out to investigate the effects of water regime under drip irrigation system on growth, tubers yield, tuber quality, leaf total chlorophyll, free proline and mineral composition as well as water relations of potato crop.

The study was conducted at Ali Moubarek Village, EL-Boustan (North Tahrir Agricultural Experimental Station, 95 Km south of Alexandria-Egypt) during 2001/2002 growing season of potato crop. The texture of the experimental soil was sandy. Imported potato tuber seeds (*Solanum tuberosum*, L.) of Diamont cultivar were used in the present study. Planting was done on 2^{ed} of October 2001, in wet soil. The potato tuber seeds were planted at 0.25 m apart, in rows of 0.75 m width and 40.0 m length. Irrigation water was applied throughout a drip irrigation network using drippers of 4.0 L/hr capacity. The irrigation water was applied at six frequencies: 60, 70, 80, 90, 100 and 110% of reference evapotranspiration. The results revealed that foliage characteristics (i.e., plant height, shoot fresh weight, shoot dry weight, shoot dry matter and shoot water content) were significantly affected by irrigation regime, in which increasing the amount of Irrigation water increased the vegetative growth. The data also, clearly indicated that increasing irrigation significantly increased leaf characteristics (total chlorophyll, leaf water contents i.e., free water content (FWC), bound water content (BWC), total water content (TWC), and relative water content (RWC)). Leaf proline content substantially increased with increasing water stress (decreasing the amount of irrigation water). Increasing the amount of irrigation water resulted in increasing the leaf nutrients content. Irrigation at 90% of ET_0 resulted in improving the potato tuber physical and chemical characteristics. The maximum tubers yield was attained at 90% of ET_0 treatment (21.359 ton/fed.). In addition, the maximum water use efficiency was attained at the same level of irrigation water (17.249 kg tubers/ m^3 of applied water). The most soil moisture was extracted from the top 40 cm soil layer and was found to increased significantly with increasing the amount of irrigation water. The optimum soil moisture tension for potato crop was between 0.25 and 0.35 bar. The most important outcomes from the present study are clarifying the important role of irrigation regime with drip irrigation system in improving the potato growth and tuber yield. Also, good distribution of moisture overall the root zone depth, that can enhance the plant growth and yield of potato crop. The present study recommends 90% of ET_0 (1238.3 m^3 of applied water/fed) to achieve highest potato yield and tuber quality under the same present conditions.

<u>Key words:</u> potato crop, reference evapotranspiration, water-use efficiency, soil moisture extraction pattern, soil moisture tension, water stress.

INTRODUCTION

Water is the most important factor in agriculture, especially in areas of limited water resources such as arid regions. Water deficit can cause serious losses in most crops and has been shown to affect many plant physiological processes, for example, stomatal opening (Henson *et al.*, 1989), plant water use (Bradford and Hsiao, 1982), plant water potential (McCutchan and shackel, 1992), CO_2 assimilation (Robinson *et al.*, 1988), plant growth (Acevedo *et al.*, 1971 and Abdel-Nasser and EL-Shazly,2000), plant productivity (Bradford and Hsiao, 1982) and sugar accumulation, (Handa *et al.*, 1983). On the other hand, water logging can reduce photosynthesis (Childers and White, 1950), transpiration and stomatal conductance (Andersen *et al.*, 1984), shoot and root growth (Rom and Brown, 1979) and fruit yield (Olien, 1987 and Abdel-Nasser and EL-Shazly,2000). Thus, improving management of irrigation water may lead to substantial water saving and improvement of plant growth and productivity. One of the best approaches to achieve good water management program is estimating the response of crop to different irrigation regimes.

At the new reclaimed area in Egypt such as sandy soil, there is a critical balance between water requirements and water consumption, thus, water saving is becoming a decisive factor for agricultural expansion. So, irrigation should be manipulated to maximize plant production per unit of applied water. In such areas, demands for irrigation scheduling and determining the crop water requirements impose the need to study and measure water status in the continuous soil-plant-atmosphere system. Maximizing plant production depends on timely available water, also water conservation practice, which enhance this availability to be useful.

Many irrigation experiments have shown that potato plant is relatively sensitive to moisture stress (Epstein and Grant, 1973; Phene and Sanders, 1976; Shalhevet et al., 1983; Hang and Miller, 1986; Marutani and Cruz, 1989; Shock et al., 1998; Opena and Porter, 1999; Porter et al., 1999 and Fabeiro et al., 2001). Because it has a sparse root system and approximately 85% of the root length is concentrated in the upper 0.3 m soil layer (Opena and Porter, 1999), water stress causes reduction of yield by reducing growth of crop canopy and biomass.

Scheduling water application is very critical to make the most efficient use of drip irrigation system, as excessive irrigation reduces yield, while inadequate irrigation causes water stress and reduces production. On the other hand, the intensity of the operation requires that the water supply be kept at the optimum level to maximum returns to the farmer. High-frequency water management by drip irrigation minimizes soil as a storage reservoir for water, provides at least daily requirements of water to a portion of the root zone of each plant, and maintains a high soil matric potential in the rhizosphere to reduce plant water stress (Phene and Sanders, 1976).

However, the production of a high quality potato crop requires the maintenance of relatively high soil moisture levels throughout the tuber growth period. Extended periods of drought can reduce total yield by reducing leaf area and photosynthetic rate. Short period of water stress can substantially increase the incidence of secondary growth, misshaped tubers, growth cracks and sugar end (Stark and Dwelle, 1989).

Therefore, the present investigation was carried out to study the effect of water stress under drip irrigation system on growth, yield, fruit quality, leaf total chlorophyll, free proline and mineral composition as well as water- use efficiency of potato plant.

MATERIALS AND METHODS

The present study was conducted at Ali Moubarek Village, EL-Boustan (North Tahrir Agricultural Experimental Station, 95 Km south of

Alexandria - Egypt) during 2001/2002 growing season of potato plant. The texture of the experimental soil was sandy. Some of its physical and chemical properties were determined before cultivation according to Carter (1993). The main physical and chemical characteristics of the soil are presented in Table (1).

Table (1). The main physical and chemical characteristics of the experimental soil for growing potato plant during 2001/2002 growing season

Parameters	Soil depth, cm	
	0-30	30-60
Particle-size distribution		
Sand%	89.2	87.3
Silt%	7.7	8.5
Clay%	3.1	4.2
Textural class	Sandy	Sandy
Saturation water content, cm^3/cm^3	0.382	0.391
Field capacity cm^3	0.211	0.215
Permanent wilting point, cm^3/cm^3	0.055	0.054
Available water, cm^3/cm^3	0.156	0.161
Bulk density mg/m^3	1.638	1.649
Saturated hydraulic Conductivity, cm/day	234.1	227.3
Organic matter, %	0.45	0.41
Calcium carbonates, %	4.1	3.2
pH (1 : 1 soil : water suspension)	7.6	7.8
EC(1: 1 soil: water extract), dS/m	1.25	1.10
Soluble Cations, Cmole(+)/Kg soil		
Ca2+	3.85	3.41
Mg^{2+}	2.10	1.92
Na^{+}	5.75	5.25
K^{+}	0.70	0.42
Soluble Anions, Cmole(-)/Kg soil		
$CO^{=}_3$	-	-
HCO^{-}_3	1.92	1.73
Cl^{-}	4.00	3.50
$SO_4^{=}$	6.42	5.63
Available nutrients, mg/Kg soil		
N	32.1	28.1
P	5.7	6.1
K	65.3	58.9
Fe	3.2	2.9
Mn	1.1	2.2
Cu	0.15	0.18
Zn	0.55	0.61
B	0.21	0.25

Imported potato tuber seeds (*Solanum tuberosum*, L.) of Diamont cultivar were used in the present study. Planting was carried out on 2[ed] of October 2001, in wet soil. The potato seeds were planted at 0.25 m apart in the row, in 0.75 m width and 40.0 m length rows.

Fertilization:

Fertilization was carried out using nutrient solution containing all essential nutrients for potato. The nutrients were supplied with irrigation water (fertigation system). The concentrations of all essential elements in irrigation water are presented in Table (2). The fertigation was applied during the growing period two times weekly.

Table(2).Sources and concentrations of nutrients used for preparing the nutrient solutions used for potato fertigation

Element	**Concentration (mg/L)**	**Sources**
NO_3-N	120	Calcium Nitrates
NH_4-N	30	Ammonium Sulphate
P	70	Calcium super phosphates
K	280	Potassium Sulphate
Ca	140	Calcium Nitrates
Mg	24	Magnesium Sulphate
Fe	5.00	Fe –EDTA
Mn	0.60	Mn –EDTA
Cu	0.15	Cu –EDTA
Zn	0.25	Zn-EDTA
Mo	0.05	Ammonium Molybdate
B	0.50	Boric Acid
pH	6.4	

Irrigation regimes:

Irrigation water was supplied throughout a drip irrigation network (Karmeli and Keller, 1975) using drippers of 4.0 L/hr capacity. The irrigation regimes were:

1. Irrigation at 60% of reference evapotranspiration.
2. Irrigation at 70% of reference evapotranspiration.
3. Irrigation at 80% of reference evapotranspiration.
4. Irrigation at 90% of reference evapotranspiration.
5. Irrigation at 100% of reference evapotranspiration.
6. Irrigation at 110% of reference evapotranspiration.

The irrigation requirement was computed according to the following equation:

$$ET_{crop} = \frac{ET_{drip}}{E_a(1-LR)}$$

where:

ET_{crop} is the crop evapotranspiration, mm/day

ET_{drip} is the water consumptive use under drip irrigation system, mm/day

E_a is the efficiency of irrigation system (assumed as 90 % for drip irrigation system).

LR is the Leaching Requirements required for salt leaching (assumed as 15 %) .

and

$$ET_{drip} = K_r * K_c * ET_p$$

K_r is the reduction factor that reflects the percent of soil covering by plant foliage. K_r can be calculated by the equation described in (Karmeli and Keller, 1975):

$$K_r = GC + 0.5(1 - GC)$$

Where

GC is the ground cover fraction (the plant canopy area divided by soil area occupied by one plant). We can assumed that GC = 0.60.

K_c is the crop coefficient ranging from 0.40 to 1.15 for potato crop (Allen *et al.,*1998).

ET_0 is the reference evapotranspiration calculated with FAO Penman-Monteith equation (Allen *et al*., 1998) expressed as :

$$ET_0 = \frac{0.408\Delta(R_n - G) + \gamma \frac{900}{T + 273} U_2 (e_s - e_a)}{\Delta + \gamma(1 + 0.34U_2)}$$

where:

ET0	Potential evapotranspiration, mm day^{-1}
Rn	Net radiation at the crop surface, MJ m-2 day^{-1},
G	Soil heat flux density, MJ m-2 day^{-1}, Generally very small and assumed to be zero).
T	Mean daily air temperature at 2.0 m height, °C,
U2	Wind speed at 2 m height, m s^{-1} ,
e_s	Saturation vapor pressure at 1.5 to 2.5-m height, kPa,
e_a	Actual vapor pressure at 1.5 to 2.5-m height, kPa,
e_s- e_a	Saturation vapor pressure deficit, Kpa,
Δ	Slope of vapor pressure curve, kPa°C^{-1},
γ	Psychrometric constant, kPa°C^{-1}

The climatic data were collected from the Tahrir Meteorology Station near by the experiment location.

Soil moisture tension was monitored for each treatment at 30 cm depth during the growing season.

The irrigation treatments were started at 16 October 2001 and lasted up to February 9, 2002, ten days before harvesting (19th of February, 2002). The treatments were arranged in randomized complete block design with four replications (the replication is represented by one row, 0.75 m width and 40.0 m length with area of 30.0 m^2).

After 80 days from planting, plant samples were collected from each treatment (10 plants of each replication) to determine the vegetative measurements i.e., plant height and foliage fresh and dry weights. Also, foliage dry matter was calculated.

Leaf samples were collected from each treatment (10 plants for each replication). Each leaf sample was divided into two portions. In the first portion, leaves were washed with tap water, distilled water, air-dried then oven dried at 65C؛ to a constant weight. The dried samples were ground and then digested with concentrated sulfuric-acid + 30% hydrogen peroxide according to the method of Wolf (1982). Total N was determined by micro-Kjeldahl method (Jackson, 1973). Total phosphorus was determined according to the method of Murphy and Riley (1962). Total potassium was determined by a Flame Photometer (Jackson, 1973). In the other portion of each leaf sample (fresh leaf material), total chlorophyll content was determined according to the method of Moran and Porath (1980). Total water content (TWC) and relative water content (RWC) were determined by the method of Weatherly (1950 and 1951). Free water content (FWC) and bound water content (BWC) were determined according to Abdel-Rasoul *et al.* (1987). Leaf free proline content was determined as described by Bates *et al.* (1973).

At harvesting time, tubers yield and tuber characteristics were determined as average of 10 random plants i.e., No. of tubers per plant, tubers yield per plant, average tuber weight and no. of tuber available for export. Physical and chemical characteristics of potato tubers were determined, i.e., tuber dry matter content, ash content, tuber length, tuber diameter and specific gravity (by dividing the tuber weight by its volume). Grading index was calculated by grading the tubers yield of 10 hills into 3 grads according to the tuber diameter; I (<30 mm); II (30-60 mm) and III (> 60 mm) as reported by EL-Gamal (1980):

Grading index= س {the weight or number of the first grad (I) x 1
+ the weight or number of the second grad (II) x 2
+ the weight or number of the third grad (III) x 3}

Starch content (%) was determined using the method described in A.O.A.C.(1980) in the tuber dry matter. Reducing and non-reducing sugar contents (%) were determined using the method of Dubois *et al*.(1956) on fresh weight basis. Protein content (%) was determined in dry matter basis using the method of Richards (1972) with suitable constant (N X 6.25). Tuber nutrients content was determined by digesting the dry matter with H_2SO_4 +

30% H_2O_2 digest (Wolf, 1982). The final solution was employed for the determination of N, P and K contents as mentioned before.

The collected data were subjected to analysis of variance according to Steel and Torrie (1982). Correlation and regression were carried out according to Draper and Smith (1982) using statistical package of **Microsoft EXCEL** software.

RESULTS AND DISCUSSION

1. Foliage characteristics:

Foliage characteristics (i.e., plant height, shoot fresh weight, shoot dry weight, shoot dry matter % and shoot water content) as affected by irrigation regime are presented in Table (3).

Increasing soil water at irrigation resulted in significant increases in vegetative growth. The highest values were attained at the high level of irrigation (110% of ET_0).

The reduction of vegetative growth as a result of decreasing the volume of irrigation water (60% of ET0) may be due to the major effect of water stress in decreasing the water uptake by root system as a result of decreasing root function (Rowe and Bearsell,1973). The present results are in accordance with the previous results of Abdel-Nasser (1991) and Abdel-Nasser and EL-Shazly(2000).

Table(3). Foliage characteristics of potato crop as affected by irrigation regime

Irrigation regime	Plant height (cm)	Shoot fresh weight (g/plant)	Root fresh weight (g/plant)	Shoot dry weight (g/plant)	Shoot dry matter (%)	Shoot water content (%)
0.6 ET_0	28.8	231.42	28.41	25.32	10.94	89.06
0.7 ET_0	29.7	236.33	29.82	26.88	11.37	88.63
0.8ET_0	31.3	241.25	30.71	28.48	11.81	88.19
0.9 ET_0	34.7	248.51	32.13	29.85	12.01	87.99
1.0 ET_0	37.2	256.44	33.45	32.12	12.53	87.47
1.1 ET_0	38.5	264.26	34.72	34.01	12.87	87.13
L.S.D. (0.05)	1.72	2.83	2.26	2.69	1.22	1.22

2. Leaf characteristics:

Total chlorophyll content of potato leaves as affected by irrigation regimes is presented in Table (4). The data clearly indicate that increasing amount of irrigation water significantly increase the total leaf content of chlorophyll. Such increase may be due to improve the plant growth as a result of more water and nutrients uptakes, such as N, K, Mg and Fe. Such elements have close association in chlorophyll biosynthesis (Hall and Rao, 1996). Also, it may be attributed for increasing photosynthesis rate as a result of more absorption of available nutrients, which cause an increase in growth and photosynthesis efficiency.

This result is true because of by increasing water stress, the plant has less ability to absorb water. Thus, the nutrients uptake decreased. Also, such reduction in chlorophyll content may be attributed to the role of water as a substrate for all vital processes in plant tissue especially in chlorophyll formation (Abdel-Nasser and El-Shazly, 2000 and Abdel-Nasser and Hussein, 2001).

Data presented in Table (4) indicate significant effects of irrigation regime in increasing the leaf water contents i.e., free water content (FWC), bound water content (BWC), total water content (TWC), and relative water content (RWC). This result may be attributed to more water absorption by potato plants as a result of more vegetative growth and more nutrients uptake. The less leaf water contents under water stress conditions (less amount of irrigation water at 60% of ET_0) can be explained on the fact that under high soil moisture tension, the moisture becomes less available to plant absorption, thus the leaf water content decreased (Werner, 1954, Slatyer, 1969, Epstein and Grant, 1973 and Abd-Allah, 1996). The same trend was noticed with specific leaf area, in which it increased with increasing amount of irrigation water. This result my be attributed to the role of water in increasing the plant growth.

It is evident from the data in Table (4) that leaf proline content substantially increased with increasing water stress (decreasing irrigation I.e. 60% of ET_0). Moreover, there were significant differences between irrigation treatments. Such results may be due to the role of proline in regulating water transport in plant tissues (Aloni and Rosenshtein, 1984 and Srinivasa Rao, 1986). Similar results were obtained by Good and Zaplachinski (1994), they found a marked increase in proline content of drought-stressed leaves. Also, the data of Abdel-Nasser and El-Shazly (2000) confirmed the present result. The results of many studies suggest that the relative accumulation of proline in response to water stress is likely to vary between plant species (Good and Zaplachinski, 1994, and Abdel-Nasser and El-Shazly, 2000). They found a marked increase in proline content for water-stressed leaves.

The data in Table (4) generally indicate that increasing amount of irrigation water increased leaf nutrients content (N, P and K,). The marked decrease of leaf nutrients content was found at higher water stress (60% of ET_0 treatment). Such a reduction may be explained on the basis that under water stress, the soil moisture became unavailable to root uptake, thereby, decreased nutrient uptake by plants (Mengel and Kirkby, 1987), in addition to general weakness of plant conditions as a result of water stress that reflected on plant absorption and translocation (Abdel-Nasser and EL-Shazly, 2000).

3. Tuber physical characteristics:

Data presented in Table (5) show the effects of irrigation regimes on potato tuber physical characteristics. Tuber physical characteristics, such as No. of tubers per plant, average tuber weight, tubers available to export, grading index by number and by weight, tuber length, tuber diameter, tuber shape index and tuber specific gravity, significantly affected by irrigation regimes (Table, 5). The present results are in accordance with the results of Abd-Allah (1996). The maximum values were attained with 100% of ET0 treatments and a reduction was noticed with higher irrigation water (110% of ET_0). The reduction in tuber physical characteristic at highest water application may be due to the role of excessive water in decreasing some metabolic processes of root system.

4. Tuber chemical characteristics:

Data presented in Table (6) show the effects of irrigation regimes on potato tuber chemical characteristics. Tuber chemical characteristics such as dry matter content, ash content, starch content, reducing sugars and protein content significantly increased by increasing the amout of irrigation watyer. In addition, highest irrigation treatment (100 and 110% of ET_0) decreased the chemical characteristic of tubers. The same results were reported by Abd-Allah(1996).

Table(4). Leaf total chlorophyll, water contents and nutrients content of potato crop as affected by irrigation regime

Irrigation regime	Leaf Total chlorophyll (mg/100g)	Free Water content (%)	Bound water content (%)	Total water content (%)	Relative water content (%)	Specific leaf weight (g/m^2)	Proline content (mg/g)	Leaf nutrients content, %		
								N	P	K
0.6 ET_0	262	18.72	59.82	78.54	76.76	28.21	6.99	2.12	0.38	2.75
0.7 ET_0	278	19.31	60.81	80.12	78.75	32.31	6.75	2.19	0.41	2.82
0.8ET_0	282	20.82	61.00	81.82	79.21	34.68	5.80	2.25	0.49	2.94
0.9 ET_0	298	21.43	62.34	83.77	80.87	36.54	4.87	2.32	0.55	3.07
1.0 ET_0	308	21.98	62.84	84.82	81.21	37.42	3.77	2.38	0.60	3.17
1.1 ET_0	312	22.84	62.88	85.72	82.76	38.78	3.75	2.42	0.63	3.21
L.S.D.(0.05)	11.72	1.31	1.36	1.64	1.12	1.32	0.76	0.09	0.12	0.15

Table(5).Tuber physical characteristics of potato crop as affected by irrigation regime

Irrigation regime	No.of tubers/plant	Average Tuber weight (g)	tuber available to export (%)	Grading index by number	Grading index by weight	Tuber length (cm)	Tuber diameter (cm)	Tuber shape index	Specific gravity
0.6 ET_0	4.80	130.01	81.42	15.40	1982.42	8.00	5.00	1.600	1.0684
0.7 ET_0	5.10	133.41	84.31	15.70	2054.18	8.20	5.20	1.577	1.0712
0.8ET_0	5.70	136.22	86.21	16.20	2132.41	8.60	5.40	1.593	1.0784
0.9 ET_0	6.70	142.32	87.45	16.90	2316.72	8.90	5.60	1.589	1.0882
1.0 ET_0	6.50	140.21	86.82	16.70	2241.75	8.80	5.50	1.600	1.0811
1.1 ET_0	6.30	138.85	84.32	16.50	2189.42	8.60	5.30	1.623	1.0782
L.S.D.(0.05)	0.28	3.54	1.51	0.72	121.8	0.38	0.42	0.071	0.0119

Table(6). Tuber chemical composition of potato crop as affected by irrigation regime

Irrigation regime	Dry matter content (%)	Ash content (%)	Starch content (%)	Reducing sugars content (%)	Protein content (%)	Tuber nutrients content, %		
						N	P	K
0.6 ET_0	18.82	5.11	14.51	0.382	7.13	1.14	0.17	2.15
0.7 ET_0	19.05	5.24	14.61	0.375	7.19	1.15	0.19	2.21
0.8ET_0	19.41	5.30	14.78	0.362	7.25	1.16	0.21	2.24
0.9 ET_0	20.13	5.41	15.22	0.352	7.38	1.18	0.22	2.26
1.0 ET_0	20.00	5.28	15.00	0.341	7.31	1.17	0.23	2.26
1.1 ET_0	19.83	5.20	14.85	0.332	7.19	1.18	0.22	2.27
L.S.D.(0.05)	0.62	0.18	0.40	0.022	0.22	0.03	0.03	0.10

The effects of irrigation regimes on tuber nutrients content are also shown in Table (6). Tuber nutrients content significantly increased with increasing the amount of irrigation water.

5. Tubers yield, Water-Use Efficiency and production function:

The calculated water use according to the irrigation regimes were 2066, 4132 and 8264 m^3/fed/season corresponding to 15, 30 and 60 minutes per day.

Table (7) shows the effect of irrigation regimes on potato tubers yield and water-use efficiency. Increasing amounts of Irrigation significantly improved tubers yield. The highest values of tubers yield were attained with 90% of ET_0 (21.359 ton /fed.).

The water-use efficiency (WUE) was calculated according to the following equation:

$$WUE\left(Kg\ tubers/m^3\ applied\ water\right)=\frac{Tubers\ yield\left(Kg/fed.\right)}{Applied\ water\left(m^3/fed./season\right)}$$

Table (7) Potato tubers yield, water use efficiency and soil moisture extraction at soil depths as affected by irrigation regime

Irrigation regime	Tuber Yield (g/plant)	Gross yield (Ton/fed)	Water use (m^3/fed)	WUE (Kg/m^3)	Soil moisture extraction, %		
					0-20 cm	20-40 cm	40-60 cm
0.6 ET_0	624.05	13.074	825.5	15.838	56.32	28.32	15.36
0.7 ET_0	680.39	15.799	963.1	16.405	62.34	25.43	12.23
0.8ET_0	776.45	18.301	1100.7	16.627	66.52	22.58	10.90
0.9 ET_0	953.54	21.359	1238.3	17.249	71.82	20.82	7.36
1.0 ET_0	911.37	20.799	1375.9	15.117	76.22	18.24	5.54
1.1 ET_0	874.76	19.199	1513.4	12.686	78.82	16.48	4.70
L.S.D. (0.05)	53.93	1.363	59.5	1.051	3.71	1.94	5.55

Concerning the water saving concept, the values of WUE as affected by irrigation regimes are presented in Table (7). The results indicate that the best tuber water use efficiency was attained with 90% of ET_0. The WUE was 17.249 Kg tubers/m^3 applied water. The higher and lower amounts of irrigation water tend to decrease the WUE.

In the present study, the production function was done between the total amount of applied irrigation water vs. fresh tuber yield. Through non-linear regression analysis, the obtained mathematical function showed a highly significant determination factor(R^2=0.9559).

$$Y = -3E - 05 * X^2 + 0.0848 * X - 35.667$$

where

Y is the tuber yield, ton/fed.

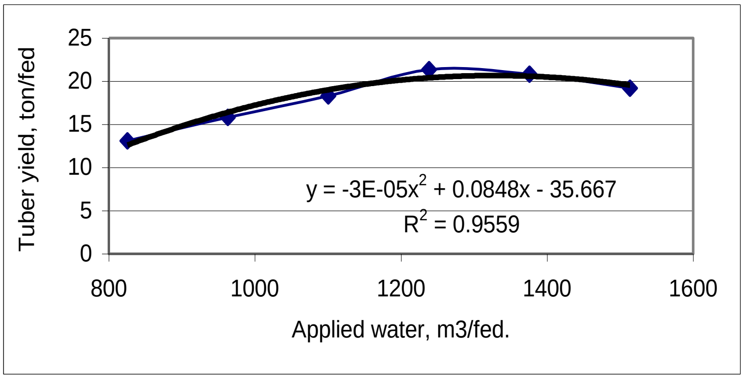
X is the water applied, m^3/fed

Figure(1) shows the relationship between the total amount of applied irrigation water and total fresh tuber yield. The production function showed that tuber yield near the 90% of ET_0 (1325,6 m^3/fed) was close to the theoretical maximum tuber yield(20.56 ton/fed.), then the water use efficiency is 15.51 kg tuber/m^3 of applied irrigation water.

6. Soil moisture extraction pattern and soil moisture tension:

The results illustrated in Table (7) showed that most of the soil moisture was extracted from the top 40 cm soil layer for all treatments, moreover, the soil moisture extraction from the top 40 cm soil layer was increased significantly as the amount of irrigation water increased.

The high percentage of moisture extraction from the top 40 cm soil layer might be due to increase evaporation loss from the surface layer against the atmospheric conditions (Ritchie, 1971 and Hsiao, 1973). The moisture extraction from the deeper layer was due to less root ramification.



Figure(1) Tuber water-production function

The increasing moisture extraction under high irrigation frequency (110% of ET_0) may be due to that water was more available for evaporation and plant uptake, consequently increased the moisture contribution (Gardner, 1960). Under low water application (60% of ET_0 treatment), moisture extraction was increased from the deeper layer. Such results could be interpreted on the basis that, as soil moisture tension increased (less applied water), the root penetration increased to get more moisture from deeper layers (Sen *et al.,*1984). Dargan and Ram (1969) reported that moisture depletion percentage decreased with increasing the depth of root zone. The results of Abdel-Nasser and Hussein (2001) and Abdel-Nasser and EL-Shazly (2000) confirmed the present results.

The soil moisture tension were recorded during the growing season at 30 cm depth. Soil moisture tension of 60% ET_0 treatment was ranged between 0.75 and 0.85 bar, while the soil moisture tension for 100%ET_0 treatment was ranged between 0.10 and 0.20 bar. These values confirmed the water stress at low irrigation regime. The optimum soil moisture tension for potato was between 0.25 and 0.35 bar corresponding to 90% ET_0 treatment.

The most important outcomes from the present study are clarifying the important role of irrigation regime with drip irrigation system in improving the potato growth and tuber yield. Also, good distribution of moisture overall the root zone depth, that can enhance the plant growth and yield of potato crop. The present study recommends the 90% of ET0 (1238.3 m^3 of applied water/fed) to achieve highest potato yield and tuber quality under the present conditions.

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الملخص العربى

إدارة الري لمحصول البطاطس النامى فى ارض رمليه تحت نظام الري بالتنقيط

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أجريت الدراسة الحالية لبحث تأثيرات الرجيم المائي على النمو – محصول الدرنات – جودة الدرنات – محتوى الكلوروفيل والبرولين وكذلك العناصر الغذائية في الأوراق مع دراسة العلاقات المائية لمحصول البطاطس .

أجريت الدراسة الحالية بقرية على مبارك – منطقة البستان – محطة التجارب الزراعية بالتحرير – جمهورية مصر العربية خلال موسم النمو ٢٠٠١/٢٠٠٢ لمحصول البطاطس في تربة ذات قوام رملي . وقد استخدمت في الدراسة تقاوي البطاطس المستوردة صنف ديامونت . تم زراعة ارض التجربة في الموسم الشتوي وقد زرعت تقاوي البطاطس في التربة الرطبة على أبعاد ٢٥., متر في خطوط بعرض ٧٥و.متر وطول ٤٠ متر وتم ريها من خلال شبكة للري بالتنقيط باستخدام نقاطات ذات سعة ٤ لتر / ساعة . أضيفت مياه الري بستة معدلات هي ٦٠، ٧٠، ٨٠، ٩٠، ١٠٠و ١١٠% من البخر نتح المرجعى . . أوضحت النتائج أن خواص المجموع الخضري (طول الدرنات – الوزن الأخضر- الوزن الجاف – محتوى المادة الجافة ومحتوى العرش من الماء) تأثرت معنويا كنتيجة لزيادة كمية مياه الري المستخدمة –تظهر النتائج بوضوح أن الري عند ٩٠ % من البخر نتح المرجعي أدي إلى زيادة معنوية في محتوى الأوراق من الماء مثل الماء الحر – الماء المقيد- الماء النسبي و الماء الكلى . كما زاد محتوى الأوراق من البرولين مع زيادة الإجهاد المائي (نقص كمية مياه الري) . زيادة كمية مياه الري أدت إلى زيادة محتوى الأوراق من العناصر الغذائية . أدى الري عند ٩٠ % من معدل البخر نتح المرجعي إلى تحسن الخواص الفيزيائية والكيمائية للدرنات وقد تحقق أقصى محصول للدرنات مع معاملة الري عند ٩٠ % من معدل البخر نتح المرجعى (٢١,٣٥٩طن / فدان). كما أن أقصى كفاءة الأستعمالية للماء تم تسجيلها عند نفس المعدل من الرى(١٧ كجم درنات/ مترمكعب من الماء المضاف). وقد وجد أن معظم الرطوبة قد تم استنفاذها من الطبقة السطحية ٤٠ سم وقد زاد الاستنفاذ مع زيادة كمية مياه الري . كما أن الشد الرطوبى المناسب لمحصول البطاطس كان في حدود ٢٥ إلى ٣٥ سنتى بار . أن الدراسة الحالية توضح أهمية الرجيم المائي تحت نظام الري بالتنقيط في تحسين نمو البطاطس ومحصول الدرنات كذلك التوزيع الجيد للرطوبة في منطقة انتشار الجذور والتي تؤدى إلي تنشيط نمو النبات وزيادة محصول البطاطس . والدراسة الحالية توصى بمعدل ري يعادل ٩٠% من معدل البخر نتح المرجعي(١٢٣٨ متر مكعب من الماء المضاف/ فدان) تحت نظام الري بالتنقيط في التربة الرملية للوصول إلى أقصى محصول درنات للبطاطس تحت الظروف المشابهة للدراسة الحالية .