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EFFECTS OF SOIL WATER MATRIC POTENTIAL (SWMP) ON GROWTH, YIELD AND QUALITY OF TWO POTATO CULTIVARS.

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ABSTRACT

Two field experiments were carried out during the summer seasons of 2000 and 2001. The objective of this study was to investigate the effects of soil water matric potential (SWMP) treatments (-35, -45, -55, -65 and -75 $J.kg^{-1}$) on vegetative growth, yield and quality of the two potato cultivars Diamont and Draga. The obtained results of the two seasons showed that irrigation at -55 $J.kg^{-1}$ was superior and significantly increased plant height, leaf area, foliage fresh and dry weights, average tuber weight and tuber yield, compared with the other four SWMP treatments. Results showed also that the lowest SWMP (-75 $J.kg^{-1}$) decreased the previous mentioned parameters more than the highest one (-35 $J.kg^{-1}$). Dry matter, starch and specific gravity of tubers increased significantly as the SWMP treatments decreased, while total sugars decreased by increasing SWMP. There were some insignificant differences on nitrogen, phosphorus and potassium contents due to SWMP treatments. The cultivar Diamont showed higher mean values of plant height, leaf area, foliage fresh and dry weights, average tuber weight and total tuber yield, compared with Draga cultivar. Tubers' quality;in terms of dry matter, starch, total sugars and nitrogen contents; appeared significantly better for Diamont than Draga. The greatest response in terms of vegetative growth, yield and quality of potato were obtained when Diamont cultivar was irrigated at -55 $J.kg^{-1}$ SWMP

INTRODUCTION

Potato (*Solanum tuberosum, L.*) is one of the most important vegetable crops in Egypt for local consumption and exportation. It is a heat and drought sensitive crop; which in hot climates, usually, requires large water applications for optimum production (Shalhevet *et al.*, 1983). Any delay in irrigation timing or insufficient water supply results in water stress and yield reduction; whereas, too frequent irrigation or adding excessive amounts of water result in water losses and / or yield reduction (Vanloon, 1981; Abo-Hussein, 1995; Feibert *et al.*, 1998 and Hodges, 1999). Thus, an adequate water supply is required for high yield and quality of potato. Measurement of soil water content is perhaps the most obvious method for scheduling irrigation management. The measurement of soil water matric potential is probably a better indication of plants needs for irrigation, since it estimates the differences in matric potential between the soil and the plants that must be overcomed by plants to take up water. Furthermore, the relationship between crop growth and soil water matric potential in the soil is independent of soil texture (Doorenbos and Pruitt, 1975). Most researches on irrigation management for potato production delt with soil water content (Miller and Martin, 1983; Silva *et al.* 1991; Stark *et al.*, 1993; Feibert *et al.*, 1998; and Roth and Albrecht, 1999). However, few studies examined the soil water matric potential (SWMP) to define potato water requirements for a maximum production (Ghoneim *et al.*, 1974; Holder and Cary, 1984; Lynch and Tai, 1989; Bedawy and Porter,1998 and Shae et al.,1999).

Differences in irrigation treatments among potato cultivars were studied by Lynch and Tai (1989), Levy (1992), Porter and Bedaiwy(1998), Steyn et al.,(1998) and Werner *et al.*, (1998). In newly reclaimed sandy soils in Egypt, the growers use the modern irrigation systems (trickle, mini-sprinklers and sprinkler), whereas, in Delta and Nile valley they, still, use surface irrigation. In an attempt to improve the surface irrigation, tensiometers were used to measure the soil matric potential to define the proper timing of irrigation. The method is simple to operate since it requires only a periodic reading and recording of data.. The objectives of this work were to determine the optimum soil water matric potential and to study its effects on growth, yield and quality of two potato cultivars.

MATERIALS AND METHODS

Two field experiments were carried out during the summer seasons of 2000 and 2001 at Shobrakheet region, Behera governorate. Each experiment included 10 treatments; consisting of the combinations among five irrigation treatments and two potato cultivars. The irrigation treatments; i.e. soil water matric potential (SWMP); were -35, -45, -55, -65 and -75 J kg^{-1} . It is known that soil at a high SWMP contains more water than a soil at a low SWMP. The two cultivars were Diamont and Draga. Seed potato pieces of the two cultivars were planted in ridges, 70 cm wide and 5 m long and spaced at 25 cm apart on January 25 and 30 in 2000 and 2001, respectively. Each treatment consisted of 4 rows. The experimental layout was a split-plots in a randomized complete blocks design with three replications. The five irrigation treatments were randomly distributed in the main plots; whereas, the two cultivars were randomized in the sub- plots. All experimental units received one irrigation (28 days after planting), and then tensiometers were properly inserted into the soil of each treatment at equal depths (20 cm) and in different spots. Plants were thus irrigated at different time-intervals according to the readings of soil water matric potential of the tensiometers, using a surface irrigation system. When the tensiometer's reading reached the SWMP value of a particular treatment, irrigation water was applied till the soil reached its saturation capacity. Guard rows were left between each two adjacent experimental units. All treatments received 450 kg calcium superphosphte (15.5% P_2O_5), 500 kg ammonium sulphate (20.5 % N) and 150kg potassium sulphate (48 % K_2O) fed^{-1}. Superphosphate was applied pre-sowing date; whereas ammonium sulphate and potassium sulphate were added in two equal portions, i.e. at 6 and 9 weeks after planting. All other cultural practices were adopted whenever they were necessary and as commonly recommended in the commercial production of potatoes.

The following data were recorded:

1- Vegetative growth: Ten randomly selected plants were chosen from the first two rows of each treatment; 90 days after planting, to determine plant height (cm), number of main stems plant^{-1},leaf area(m^2), and foliage fresh and dry weights plant^{-1}.
2- Tuber's yield: At harvest; 120 days after sowing, tubers of the third and fourth rows of each treatment were harvested and weighed. Average tuber's weight, total yield plant^{-1} and total yield fed^{-1}were calculated.
3- Tuber's quality: At harvest; 120 days after planting, tuber's samples were saved, washed, dried at 70° C to a constant weight to determine dry matter content (%) then ground to determine total N content, as described by Chapman and Pratt(1961).Phosphorus content was determined as outlined by Allen (1959) and potassium content was determined by the flame photometer method, according to Pipper (1950).Starch (%) and total sugars (%) were determined according to the methods of the A.O.A.C. (1992). Specific gravity of tubers was determined by weight in air/weight in water method.

Prior to conducting the experiments, soil samples of the upper 25 cm layer were collected, and physically and chemically analyzed according to the published procedures (Black, 1965). The physical and chemical properties of the soil during the two seasons were as follow:

Seasons	Physical properties				Chemical properties				
	Sand	Silt	Clay	Texture	Ec ds m^{-1}	pH	N %	Pppm	K Ppm
2000	22.11	34.08	43.81	Clay loam	2.34	8.06	0.082	21	191
2001	22.43	34.64	42.93	Clay loam	2.21	7.91	0.093	16	208

All obtained data were statistically analyzed using Costat software (1985). Comparisons among the means of the various treatments were performed, using the revised least significant difference procedure at P=0.05 level, as illustrated by EL-Rawy and Khalf-Allah (1980).

RESULTS AND DISCUSSION

I- Vegetative growth:

The effects of soil water matric potential (SWMP) on the vegetative growth characters of potatoes are presented in Table (1). Irrespective of number of main stems plant^{-1}, other vegetative growth characters were significantly affected as a result of SWMP treatments. The results indicated that irrigation at SWMP (-55 J.kg^{-1}) showed higher mean values of plant height, leaf area and foliage fresh and dry weights than those of the other four SWMP levels in both seasons. The results indicated also that the lowest SWMP (-75 J.kg^{-1}) decreased the vegetative growth characters more than the highest SWMP (-35J.kg^{-1}). Water deficit reduced plant growth by reducing photosynthesis through the reduction of leaf area, foliage weight, closure of stomata and decreasing the efficiency of carbon fixation. Furthermore, ions uptake might also be reduced as a result of low movement of minerals in dry soils (Vanloon, 1981 and Krammer, 1983). Similar trends were reported by Ghoneim *et al.*, (1974) Lipe and Wendt (1978), Holder and Cary (1984), Lynch and Tai (1989), Stark (1993), Steyn *et al.*,(1998) and Hodges (1999). Similar results were also noticed by Gabr *et al.*, (2000) on peas.

Table (1): Effect of soil water matric potential (SWMP) on vegetative growth of two potato cultivar during 2000 and 2001 seasons.

Treatments		2000					2001				
SWMP $J.kg^{-1}$	Cultiva	Plant height (cm)	No. of main stems $plant^{-1}$	Leaf area (m^2)	Foliage fresh weight (gm)	Foliage dry weight (gm)	Plant height (cm)	No. of main stems $plant^{-1}$	Leaf area (m^2)	Foliage fresh weight (gm)	Foliage dry weight (gm)
-35		47.16	3.11	0.354	243.00	46.45	39.66	2.85	0.318	224.16	42.31
-45		49.50	2.95	0.367	242.83	47.21	41.66	2.85	0.335	253.00	43.46
-55		52.00	3.11	0.384	260.66	49.83	46.16	2.95	0.354	261.66	48.90
-65		51.66	3.05	0.376	253.83	48.38	42.83	2.85	0.347	251.83	47.66
-75		43.50	3.06	0.349	230.66	43.55	36.83	2.84	0.303	214.83	39.50
L.S.D. at 0.05		1.59	N.S.*	0.010	7.47	0.80	0.63	N.S.	0.008	11.00	1.16
	Diamon	50.80	3.50	0.379	262.33	51.32	42.40	3.22	0.345	249.46	47.19
	Draga	46.73	2.62	0.348	230.06	42.94	40.46	2.52	0.318	225.53	41.54
L.S.D. at 0.05		0.96	N.S.	0.019	6.49	1.05	0.68	N.S.	0.014	4.35	0.97
-35	Diamon	48.33	3.50	0.367	260.00	51.10	40.66	3.2	0.331	237.66	45.93
	Draga	46.00	2.73	0.341	226.00	41.80	38.66	2.5	0.306	210.66	38.70
-45	Diamon	51.66	3.33	0.381	253.33	51.10	42.00	3.2	0.347	240.33	45.73
	Draga	47.33	2.53	0.353	232.33	43.33	41.33	2.5	0.322	229.66	41.20
-55	Diamon	54.33	3.60	0.399	279.33	54.33	46.66	3.3	0.369	272.00	51.79
	Draga	49.66	2.63	0.368	242.00	45.33	45.66	2.6	0.340	251.33	45.83
-65	Diamon	53.66	3.46	0.393	272.00	52.33	44.00	3.2	0.362	268.66	50.66
	Draga	49.66	2.63	0.359	235.66	44.53	41.66	2.5	0.333	235.00	44.66
-75	Diamon	46.00	3.56	0.356	247.00	47.30	38.66	3.1	0.317	228.66	41.66
	Draga	41.00	2.56	0.323	214.33	39.80	35.00	2.5	0.288	201.00	37.33
L.S.D. at 0.05		2.22	N.S.	0.028	14.54	2.23	1.52	N.S.	0.022	16.74	2.17

* N.S.=Not significant.

Data presented in Table (1) indicated that potato cultivars significantly differed in their vegetative growth characters in both seasons. Diamont cultivar showed higher mean values of plant height, leaf area and foliage fresh and dry weights than those of Draga cultivar. However, number of main stems $plant^{-1}$ did not significantly differ. The detected differences on the vegetative growth characters of the two tested cultivars could be related to their genetic features. The obtained results are in agreement with those of Lynch and Tai (1988 and 1989), Miller and Martin (1990), Gabr and Sarg (1998), Steyn et al. (1998), Quintero *et al.* (1998) and Werner *et al.*,(1998).

The effects of the interaction between the different SWMP levels and potato cultivars on plant height, leaf area, and foliage fresh and dry weights were significant in both seasons (Table 2). However, number of main stems $plant^{-1}$ was not significantly affected. The treatment combination of growing Diamont cultivar with irrigation at (-55 $J.kg^{-1}$) recorded the highest mean values of the previous mentioned vegetative growth characters.

Table (2):Effect of soil water matric potential (SWMP) on yield and its components of two potato cultivars during 2000 and 2001 seasons.

Treatments		2000			2001		
SWMP $J.kg^{-1}$	Cultivar	Average Tuber Weight (gm)	Tuber yield $plant^{-1}$	Total Tuber yield (ton fed^{-1}	Average tuber weight(gm)	Tuber yield $plant^{-1}$	Total tuberyield (ton fed^{-1}
-35		60.00	352.22	8.05	55.66	335.96	7.45
-45		67.33	419.03	9.57	62.33	388.03	8.86
-55		74.00	525.51	12.08	67.33	499.99	11.42
-65		73.16	510.56	11.71	76.00	481.64	11.00
-75		56.33	313.86	7.17	51.83	321.80	7.35
L.S.D. at 0.05		1.12	15.14	0.39	1.14	15.62	0.49
	Diamont	69.80	464.36	10.62	63.93	437.83	10.00
	Draga	62.53	384.12	8.81	57.73	373.06	8.43
L.S.D. at 0.05		0.51	8.55	0.26	0.51	6.11	0.30
-35	Diamont	64.00	394.44	9.01	59.33	355.06	8.11
	Draga	56.00	310.12	7.08	52.00	316.85	6.80
-45	Diamont	71.00	463.45	10.59	64.33	419.83	9.59
	Draga	63.66	374.60	8.56	60.33	356.23	8.14
-55	Diamont	78.00	571.39	13.05	71.33	537.56	12.28
	Draga	70.00	479.64	11.11	63.33	462.43	10.56
-65	Diamont	78.00	556.53	12.80	70.66	510.71	11.67
	Draga	68.33	464.60	10.62	63.33	452.22	10.33
-75	Diamont	58.00	363.09	7.68	54.00	366.00	8.36
	Draga	54.66	291.62	6.66	49.66	277.60	6.34
L.S.D. at 0.05		1.15	32.18	0.54	1.42	35.68	0.67

II-Tuber yield:

The effects of SWMP treatments on tubers' yield and its components of the two potato cultivars are presented in Table (2). Data revealed that irrigation at different SWMP levels, significantly, affected total yield and its components of potato. Irrigation at SWMP (-55 $J.kg^{-1}$) showed higher mean values of average tuber's weight, total tubers' yield than those of the other four SWMP levels. Irrigation treatment at (-75 $J.kg^{-1}$) reduced tubers' yield and its components to a much greater extent than did the treatment SWMP (-35 $J.kg^{-1}$). The increase on total tubers' yield with SWMP at (-55 $J.kg^{-1}$) was estimated to be 51.67, 27.55, 3.49 and 61.92% over that of SWMP at -35, -45, -65 and-75 $J.kg^{-1}$, as average of the two seasons, respectively. The favorable effects of SWMP at (-55 $J.kg^{-1}$) could be due to providing the optimum water requirements, which led to a higher yield. The low yield obtained at SWMP at (-35 $J.kg^{-1}$); i.e., excessive irrigation; might be attributed to the resultant aeration stress and to the excessive leaching of plant nutrients from the root zone. However, the low yield recorded at SWMP (-75 $J.kg^{-1}$) i.e.; low water supply, might be due to the decrease in soil water content. The rate of transpiration exceeded the rate of water absorption resulting in a disturbed water balance and closing of the stomata to prevent continued water losses. Closure of stomata reduced the supply of CO_2 and, hence, reduced photosynthesis and produced yield (Krammer, 1983). Moreover, the low water supply reduced the net assimilation and caused reductions on tuber's weight, tuber's size and tubers' number plant^{-1}, which reduced the total yield (Vanloon, 1981 and Abo-Hussein, 1995). Similar results were reported by Ghoneim *et al.* (1974), Lipe and Wendt (1978), Lynch and Tai (1989), Stark et al. (1993), Feibert *et al.* (1998), Hodges (1999) and Shae *et al.*(1999), on potato, and Gabr *et al.*(2000) on peas.

Data in Table (2) showed that the cultivar Diamont proved to be superior and associated with the highest mean values of average tuber's weight, and tubers' yield, compared with Draga cultivar in the two seasons. The detected differences among the two cultivars might be attributed to their different genotypes. Similar trends were reported by Mohamedali (1989), Levy (1992), Bedaiwy and Porter (1998), Gabr and Sarg (1998), and Steyn *et al.* (1998).

The interaction effects between the SWMP levels and the two potato cultivars were found significant in both seasons (Table,2). The treatment combination which included the SWMP (-55 J.kg^{-1}) and Diamont cultivar recorded the highest mean values for average tuber's weight, and total tubers' yield.

III -Tuber's quality:

The effects of SWMP and cultivars on potato tuber's quality are presented in Table (3). The obtained results, generally, reflected significant differences among (SWMP) treatments on tuber's dry matter, starch, total sugars and specific gravity. However, they failed to reflect any significant effects on N, P and K contents in both seasons. Reducing the SWMP from -35 to -75 J.kg^{-1}, significantly increased tuber's dry matter, starch and specific gravity; however, it decreased total sugars in both seasons. The results referred also that it was possible to have potatoes with a high starch content by reducing the SWMP. On the contrary; it was possible to have potatoes with a high sugars content by increasing the SWMP. Similar trends were obtained by Miller and Martin (1990), Abo-Hussein (1995) and Porter and Bedaiwy (1998), on potato, and Gabr *et al.* (2000) on peas.

Data presented in Table (3) revealed that the two potato cultivates differed in their tuber's dry matter, starch, total sugars, specific gravity and nitrogen content, in both seasons. However, phosphorus and potassium contents did not reflect any significant differences. In this respect, Diamont cultivar showed the highest mean values of the above mentioned characters, compared with Draga cultivar. The obtained results are in harmony with those reported by Miller and Martin (1990), Levy (1992), Gabr and Sarg (1998), Porter and Bedaiwy (1998) and Werner *et al.* (1998).

The effects of the interactions between SWMP and cultivars were not found significant for all quality parameters. Therefore, Table (3) shows only the main effects of the two studied factors.

This study provides an evidence about the possibility of using tensiometers to define the optimum time of irrigation, especially in the soils where the surface irrigation is still used. Moreover, it rationalizes the water use and, at the same time increases productivity of potato. The obtained results indicated generally that the treatment combination of SWMP at (-55 J.kg^{-1}) with Diamont cultivar gave the maximum yield and quality of potato.

Table (3): Effect of soil water matric potential (SWMP) on tuber's quality of two potato cultivars during 2000 and 2001 seasons.

Treatments		2000						
SWMP J.kg-1	Cultivar Var	Dry matter (%)	Starch (%)	Total sugars (%)	Specific gravity	N (%)	P (%)	K (%)
-35		18.75	60.30	4.92	1.061	1.26	0.22	2.61
-45		19.24	61.98	4.70	1.070	1.27	0.23	2.58
-55		19.73	64.10	4.55	1.071	1.28	0.23	2.56
-65		19.82	65.19	4.39	1.079	1.28	0.22	2.54
-75		19.96	65.57	4.23	1.085	1.27	0.22	2.52
L.S.D. at 0.05		0.1 6	1.11	0.18	0.004	N.S.*	N.S.	N.S.
	Diamont	20.13	65.97	5.07	1.081	1.37	0.23	2.57
	Draga	18.87	60.89	4.05	1.056	1.25	0.22	2.56
L.S.D. at 0.05		0.76	3.43	0.32	0.012	0.08	N.S.	N.S.
		2001						
-35		18.96	58.54	4.71	1.044	1.21	0.18	2.39
-45		19.42	60.26	4.51	1.052	1.23	0.18	2.38
-55		19.83	62.19	4.28	1.058	1.24	0.19	2.38
-65		19.98	63.03	4.07	1.062	1.24	0.17	2.37
-75		20.09	63.50	3.86	1.065	1.23	0.18	2.36
L.S.D. at 0.05		0.19	1.03	0.19	0.006	N.S.	N.S.	N.S.
	Diamont	20.39	63.69	4.70	1.062	1.24	0.20	2.38
	Draga	18.93	59.32	3.87	1.051	1.22	0.18	2.37
L.S.D. at 0.05		0.64	3.16	0.29	0.008	0.01	N.S.	N.S.

*N.S.=Not significant.

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تاثير جهد الشد الرطوبى للتربة على نمو ومحصول وجودة صنفين من البطاطس

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اجريت تجربتان حقليتان فى الموسم الصيفى لعامى ٢٠٠٠و٢٠٠١ بهدف دراسة تأثير جهد الشد الرطوبى للتربة (-٣٥، -٤٥، -٥٥، -٦٥، -٧٥ جول/كجم) باستخدام التشوميترات على النمو الخضرى والمحصول وجودة صنفين من البطاطس هما دايمونت ودراجا.

اوضحت النتائج من خلال موسمى الزراعة ان اضافة مياه الرى عند مستوى جهد الشد الرطوبى (-٥٥ جول/كجم) قد تفوق معنويا واعطى اعلى القيم لكل من ارتفاع النبات والمساحة الورقية، والوزن الطازج والجاف للمجموع الخضرى ومتوسط وزن الدرنات ومحصول الدرنات الكلى وذلك مقارنة بالاربع معاملات الاخرى لجهد الشد الرطوبى. اشارت الدراسة ان المحتوى الرطوبى المنخفض (-٧٥جول/ كجم) قد ادى الى انخفاض مقاييس النمو السابقة مقارنة بالمحتوى الرطوبى العالى (-٣٥ جول/كجم). اوضحت الدراسة ايضا ان محتوى الدرنات من المادة الجافة والنشا والكثافة النوعية قد زادت بنقص جهد الشد الرطوبى بعد (-٣٥) الى (-٧٥) جول/ كجم. وعلى النقيض من ذلك، فان السكريات الكلية قد نقصت بزيادته. واشارت الدراسة ايضا الى ان محتوى الدرنات من النيتروجين والفسفور والبوتاسيوم لم تتأثر بمعاملات جهد الشد الرطوبى.

كما اوضحت الدراسة ان الصنف دايمونت قد اعطى افضل القيم لكل من ارتفاع النبات والمساحة الورقية والوزن الطازج والجاف للمجموع الخضرى ومتوسط وزن الدرنات والمحصول الكلى للدرنات، مقارنة بالصنف دراجا. واشارت الدراسة الى ان محتوى الدرنات من المادة الجافة والنسا والسكريات الكلية والنيتروجين كان افضل معنويا للصنف دايمونت بالمقارنة بالصنف دراجا.

وقد اظهرت الدراسة بصفة عامة ان افضل معاملة تداخلية بالنسبة للنمو الخضرى والمحصول وجودة درنات البطاطس هى اضافة مياه الرى عند مستوى (-٥٥ جول/كجم) للصنف دايمونت.