J. Agric. Sci. Mansoura Univ., 27(11):7547 - 7571,2002

PHYSIOLOGICAL RESPONSE OF SWEET POTATO*(Ipomoea batatas (L.) Lam)* PLANTS TO WATER STRESS AT DIFFERENT GROWTH STAGES IN RELATION TO NITROGEN FERTILIZATION AT VARYING LEVELS

Abd El-Fattah, M.A.[1]; Mervat E. Sorial [2] and I.M. Ghoneim[1]

1. **Dept. of Vegetable crops, Faculty of Agric., Alexandria University.**
2. **Dept. of Agric. Botany, Faculty of Agric., Menofiya University.**

ABSTRACT

The response of sweet potato (*Ipomoea batatas (L.) Lam*) plants cv. "Abees" to water stress , imposed at vegetative growth (WS_1) or root enlargement (WS_2) stages, under four varying N-fertilizer levels (0, 30, 60 and 90 kg N/fed.) and their ointeraction effects were studied. Two field experiments were conducted during the summer seasons of 2000 and 2001 at the Agricultural Experimental Station, Faculty of Agriculture, Alexandria University.

The obtained results, in general, recorded significant decrements in all vegetative growth characters of sweet potato plants, expressed as main stem length , number of branches, leaf area and shoot dry weight as well as relative water content (%) and leaf water potential, due to water stress at WS_1 and WS_2, in both seasons, compared with the unstressed plants (WS_0). On the other hand, N-fertilization at all applied levels gave significant increments in these characters, compared with unfertilized plants, under all water stress conditions.

Results showed, also, significant decreases in the contents of photosynthetic pigments (chl. a, b and carotenoids) and total carbohydrats and significant increases in total soluble sugars as well as N, protein and proline contents of sweet potato leaves, under WS_1 and WS2 , however , the application of N at 60 kg N/ fed. significantly increased the contents of photosynthetic pigments, total carbohydrates, and leaf water potential but significantly reduced total soluble sugars, N and protein as well as proline contents, especially under WS_1 and WS_2.

Tuberous root yield of sweet potato and average root number, per plant, as well as quality characteristics of roots, expressed as average root weight, root length and diameter and dry matter content (%) and also chemical composition of roots (total carotene, reducing sugars, starch , protein and minerals contents) were significantly reduced under water stress conditions. However, the application of N up to 60 kg N/fed. significantly increased root yield, improved root quality and enhanced its chemical composition and could overcome the adverse effects of water stress on sweet potato productivity.

It could be recommended the use of N-fertilizer at moderate levels to mitigate the negative effect of water stress on sweet potato plants, on the other hand, N deficit and high N levels should be avoid under water stress conditions.

INTRODUCTION

In semiarid regions, a lack of available water in the top soil and a corresponding decline in nutrient availability during the growing season are common phenomena (Marschner, 1996). Whereas, crop production is particularly sensitive to deficiencies of soil moisture and nutrients, especially N (Smittle and Treadgill, 1982 and Costa *et al.* 1997).

Sweet potato (*Ipomoea batatas* (L.) Lam.) is one of the important vegetable crops in Egypt and many other countries in the world due to its importance as a human foods, as a raw material for industrial purposes and as an animal feed. Its storage root yield is a function of both photosynthetic source potential and storage roots sink capacity (Bouwkamp and Hassan, 1988), and yield is reduced when either is limiting. Many factors have been reported to affect sweet potato storage roots yield and quality, such as, fertilization and irrigation (Roysell *et al.*, 1974; Said *et al.*, 1984; Smittle *et al.*, 1990; Nair and Nair, 1995; Prasad *et al.*, 1997 and Sadek, 2000).

Sweet potato is highly responsive to N-fertilization. Many workers reported that growth and yield of sweet potato plants were more influenced by the applied N-rates rather than by N-sources. For example, Yeh *et al.* (1981), Li and Yen (1988) and Mishra *et al.* (1992) mentioned that most cultivars of sweet potato, generally, reacted adversely to the excessive N-levels by yielding less than with the moderate N-levels.

On the other hand, soil moisture content is one important factor affecting tuber quality (Gunel and Karadogan, 1998). In some vegetable crops, moisture stress during specific growth stage, seriously depresses the yield (Janick, 1979). Although sweet potato plants are generally drought resistant , even intermittent periods of moisture and / or nutritional stress can dramatically reduce plant growth and limit root size and total yield . Lack of moisture during root enlargement stage may cause a reduction of tuberous roots yield (Jones *et al.*, 1985 and Bhattacharya *et al.*, 1990). In addition, the allocation of dry matter between roots and shoots seems to be determined largely by development stage of the crop (kleemola *et al.*, 1996). Hence, it has been concluded that roots and shoots are at least partly complementary in function and are depended on each other. Moreover, the maximum benefits of irrigation are dependent upon the existance of a readily available nitrogen supply (Janick, 1979).

Furthermore, water availability and the amount of applied N may influence the amount of N and starch stored in the roots of sweet potato (Patil *et al.*, 1990 Bhattacharya *et al.*, 1990 and Osaki *et al.*, 1995).

Research with other vegetable crops shows that an interaction often exists between irrigation and N-fertilization treatments, and that there is an optimum application of irrigation water (or soil moisture condition) for an optimum N application (Smittle and Threadgill, 1982 on squash; Hegde, 1987 on radish; Abdalla, 1992 on onion, Plies-Balzer *et al.*, 1995 on faba beans, Thompson and Doerge, 1995 on lettuce and Conzalez – Meler *et al.*, 1997 on beans and Pepper plants).

The work reported here was to evaluate the effects of water stress condition, imposed at different growth stages and N-fertilization levels on physiological behaviour, water relations, chemical constituents, yield and quality of sweet potato plants and to determine the significance of the interaction between them.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Farm, Faculty of Agriculture, Alexandria University, during 2000 and 2001 summer seasons to study the effects of different N-fertilization levels on vegetative growth characters, tuberous root yield and its quality characteristics of sweet potato plants grown under water stress, imposed at different growth stages as well as to investigate the interaction effects between water stress conditions and N-levels on the performance and productivity of sweet potato plants.

The soil of the experimental sites was silty clay loam in texture with pH 8.14 and 8.28, EC = 3.34 and 3.41 $ds.m^{-1}$, Organic matter 0.88 and 0.92 % and contained 0.144 and 0.139% N, 0.051 and 0.058% P and 0.064 and 0.069 % K in the first and second seasons; respectively.

Selected cuttings (20-25 cm in length) of sweet potato cv. Abees were transplanted in rows at distances of 25 cm apart on April 20, 2000 and April 22 , 2001, in the first and second seasons, respectively.

The experiments included 12 treatments gained from the combination of three water stress treatments (WS_0, WS_1 and WS_2) and four N-fertilizer levels (0, 30, 60 and 90 kg N/ feddan). The experimental layout used was split-plots in randomized complete block design with three replications, water stress treatments comprising the main plots and N-fertilizer levels the sub-plots.

Sweet potato plants were subjected to water stress by withholding irrigation water during one of the following stages of growth development :-

1. WS_0 = well – watered throughout the entire experiment (control).
2. WS_1 = Water stress which was imposed by intermitting irrigation during vegetative growth stage (60 days after planting).
3. WS_2 = water stress which was imposed by intermitting irrigation during root enlargement stage (90 days after planting).

The irrigation was stopped at the different above mentioned times (WS_1 and WS_2) until the sweet potato plants severe wilted, then the irrigation restarted again till the end of the experiment.

Four levels of nitrogen fertilizer, i.e. 0.0 (control), 30 , 60 and 90 kg N/ feddan, in the form of ammonium sulphate (20.5% N) were applied directly, as soil application, in three equal portions , 21 , 35 and 56 days after transplanting, and were distributed randomly in sub-plots within each main-plot. Each sub-plot consisted of five rows, 4.5 m long and 70 cm apart, occuping an area of 15.75 m^2 . The sub-plots were relatively small in order to maintain equal distribution of irrigation water. Guard rows were left to separate the sub-plots. Each main plot was isolated from adjacent main plots by an intervening border of three non-irrigated rows. This border prevented irrigation seepage across main plots.

All sub-plots received equal amounts of P and K-fertilizers. A seasonal total of 50 kg P_2O_5 $fed.^{-1}$ as calcium superphosphate (15.5% P_2O_5) was broadcasted during soil preparation. Potassium sulphate (48% K_2O) was applied at rate of 50 kg K_2O $fed.^{-1}$ in three equal split portions, which were added at 28 , 42 and 56 days after transplanting. Pest control and other agricultural practices, such as cultivation, were applied whenever it was necessary and as commonly recommended in the commercial sweet potato production. Harvesting was carried out 148 and 150 days after planting , in the first and second seasons, respectively .

The following data, in both seasons, were recorded :-

1. Vegetative growth characters :-

Ten sweet potato plants were randomly chosen from the outer two rows of each sub-plot, at 100 days after planting (ten days after WS_2 application). In each plant sample, the main stem length, number of branches per plant, plant leaf area and shoot dry weight per plant, were determined and recorded. Leaf area was determined according to Koller (1972). The following formula was used : LA = (DWL / D W D) x number of disks x disk area, where DWL and DWD refer to dry weight of leaves and disks, respectively. Shoot dry weight was determined by drying the leaves and stems of plants to constant weight in an electric oven at 70 C for 72 hours (A.O.A.C., 1980).

2. Water relations :-

a) Relative water content (RWC%) :

The RWC was measured in fresh leaves during the development of stress and just prior restarting the irrigation and it was calculated by using the formula of Hsiao (1990) :

RWC = [$(w_t - w_f) / (w_f - w_d)$ x 100] , where: w_t = turgid weight , w_f = fresh weight and w_d = dry weight.

b) Leaf water potential and Osmotic pressure :-

Leaf water potential (ψ_W) was measured using the modified dye method of Marathe (1989). Values of the total soluble solids of the cell sap were obtained for the pressed sap using the Abbe Refractometer and Osmotic pressure values ($\psi_?$) were calculated by using special Tables according to the method described by Goseve (1960). Leaf turger potential (ψ_t) was calculated from the relationship : $\psi_w = \psi_? + \psi_t$, assuming leaf matrix potential was zero (Nobel, 1991).

3. Leaf chemical analysis :-

The same plant samples, which were chosen for above mentioned vegetative growth characters determination, were used for the determination of the following chemical analysis, in both seasons :

a) Leaf chlorophyll a and b and carotenoids contents, according to the method of Witham *et al.*, (1971).
b) Free proline in fresh leaves was measured using the method described by Bates *et al.* (1973).
c) Total carbohydrates and total soluble sugars contents in sweet potato leaves was determined according to the method of Dubois *et al.* (1956).
d) Total nitrogen content in dry leaves was determined using the micro –Kjeldahl method, as described by Ling (1963). Protein content was calculated by multiplication N% x 6.25.
e) Phosphorus and potassium were determined in dried leaves following the method of Chapman and Pratt (1961).

4. Tuberous root yield and its quality :-

To estimate the sweet potato yield at the end of the experiments, in both seasons , the plants of sweet potato of the three middle rows for each sub-plot were harvested. After harvest, records were carried out on the following yield components and root quality :-

a) Average yield per plant as a number and weight of roots .
b) Total tuberous roots per feddan as weight (in Ton).
c) Marketable yield per plant as weight of roots .
d) Marketable yield per feddan as weight (in Ton).
e) Average root weight (gram).
f) Average root length (cm).
g) Average root diameter (cm).
h) Root dry matter content (%).

5.Tuberous root chemical characteristics :-

a) Tuberous roots samples, from the middle row of each sub-plot, at harvest, were collected, washed , dried, ground and used to find out N, P and K concentrations according to the published procedures (A. O. A. C., 1992). Total protein content of roots was calculated by multiplication N% x 6.25.
b) Total carotene content of roots was determined as outlined by Davies (1976).
c) Reducing sugars content (%) of roots was determined in freshly harvested tubers using the method of Munson and Walker as described by A.O.A.C. (1945).
d) Starch content (%) was measured in freshly harvested tuberous roots as mentioned by Malik and Singh (1980).

All collected data of both seasons were statistically analyzed using Costat Software (1985). Treatment means were also compared based on the revised L.S.D. test at 0.05 level (Snedecor and Cochran, 1981).

RESULTS AND DISCUSSION

1. Vegetative growth characters :

Results of this study indicated that water stress at all growth stages, in general, had negative effects on all vegetative growth characters of sweet potato plants. Data in Table (1) showed clearly significant decrements in all studied characters of vegetative growth, as expressed by main stem length (plant height), number of branches, leaf area and shoot dry weight, per plant, due to the application of water stress which was imposed either at vegetative growth stage (WS_1) or root enlargement stage (WS_2), compared with the unstressed plants (WS_0), in both seasons. Data indicated, also, that the difference in stem length reduction due to WS_1 and WS_2 were insignificant, however, WS_2 significantly decreased the number of branches, compared with WS_1 treatment. On the other hand, WS_1 treatment significantly reduced leaf area and shoot dry weight, per plant, compared with WS_2 treatment, in both seasons. Similar reduction in vine growth and leaf area of sweet potato plants due to water stress conditions were found by Jones *et al.* (1985) and Bhattacharya *et al.* (1990), and Younis *et al.* (1994) who showed also that water stress caused reduction in photosynthesis and CO_2 fixation rate as well as inhibited the metabolism of soluble to insoluble photosynthates of sweet potato plant. Moreover , many other investigators recorded similar reduction in vegetative growth characters of several vegetables due to water stress conditions, such as Gu *et al.* (1996) on tomatoes; Costa *et al.* (1997) on potatoes and more recently by Abd El-Fattah and Sorial (2001) on taro plants They concluded also that crop development was adversely affected by continuous water deficit.

Table (1) : Vegetative growth of sweet potato as affected by water stress at different growth stages, N-fertilization levels and their interaction, in 2000 and 2001 seasons.

Treatments		Main stem length (cm)		No. of branches per plant		Plant leaf area (m^2)		Shoot dry weight Per plant (gm)	
Water stress (WS)	Nitrogen level kg N/fed.								
		2000							
WS0		144.33	A	12.38	A	1.126	A	118.68	A
WS1		132.50	B	10.18	B	0.871	C	95.68	C
WS2		123.50	B	8.88	C	0.938	B	101.96	B
	0	119.78	D	9.27	D	0.824	C	85.39	D
	30	133.00	C	10.03	C	0.952	B	104.98	C
	60	137.89	B	10.86	B	1.138	A	122.08	A
	90	143.11	A	11.77	A	0.999	B	109.31	B
WS0	0	130.33	cd	10.77	d	0.990	bc	101.20	e
	30	140.33	bc	11.87	c	1.103	b	117.000	b
	60	148.33	ab	12.80	b	1.310	a	139.20	a
	90	158.33	a	14.10	a	1.100	b	117.30	b
WS1	0	122.67	de	9.40	f	0.720	e	73.60	g
	30	132.67	bcd	9.80	ef	0.827	de	95.47	e
	60	135.67	bcd	10.40	de	1.003	bc	111.10	bc
	90	139.00	bc	11.13	c	0.933	cd	102.57	de
WS2	0	106.33	e	7.63	g	0.763	e	81.36	f
	30	126.00	cd	8.43	g	0.927	cd	102.47	de
	60	129.67	cd	9.37	f	1.100	b	115.93	b
	90	132.00	cd	10.07	def	0.963	bc	108.07	cd
		2001							
WS0		142.09	A	12.90	A	1.156	A	119.88	A
WS1		129.50	B	10.48	B	0.900	C	96.90	C
WS2		123.25	B	9.33	C	0.973	B	103.10	B
	0	116.89	D	9.51	D	0.835	C	86.60	D
	30	130.33	C	10.40	C	0.983	B	106.07	C
	60	137.22	B	11.45	B	1.165	A	123.33	A
	90	142.00	A	12.24	A	1.055	B	110.37	B
WS0	0	128.00	cd	11.00	d	0.977	bc	102.30	e
	30	136.67	bc	12.40	c	1.117	b	118.10	b
	60	147.67	ab	13.40	b	1.333	a	140.40	a
	90	156.00	a	14.80	a	1.197	b	118.70	b
WS1	0	117.33	e	9.60	f	0.747	e	74.70	g
	30	129.33	bcd	10.13	ef	0.883	de	96.50	e
	60	133.67	bcd	10.67	ef	1.013	bc	112.50	bc
	90	137.67	bc	11.50	cd	0.957	cd	103.50	de
WS2	0	105.33	e	7.93	g	0.780	e	82.80	f
	30	125.00	cd	8.67	g	0.950	cd	103.60	de
	60	130.33	cd	10.27	ef	1.150	b	117.10	b
	90	132.33	cd	10.43	ef	1.010	bc	108.90	cd

-Values marked with same alphabetical letter (s), within a comparable group of means, do n`ot significantly differ, using revised L.S.D. test at 0.05 level .

In addition, the reduction in dry weight might be attributed to hormonal changes and other factors such as mineral deficiencies and dehydration (El-Zeiny *et al.*1987).

Moreover, Xu *et al.* (1995) found also that transpiration rate of tomato plants was reduced by low soil water content. Furthermore, Aziz *et al.* (1993) indicated that increased water stress decreased shoot fresh and dry weight and the amounts of free and total water in leaves of maize and faba bean plants. Also, Hogh – Jensen and Schjoerring (1997) recorded reduction in net photosynthesis under water stress conditions.

Regarding the effect of N-fertilization , data in Table (1), generally, indicated significant increments in all studied growth characters of sweet potato plants due to N application and the increases in main stem length and number of branches, in both seasons, were corresponding to increased N levels. However, the application of N at 60 kg N/ fed. gave significant higher mean values for plant leaf area and shoot dry weight, compared with those of the control or other N levels, in both seasons.

The necessity of nitrogen for sweet potato plant growth has bean demonstrated by several researchers such as Knavel (1971), Bourke (1985), Wanas (1987), Osaki *et al.* (1995) and Guertal and Kemble (1997) and more recently by Sadek (2000). They concluded that the application of N-fertilizer or increasing the supplied N-rate increased gradually and significantly all traits of vine growth of sweet potato plants, i.e. main stem length, leaf area, number of leaves, fresh and dry weight of shoots, relative growth rate as well as net assimilation.

Nitrogen is essential for plant growth as it is a constituent of all proteins and nucleic acids and hence of all protoplasm (Marschner, 1996). As the level of the nitrogen supply increases, the extra protein produced allows the plant leaves to grow larger and hence to have a larger surface available for photosynthesis (Bhagsari and Harmon, 1982). Moreover, Schenk (1996) showed that nitrogen demand of plants likely depends on the growth because N is the major constituent of numerous products of plant metabolism .

With respect to the interactive effect between water stress conditions and N levels, data in Table (1) indicated, also, that sweet potato plants which received 60 or 90 kg N/ fed. had the higher mean values for most vegetative growth characters under WS_1, and WS_2, than those plants which received no nitrogen or the lower level of nitrogen, in both seasons. This result means that N could be mitigate the adverse effects due to water stress at either vegetative growth or root enlargement stages. Similar interaction effects were also obtained by Smittle and Threadgill (1982) on squash plants, Conzalez-Meler *et al.* (1997) on beans and pepper plants and by Costa *et al.* (1997) on potatoes.

The total N-uptake decreased with decreasing frequency of irrigation in radish plants (Hegde, 1987). In addition, Conzalez-Meler *et al.* (1997) found that the cytochrome pathway of respiration was affected by mild drought and severe N stress . Moreover, Skinner *et al.* (1998) stated that when early season moisture was available, roots proliferated throughout the soil profile and quickly became available to take up fertilizer N. Furthermore, the amount of water that can be efficiently utilized is primarily related to the level of soil fertility , especially available nitrogen supply (Janick, 1979).

2. Water Relations :

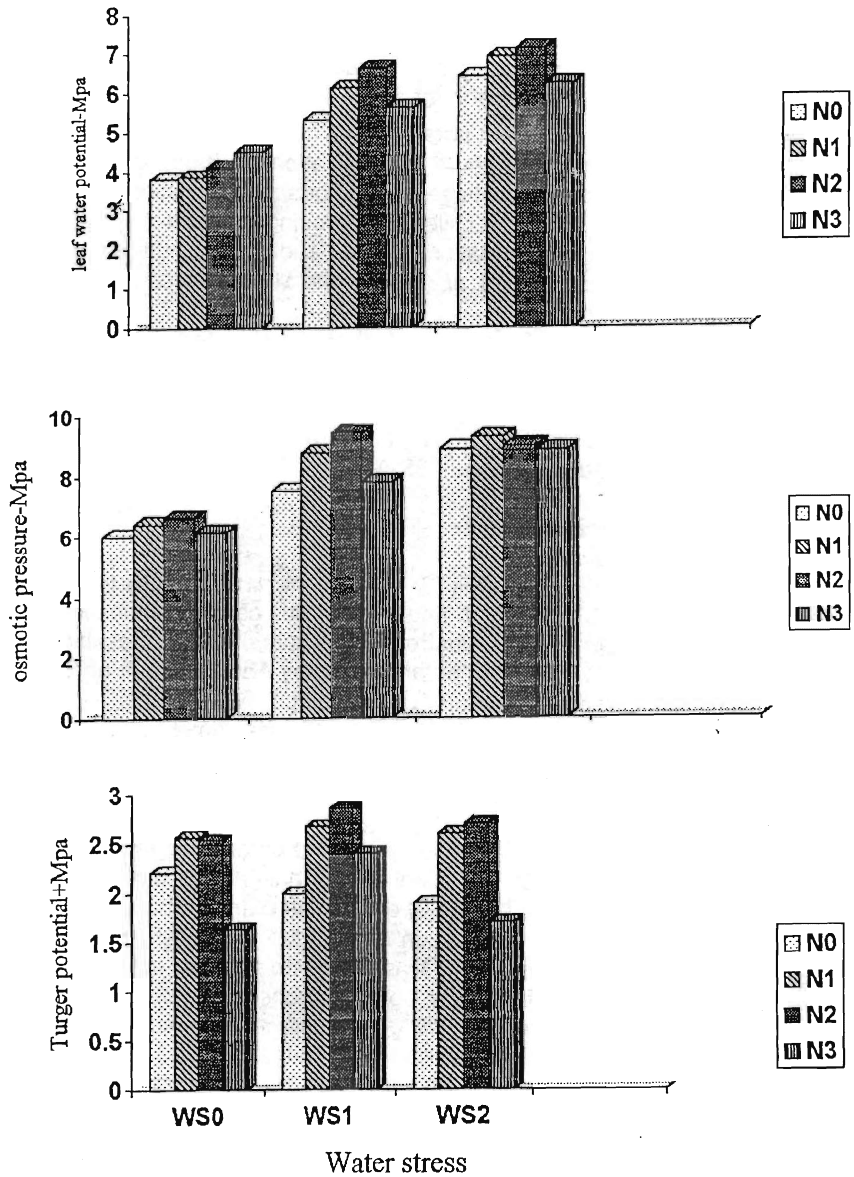
Data presented in Table (2) and Fig. (1) showed that relative water content (RWC%) and leaf water potential in sweet potato leaves were significantly decreased but the osmotic pressure (? ? ? was decreased (more negative) ? ? due to water stress application. The reduction in the RWC due to WS1 was significantly higher than that obtained from WS_2, compared with the unstressed plants, in both seasons. Similar results were obtained by Ruilian and Gang (1997) on peas and by Abd El-Fattah and Sorial (2001) on taro leaves. In addt on , Bhattacharya *et al.* (1990) and Herz et al (1993) showed that sweet potato plants subjected to water stress have lower water potential. Moreover, Peuelas *et al.* (1993) stated that the water status indices generally became significant only when water stress was well developed (RWC less than 80-85%). This reduction in RWC under stress condition may be due to relatively low root ability to absorb water from the soil.

Table (2) : Relative water content %, photosynthetic and proline concentration of sweet potato levels as affected by water stress at different growth stages, N-fertilization levels and their interaction, in 2000 and 2001 seasons.

Treatments: Water stress (WS)	Treatments: Nitrogen level kg N/fed.	Relative water content (RWC%)		Chlorophyll a (mg/g d wt.)		Chlorophyll b (mg/g d wt.)		Carotenoids (mg/g d wt.)		Proline (µg/g d wt.)	
		2000									
WS0		85.52	A	2.579	A	1.243	A	0.893	A	137.25	B
WS1		78.28	C	2.248	C	1.086	C	0.863	B	404.17	A
WS2		79.53	B	2.342	B	1.143	B	0.878	B	403.58	A
	0	80.13	C	2.021	C	1.036	C	0.815	B	343.56	A
	30	81.32	B	2.164	C	1.150	B	0.875	A	296.11	B
	60	82.68	A	2.817	A	1.318	A	0.895	A	289.44	B
	90	79.94	C	2.555	B	1.125	B	0.925	A	330.89	A
WS0	0	84.60	bc	2.169	def	1.113	de	0.822	a	134.33	c
	30	85.47	b	2.313	cde	1.276	bc	0.884	a	137.00	c
	60	86.90	a	3.133	a	1.386	a	0.916	a	137.00	c
	90	84.03	c	2.701	b	1.196	cd	0.949	a	140.33	c
WS1	0	77.03	h	1.919	f	0.987	f	0.809	a	451.00	a
	30	78.57	f	2.045	ef	1.053	ef	0.861	a	378.67	b
	60	80.07	de	2.551	bc	1.237	bc	0.879	a	362.33	b
	90	77.47	gh	2.478	bcd	1.066	ef	0.902	a	424.67	ab
WS2	0	78.77	f	1.977	ef	1.007	f	0.815	a	445.33	a
	30	79.93	e	2.135	def	1.120	de	0.881	a	372.67	b
	60	81.07	d	2.769	ab	1.330	ab	0.891	a	368.67	b
	90	78.33	fg	2.486	bcd	1.114	de	0.924	a	427.67	ab
		2001									
WS0		85.52	A	2.502	A	1.183	A	0.871	A	136.58	B
WS1		78.28	C	2.180	C	1.014	B	0.832	C	405.92	A
WS2		79.53	B	2.266	B	1.069	B	0.852	B	406.58	A
	0	80.13	C	1.959	C	0.959	C	0.772	B	345.67	A
	30	81.32	B	2.106	C	1.069	B	0.851	A	297.55	B
	60	82.68	A	2.721	A	1.255	A	0.888	A	290.00	B
	90	79.94	C	2.479	B	1.072	B	0.894	A	332.22	A
WS0	0	84.60	bc	2.112	def	1.049	de	0.786	a	132.00	c
	30	85.47	b	2.247	cde	1.197	bc	0.874	a	136.00	c
	60	86.90	a	3.018	a	1.333	a	0.907	a	136.67	c
	90	84.03	c	2.632	b	1.153	cd	0.915	a	141.67	c
WS1	0	77.03	h	1.851	f	0.909	f	0.757	a	454.33	a
	30	78.57	f	1.998	ef	0.968	ef	0.831	a	380.33	b
	60	80.07	de	2.470	bc	1.178	bc	0.867	a	363.33	b
	90	77.47	gh	2.403	bcd	1.002	ef	0.875	a	425.67	ab
WS2	0	78.77	f	1.914	ef	0.918	fF	0.774	a	450.67	a
	30	79.93	e	2.074	def	1.044	de	0.849	a	376.33	b
	60	81.07	d	2.674	ab	1.254	ab	0.890	a	370.00	b
	90	78.33	fg	2.403	bcd	1.062	de	0.893	a	429.33	ab

Values marked with same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

Fig 1. Effect of water stress and N-fertilization levels at different growth stages on leaf water potential,osmotic pressure and turger potential of sweet potato leaves



The data presented in Table (2) and Fig. (1) showed also that the RWC%, ψ_w and ψ_t were significantly greater in the sweet potato plants which received N fertilizer at 60 kg N/ fed. followed by those plants which received N at 30 kg N/ fed., compared with the control plants or those plant which received N at 90 kg N/ fed. The interaction effects between N-levels and water stress at different growth stages reflected also the same trend. Since, it can be noticed that the application of N at 30 or 60 kg N/fed. significantly increased RWC and ψ_t of sweet potato plants grown under WS1 and WS2, compared with those grown without N-fertilization or those plants which received N at 90 kg N/ fed. , in both seasons. Thus, N-application at 30 or 60 kg N/ fed., in general, were effective in improving plant water status and releasing water stress under unfavorable soil moisture conditions. Results were also found by Kleemola *et al.* (1996) and Morant Avice *et al.* (1998), seemed to confirm this finding.

It can be observed from Fig. (1) that, nitrogen fertilizer application especially at 60 kg N/ fed. , recorded higher turger potential (ψ_t) under water stress compared with others, meanwhile N at 90 kg N/ fed., altered this effect. This means that the application of N at 60 kg N/ fed. could altered the adverse effect of water stress (Ashraf 1999) .

3. Leaf chemical analysis :-

a) Photosynthetic pigments :

Results presented in Table (2) showed that water stress treatments significantly decreased Chl. a, Chl. b and carotenoids concentrations in sweet potato leaves, compared with unstressed plants. Similar results were obtained by Costa *et al.* (1997) on potatoes and by Abd El-Fattah and Sorial (2001) on taro plants, seemed to confirm this finding.

Concerning the effect of N-fertilizer, data in the same Table indicated also that N at 60 kg/ fed. significantly increased Chl. a and b contents of sweet potato leaves, compared with the control treatment and other N levels, in both seasons, however, all N-levels significantly increased carotenoids content of sweet potato leaves, compared with the unfertilized plants. Similar results were reported by Abd El-Fattah and Sorial (1998) on lettuce plants and by Abd El-Fattah and Sorial (2000) on squash plants. Moreover, data in Table (2) showed significant interaction effect due to water stress and N-levels on chlorophyll contents of sweet potato leaves. Whereas, The application of N at 60 kg N/ fed. in both seasons, could be mitigated the adverse effect of water stress at all growth stages, compared with the unfertilized plants or those plants which received the other levels of N under water stress conditions. However, no significant interaction effects between WS and N- levels were found on carotenoids content of sweet potato leaves, in both seasons. The same trend was also obtained by Abdalla (1992) on onion plants, and concluded also medium level of N application seemed to be best treatment in increasing total chlorophyll content in onion leaves.

b) Proline concentration :-

Results in Table (2) showed also that water stress treatments significantly enhanced proline accumulation in sweet potato leaves comparing with the unstressed plant. Moreover, there were no significant differences between both water stress treatments (WS_1 and WS_2) on proline concentration. Hanson (1980) reported free proline accumulates in the leaves of very many plant species subjected to water stress . Similar finding was also obtained by Garg *et al.* (1998) on cluster bean plants, Ruilian and Gang (1997) on peas and Abd El-Fattah and Sorial (2001) on taro plants. Moreover, Joyce *et al.* (1992) stated that both the carbohydrates produced and the energy fixed during current photosynsis have been suggested to be involved in proline accumulation during water stress application.

Data in the same Table showed that the application of N at 30 or 60 kg N/fed. significantly reduced the accumulation of proline in sweet potato leaves compared with the unfertilized plants or those plants which received N at 90 kg N/ fed., in both seasons. The same trend was obtained also by the interaction effect between water stress and N-levels. This means that the moderate levels of N could be mitigate the bad effects due to water stress conditions.

c) Total carbohydrates and total soluble sugars :

Data presented in Table (3) showed that imposing sweet potato plants to water stress at vegetative growth stage led to a significant decrease in total carbohydrates in its leaves. Meanwhile, subjecting the sweet potato plants to water stress at root enlargement stage caused a further significant reduction in total carbohydrates content, compared with unstressed plants, in both seasons. Similar results were also found by Abd El-Fattah and Sorial (2001) on taro plants, seemed to confirm this finding. The decrement in total carbohydrates under water stress condition may be due to the hydrolysis of total carbohydrates to soluble sugars as a result of increasing in hydrolysis enzymes (Abd-Alla and Abdel-Wahab, 1995). Whereas, the data presented in the same Table show also that water stress at both growth stages caused significant increases in total soluble sugars of sweet potato leaves, in both seasons. Moreover, Janoudi *et al.* (1993) stated that water stressed cucumber plants had higher contents of sucrose and raffinose than those of well-waterred plants. Furthermore, Zhang and Archbold (1993) found that water deficit increased the total soluble carbohydrate concentration from 1.4 to 2.4 fold for strawberry plants.

It can be observed from the results presented in Table (3) that , in general , the application of N at all levels significantly increased total carbohydrates of sweet potato leaves, however, it caused significant decrements in total soluble sugars in leaves, in both seasons. Similar results were also obtained by Kim *et al.* (1985) and El-Sayed (1987) on sweet potato plants due to N-fertilizer application.

The interaction effect between water stress and N-levels (Table 3) showed that the application of N at moderate levels, i.e. 30 or 60 kg N/ fed. could be mitigated the adverse effects of water stress on total carbohydrates and total soluble sugars of sweet potato leaves.

Table (3): **Chemical analysis of sweet potato levels as affected by water stress at different growth stages, n-fertilization levels and their interaction, in 2000 and 2001 seasons.**

Treatments		Total carbohy-drates (mg/ g dry wt.)	Total soluble sugars (mg/ g dry wt.)	N (% dry wt.)	P (% dry wt.)	K (% dry wt.)	Total protein %
Water stress (WS)	Nitrogen level kg N/fed.						
		2000					
WS0		126.17 A	11.844 B	3.673 B	0.310 A	3.246 A	22.960 B
WS1		79.42 B	14.974 A	4.203 A	0.262 B	2.873 C	26.359 A
WS2		74.33 C	14.705 A	4.212 A	0.272 B	2.969 B	26.338 A
	0	75.44 C	14.671 A	3.462 D	0.258 C	2.537 C	21.640 D
	30	100.11 B	13.610 B	3.967 C	0.285 B	3.042 B	24.803 C
	60	112.22 A	13.474 B	4.259 B	0.298 A	3.207 A	26.744 B
	90	85.44 C	13.609 B	4.430 A	0.285 B	3.330 A	27.689 A
WS0	0	115.33 bc	12.487 d	2.977 e	0.285 a	2.852 d	18.607 e
	30	126.33 ab	11.690 de	3.513 d	0.317 a	3.256 ab	21.960 d
	60	138.33 a	11.923 de	4.007 bc	0.323 a	3.394 a	25.043 bc
	90	124.67 ab	11.277 e	4.197 ab	0.314 a	3.481 a	26.230 ab
WS1	0	59.33 f	15.923 a	3.727 ad	0.240 a	2.355 e	23.290 cd
	30	89.00 d	14.793 bc	4.197 ab	0.265 a	2.898 cd	26.230 ab
	60	101.00 cd	14.303 c	4.367 ab	0.282 a	3.053 bcd	27.667 a
	90	68.33 ef	14.877 bc	4.520 a	0.260 a	3.184 abc	28.250 a
WS2	0	51.67 f	15.603 ab	3.683 cd	0.247 a	3.405 e	23.023 cd
	30	85.00 de	14.347 c	4.190 ab	0.273 a	2.973 bcd	26.220 ab
	60	97.33 cd	14.197 c	4.403 ab	0.288 a	3.175 abc	27.523 a
	90	63.33 f	14.673 c	4.573 a	0.280 a	3..323 a	28.587 a
		2001					
WS0		127.58 A	11.954 B	3.573 B	0.306 A	3.184 A	22.34 B
WS1		80.92 B	15.067 A	4.188 A	0.261 B	2.826 C	26.18 A
WS2		77.33 C	14.762 A	4.117 A	0.271 B	2.929 B	25.74 A
	0	76.89 D	14.762 A	3.382 D	0.253 C	2.503 C	21.14 D
	30	101.33 B	13.717 B	3.879 C	0.284 B	2.967 B	24.25 C
	60	113.44 A	13.551 B	4.204 B	0.296 A	3.155 A	26.28 B
	90	89.55 C	13.681 B	4.373 A	0.284 B	3.293 A	27.33 A
WS0	0	116.67 b	12.593 d	2.870 e	0.276 a	2.827 d	17.94 e
	30	127.33 ab	11.800 de	3.417 d	0.315 a	3.160 ab	21.36 d
	60	139.33 a	12.013 de	3.893 bc	0.319 a	3.322 a	24.33 bc
	90	127.33 ab	11.410 e	4.113 ab	0.314 a	3.429 a	25.71 b
WS1	0	60.67 ef	16.023 a	3.690 cd	0.240 a	2.318 e	23.06 cd
	30	90.33 cd	14.927 bc	4.120 ab	0.264 a	2.825 cd	25.75 b
	60	102.33 c	14.393 c	4.407 ab	0.281 a	2.998 bcd	27.55 a
	90	70.33 e	14.927 bc	4.537 a	0.260 a	3.163 abc	28.35 a
WS2	0	53.33 f	15.673 ab	3.587 cd	0.244 a	2.365 e	22.42 cd
	30	86.33 d	14.423 c	4.100 ab	0.272 a	2.917 bcd	25.63 b
	60	98.67 c	14.247 c	4.313 ab	0.287 a	3.146 ab	26.96 a
	90	71.00 e	14.707 c	4.470 a	0.279 a	3.288 a	27.94 a

- **Values marked with same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.**

d) Minerals content and total protein :

It is clear from the results in the same Table (3) that under water stress condition, there was a significant increase in both N and total protein contents of sweet potato leaves, in both seasons, compared with the control plants. The differences between the effect of WS1 and WS2 were not significant . Similar finding was also found by Abd El-Fattah and Sorial (2001) on taro plants. Moreover, Campalans *et al.* (1999) stated that many different proteins accumulated in response to water deficit. Furthermore, Ashraf and Yasmin (1995) concluded that the increase in N concentration of bean leaves under low soil moisture could be attributed to a incompletely utilization of N in the formation of new cells and , consequently, accumulate in the plant tissues.

Respecting the N-fertilizer effect and its interaction with water stress on N and protein contents , data in Table (3) show significant increments in these contents in sweet potato leaves, in both seasons, and these increments in N and prolein contents were corresponding to increased N levels. The interaction effect had the same trend , in both seasons. Similar N and protein increments were also obtained by Mascianica *et al.* (1985) on sweet potato plants due to N application . Moreover, Hegde (1987) stated that N content of radish leaves tended to increase with decrease in soil water potential, when accompanied with N level increasing.

Concerning P and K contents, data presented in Table (3) indicated that water stress significantly decreased both minerals content in sweet potato leaves, compared with unstressed plants. Similar results were found by Gawish and Fattahallah ((1997) and Abd El-Fattah and Sorial (2001) on taro plants.

N-application significantly increased both P and K contents, compared with unfertilized plants, in both seasons. Moreover, the application of N-fertilizer at all levels under water stress significantly enhanced K content of sweet potato plants grown under WS_1 or WS_2, however, the interaction effect was insignificant with respect to P content. Similar findings were also obtained by Hegde (1987) on radish and by Abdalla (1992) on onion plants.

4. Tuberous root yield and its quality :

Regarding water stress, data in Table (4) showed significant decrements in total root yield, express as gram per plant or ton/ feddan and number of roots/ plant as well as marketable yield of sweet potato plants grown under water stress, imposed at vegetative growth or root enlargement stages, compared with unstressed plants . However, no significant differences were detected between yield reduction due to WS_1 and WS2 with the exception of the number of roots per plant, whereas, water stress at vegetative growth stage significantly decreased the average number of roots , compared with water stress at root enlargement stage, in both seasons. These results are in accordance with those obtained by Jones *et al.* (1985), Smittle *et al.* (1990) and Bhattacharya *et al.* (1990) on sweet potato plants, Costa *et al.* (1997) on potatoes and more recently by Abd El-Fattah and Sorial (2001) on taro plants .

This reduction in tuberous root yield of sweet potato under water stress conditions may be attributed to the reduction in vegetative growth characters (Table1) and the depression of the chemical and biochemical composition of sweet potato leaves under water stress (Tables 2 and 3), which were recorded and discussed previously. Bouwkamp and Hassam (1988) came to the same conclusion on sweet potato plants. In addition, low soil moisture potential affected adversely the hormonal balance, plant development, translocation and partition of assimilates of photosynthesis among different organs throughout negative effect on leaf water potential (Hsiao and Acevedo , 1974), which in turn resulted in low yield . Moreover, final root yield of sweet potatoes was correlated significantly (r = 0.87) with photosynthate partitioning at all stages of growth (Bhagsari and Harmon, 1982).

Data in Table (4) showed, also, significant increments in the total yield of sweet potatoes, expressed as weight of roots/ plant or number of roots / plant as well as total yield / fed. and marketable yield, due to the application of N at 30 or 60 kg N/ fed. , in both seasons, compared with the control treatment or the higher level of N (90 kg/ fed.) . These results are in agreement with those reported by many researchers on sweet potatoes, such as Dayal and Sharma (1993) and Marcano and Diaz (1994) and more recently by Sadek (2000). However, many other inverstigators stated that medium N levels have greater root yield and number of roots per plant and further increase in N level decreased the number of roots/ plant (Knavel, 1971; Wanas, 1979; Mohamed, 1984 and El Sayed, 1987). In addition, Purcell *et al.* (1982) and Van der werf and Nagel(1996) stated that increasing N level decreased total root yield of sweet potato, or did not affect yield. Moreover, Martinez *et al.* (1990) showed that N at lower level (65 kg N/ha = 26 kg N/ fed.) gave the most economic tuberous root yield in the wet and dry seasons.

Also, Li and Yen (1988) showed that sweet potato fed on 60 kg N/ha., gained the higher yield as compared with unfertilized plants, while doubling the N rate increased shoot growth but not tuber yield.

This increase in total yield of sweet potatoes due to N application at moderate levels might be directly attributed to the increase in average number of roots, average root weight of root , average root weight, root length and diameter (Table 5) , or indirectly attributed to the enhancement of vegetative growth characters (Table 1) as well as the increase in the chemical and biochemical composition of sweet potato leaves (Tables 2 and 3). Since, nitrogen is an important constituent of chlorophyll which increases photosynthesis, resulting in assimilation of more carbohydrates, as well as higher shoot apex in soluble N, starch , cytokinin and gibberellins (Zhong *et al.*, 1989).

The results in Table (4), also showed that there was a significant effect due to the interaction between N levels and water stress treatments on total yield of sweet potatoes, in both seasons. The application of N at medium level (60 kg N/ fed.) gave significant increments in total yield of sweet potato plants grown under either well watering or under water stress (WS_1 and WS_2) and this level of N could be mitigated the adverse effects of water stress on sweet potato yield . Similar interaction effects were also obtained by Smittle and Threadgill (1982) on squash yield, Hegde (1987) on radish yield and Abdalla (1992) on onion yield.

The results presented in Table (5) show significant depression in all quality characteristics of sweet potato roots, expressed as average root weight, average root length and diameter dry matter content (%), due to water stress imposed at vegetative growth and root enlargement stages, in both seasons. The adverse effects of water stress at the root enlargement stage or root quality was greater than those obtained from water stress at vegetative growth stage, compared with the unstressed plants. Similar negative effects of water stress on root quality of sweet potatoes was found by Lana and Peterson (1956), Jones *et al.* (1985), Smittle *et al.* (1990) and Bhattacharge *et al.* (1990). Moreover, similar quality depression due to water stress conditions was reported by Hegde (1987) on radish roots, Abdalla (1992) on onion bulbs, Eldredge *et al.* (1996) and Gunel and Karadogan (1998) on potato tublers, Shibairo *et al.* (1998) on carrot roots and more recently by Abd El-Fattah and Sorial (2001) on taro corms.

Table (5) : Quality characteristics of sweet potato as affected by water stress at different growth stages, N-fertilization levels and their interaction, during 2000 and 2001 seasons.

Treatments		Average root weight (g)		Average root length (cm)		Average root diameter (cm)		Dry matter content % In roots	
Water stress (WS)	N- level kg N/fed.								
		2000							
WS0		137.87	A	13.333	A	5.267	A	26.284	A
WS1		127.317	AB	12.383	B	4.850	B	25.882	B
WS2		122.092	B	12.217	B	4.667	C	25.483	C
	0	114.600	C	11.456	C	4.756	C	26.749	A
	30	132.722	B	12.733	B	5.067	B	26.060	B
	60	147.644	A	14.067	A	5.522	A	25.798	C
	90	121.400	C	12.322	B	4.367	D	24.926	D
WS0	**0**	121.167	cde	12.467	cde	5.067	cde	27.033	a
	30	131.733	bcd	13.167	bc	5.533	ab	26.657	bc
	60	157.800	a	14.667	a	5.867	a	26.157	de
	90	140.767	abc	13.033	bcd	4.600	fg	25.290	g
WS1	**0**	113.533	de	11.133	fg	4.667	efg	26.813	ab
	30	133.533	bcd	12.500	cde	4.867	def	25.947	a
	60	145.333	ab	13.833	ab	5.467	abc	25.913	ef
	90	116.867	de	12.067	def	4.400	gh	24.853	h
WS2	**0**	109.100	a	10.767	g	4.533	fg	26.400	cd
	30	132.900	bcd	12.533	cde	4.800	def	25.577	fg
	60	139.800	abc	13.700	ab	5.233	bcd	25.323	g
	90	106.567	e	11.867	ef	4.100	h	24.633	h
		2001							
WS0		133.402	A	13.358	A	5.308	A	26.304	A
WS1		128.166	B	12.483	B	4.867	B	25.772	B
WS2		115.537	C	12.258	B	4.592	C	25.416	C
	0	112.140	D	11.400	C	4.689	C	26.714	A
	30	128.496	B	12.867	B	5.078	B	25.992	B
	60	141.562	A	14.178	A	5.556	A	25.763	B
	90	120.609	C	12.356	B	4.367	D	24.852	C
WS0	**0**	120.390	cd	12.333	cde	5.000	cde	27.103	a
	30	124.890	bc	13.367	bc	5.600	ab	26.620	bc
	60	148.820	a	14.800	a	5.967	a	26.230	de
	90	139.507	abc	12.933	bcd	4.667	fg	25.263	g
WS1	**0**	119.347	de	11.200	fg	4.600	efg	26.703	ab
	30	128.640	bcd	12.633	cde	4.900	def	25.853	e
	60	148.117	Ab	13.933	ab	5.533	abc	25.793	ef
	90	116.560	de	12.167	def	4.433	gh	24.736	h
WS2	**0**	96.683	f	10.667	g	4.467	fg	26.337	cd
	30	131.957	ab	12.600	cde	4.733	def	25.503	fg
	60	127.750	bcd	13.800	ab	5.167	bcd	25.267	g
	90	105.760	ef	11.967	ef	4.000	h	24.557	h

- Values marked with same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.

Concerning the effects of N application on root quality, data in Table (5) show significant improvement in average root weight, average root length and diameter, when applied up to 60 kg N/ fed, compared with the control treatment, however, the higher level of N (90 kg N/ fed.) was found to be unvaluable for root quality improvement, in both seasons. On the other hand, all N levels caused significant reduction in root dry matter content , compared with the control treatment, in both seasons. Similar results were obtained by Knavel (1971) with respect to average root weight and root length and diemeter . However , Hammet and Miller (1982) and Osaki *et al.* (1995) reported similar reduction in root dry matter content of sweet potato at the high N rates.

Respecting the interaction effect between water stress and N-levels treatments, data in Table (5) showed that the application of N at moderate level (60 kg N/fed.) gave significantly higher values for root quality characteristics of sweet potato plants grown under water stress, imposed at all stages of growth, compared with the unfertilized plants and those plants received the lower and the higher levels of N, in both seasons, with the exception of root dry matter content. Similar interaction effects were also found by Smittle and Threadgill (1982) on squash quality, Hegde (1987) on radish root quality, Abdalla (1992) on onion bulb quality, Thompson and Doerye (1995) on lettuce quality and Conzalez – Meler *et al.* (1997) on beans and pepper fruit quality. Moreover, Constantin *et al.* (1974) reported significant interaction effects between irrigation and nitrogen fertilization on quality of sweet potatoes.

5. Tuberous root chemical characteristics :

It is clear from the results in Table (6) that water stress treatment caused significant depression in all chemical composition of sweet potato roots, expressed as total carotene, reducing sugars, starch and protein contents as well as minerals content, compared with the unstressed plants, in both seasons. The adverse effects of water stress at root enlargement stage was greater than those obtained from water stress at vegetative growth stage. Similar reductions in chemical composition were obtained by Bhattacharya *et al.* (1990) with respect to root starch content of sweet potatoes, Gunel and Karadogan (1998) with respect to starch and protein contents of potato tubers and Abd El-Fattah and Sorial (2001) with respect to total carbohydrates and minerals content of taro corms.

With respect to the effect of N-fertilization on chemical composition of sweet potato roots, data in Table (6) indicated that all chemical compounds of sweet potato roots were significantly increased due to N-application, especially at moderate N level (60 kg N/fed.) , compared with unfertilized plants , in both seasons. Similar enhancing effect of N application on chemical composition of sweet potato roots was also reported by Wanas (1979), Purcell *et al.* (1982), Constantin *et al.* (1984), El-Sayed (1987), Patil *et al.* (1990) and Osaki *et al.* (1995) and more recently by Sadek (2000).

Table (6) : Chemical analysis of sweet potato roots as affected by water stress at different growth stages, N-fertilization levels and their interaction, during 2000 and 2001 seasons.

Treatments		Total carotene Mg/g dry wt.	Reducing sugars %	Starch content %	N %	P %	K %	Total protein %
Water stress (WS)	Nitrogen level kg N/fed.							
		2000						
WS0		0.755 A	3.483 A	15.741 A	0.358 A	0.351 A	2.917 A	2.234 A
WS1		0.649 B	2.929 B	14.176 B	0.314 B	0.340 AB	2.734 B	1.963 B
WS2		0.560 C	2.846 C	13.895 C	0.309 C	0.338 B	2.668 C	1.925 B
	0	0.469 D	2.627 C	13.669 C	0.307 C	0.329 B	2.452 D	1.914 C
	30	0.636 C	3.078 B	14.580 B	0.321 B	0.349 A	2.720 C	2.003 B
	60	0.789 A	3.484 A	15.333 A	0.340 A	0.357 A	2.911 B	2.128 A
	90	0.724 B	3.156 B	14.833 B	0.339 A	0.336 B	3.010 A	2.118 A
WS0	**0**	0.557 Ef	2.930 e	14.490 de	0.320 c	0.344 a	2.684 e	2.000 cde
	30	0.700 Cd	3.313 c	15.433 b	0.343 ab	0.356 a	2.791 cde	2.140 bc
	60	0.835 B	3.743 b	16.010 b	0.370 ab	0.365 a	2.989 b	2.313 ab
	90	0.928 A	3.947 a	17.030 a	0.397 a	0.340 a	3.205 a	2.483 a
WS1	**0**	0.461 gh	2.600 g	13.407 fg	0.303 c	0.321 a	2.382 f	1.890 de
	30	0.632 de	3.010 de	14.320 de	0.311 c	0.344 a	2.698 de	1.943 de
	60	0.770 bc	3.287 cd	15.110 c	0.327 bc	0.354 a	2.889 bc	2.043 cd
	90	0.734 c	2.820 ef	13.867 ef	0.316 c	0.335 a	2.969 b	1.977 cde
WS2	**0**	0.388 h	2.350 h	13.110 g	0.297 c	0.323 a	2.289 f	1.853 e
	30	0.577 ef	2.910 ef	13.987 ef	0.308 c	0.349 a	2.673 e	1.927 de
	60	0.762 bc	3.423 c	14.880 cd	0.324 bc	0.354 a	2.855 bcd	2.027 cd
	90	0.511 fg	2.700 fg	13.603 fg	0.303 c	0.333 a	2.855 bcd	1.893 de
		2001						
WS0		0.750 A	3.435 A	15.684 A	0.352 A	0.347 A	2.868 A	2.202 A
WS1		0.641 B	2.880 B	14.143 B	0.313 B	0.336 B	2.699 B	1.955 B
WS2		0.553 C	2.786 C	13.821 C	0.304 C	0.337 B	2.627 B	1.903 B
	0	0.461 D	2.551 C	13.613 C	0.302 C	0.324 B	2.399 D	1.892 C
	30	0.634 C	3.037 B	14.513 B	0.317 B	0.347 A	2.675 C	1.980 B
	60	0.789 A	3.423 A	15.284 A	0.337 A	0.356 A	2.885 B	2.103 A
	90	0.710 B	3.124 B	14.787 B	0.337 A	0.334 B	2.967 A	2.105 A
WS0	**0**	0.550 ef	2.827 e	14.417 d	0.315 cd	0.337 a	2.605 e	1.971 cde
	30	0.707 cd	3.287 c	15.380 bc	0.339 c	0.352 a	2.748 cde	2.117 bc
	60	0.849 b	3.710 b	15.953 b	0.362 b	0.363 a	2.962 b	2.260 ab
	90	0.896 a	3.917 a	16.987 a	0.394 a	0.338 a	3.158 a	2.460 a
WS1	**0**	0.452 gh	2.540 g	13.373 fg	0.299 de	0.318 a	2.330 f	1.871 de
	30	0.623 de	2.960 de	14.260 de	0.310 de	0.343 a	2.659 de	1.939 de
	60	0.764 bc	3.223 cd	15.120 c	0.326 c	0.353 a	2.872 bc	2.038 cd
	90	0.727 c	2.797 ef	13.820 ef	0.315 cd	0.332 a	2.937 b	1.971 cde
WS2	**0**	0.381 h	2.287 h	13.050 g	0.293 e	0.317 a	2.262 f	1.833 e
	30	0.571 ef	2.863 ef	13.900 ef	0.302 d	0.345 a	2.618 e	1.885 de
	60	0.753 bc	3.337 c	14.780 cd	0.322 c	0.352 a	2.820 bcd	2.010 cd
	90	0.507 fg	2.657 fg	13.553 fg	0.301 e	0.332 a	2.806 bcd	1.883 de

- **Values marked with same alphabetical letter (s), within a comparable group of means, do not significantly differ, using revised L.S.D. test at 0.05 level.**

The interaction effects between water stress and N-levels (Table 6) showed also that the application of N at medium level (60 kg N/fed.) seemed to be the best treatment in increasing all chemical compounds of sweet potato roots under WS_1 and WS_2 , compared with unfertilized plants and those received other N levels, in both seasons. Whereas, the application of this moderate level could be mitigated the adverse effects of water stress treatments on chemical composition of sweet potato roots. Similar finding was also obtained by Hegde (1987) on radish roots and by Abdalla (1992) on onion bulbs.

CONCLUSION

The effect of soil moisture variation on crop growth has been the subject of much research particularly in irrigated agriculture . Sweet potato being a vegetable crop with very high growth rate needs adequate supply of water and N for better growth, yield and quality. Whereas, a well – watered crop is more capable to take benefit of the applied fertilizer (Costa *et al.*, 1997). The influence of water supply in determining sweet potato yield is clearly established (Jones, 1961 and Bhattacharya *et al.*, 1990) with a significant decrease in yield reported for some of the cultivars of sweet potato in field experiments under water stress conditions . The reduction of yield was more marked during plant maturity than during the initial period of vegetative growth (Jones *et al.*, 1985). Moreover, keeping fertilizer in the root zone is only helpful if enough water is also present to allow root growth and nutrient up take (Skinner *et al.*, 1998), in addition fertilizer N uptake was reduced 50% in a dry year. Furthermore, some sweet potato cultivars are capable of producing high yield on low or medium N level soil without fertilizer N addition (Hill *et al.*, 1990) .

The results obtained in this study show that the sweet potato plants subjected to water stress imposed at different stages of growth produced significantly lower root yield than that obtained from the unstressed plants. Moreover, this reduction in root yield was associated with similar reduction in leaf water potential and relative water content (RWC%) as well as depression in most leaf chemical analysis , in addition, it caused reduction in root quality characteristics.

On the other hand, the results of this investigation show that medium level of N application seemed to be the best treatment in increasing root yield of sweet potato under water stress conditions. In addition, it caused enhancement in all vegetative growth characters, chemical composition either in leaves or roots and improved root quality.

Moreover, this treatment led to improved water relations of sweet potato leaves under water stress and reduced proline accumulation in leaves, compared with the unfertilized plants and the application of the lower or higher N levels. It is therefore suggested that N levels and water conditions can interact to influence the productivity and quality of sweet potato plants as well as to influence water use efficiency (Hogh – Jensen and Schjorring, 1997).

In conclusion , it can be recommended the application of nitrogen fertilizer at moderate levels in order to mitigate the adverse effects of water stress at different stage of growth and to avoid N deficit or higher N levels which can not overcome the all deleterious effects of water stress.

REFERENCES

Abdalla, A.A. (1992). Effect of soil moisture stress and nitrogen fertilization on onion plants. Ph.D Thesis, Dept. of Horticulture, Faculty of Agriculture, Ain Shams Univ., Egypt.

Abd-Alla, M.H. and A.H. Abdel-Wahab (1995). Response of nitrogen fixation, nodule activities and growth to potassium supply in water-stressed broad bean . J. Plant Nutrition , 18 (7) : 1319-1402.

Abd El-Fattah, M. A. and M.E. Sorial (1998). Efficiency of biofertilization on responses of the productivity and chemical composition of Lettuce plants grown under different nitrogen levels. Menofiya J. Agric. Res., 23 (5) : 1185 – 1207.

Abd-El-Fattah, M.A. and M.E. Sorial (2000). Sex expression and productivity responses of summer squash to biofertilizer application under different nitrogen levels. Zagazig J. Agric. Res., 27 (2) : 255 – 281.

Abd El-Fattah, M. A. and M.E. Sorial (2001). Mitigation of the adverse effects of water stress imposed at different growth stages of taro plants using several treatments. III. Effects of mulching and K-fertilizer application and their interaction. Minufiya J. Agric. Res., 26 (4) : 1035 – 1069.

A.O.A.C. (1945). Association of Official Agricultural Chemists. 6th ed, Washington, D.C., U.S.A.

A.O.A.C. (1980). Official Methods of Analysis, 13rd ed. Association of Official Analyical Chemists, Washington, D.C., U.S.A.

A.O.A.C. (1992). Official Methods of Analysis, 12th Ed., Association of Official Analytical Chemists, Washington, D.C., U.S.A. P. 1359.

Ashraf, M. (1999). Interactive effects of salt (NaCl) and nitrogen form on growth, water relations and photosynthetic capacity of sunflower (*Helianthus annus* L.). Ann. App. Biol., 135 : 509 – 513.

Ashraf, M. and N. Yasmin. (1995). Response of four arid zone grass species from varying habitats to drought stress. Bilogia Plant. , 37 (4) : 567 – 575.

Aziz, M.A.; E. Abu-Gabal; M. A. El – Toni and M. Galal. (1993). Effect of irrigation water salinity and soil moisture stress on some characters of plants grown in different soils. Egyptian J. Soil Sci., 33 (1) : 47 – 62.

Bates, L. S.; R. P. Waldren and I.D. Teare. (1973). Rapid determination of free proline for water stress studies. Plant and Soil, 39 : 205-207.

Bhagsari, A. S. and S.A. Harmon (1982). Photosynthesis and Photosynthate partitioning in sweet potato genotypes. J. Amer. Soc. Hort. Sci., 107 (3): 506 – 510.

Bhattacharya, N. C.; D.R. Hileman; P.P. Ghosh and R.L. Musser (1990). Interaction of enriched CO_2 and water stress on the physiology and biomass production in sweet potato grown in open-top chambers plants, Cell and Environment (1990) , 13 : 933 –940.

Bourke, R.M. (1985). Influence of nitrogen and potassium fertilizer on growth of sweet potato (*Ipomoea batata*, L.) Field Crop Res., 12 (4) : 363 – 375.

Bouwkamp, J.C. and M. N. M. Hassam (1988). Source – Sink relationship in sweet potato. J. Amer. Soc. Hort. Sci., 113 (4) : 627 –29.

Campalans, A.; R. Messequer; A. Goday and M. Pages (1999). Plant responses to drought from ABA signal transduction events to the action of the induced proteins. Plant Physoil Biochem., 1999, 37 (5) : 327 – 340.

Chapman, H.D. and P.E. Pratt (1961). Methods of Analysis of Soil, Plant and Water. Div. Of Agric. Sci.m Univ. of California.

Constantin, R. J.; T. Hernandez and L. G. Jones (1974). Effects of irrigation and nitrogen fertilization on quality of sweet potatoes. J. Amer. Soc. Hort. Sci., 99 : 308 – 310.

Constantin, R.J.; L. G. Jones; H.L. Hammett; T.P. Hernandez and C. G. Kanlich (1984). The response of three sweet potato cultivars to varying levels of nitrogen. J. Amer. Soc. Hort. Sci., 109 (5) : 610 – 614.

Conzalez – Meler, M.A.; R. Matamala and J. Penuelas. (1997). Effects of prolonged drought stress and nitrogen deficiency on the respiratory O2 uptake of bean and pepper leaves. Photosynthetica, 34 (4) : 505 – 512 [C.F. Hort. Abst., 1998, 68 (9) : 7739].

Costa, L.D.; G. Delleve; G. Kgianquinto; R. Giovanardi and A. peressotti. (1997). Yield, water use efficiency and nitrogen uptake in potato influence of drought stress. Potato Research, 40 : 19 – 34.

Castat (1985). User's Manual version 3, CoHort, Tusson, Arizona, U.S.A.

Davies, B.H. (1976). Analysis of carotenoid pigment in : T.W. Goodwin (ed), chemistry and Biochemistry of plant pigments. Academic Press, London annd New York.

Dayal, T.R. and R.P. Sharma (1993). Response of sweet potato (*Ipomoea batatas,* L.) to fertilizer, method and time of planting and spacing. Indian J. Agron., 38 (3) : 431 – 435.

Dubois, M.; K.A. Gilles; J. Hamilton; R. Robers and F. Smith. (1956). Colorimetric method for determination of sugar and related substances. Anal. Chem., 28 : 350.

Eldredge E.P.; Z.A. Holmes, A.R. Mosley; C.C. Shock and T. D. Streber. (1996). Effects of transitory water stress on potato tuber stem and reducing sugar and fry color. Potato J., 73 : 517 – 30.

El-Sayed, M. M. (1987). The response of sweet potato to different fertilizer treatments. Egypt. J. Appl. Sci., 12 : 435 – 441.

El-Zeiny, H.A.; M.A.Ashoub and M.H. Mohamed (1987). Effect of different levels of soil moisture and gibberellic acid on faba bean (*Vicia faba*, L.). Annals Agric. Sci., Fac. Agric. Ain Shams Univer. Cairo, Egypt., 33 (1) : 179 – 198.

Garg, B.K.; S.P. Vyas; S. Kathju and A. N. Lahirl. (1998). Influence of water deficit stress at various growth stage on some enzymes of nitrogen metabolism and yield in Cluster bean genotypes. Indian Jour. Of Plant Physiol., (1998), 3 (3) : 214 – 218.

Gawish, R. A. and M. A. Fattahallah (1997). Modification of irrigation requirements of taro (*Colocasia esculenta* L. Schott) through the application antitranspirants. Menofiya J. Agric. Res., 22 (5) : 1353-1387.

Goseve , N. A. (1960). Some Methods in studying plant water relation. Leningrad, Acad. Of Science. U.S.S.R.

Gu, S.; L. H. Fuchigami; S.H. Guah and C. Shin (1996). Effect of short-term water stress, hydrophilic polymer amendment, and antitranspirant on stomatal status, transpiration, water loss and growth in Better Boy tomato plants. J. Amer. Soc. Hort. Sci., 121 (5): 831 – 837.

Guertral. E. A. and J. A. Kemble. (1997). Nitrogen rate and withing – raw plant spacing effects on sweet potato yield and grade. Plant Nutrition J., 20 (2/3) : 355-360.

Gunel, E. and T.K. Karadogan. (1998). Effect of irrigation applied at different growth stage, and length of irrigation period on quality characters of potato tubers. Potato Res., 41 : 9- 19.

Hammett, L. K. and C. H. Miller (1982). Influence of mineral nutrition and storage on quality factors of sweet potato. J. Amer. Soc. Hort. Sci., 107 (6) : 972-975.

Hanson, A. D. (1980). Interpreting the metabolic responses of plants to water stress. HortScience, 15 (5): 623 – 629.

Hegde, D.M. (1987). Effect of soil water potential, method of irrigation and nitrogen on yield, N uptake and water use of radish. Indian Jour. Agron., 32 (1) : 24 – 29.

Herz, P.; H. Stutzel and W. Aufhammer (1993). Adaptation of faba beans to water stress. In Proceeding Second Congress of the European Soc. Of Agronomy (1992) : 86 – 87, ISB No. 951075 83 [C.F.Hort. Abst., 1993, 63 (5) : 3446].

Hill, W. A.; H. Dodo; S. K. Hahn; K. Mulongoy and S. O. Adeyeye (1990). Sweet potato root and biomass production with and without nitrogen fertilization. Agron. J., 82 : 1120 – 1122.

Hogh-Jensen, H. and J.K. Schjoerring (1997). Effects of drought and inorganic N form on nitrogen fixation and carbon isotope discrimination in *Trifolium repens*. Plant Physiol. Biochem., 35 (1) : 55 – 62.

Hsiao, T.C. and E. Acevedo (1974). Plant response to water deficits, water use efficiency and drought resistance . Agric. Meteorology, 14 : 59 – 84.

Hsiao, T.C. (1990). Measurements of plant water status. In : Stewart B.A., Nielsen, D.R., eds. Irrigation of agricultural crops. Agronomy No. 30, Madison, American Society of Agronomy, 243 – 279.

Kim, J.Y.; M.C. Acock; J.O. Garner; C.C. Singletary and M. L. Salin. (1985). Effect of nitrogen fertilization on alcohol Soluble Carbohydrate content of sweet potato roots. HortScience, 20 (3) : 434-435.

Kleemola, J.; M. Teitinen and T.Karvonen (1996). Modelling Crop growth and biomass Paritioning to shoots and roots in relation to nitrogen and water availability, using a maximization principle. Plant and Soil, 185: 101-111.

Knavel, D.E. (1971). The influence of nitrogen and potassium nutrition on vine and root development of the Allgolb sweet potato at early stage of storage root development. J. Amer. Soc. Hort. Sci., 96 (6) : 718 – 720.

Koller, H.R. (1972). Leaf area-leaf weight relationship in the soybean canopy. Crop. Sci., 12 : 180 – 183.

Janick, J. (1979). Horticultural Science. W.H. Freeman and Campany, San Francisco.

Janoudi, A. K.; I.E. Wilder, and J.A. Flore. (1993). Water deficits and environmental factors affect photosynthesis in leaves of cucumber (*Cucumis sativus* L.). J. Amer. Soc. Hort. Sci., 118 (3) : 366 – 370.

Jones, S.T. (1961). Effects of irrigation at different levels of soil moisture on yield and evapotranspiration rate of potatoes. Proc. Amer. Soc. Hort. Sci., 77 : 458 – 462.

Jones, R.; W. F. Hayslett and J.C. Hillsmann. (1985). Sweet potato response to water stress at different stage of growth. HortScience, 20(4) : 654.

Joyce, P.A.; D. Aspinall and L.G. Paleg. (1992). Photosynthesis and the accumulation of proline response to water deficit. Aust. J. Plant Physiol, 19 : 249 – 261.

Lana, E.P. and L.E. Peterson. (1956). The effect of Fertilizer-irrigation combination on sweet potatoes in Buckuuer Carse sand. Proc. Amer. Soc. Hort. Sci., 68 : 400 – 405.

Li, L. and H.F. Yen. (1988). The effects of cultural practices on dry matter production and partition of sweet potato (*Ipomoea batata*, L.). cultivars. J. Agric. Assoc. China, 141 : 47 – 61 [C.F. Field Crop Abst., 41 : 6134, 1980].

Ling, E.R. (1963). Determination of total nitrogen by semimicro – Kgeldahl method. Dairy Chem., 11 : 23 – 84.

Malik, C.L. and M.B. Singh (1980). Plant enzymology and histoenzymology. A Text Manual – Kalynia Publishers. New Delhi.

Marathe, R. P. (1989). Physiological investigation into the differences in survival of finger milet (Fleucine caracand, Gaer tn.) and Soybean (*Glycin max* L.) subjected to moisture stress. MSc. Thesis, University Agric. Sci., Bangalore, India.

Marcano, A. J. and L. A. Diaz (1994). Effect of application of six combination of N, P and K on yield of roots and foliage of sweet potato. Agron. Trop. Macacay., 44 (2) : 317 – 355. [C.F] Soils and Fert., 58 : 12174 , 1995].

Marschner, H.C. (1996). Mineral nutrition of higher plants. Second Edition. Academic Press Limited Text Book, pp. 864.

Martinez, R. L.,; P. J. M. Rodriquez and M. T. O. Morales. (1990). Effect of different nitrogen sources and rates on the yields of sweet potato under spring and dry conditions. Viandas Tropicales, 10 (2) : 63 – 77 [C.F. Soil and Fertilizers, 53 (2) : 2206 , 1990].

Mascianica , M. P.; R. B. Bellinders; B. Graves; R.D. Morse and H. Talleyrand (1985). Forecasting of N-fertilizer requirements for sweet potato. J. Amer. Soc. Hort. Sci., 110 (3) : 358 – 361.

Mishra, S.; S.S. Mishra and U.P. Sinka (1992). Studies on two tier cropping systems of sweet potato in relation to fertility levels and growth regulators . Root Crop. J., 18 (1) : 6-9.

Mohamed, M. B. (1984). Effects of bed preparation and nitrogen fertilization on growth, yield and quality of sweet potato. Acta Hort., 143 (4) : 29 – 34.

Morant-Avice, A.; E. Pradier and R. Honchi (1998). Osmotic adjustment in triticales grown in presence of NaCl. Biologia Plantarum, 41 (2) : 227 – 234.

Nair, G. M. and V. M. Nair (1995). Influence of irrigation and fertilizers on the growth attributes of sweet potatoes. Root Crop. J., 2 (11) : 17 – 23.

Nobel, P.S. (1991). Physiochemical and environmental plant physiology. New York, Academic Press.

Osaki, M.; H. Ueda; T. Shinano; H. Matsui and T. Tadano (1995). Accumulation of carbon and nitrogen compounds in sweet potato plants grown under deficiency of N, P, or K nutrients. Soil Sci. and Plant Natr., 41 (3) : 547 – 555.

Patil, Y.B.; A.A. Patil; B.B. Malalageri and V.S. Patil (1990). Effect of level of N and K on growth and yield of sweet potato. Root Crop. J., 18 (1) : 58-61.

Peuuelas, J.; I. Fillella; C. Biel; L. Serrano and R. Save (1993). The reflectance at the 950 – 970 nm region as an indicator of plant water status. International Jour. Of Remote sensing (1993), 14 (10) : 1887 – 1905 [C.F. Hort. Abst., 1994, 64(2) : 1103].

Plies-Balzer, E.; T. Konge; S. Schubert. And K. Mengel (1995). Effect of water stress on plant growth, nitrogenase activity and nitrogen economy of four cultivars of Vicia faba. European J. Agron., 4 (2) : 167 – 173. [C.F. Field Crop Abst., 1995, 48 (11) : 8225].

Prasad, U.K.; T.N. Prasad; Narayan and A. Kumer (1997). Effects of soil moisture regines on sweet potato yield, potassium balance and water use efficiency. J. of Potassium Res., 13 (4) : 283 – 89.

Purcell, A. E.; W.M. Walter; J. J. Nicholaides; W.W. Collins and H. Chancy. (1982). Nitrogen, Potassium, Sulfur fertilization and protein content of sweet potato roots. J. Amer. Soc. Hort. Sci., 107 (3) : 425 – 427.

Roysell, J.C.; P.H. Travis and L. G. Jones (1974). Effect of irrigation and nitrogen fertilization on quality of sweet potatoes. J. Amer. Soc. Hort. Sci., 19(4) : 308 – 310.

Ruilian, Z. and W. Gang. (1997). Water stress induced changes in protection enzyme activities and effects of proline enhancement on drought resistance peas. Acta Prataculturae Sinica, 1997, 6 (4) : 39 – 43 [C.F. Hort. Abst., 1998, 68 (12) : 10545].

Sadek, U. M. S. (2000). Studies on Bio and Chemical fertilization on sweet potato (*Ipomoea batatas*, L.) Msc. Thesis, Horticulture Science , Faculty of Agric., Mansoura Univ., Mansoura, Egypt.

Said, M. S.; M.A. El-Beheidi, M.A. I. Khalil; M. El-Gazar and O. M. El-Hassan. (1984). Studies on the effect of some cultural practices on sweet potato yield. I. Effect of water supply and nitrogen fertilization. J. Agric. Sci., Mansoura Univ., 9 (3) : 422 – 427.

Schenk, M. K. (1996). Regulation of nitrogen uptake on the whole plant level. Plant and Soil, 181 : 131 – 137.

Shibairo, S.I.; Upadhyaya, M. K. and P. M.A. Toivonen (1998). Influence of pre harvest water stress on postharvest moisture loss of *carrots (Daucus carota* , L.). Jour. Hort. Sci. and Biotechnology, 73 (3) : 347 – 352.

Skinner, R. H.; J.D. Hanson and J. G. Benjemin. (1998). Root distribution following spatial separation water and nitrogen supply in furrow irrigation corn . Plant and Soil, 199 : 187 – 194.

Smittle, D.A. and E. D. Threadgill. (1982) . Response of squash to irrigation, nitrogen fertilization and tillage system. J. Amer. Soc. Hort. Sci., 107 (3) : 437 – 440.

Smittle, D.A.; M.R. Mall and J. R. Stansell (1990) . Effects of irrigation regimes on yield and water use by sweet potato. J. Amer. Soc. Hort. Sci., 115 (5) : 712 – 714.

Snedecor, G. W. and W. G. Cochran. (1981). Statistical Methods. 7th Ed., Iowa State. Univ., Press Amer., Iowa, U.S.A.

Thompson, T. L. and Doerge, T.A. (1995). Nitrogen and water rades for sub-surface trickle-irrigated Romaine lettuce. HortScience, 30 (6) : 1233 – 1237.

Van der Werf, A. and O.W. Nagel (1996). Carbon allocation to shoots and roots in relation to nitrogen supply is mediated by cytokinins and sucrose : Opinion . Plant and Soil, 185 : 21 – 32.

Wanas, N. M. (1979). Studies on some factors affecting the quantity and quality of sweet potato . MSc. Thesis, Faculty of Agric., Minufiya Univ., Egypt.

Wanas , N.M. (1987). Some factors affecting productivity and quality of some sweet potato cultivars . Ph D. Thesis, Agric., Minufiya Univ., Egypt.

Witham, F. H.; D.F. Blaydes and R. M. Devlin. (1971). Experiments in plant physiology . Van Nostrans Reinhold, New York.

Xu, H.; L. Gauthier and A. Gosselin. (1995). Stomatal and Cuticular transpiration of greenhouse tomato plants in response to high solution electrical conductivity and low soil water content. J. Amer. Soc. Hort. Sci., 120 (3) : 417 – 422.

Yeh, T. P.; Y. T. Chen and C. C. Sun. (1981). The effect of fertilizers application on the nutrient composition of high protein cultivars of sweet potato. J. Agric. Assoc. China, 113:33-40. [C.F. Soil and Fert., 46 : 1122 , 1983]

Younis, M. E.; O.A. El-Shahaby; M.N.A. Hassaneen and A.M. Gaber. (1994). Plant growth, metabolism and adaptation in relation to stress conditions. XVII. Influence of different water treatments on stomatal apparatus, pigments photosynthetic capacity in *Vicia faba*. Jour. Of Arid Environment., 1993, 25 (2) : 221 – 232.

Zhang, B. and D. D. Archbold. (1993). Solute accumulation in leaves of *Fragaria chiloennsis* and *F. virginiana* selection responds to water deficit stress. J. Amer. Soc. Hort. Sci., 118 (2) : 280 – 285.

Zhong, L. F.; T. Kato; X. P. Xu and Y. Fukumoto (1989). Comparative studies on the physiological characteristics in solanaceous fruit vegetables. 4 constituents and photosynthetic function. Research Reports of Kochi Univ., Agricultural Science, 38 : 35 – 40 [C. F. Hort. Abst., 1991, 61 (5): 3619].

J. Agric. Sci. Mansoura Univ., 27(11), November, 2002

الإستجابه الفسيولوجية لنبات البطاطا للعطش (نقص الماء) خلال مراحل النمو المختلفة وعلاقتها بتأثير التسميد الأزوتى بمعدلات مختلفة

محمد أحمد عبد الفتاح * ، مرفت إدوارد سوريال ** ، إبراهيم محمد غنيم*
* قسم الخضر – كلية الزراعة – جامعة الإسكندرية
** قسم النبات الزراعي – كلية الزراعة – جامعة المنوفية

أجريت تجربتان حقليتان موسمي ٢٠٠٠ ، ٢٠٠١ بمحطة البحوث الزراعية لكلية الزراعة – جامعة الإسكندرية لدراسة الإستجابة الفسيولوجية لنباتات البطاطا (صنف أبيس) المعرضة للعطش (نقص الماء أو الإجهاد المائي) عند فترات مختلفة من مراحل نموها تحت معدلات مختلفة من السماد الأزوتي (صفر ، ٣٠ ، ٦٠، ٩٠ كجم ن للفدان) وكذلك لدراسة تأثير التفاعل بين معاملات الإجهاد المائي ومعدلات السماد الأزوتي علي النمو والتركيب الكيماوي ومحصول جذور البطاطا وجودته.

فقد عرضت نباتات البطاطا لمعاملات نقص الماء بمنع الري أثناء مرحلة النمو الخضري (بعد ٦٠ يوم من الزراعة) أو أثناء امتلاء وكبر الجذور (بعد ٩٠ يوم من الزراعة) مقارنة بالري العادي بدون تعرض لأي إجهاد مائي تحت ظروف تطبيق المعدلات المختلفة المذكورة من السماد الأزوتي.

وقد بينت النتائج بوجه عام أن تطبيق معاملات الإجهاد المائي أثناء مرحلتي النمو الخضري أو امتلاء وكبر الجذور قد أدي إلي انخفاض معنوي في جميع صفات النمو الخضري متمثلة في طول الساق الرئيسية، عدد الأفرع الجانبية ، المساحة الورقية والوزن الجاف للنبات. كما أدت معاملات الإجهاد المائي إلي انخفاض كل من المحتوي النسبي للماء والجهد المائي لأوراق البطاطا وأيضاً حدوث انخفاض معنوي في محتوي الأوراق من الصبغات المسئولة عن التمثيل الضوئي مثل كلوروفيل أ، ب والكاروتينات وكذلك المواد الكربوهيدراتية الكلية بينما أدت لحدوث ارتفاع معنوي في محتوي الأوراق من كل من السكريات الذائبة الكلية والبرولين.

وفوق كل ذلك أدي تعرض نباتات البطاطا لمعاملات الإجهاد المائي خلال مراحل النمو المختلفة إلي حدوث انخفاض معنوي في محصول النبات الواحد من الجذور سواء بالعدد أو الوزن وكذلك محصول الفدان والمحصول الصالح للتسويق وأيضاً أدت إلي التأثير السلبي علي صفات الجودة لهذه الجذور مثل متوسط وزن الجذر وطول وقطر الجذر ومحتواها من المادة الجافة وكذلك انخفاض معنوي في محتوي الجذور من المواد الغذائية الهامة التي تحدد جودة البطاطا مثل الكاروتين والسكريات المختزلة والنشا والبروتين وكذلك العناصر المعدنية مثل النتروجين والفوسفور والبوتاسيوم.

ومن ناحية أخري بينت النتائج أن تطبيق السماد الأزوتي بجمع المعدلات المضافة قد أدي إلي حدوث زيادة معنوية في جميع صفات المجموع الخضري وكانت هذه الزيادة متناسبة مع زيادة معدل التسميد الأزوتي . كذلك أدي التسميد الأزوتي لزيادة جميع المركبات الكيميائية المقدرة في أوراق البطاطا بينما أدي لحدوث نقص في محتوي الأوراق من السكريات الذائبة الكلية والبرولين.

بالنسبة لتأثير التسميد الأزوتي علي كمية محصول البطاطا وجودته فقد بينت النتائج زيادة معنوية في محصول جذور البطاطا عند تطبيق السماد الأزوتي حتى معدل ٦٠ كجم ن للفدان وزيادة معدل التسميد الأزوتي عن ذلك لم يكن مفيداً في حالة كمية المحصول وجودته.

وبخصوص تأثير التداخل بين معاملات الإجهاد المائي ومعدلات التسميد الأزوتى بينت النتائج أن تطبيق المعدل المتوسط (٦٠ كجم ن/ للفدان) كان له تأثير إيجابي علي تقليل التأثيرات السيئة لنقص الماء علي النمو الخضري والمحتويات الكمياوية للأوراق وكذلك زيادة محصول جذور البطاطا وتحسين جودتها تحت ظروف نقص الماء أثناء مراحل النمو المختلفة وذلك بالمقارنة بالمعدلات الأخرى.

ويمكن من خلال نتائج هذه الدراسة التوصية بتطبيق التسميد الأزوتى بالمعدلات المعتدلة (حتى ٦٠ كجم ن / للفدان) في حالة تعرض نباتات البطاطا لحالات نقص الماء أثناء مراحل النمو المختلفة وذلك لتخفيف الآثار السيئة لتأثير الإجهاد المائي علي نمو ومحصول البطاطا وجودته وكذلك يجب تفادي حدوث نقص النتروجين في التربة أو زيادته باستخدام معدلات عالية اكثر من اللازم لأن ذلك قد يعمل علي زيادة التأثير السيئ لنقص الماء علي نمو محصول البطاطا وجودته.