The Impact of Spraying with Different Concentrations of Seaweed Extract under Different Levels of Mineral NPK Fertilizers on Sweet Potato (*Ipomoea batatas* (L.)) Plants

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ABSTRACT

Two field experiments were carried out at the Agriculture Experimental Station Farm (Abies region), Faculty of Agriculture, Alexandria University; during the two summer seasons of 2013 and 2014. The objective of this study was to assess the response of sweet potato plants (Abies cv.) to the spraying with three concentrations of seaweed extract (0.5%, 0.75% and 1%), as well as a control treatment (spraying with distilled water) under, varying NPK levels of mineral fertilizer (25%, 50%, 75% and 100 % of the recommended rate, in addition to a control treatment, without NPK application) and their interactions on vegetative growth characters , yield and its components as well as on some chemical compositions characters of tuber roots. The results revealed that the gradual increases of NPK fertilizer levels were accompanied with significant increases on sweet potato growth, yield and its components as well as the chemical composition of tuber roots. Spraying of sweet potato plants with seaweed extract at the concentration of 0.75% led to positive response on the all studied traits, in both growing seasons. Generally, the most efficient treatment combination which gave the best sweet potato growth, yield and tuber roots chemical compositions, was the application of NPK mineral fertilizer, at the rate of 75% of the recommended, with seaweed foliar spray at the concentration of 75% . On this regard, it is possible to reduce the NPK mineral fertilization by 25%, through using a foliar spray of 0.75% seaweed extract concentration without compromising the production value of the sweet potato plants, concerning the quantity and quality of tuber roots.

Key words: Sweet potato, *Ascophyllum nodosum* extract, Minimizing NPK mineral fertilizers.

INTRODUCTION

Sweet potato (*Ipomoea batatas* L.) which belongs to the family Convolvulaceae is becoming the most widely distributed root crop in most developing countries. It is grown in almost all soil types in most parts of the tropics and warm temperature regions. Moreover, it is an excellent source of complex carbohydrates, high antioxidants, vitamins (A and B) , starch and nutrients (Woolfe, 1992). Sweet potato is widely used in Egypt as a popular human food, green foliage and unmarketable roots are used as a raw material in many industries such as starch and alcohol.

Plant nutrients are essential for the production of crops and healthy food for the worlds' expanding population. Fertilization is one of the most reliable factors to provide plant nutritional requirements. Among the different nutrients, nitrogen (N), phosphorus (P) and potassium (K) are highly required by plants so are called macronutrients. NPK play so many vital roles in physiological and biochemical processes in plants. The use of chemical fertilizer, organic fertilizer or bio-fertilizer has its advantage and disadvantage in the context of nutrient supply, crop growth and environmental quality (Sadek, 2000). Sweet potato plant's response to fertilization, in general, and to nitrogen and potassium particularly; where, these two elements have been recognized as a vital step in stepping up the tuber roots yield of sweet potato (Purcell *et al.*;1982; Hammett *et al.*;1984; Kamel *et al.*;1990; Feleafel, 2001; Abd El Fattah *et al.*,2002 and Mansour *et al.*;2002). Application of the highest level of P (100% P_2O_5) enhanced mean values of vine length, leaves number and vine fresh weight; also, increased root quantity and quality traits.(Abdel-Razzak, *et al.*;2013).

Many studies in the past three decades have found wide application in modern agriculture for the use of marine macroalgae (seaweeds) as a fertilizer. The most commonly used seaweed is the brown seaweed (*Ascophyllum nodosum*). Seaweed extracts which are now available commercially labeled as Maxicorp (Sea born), Algifert (Marinure), Goemar GA 14, Seaspray, Seasol, SM3, Cylex ,Sea crop 16 and Acadian (Jeanin *et al.*;1991). These products are used as a whole or finely chopped powdered algal manure or aqueous extracts. The use of seaweeds as manure in farming practices is very ancient and common practice among the Romans and also practiced in Britain, France, Spain, Japan and china.

Seaweeds contain all the trace elements and plant growth hormones required by plants. It was reported that seaweed manure is rich in potassium; but, poor in nitrogen and phosphorus in combarison to the farm manure (Tay *et al.*;1987). There are many plant growth hormones, regulators and promoters available to enhance yield attributes (Crouch and Van Staden; 1992 and 1993). Seaweed liquid fertilizers will be useful for achieving higher agricultural production, because of the extract contents. Seaweed extracts have been reported to stimulate the growth and yield of plants (Zamani *et al.*;2013), develop tolerance to environment stress (Zhang and Schmidt, 2000 and Zhang *et al.*;2003) and increase nutrient uptake from the soil (Verkleij; 1992; and Turan and Köse, 2004). Crouch and Van Staden, (1994) reported that liquid extracts, obtained from seaweeds, have been used in modern agriculture and gained importance as foliar sprays to many crops; including various grasses, cereals, flowers and vegetable species.

In recent years, the use of seaweeds in modern agriculture has been investigated by many researchers. Yield and nutritional quality of okra fruits, significantly increased (20.47%) by a liquid seaweed fertilizer (LSF) spray (2.5%), as reported by Zodape *et al.;* (2008). Addition seaweed extracts led to improving the productivity of seed yield and the percentage of protein in broad bean plants (Jasim and Obaid; 2014). Also, application of seaweed extracts recorded significant increases in the percentages of nitrogen , total soluble solids and protein content of potato tubers (Sarhan; 2011 and Haider *et al.*;2012) and led to improve most vegetative growth and fruiting characters of both cucumber and garlic (Obaid *et al.*;2011 and Fawzy *et al.*;2012). While, using seaweed extracts with strawberry crop did not reflect any significant difference on yield and biological yield characters (Prokkola and Kivijärvi; 2007).

Therefore, the goal of this study aimed to determine the impact of foliar spraying of seaweed extracts, as an organic fertilizer, under different levels of mineral NPK fertilizer on growth and yield of sweet potato plants. A special attention was also directed to study the possibility of reducing the rates of the mineral fertilizers NPK, through using some different concentrations of seaweed extracts to maximize the yield and quality of sweet potato tuber roots.

MATERIALS AND METHODS

Two field trials were carried out at the Agriculture Experimental Station Farm, Faculty of Agriculture, Alexandria University; at Abies. A. R. E. during the summer seasons of 2013 and 2014. This study was conducted to evaluate the effect of foliar spraying of brown seaweed extracts (*Ascophyllum nodosum*), under some different levels of inorganic fertilizers (NPK) on sweet potato plants growth, yield and its components of tubers quality as well as some chemical constituents of tuber roots.

Preliminary to each experiment, soil samples from surface layers (0 - 30 cm) of the experimental area were taken at random and prepared to analysis according to the procedures described by Page *et al.;* (1982). The results of soil analyses are shown in Table (1).

Seaweed Extracts Source.

Ascophyllum nodosum extracts are arguably the most widely used and researched seaweed species in agriculture (Senn, 1987). Seaweed extract powder from *Ascophyllum nodosum* (Acadian) was used in this study, ordered from Arman Sabz Adlineh Co., Tehran, Iran. The chemical composition of Acadian extract powder is shown in Table (2).

Experimental Design.

The experimental treatments were arranged in a split-plot system in a randomized complete blocks design (R.C.B.D.), with three replications. Each replicate contained twenty treatments representing all possible combinations among the five levels of NPK fertilizer (0%, 25%, 50%, 75% and 100% of the commercially recommended rate) and the four seaweed extract concentrations (0%, 0.5%, 0.75% and 1%) . The recommended levels of NPK fertilizers for sweet potato commercial production are (20 kg N, 96 kg K_2O and 45 kg P_2O_5 / fed.). Each sub-plot consisted of four rows, 4 m long and 0.7 m wide. The main plots were assigned to represent the five levels of NPK fertilizer; while, the four concentrations of seaweed extract were randomly distributed in the sub-plots of each main plot. A guard row was left without planting to separate each two adjacent sub-plots.

Experimental Work.

The most famous Egyptian sweet potato local cultivar 'Abies', distinguised with a purple skin and sweet orange-flesh, was used in this study. Sweet potato vine cuttings of 20 cm length were planted, at 30 cm within rows, on the 5th of may, in the first and the second seasons. The experimental units received the assigned levels of phosphorus fertilizer, in the form of calcium super phosphate (15.5% P_2O_5), before planting and those of NK, in the forms of ammonium sulfate (20.5% N) and potassium sulfate (48.5% K_2O), respectively. N fertilizer was equally side-dressed to the soil in three diverse intervals; after 3, 7 and 10 weeks from planting. The doses of K fertilizer were equally applied after 3 and 7 weeks from planting. The foliar spraying of the different concentrations of seaweed extract were practiced three times; after 3, 6 and 9 weeks from planting. All other cultural practices such as irrigation and weeding were uniform for all the experimental units.

Data Recorded:

Vegetative growth characters: Four plants were randomly picked up from each sub- plot, two weeks before harvesting (around 100 days from planting),

Table 1: Some soil physical and chemical properties of the experimental sites of the two summer seasons of 2013 and 2014.

Properties / Seasons	Physical				Chemical					
	Sand %	Silt %	Clay %	Texture	pH	E.C. ds.m-1	O.M %	N ppm	P ppm	K ppm
2013	32.34	23.5	44.0	Clay loam	8.04	1.29	1.12	176.00	35.18	500.00
2014	33.17	22.1	43.8	Clay loam	8.16	1.26	2.43	163.72	32.41	459.00

Table 2: The Chemical Composition of Acadian marine plant extract powder from *Ascophyllum nodosum*.

Physical data:	
NPK and mineral (ash)	45 % - 55 %
Moisture	Max 10%
Alganic acid	Min 10%
Mannitol	Min 4 %
Amino acid	Min 4 %
Other organic matter derived from seaweed	Min 20 %
Guaranteed minimum analyses:	
Total nitrogen (N)	0.8 – 1.5 %
Available phosphoric acid (P_2O_5)	1 - 2 %
Soluble potash (K_2O)	17 – 22 %

to measure the following characters: vine length plant^{-1} (cm), number of branches plant^{-1} and number of leaves plant^{-1}.

Tuber roots yield and its components: At harvesting stage (at 120 days from planting), a sample of four plants, from each sub-plot, was randomly chosen to record the following characters: number of tuber roots plant^{-1}, total tuber roots yield (kg) plant^{-1}, marketable tuber roots yield (%) and total tuber roots yield fed^{-1} (ton).

Chemical composition of tuber roots: A random sample of five uniform roots from each sub-plot was carefully washed with distilled water, then weighted and prepaired for some tuber roots chamical analyses. Total carotene as β-carotene (mg 100 g^{-1} fresh weight) was measured, according to Witham, *et al.* (1971). Total sugars %, starch% and carbohydrates % were determined, following the standard methods of association of official analytical chemists (A.O.A.C., 1995).

Statistical Analyses:

All obtained data were statistically analyzed according to the used experimental design, using the computer program Co-Stat Software (2004). The comparisons among the means of the various treatments were achieved, using Duncan's multiple range tests, at 0.05 probability level (Steel and Torrie; 1980).

RESULTS AND DISCUSSIONS

The results regarding the influence of seaweed extract concentrations, varying levels of mineral NPK fertilizer, and their interactions on the vegetative growth characters, roots yield and its components, and chemical constituents of sweet potato tuber roots (Abies cv.) are shown in Tables (3 – 5).

Vegetative growth characters.

Regarding the influence of NPK fertilizer levels, data in Table(3), clearly, reflected significant increments in all studied growth characters of sweet potato plants due to NPK application, compared to the control treatment. The detected increases in all growth characters, in both seasons, were generally corresponding to the increase in NPK levels. However, it was generally noticed that insignificant differences were detected in all studied growth characters due to increasing the applied NPK level from 75% to 100%, in both seasons. These results could probably be generally explained on the basis that the available NPK content in the experimental soil area was apparantly low (Table 1), which reflected the detected high response to the increased supplies of these nutrients. The obtained results are in harmony with those reported by Kamel *et al.* (1990), Feleafel (2001), Mansour *et al.* (2002) and Abdel-Razzak *et al.* (2013); who concluded that the best plant growth of sweet potato plants was attained by the plants that received the commercially recommended rates of NPK fertilizers; in addition to the agreement with the outcome of Arisha and Bardisi (1999) on the potato crop. It was also reported by Sadek (2002) andAbd El- Fattah *et al.*(2002), that the application of N-fertilizer increased gradually and significantly all traits of vine growth of sweet potato plants. Moreover, Schenk (1996) stated that N is the major constituent of numerous products of plant metabolism.

Some positive responses of sweet potato plants to the foliar application of seaweed extract concentrations were noticeable for studied vegetative growth characters (Table, 3). However, the detected increments in vine length, in both seasons, due to seaweed extract application were insignificant . On the other hand, the application of 0.75% and 1.0% concentrations increased significantly the number of branches per plant, in both seasons; whereas, the use of 0.75% concentration number of leaves per plant, relative to the untrated plants, but only in the first season. These results, generally agreed with the findings of Kowalski *et al.* (1999), Sarhan (2011) and Haider *et al.* (2012); who noticed the effect of spraying seaweed extracts on increasing the vegetative growth of potato crop. A possible explanation for the increased plant growth, due to using seaweed extracts, is that the extracts contain auxins,

Table 3: Mean of vegetative growth characters of sweet potato plants 'Abies' cv. as affected by NPK levels, seaweed extract (SWE) concentrations and their interaction, during 2013 and 2014 summer seasons.

Treatments		Vine length Plant^{-1} 2013	Vine length Plant^{-1} 2014	No. of branches plant^{-1} 2013	No. of branches plant^{-1} 2014	No. of leaves plant^{-1} 2013	No. of leaves plant^{-1} 2014
NPK %							
0 %		117.41 *D	117.08 C	3.41 C	3.75 C	122.33 D	152.58 D
25 %		156.91 C	165.33 B	4.58 B	4.33 B	165.33 C	178.91 C
50 %		168.58 B	167.75 B	4.83 AB	4.75 B	185.16 BC	191.75 B
75 %		181.58 A	175.33 AB	5.17 AB	5.42 A	204.50 AB	206.08 A
100 %		183.67 A	183.58 A	5.25 A	5.42 A	214.91 A	211.58 A
SWE Cons.							
0 %		156.60 A	158.73 A	4.2 B	4.33 B	169.33 B	180.80 A
0.50 %		162.93 A	157.53 A	4.33 B	4.20 B	177.26 AB	191.13 A
0.75 %		162.80 A	167.53 A	5.00 A	5.23 A	185.53 A	190.53 A
1.0 %		164.14 A	163.47 A	5.16 A	5.13 A	181.66 AB	190.26 A
NPK% X SWE Cons.							
NPK 0 %	0 %	111.00 e	108.67 e	3.29 d	3.33 e	102.67 h	136.00 g
	0.50 %	122.67 e	124.33 de	3.33 d	3.33 e	136.67 fg	165.67 ef
	0.75 %	119.33 e	118.33 e	3.67 d	4.00 c-e	125.33 gh	163.67 e-g
	1.0 %	116.67 e	117.00 e	3.33 d	4.33 b-e	124.67 gh	145.00 fg
NPK 25%	0 %	138.67 de	141.33 cd	4.00 cd	3.67 de	165.33 d-f	169.33 d-f
	0.50 %	163.67 b-d	162.67 bc	4.00 cd	4.00 c-e	168.33 c-e	182.00 c-e
	0.75 %	162.00 cd	174.33 ab	5.00 a-c	5.00 a-d	166.00 d-f	176.00 de
	1.0 %	163.33 b-d	183.00 ab	5.33 ab	4.67 a-e	161.67 ef	188.33 a-e3
NPK 50%	0 %	161.00 cd	167.33 b	4.33 b-d	4.00 c-e	161.67 ef	174.67 de
	0.50 %	175.33 a-c	159.67 bc	4.00 cd	3.67 de	181.00 b-e	200.00 a-d
	0.75 %	162.67 cd	181.33 ab	5.34 ab	5.67 ab	194.33 a-d	183.67 b-e
	1.0 %	175.33 a-c	162.67 bc	5.33 ab	5.67 ab	203.67 ab	208.67 a-c
NPK 75%	0 %	180.00 a-c	178.33 ab	4.33 b-d	5.00 a-d	199.33 a-c	209.67 a-c
	0.50 %	175.67 a-c	165.33 b	5.00 a-c	5.00 a-d	196.33 a-d	197.00 a-d
	0.75 %	194.67 a	184.00 ab	5.67 a	6.00 a	206.33 ab	219.00 a
	1.0 %	176.00 a-c	173.67 ab	5.67 a	5.67 ab	203.00 ab	198.67 a-d
NPK 100%	0 %	192.67 ab	198.00 a	5.00 a-c	5.67 ab	217.67 a	214.33 ab
	0.50 %	177.33 a-c	175.67 ab	5.33 ab	5.00 a-d	204.00 ab	211.00 a-c
	0.75 %	175.33 a-c	179.67 ab	5.00 a-c	5.67 ab	222.67 a	210.33 a-c
	1.0 %	189.33 a-c	181.00 ab	5.67 a	5.33 a-c	215.33 a	210.67 a-c

* Values followed by similar letter (s), within a comparable group of means, do not significantly differ, using Duncan' s multiple range test, at 0.05 level.

gibberellins, and precursors of ethylene, betaine and cytokinins, which are present and potentially involved in enhancing plant growth responses (Crouch and Van Staden; 1993).

The results concerning the effect of the first-order interaction between the two studied main factors are presented in Table (3). Generally , some positive significant interaction effects on mean values of vine length plant^{-1} (cm), number of branches plant^{-1}, and number of leaves plant^{-1} were noticed in both growing seasons. It is apparent the addition of NPK fertilizers at the rates of 75% with the foliar spray with 0.75% of seaweed extracts led to marked increases on the mean values of all above mentioned characters. The favorable influences of seaweed extract application on the studied vegetative growth characters appeared to be in a general agreement with the results obtained by Crouch and Van Staden, (1993); who indicated that the growth characteristics; like plant height, fresh weight and leaf area; of *Arachis hypogaea* were enhanced due to the seaweed liquid fertilizers (SLFs) treatments individually as well as along with chemical fertilizers.

Tuber roots yield and its components.

The results of the effects of NPK fertilizer levels, seaweed extract concentrations and their interactions on the tuber roots yield and its components of sweet potato are listed in Table (4). Regarding the influences of NPK fertilizer levels, the results reflected clearly that the mean values of the characters; number of tuber roots plant^{-1}, yield plant^{-1} (kg), marketable yield (%) and total yield fed^{-1} (ton); increased generally by increasing the NPK level up to 75% level. Most of the detected increments were found significant in all characters of root yield and its components, in both growing seasons. However, the application of the highest level (100% NPK) did not result in a further significant increase in the mean values of the four previously mentioned characters. Only one exception was recorded in the character total tuber roots yield fed^{-1} (ton), which gave significantly a higher mean value at 100% NPK than that of 75% NPK, in the two studied seasons. These results reflected a general correspondence with those obtained by Arisha and Bardisi (1999) on potato plants.

Positive responses of sweet potato plants to foliar application of seaweed extract concentrations were noticed on tuber roots yield and its components characters. Among the foliar spray of seaweed extract treatments, the highest mean values of number of tuber roots plant^{-1}, tuber roots yield plant^{-1} (kg), marketable tuber roots yield (%) and total tuber roots yield fed^{-1} (ton) were generally recorded for the level of 0.75% foliar spray with insignificant mean values from those of 1.0% foliar spray, during the two successive seasons. These results refelected similar trends to those reported by Kowalski, *et al.* (1999), Sarhan (2011) and Haider *et al.* (2012), who studyied the effect of spraying seaweed extracts on increasing the productivity of potato crop.

The results concerning the effect of the first-order interaction between the two studied main factors are presented in Table (4). The interaction had a positive and significant effects on mean values of number of tuber roots plant^{-1}, tuber roots yield plant^{-1} (kg) , marketable tuber roots yield (%) and total tuber roots yield fed^{-1} (ton), in both growing seasons. Generally, it was that the addition of NPK fertilizer at the rate of 75% NPK with 0.75% of seaweed extract led to marked increases on the mean values of the four mentioned characters. The favorable influences of seaweed extracts application on tuber roots yield and its components could be related to the vital role of seaweed extracts as plant growth stimulants on the increase of the availability of nutrient supply, improving the efficiency of macro-elements as well as its ability to meet some micro-elements requirements of the crop; as mentioned by Sridhar and Rengasamy (2010 and 2012), who studied the possibility of spraying seaweed extracts to reduce the required amounts of NPK as a mineral fertilization for both the peanut and pepper plants.

Tuber roots chemical composition.

Concerning the results of the effects of NPK fertilizer levels, seaweed extract concentrations and their interactions on the tuber roots quality of sweet potato, viz. total sugars(%), starch(%), carbohydrates (%) and carotene (mg 100 g^{-1} fresh weight); are listed in Table (5). The results showed that using different levels of NPK mineral fertilizer of the commercially recommended rate led to significant increments on the mean values of total sugars, starch, carbohydrates and carotene contents, in both seasons. Among the various used levels of NPK fertilizers, the two highest one (75% NPK and 100% NPK) produced significantly higher mean values for all above mentioned characters; and insignificant differences between the two high levels. The results of Purcell *et al.* (1982), Hammett *et al.* (1984), Kamel *et al.* (1990), Feleafel (2001) and Mansour *et al.*(2002), generally, refelected similar trends to those obtained in the present study. These investigators observed that sweet potato plant's responsed to fertilization, in general; and to N and, K in particular, that were recognized as a vital step in stepping up the tuber roots yield of sweet potato.

Regarding the main effect of seaweed extract concentrations, the results showed that increasing the concentration of seaweed extract led to significant increases on the mean values of total sugars, starch, carbohydrates and carotene contents;

Table 4: Mean of root yield and its components of sweet potato plants 'Abies' cv. as affected by NPK levels, seaweed extract (SWE) concentrations and their interaction, during 2013 and 2014 summer seasons.

Characters / Treatments		Number of tuber roots plant^{-1}		Total tuber roots yield (kg) plant^{-1}		Marketable tuber roots yield (%)		Total tuber root yield Fed^{-1} (ton)	
		2013	2014	2013	2014	2013	2014	2013	2014
NPK %									
0 %		1.42 *D	1.25 D	0.29 D	0.34 D	57.88 C	59.48 D	1.53 E	1.73 E
25 %		2.58 C	2.75 C	0.87 C	0.80 C	82.18 B	81.28 C	5.00 D	4.94 D
50 %		4.32 B	4.17 B	1.39 B	1.32 B	86.84 AB	85.16 B	8.18 C	8.00 C
75 %		5.33 A	5.00 A	1.66 A	1.83 A	90.80 A	90.39 A	11.38 B	11.29 B
100 %		5.25 A	5.10 A	1.73 A	1.80 A	90.85 A	91.95 A	12.56 A	12.31 A
SWE Cons.									
0 %		3.46 B	3.27 C	0.96 C	1.12 C	73.98 B	78.19 B	6.56 D	6.60 C
0.50 %		3.60 AB	3.40 BC	1.12 B	1.22 B	81.84 A	82.44 A	7.27 C	7.30 B
0.75 %		4.10 A	3.87 AB	1.30 A	1.22 A	84.49 A	83.01 A	8.36 A	8.15 A
1.0 %		4.00 A	4.10 A	1.37 A	1.31 A	89.53 A	82.97 A	8.72 A	8.56 A
NPK% X SWE Cons.									
NPK 0 %	0 %	0.67 d	0.67 d	0.18 j	0.28 i	30.76 e	47.62 i	0.29 j	0.39 k
	0.50 %	1.67 c	1.00 ef	0.23 j	0.24 i	63.12 d	67.94 g	1.44 i	1.84 j
	0.75 %	1.67 c	2.00 de	0.35 j	0.42 hi	64.87 d	61.27 h	2.02 hi	2.01 j
	1.0 %	2.00 c	2.00 de	0.38 j	0.38 hi	72.76 cd	61.09 h	2.34 h	2.68 ij
NPK 25 %	0 %	2.67 bc	2.67 cd	0.68 i	0.57 gh	75.15 b-d	77.44 ef	3.37 g	3.45 i
	0.50 %	2.67 bc	3.00 cd	0.83 hi	0.92 ef	78.56 a-c	76.75 f	5.00 f	4.62 h
	0.75 %	2.33 c	2.33 d	0.93 g-i	0.73 fg	86.61 ab	84.66 b-d	5.78 e	5.68 g
	1.0 %	2.67 bc	3.00 cd	1.03 f-h	0.97 e	88.42 ab	86.32 a-d	5.87 e	6.01 fg
NPK 50 %	0 %	3.67 b	3.67 bc	1.20 eg	1.07 de	82.37 a-c	82.49 d-f	6.99 d	6.80 ef
	0.50 %	3.67 b	3.67 bc	1.18 eg	1.22 cd	87.09 ab	83.49 c-e	7.15 d	7.28 e
	0.75 %	5.00 a	4.33 ab	1.55 b-d	1.40 c	89.42 a	87.14 a-d	8.57 c	8.69 d
	1.0 %	5.00 a	5.00 a	1.63 a-c	1.60 b	88.49 ab	87.53 a-d	10.03 b	9.26 cd
NPK 75 %	0 %	5.33 a	5.00 a	1.41 c-e	1.61 b	89.61 a	90.56 a-c	9.73 b	10.09 bc
	0.50 %	5.00 a	4.33 ab	1.66 a-c	1.84 a	89.73 a	92.49 a	10.37 b	10.38 b
	0.75 %	5.67 a	5.33 a	1.94 a	1.83 a	91.45 a	92.31 a	12.78 a	12.28 a
	1.0 %	5.33 a	5.33 a	1.92 a	1.78 ab	92.45 a	90.24 a-c	12.65 a	12.41 a
NPK 100 %	0 %	5.33 a	5.00 a	1.33 a-c	1.88 a	92.02 a	92.87 a	12.45 a	12.27 a
	0.50 %	5.00 a	5.00 a	1.67 a-c	1.86 a	90.72 a	91.54 ab	12.41 a	12.42 a
	0.75 %	5.67 a	5.33 a	1.73 ab	1.70 ab	90.15 a	89.69 a-c	12.65 a	12.13 a
	1.0 %	5.00 a	5.00 a	1.90 a	1.75 ab	90.50 a	89.68 a-c	12.74 a	12.45 a

* Values followed by similar letter (s), within a comparable group of means, do not significantly differ, using Duncan' s multiple range test, at 0.05 level.

but, with insignificant differences between the two high concentrations (0.75% and 1.0%), in the two growth seasons. These results could be attributed to the effect of seaweed extract concentrations on increasing the absorption of nutrients and on photosynthesis process, that led to more accumulation of metabolites in reproductive organs; which, in turn, improved the potato tuber quality (Gawish *et al.;* 1994 and Haider, 2012). The results illustrated also that the mean values of the four studied characters under 0.5% concentration of seaweed extract were not high enough to differ significantly from those of the control treatment; in the first season, 2013.

The differences between the mean values of the contents of total sugars, starch, carbohydrates and carotene appeared to be significantly influenced by the interaction effects between the different levels of NPK fertilizer with the different concentrations of seaweed extract, in the two seasons. The combinations between the each of three concentrations of the seaweed extract; 0.5%, 0.75% and 1.0%; with NPK mineral fertilization of 75% or 100%, did not reflect any significant differences for the mean values of the four studied characters, during the two seasons.

Table 5: Mean of chemical constituents of sweet potato roots 'Abies' cv. as affected by NPK levels, seaweed extract (SWE) concentrations and their interaction, during 2013 and 2014 summer seasons.

Treatments \ Characters		Total sugars (%)		Starch (%)		Carbohydrates (%)		Total carotene (mg /100g fw)	
		2013	2014	2013	2014	2013	2014	2013	2014
NPK %									
	0 %	7.04 *C	6.45 C	9.08 D	9.54 D	16.14 D	15.99 D	3.46 C	4.06 D
	25%	7.06 C	6.95 BC	11.03 C	11.24 C	18.30 C	18.19 C	4.62 B	4.90 C
	50%	7.27 BC	7.13 B	13.51 B	12.59 B	20.56 B	19.72 B	4.85 B	5.03 C
	75%	7.80 AB	8.11 A	15.71 A	15.57 A	23.74 A	23.88 A	5.95 A	5.65 B
	100%	8.15 A	8.12 A	15.92 A	15.78 A	23.87 A	23.69 A	6.17 A	6.31 A
SWE Cons.									
	0 %	6.90 B	6.79 C	12.30 B	11.83 B	19.21 B	18.63 B	4.77 B	5.04 B
	0.50 %	7.42 AB	7.34 B	12.42 B	13.06 A	19.83 B	20.40 A	5.04 B	4.92 B
	0.75 %	7.73 A	7.76 A	13.66 A	13.35 A	21.38 A	21.11 A	5.19 A	5.22 AB
	1.0 %	7.81 A	7.51 AB	13.86 A	13.53 A	21.67 A	21.04 A	5.05 A	5.58 A
NPK% X SWE Cons.									
NPK 0 %	0 %	6.62 c-e	6.12 ef	8.79 h	7.98 h	15.41 j	14.10 k	3.21 hi	4.15 hi
	0.50%	6.8 b-e	5.96 f	8.58 h	10.63 fg	15.37 j	16.59 ij	2.89 i	3.52 i
	0.75%	7.59 a-e	7.12 b-d	9.20 h	9.30 gh	16.79 ij	16.42 j	4.16 e-i	4.33 g-i
	1.0%	7.25 a-e	6.61 c-f	9.77 h	10.26 fg	17.02 hj	16.87 hj	3.6 g-i	4.23 hi
NPK 25 %	0 %	6.56 de	6.43 d-f	10.09 gh	10.46 fg	16.65 ij	16.88 hj	4.69 d-g	4.74 f-h
	0.50%	7.54 a-e	7.26 b-d	9.97 h	11.63 ef	17.51 g-j	18.89 fg	5.11 b-f	5.01 d-h
	0.75%	7.42 a-e	7.20 b-d	11.92 fg	11.39 ef	19.33 f-i	18.59 f-i	4.62 d-g	4.47 g-i
	1.0%	7.57 a-e	6.89 c-e	12.17 f	11.52 ef	19.74 e-h	18.41 g-j	4.04 f-i	5.39 b-g
NPK 50 %	0 %	6.46 e	7.26 b-d	12.39 ef	10.66 fg	18.85 f-i	17.92 fg	5.06 b-f	5.07 d-h
	0.50%	7.09 b-e	6.96 c-e	12.92 d-f	12.44 e	20.02 e-g	19.40 ef	4.78 c-g	4.84 e-h
	0.75%	6.85 b-e	7.22 b-d	14.17 c-e	13.06 de	21.03 d-f	20.29 ef	5.17 b-f	5.08 d-h
	1.0%	7.77 a-e	7.06 b-d	14.58 cd	14.21 cd	22.35 b-e	21.27 de	4.42 e-h	5.12 d-h
NPK 75 %	0 %	6.71 b-e	6.65 c-f	14.73 cd	14.85 bc	21.44 c-f	21.50 de	5.38 b-f	5.28 c-h
	0.50%	7.55 a-e	8.59 a	14.95 b-d	15.66 a-c	22.5 b-e	24.25 a-c	5.21 c-h	6.03 ab
	0.75%	8.71 a	8.61 a	17.17 a	16.93 a	25.88 a	25.54 a	6.22 ab	5.84 a-f
	1.0%	8.25 ab	8.58 a	16.94 ab	15.69 a-c	25.18 ab	24.27 a-c	6.17 ab	6.29 a-c
NPK 100 %	0 %	8.18 a-c	7.52 bc	15.54 a-c	15.24 a-c	23.72 a-d	22.76 cd	5.48 b-e	5.96 a-e
	0.50%	8.13 a-d	7.93 ab	15.65 a-c	14.96 bc	23.78 a-d	22.89 b-d	6.40 ab	6.02 a-d
	0.75%	8.08 a-d	8.65 a	15.84 a-c	16.07 ab	23.91 a-c	24.72 ab	5.8 a-d	6.41 ab
	1.0%	8.23 ab	8.40 a	15.84 a-c	16.02 ab	24.07 a-c	24.42 a-c	6.99 a	6.85 a

* Values followed by similar letter (s), within a comparable group of means, do not significantly differ, using Duncan' s multiple range test at 0.05 level.

The results, generally, illustrated that the addition of NPK fertilizer, as 75% of recommended rate, combined with spraying seaweed extract, at 0.75% resulted in the highest mean values in all the above mentioned treats. These results reflected the general trends of the finding of Gawish *et al.*(1994) and Haider (2012).

CONCLUSIONS

From the mentiend results, it could be concluded that the tuber roots yield and its components of sweet potato were significantly enhanced in response to the application of NPK fertilizer, as 75% of the commercially recommended rate, in combination with spraying seaweed extract, at the concentration of 0.75%. Accordingly, the negative impact of using NPK mineral fertilizer could be reduced by 25%, as a result of using a seaweed extract natural alternatives to replace one fourth of the mineral fertilization, without any prejudice to the value of the quantity and quality of sweet potato crop.

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الملخص العربى

تأثير رش تركيزات مختلفة من مستخلصات الأعشاب البحرية تحت مستويات مختلفة من الأسمدة المعدنية (ن- فو- بو) على نباتات البطاطا الحلوة

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أجريت هذه الدراسة بمحطة البحوث الزراعية بمنطقة أبيس، والتابعة لكلية الزراعة- جامعة الإسكندرية، خلال الموسميين الصيفيين لعامي ٢٠١٣ و٢٠١٤. وتهدف الدراسة إلى تقييم مدي استجابة نباتات البطاطا(صنف أبيس) للرش بتركيزات مختلفة من مستخلصات الاعشاب البحرية بمعدلات مختلفة (٠,٥%، ٠,٧٥% و ١,٠%)، بالإضافة إلى معاملة المقارنة(صفر % الرش بالماء المقطر) وذلك مع مستويات مختلفة من السماد المعدنى(ن- فو- بو)، وذلك بإستخدام نسب مختلفة(٢٥%، ٥٠%، ٧٥% و١٠٠ %) من المعدل الموصى به فى الإنتاج التجارى للمحصول، بالإضافة إلى معاملة المقارنة(بدون إضافة سماد من ن- فو- بو)، وكذلك تقييم تأثير التداخل بينهم على صفات النمو الخضرى، المحصول ومكوناته وكذا بعض الصفات الكيميائية لجذور البطاطا المتدرنه.

وقد اظهرت النتائج بصورة عامة أن الإضافات التدريجية لمستويات السماد المعدنى(ن- فو- بو) قد أدت إلى زيادات معنوية على نمو نباتات البطاطا وكذلك على المحصول ومكوناته. كما أظهرت النتائج أن رش نباتات البطاطا بمستخلص الأعشاب البحرية بتركيز ٠,٧٥% قد أدى إلى استجابة إيجابية على جميع الصفات موضع الدراسة خلال موسمى النمو. وعموما، فإن التوافق بين تأثيرات المستويات المختلفة من العاملين المدروسين قد أظهرت أن المعاملة العاملية التى أعطت أفضل نمو خضرى للنباتات وأعلى محصول كلى من الجذور الدرنية- وكذلك مكونات المحصول- وأعلى قيم لمحتويات الجذور من التراكيب الكيماوية المدروسة، أتضح أنها المعاملة العاملية التى تشمل إضافة الأسمدة المعدنية(ن- فو- بو) بمعدل ٧٥% من الكميات الموصى بها فى الإنتاج التجارى للمحصول، وذلك مع الرش الورقى للنباتات بمستخلص الأعشاب البحرية بتركيز ٠,٧٥%.

ومن ذلك يتضح أن الرش الورقى بمستخلص الأعشاب البحرية بتركيز ٠,٧٥%، يؤدى إلى تقليل إستخدام التسميد المعدنى(ن- فو - بو) بمعدل ٢٥% من الكميات التى تستخدم فى الإنتاج التجارى مع المحافظة على النمو الخضرى الجيد، وكذلك الإنتاج للجذور الدرنية، كما ونوعا.