Effect of Seaweed Extract on the Growth and Productivity of Potato Plants

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Abstract

The present study aimsto study the effect of algaeextract (AE) on the growth and production of the potato plants ʻSpunta ćv.Therefore, two field experiments was carried during two spring seasons of 2017 and 2018 in Baniays, Syria. It included 4 treatments as control treatment (without treating the tubers), spraying the plants with AE atof 200 mg / l, soaking the tubers + spraying the plants,and (soaking the tubers in the given rate). Thesetwo experiments were conducted as completely randomized design with 4 replications for each treatment (15 plants per replication).

The gained results showed that the treatment with the Algae extract at the given rate(200mg/l); resulted in increases the germination of the tubers, increased the plants growth attributes as leaves number, the leaf area,tubers number, and the plant production. Thesoaking treatment of the tubers ,and spraying the plants treatments showed a clear significant increases in the leaf area, the plant production and the tubers content dry matter and the starch which recorded the highestpercent values comparing with the other treatments whereas, dry matter recorded 19.4%, and starch percentage content was 13.3 %, meanwhile, control plants showed less values 14.9 % and 9.3 %,respectively.

Keywords - *potato, amino acid, soaking, spraying, yield.*

I. INTRODUCTION

Potato *(Solanum tuberosum* L.) is considered one of the major crops as a food stable crop in the world where it ranks the fourth place after wheat, rice and maize [20].Also, it comes first of the tuberous crops where the worldwide planted area is more than 20 million hectares of the total area that planted with tuberous vegetables which is 50 million hectares [14]. Potato crop occupiesa high rankin Syria, among the other cropswhere it comes in the second place after tomato in terms of the area that planted with vegetables where the total cultivated area is more than 23 thousand hectares distributed on three seasons,whereas the Autumn *ca.*50 % of allocated area, followed by that of Spring season 40%,and finally The Summer *ca.* 10% [4].

Owing to population increase; caused a progressive increased demand for food especially the food stable crops as potato , a good nutritional crop ,rich source of energy comparing with other starchy crops that are very important on the global scale such as wheat and rice .So, the researchers recently focused their efforts on the usage of modern agricultural techniques that could achieve higher production of both quality and quantity to meet the steady increase of the population .In order to achieve this objective new agricultural techniques were adopted such as using the seaweeds extracts which are rich of many promotive substances (plant growth promoters) and humic and non humic compounds which are ecologically safe as a modern technique designed to activate the plant growth, the plant production and improving its quality [10] .

The seaweed extracts were defined as materials for improving the plant growth [23]. They were used for many centuries [12], which were used as nutritional materials and vital catalysts for producing agricultural crops and used as improving or ameliorative materials for soil characteristics due to adding as dressing agents, in addition to use itas a foliar spraying in order to increase the growth and the production of many agricultural crops [24].

These materials,also, had an important role in accelerating the germination and increasing the growthofmanycrops which led to early maturation and an increase their production [3].

Soaking seeds of both the *Capsicum* (peppers)and eggplants before germination in nourishingand organic solutions activated the germination accelerated the growth of the seedlings andimproved their quality [9]. The seaweeds extractsimproved the vegetative growth through providingthem with plants growth regulators (auxins, gibberellins, cytokinins and abscisic acid) in addition to the macronutrients NPK , and other nutrients (Fe, Cu, Mo, Mn, Zn, Co, Ni) as well as amino acids and vitamins [11].

In this respect[21] explained the positive effect of the seaweed extracts when using the compound (Kalpak) *via*foliar application and irrigating the potato plants contributed significantly in increases the vegetative growth , leafnutrients´ content , mass production ,and tubers quality .The results of [29] showed that soaking potato before planting in the seaweed extract solutions;led to increasesthe plant height, stems number,and leaf area which recorded

9700 cm^2upon using Yakil that contains Alpesris, Rangiferina, Lodonia, Arbuscula),and 3700 cm^2upon using Laminaria, compare to control treatment leaf area(2000 cm^2). Also, soaking the tubers before planting had an vital role in supporting the development of the total weight of both the plant and the tubers after 60,70, 80 days of the planting which contributed to the increase of the mass production per hectare. Foliar spraying of pepper plantswith the seaweed extracts which contain *Ascophyllum nodosum* contributed to increase the vegetative growth of the *Capsicum* plants (peppers) and their productivity as well as the increase in the concentration of some nutrients[13].Seaweeds extracts contain the necessary nutrients for plant growth and developmentas the macronutrients (K P N) and the micronutrients (Fe, B, Mg, Zn, Mo,Cu) as well as the plant hormones such as auxins, gibberellins, and cytokinins. These hormones, when added to the soil or sprayed on the plants, stimulate roots growth, increase the stem thickness and the vegetative growth via increasing the efficiency of the photosynthesis which causes an increase in the plant production [25].

Because of the economical importance of the potato crop and its role in achieving the food security. The increase of its production is considered asa crucial requirement for meeting the steady consuming need.In order to overcome this obstacle,good agricultural practices (GAP) are the reasons behind using the given or defined undependable variables as seaweed extracts and methods of potato seed manipulations.

So, this research aimed at studying the effect of the seaweeds extract ´SPRINT´ aglae on the vegetative growth performance of potato and its tubers´ yield bothquantitatively and qualitatively.

II. MATERIALS AND METHODS

A. Experimental site and plant materials treatments

Research was conducted in Tartus governorate in Almroug nearby Banias city,Syria.Potato cultivar ´Spunta´ was used as aplant material in this study (a mid –seasoncrop).The used foliar applicant was ´SPRINT´ algae.It is a liquid extract from seaweeds (Macrosetes, Ascofilm, Srasom) which contains Nitrogen and organic Carbon of plant origin 12 % produced by an the Italian firm Biolchim.The research included the following treatments:

T1 : The control (without treating the tubers with the tested compound) .

T2 : Spraying the plants with compound .

T3 : Soaking the tubers in the compound + spraying the plants with it .

T4 : Soaking the tubers in the compound .

Tubers were soaked before planted in the compound ´Sprint algae´ at a rate of 200 mg / l of water for 8 hours before the laboratory germination and for 2 hours before planting them in the soil .In the treatments 2 and 3 , the plants were sprayed after 2 weeks from the field germination at a rate of 200 mg/l of water and sprayed three times , once every ten days.

B. Cultivation operations

Cultivation was conducted on 10/2 in lines separated by a distance of 70 cm and with 30 cm between the plants in the same line and a plant density of 4.76 plant/m^2.

The field was cultivated, the sterilized and dry fertilizer was added with 200 g/ m^2, 60 g of a slow soluble and complex granulated fertilizer (Yara Mila) TE+ Mg 4.7+12:6:18.Irrigation was conducted using surface irrigation in addition to all the care practices (hoeing, Incubation, secondary fertilizing with Urea at a rate of 15 g/m^2 in addition to the protective spraying from the disease the Early Blight (*Alternaria solania)* using the fungicide Floerx WP (Mancozeb at 650g /kg, Kiralaxyl at 400 g/kg at a rate of 250g/ 100 l of water) that is executed during planting potato .Tubers were planted on February in two seasons 2017 and 2018.

C. Studied Parameters

The study included the following characters:

2-3-1 Time spanned until seed germination (day).

2-3-2 The number of the air stems/ plant.

2-3-3 plant height (cm).

2-3-4 leaf area of the plant (cm^2) : The plant leaf surface area was calculated in the stage of the complete full growth (the flowering stage) and the calculation was done using the program Digimizeraccording to [15] and according to the following formula :

The area of the leaf surface = the total weight of the vegetative canopy × the area of the leaf sample / leaf sample weight

2-3-5The leaf surface indicator was calculated by usingthe following formula:

The leaf surface area of the plant (cm^2) /the area of the plant occupying (cm^2)[8].

2-3-6) The average of tubers weight g/ tuberwas calculated as the tuber total weight of the plant / the tubers´ number.

2-3-7) The efficacy of photosynthesis (g/cm^2 / day) was calculated according to following formula:

$(w_2-w_1)(\text{Log}A_2-\text{Log}eA_1)/(A_2-A_1)(T_2-T_1)$

W_1: The dry weight of the leaves (g) at the first measurement.

W_2 : The dry weight of the leaves (g) at the second measurement .

T_1 : The first time for the plant that its dry weight was evaluated (day) .

T_2 : the second time for the plant that its dray weight was evaluated (day) .

Loge : the natural Logarithm .

A_1= The plant leaves area (cm^2) at the first phase.

A_2 =The plant leaves area (cm^2) at the second phase [19].

2-3-8) Tubers classification according to the weight,where The tubers were divided according as follows : small tubers (the tuber`s weight is less than 35 g ) , medium tubers ( the tuber`s weight is between 35-80g) and large tubers (the tuber`s weight is more than 80 g)[16] .

2-3-9) The plant yield(g/ plant)was calculated from result of the plant tubers × the average of the tuber`s weight .

2-3-10) yield of the area unit (kg / durum)was calculated from the result of
plant yield × the plant density in the area unit .

2-3-11) The compound efficacy % was calculated from the following formula:
100 × (thecropyieldof thecompound treated treatment -the cropyield in the control treatment)/(thecropyield in the compound treated treatment)according to [7]

2-3-12)The tubers dry matter (%) of the tubers by drying at (105 ° C) until the weight is costant .

2-3-13) The starch percentage(%) was determined as starch percentage as follows:
%= 0.891+17.55= (thedry materials percentage – 24.18) [6].

D. Experiment design and the treatments

The completely randomized design was adopted in conducting the experiments where they included 4 treatments with three replications for each one and 15 plants in each replication. Results were statistically analysed using program Genstat-12 to Low Significant Difference was calculated at a level of significance 5% comparing with the averages.

III. RESULTS AND DISCUSSION

A. The effect of treating with algae extracts ´Sprint´ on germination percentage and some other vegetative growth attributes

The gainedresults (Table 1) showed the positive effect of soaking the tubers inthe tested compound ´Sprint´ algaeontime spanned to accelerate the germination of seeds which was obvious in the two treatments of both soaking and soaking+ spraying. The seed germination occurred after 28 days of planting in both treatments, while it elapsed 36 days in case of spraying treatment which extended 34 days in the control treatment. This finding may be taken placedue to accelerating the growth and early maturity of the crop especially in the spring in the coastal area to achieve preferable income due to the high price of the crop during that time. The results, also, showed that soaking the tubers caused an increase in the air stem numbers. Both treatments of soaking significantly (p<0.05) surpassed the other two treatments, where the number of the air stems in the treatment of (spraying + control)was 4.7 stems and 4.9 stems in the soaking treatment. Both treatments of spray and control recorded stem numbers as 2.8 and 3 stems,respectively.

Concerning the main effect of the compound ´Sprint´ algae on the plant height, the attained results demonstrate the significant (p<0.05) surpass of the treatments soaking + spraying and spaying over the control one, where the stems´ height recorded 52,49,48 cm for the treatments spraying + soaking , spraying and soaking; consecutively, while it was 43 cm for thecontrol plants.

With reference to the area of the leaf surface ,therecorded results showed a significant (p<0.05) surpass for the treatments of ´Sprint´ algae over the control treatment , where the treatment soaking + spraying recorded the highest area of plant leaf surface (88892 cm^2 / plant) and the largest indicator of a leaf surface (2.4).It significantly (p<0.05)exceeded the other treatments, as well as spraying treatment alone surpassed the soaking treatment where the area of the leaf surface recorded 8066 cm^2 / plant and an indicator of 3.8 compare with the soaking treatment, where the recorded leaf surface area was 7097 cm^2 / plant,and the indicator was 3.4 for the soaking treatment,while leaf area of the control pant was 5600 cm^2/plant and the indicator was 2.7. This finding could be interpreted on the basis that increased leaf surface area and its indicator refer to the efficacy of photosynthetic process and assimilates accumulations and transport from source and preserved in the sink(tubers). The representative efficacy was calculated where is found that the treating with the compound sprint algae; led to significant superiority of all treatments over the control which achieved an efficacy of 0.001 g/ cm^2/day,upon comparing the treatments one to other, it was found that soaking and spraying together with the compound ´Sprint´ algaeextract presented higher efficacy with a significant superiority over the other treatments with a value of 0.0065, followed by the spraying treatment which significantly surpassed the soaking treatment and recorded a value 0.0032, and the least one was the soaking treatment where it recorded a value of 0.0017 g/cm2/day.

The reduced time spanned till germination and increasing of aerial stem number may be taken placebecause of the content of the seaweeds extracts of auxins which had a functional role in activating the cells division and increasing them which led to activating the buds growth, increasing the number of the formed cells in addition to its role in increasing the leaf surface area which positively reflected on the indicator of the leaf surface, the dry weight of the plant [17] as well as their role in activating macronutrients N,P, K which had the in activating the vegetative and the root growth of the plant and that would increase the rate of the representative photosynthesis of the plant so increase the production of the dry materials [5].

These results were matching with those ofPotato [18], and watermelon [22].

B. The effect of treating with the extract ´Sprint´algae onclassification the tubers and thepotatoyield

Results of Table (2) showed the presence of significant differences among the treatments where the plant yield of small tubers were reduced owing to the treatment of soaking in the tested extract, where their percentage of the total yieldwas 1.9 %,and was 2% in the treatment of spraying + soaking in comparison with the control treatment which its yield of small tubers was 5 % of the total plant yield. The medium tubers was 7 % of the treatment soaking + spraying, 8 % of the spraying treatment, and 10.5 % in the soaking treatment compare with the control treatment where the medium percentage of the medium tubers was 10%.

Concerning the plant yield of the large tubers, it was found that all treatments significantly (p<0.05) surpassed the control one. The treatment of soaking + spraying; recorded the highest yield of this class of tubers with significant differences with the other treatments.The plant yield of the largetubers

Was1237 g with a percentage of 91% . Also , the plants that sprayed with the tested extract;yielded tubers which recorded 966 g/ plant with a percentage (90 %) and it significantly (p<0.05) surpassed the soaking treatment where it yielded 869 g / plant with a percentage (86.6 %) , while the control treatment producedlarge tubers was 611 g with a percentage (85 %) .

C. The effect of treating with the extract on some of the productive characteristics and its efficacy

The results of the table (3) showed that soaking the tubers contributed to the increase the tubers´ number with significant differences (p<0.05) from thecontrol treatment. Spraying treatment where the differences were insignificant (p>0.05) between them. The tuber numbers per plant were 6 , 8.2 , 8 tuber/ plant for control treatments , spraying and soaking ;respectively , while the highest averages of tubers weight were for the treatment of spraying + soaking was as 166 g and 165.5 g for the spraying treatment, where they significantly (p<0.05) surpassed the treatments of control and soaking .

Concerning the productivity of the plant , results showed an increase in the productivity of the area unit when using the seaweeds extract ´Sprint aglae´ where the treatment of soaking+ spraying; produced the highest and largest productivity as 6797/kg/dunums and it significantly surpassed the control and the soaking where the productivity ofthe dunums was 5122 kg/dunums ,while the soaking treatment,significantly (p< 0.05),surpassed the control treatment; where the productivity of the dunum 4722 and 3427 kg/dunums ,consecutively.Concerning the market production (i.e. the total production of the medium-sized tubers), all treatments surpassed the control as well as recordedthe highest average of the market productiondue to the treatments of spraying (49%), soaking +spraying (89 %) and (43%) for soaking treatment

Treatment	Time spanned until germination(day)	Stems number /plant	Plant height (cm)	Surface leaf area (cm^2)	Surface leaf indicator	Representative efficacy (g/ cm^2 /day)
T1	^{a}34	^{b}3	^{b}43	^{d}5600	^{d}2.7	^{d}0.001
T2	^{a}36	^{b}2.8	^{ab}49	^{b}8066	^{b}3.8	^{b}0.0032
T3	^{b}28	^{a}4.7	^{a}52	^{a}8892	^{a}4.2	^{a} 0.0065
T4	^{b}28	^{a}4.9	^{ab}48	^{c}7097	^{c}3. 4	^{c}0.0017
LSD %	4.4	0.55	4.8	169.4	0.08	0.0005
CV(%)	9	4.9	6.6	1.5	1.5	10.9

Table (1). Percentage and the average values of seed germination and indicators of some vegetative growth (averages of two seasons) as affected by ´Sprint algae´ extract treatments.

Table (2)Average values and counterpart percentages of classified tubers and the yield of potato (average of two seasons) as affected by´Sprint´algae extract treatments.

Treatment	Tubers weigh (g / plant)						Total yield (g/plant
	Small tubers (g/plant)	%	Medium tubers (g/plant)	%	Large tubers (g/plant)	%	
T1	38b	5.0	71.0a	10	611.0d	85.0	720d
T2	25c	2.0	85.0b	8	966.0b	90.0	1076b
T3	28c	2.0	96.0ab	7	1237.0a	91.0	1361a
T4	19a	1.9	104.0a	10.5	869.0c	87.6	992c
LSD (5 %)	6.18	-	12.3		68.9	-	47.6
CV (%)	12		9		4.9		3

compare to the control treatment.

This noticeable increments (%) in the leaf surfacearea reflects its efficient indicator for photosynthetic capability and its positively effect on the productive qualities of the plant that was due to their content of nitrogen which reflect positively quantitatively and qualitatively on tubers´ production [28], in addition to their content of Potassium that facilitates the transportation of the photosynthetic assimilates from the leaves(source) to the tubers (sink) [30].These results are consistent with what the founds of on the plant of Tomato[26].

D. The effect of treating with the extract ´Sprint´ algae on the tubers´ dry matter and starch contents

Leaf surface area causedby the treated plants and its indicator as well as the production of the plant where the efficacy of the photosynthesis is closely related. The accumulation of the dry matter decreases as the decrease or the increase of indicator value of the leaf surface area over the domain (2.5 -7). Also,the changes of starch content in the tubers are positively and strongly related to the changes of the dry material, whereas the starch is the main component of the dry matter. Indeed,the change in the rate of the dry matter is accompanied by the change in the rate of the starch in the tubers [2,1]. It was observed in the Figure (1) that all experimental treatments surpassed the control onein terms of the rate of both the dry matter and the starch contents in the tubers , while the differences were taken place between the treatments of soaking and spraying; where the dry matter rates recorded 19.4 , 17.8 , 17.6 , 14.9 % and the starch rate was 13.3 , 11.9 , 11.7 , 9.3 % in the treatments of Soaking + spraying , spraying , soaking and control respectively . The reason behind this finding might

Table (3). Average and percentages values ofsome productive qualities as affected by Sprint algae extract efficacy.

Treatment	Average tubers number plant/tuber	Tuber weight average g	Total productivity		Market production		Compound efficacy	
			Area unit productivity dunum/kg	Percent of the control	Market production dunum/kg	Percent of the control	Percent of the total production	Percent of the market production
T1:Control	6.0 b	120.0b	3427.0d	-	3246d	-	-	-
T2: Spraying sprint algae	6.5 b	165.5a	5122.0b	49	5003 b	54	33	54
T3: soaking +spraying sprint algae	8.2a	166.0a	6478.0a	89	6345a	95	47	95
T4: soaking sprint algae	8.0a	124	4722.0c	43	463c	43	29	43
LSD (5%)	1.3	13.2	226.6	-	156	-	-	-
CV(%)	11.2	5.9	3.0	-	2.3	-	-	-

be due to the influence of the algae extract contents of auxins that activate the hormones and thevitamins biosyntheses in the plant tissues, in addition to their content of iron which stimulates the efficacy the photosynthesis which cause an increase the accumulated the photosynthetic assimilates in the tubers.

The positive effect of the seaweed extracts (the extract Kalpak) on the vegetative growth , the leaf surface area and its indicator and the content of both the leaves and the tubers of the nutrientswhich lead to an increase in the production of the plant as well as improving the tubers quality and their content of the dry material and the starch has been reported[27].

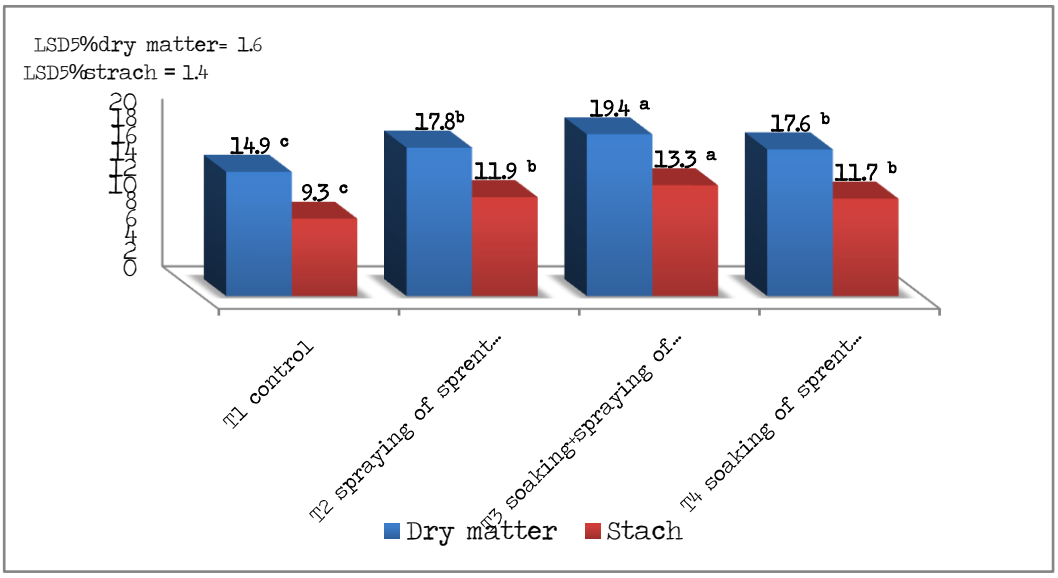

Figure (1) the effect of the treatment with the extract on the tubers content of the dry material and the starch(average of two seasons).

IV. CONCLUSIONS

In brief, the present study provides the following:

1-Treating potato plants with Sprint algae extract led to; activating the vegetative growth, increasing the yield quantitatively and qualitatively.

2-The treatments of soaking and spraying potatotubers increased the potato tubers amount and improvedboth quality and weight, as well as increased the tubersdry matter and starch contents comparewith the other treatments .

SUGGESTIONS

1-Using the compound of the extract ´Sprint algae´via soaking the tubers and foliar application with a rate of usage 200 mg/ liter of water.

2-Conducting further researches and studies about using different kinds of organic humus fertilizers and unhumus on different kinds of vegetative crops in different environmental regions of the country.

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