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Effect of foliar application with zinc and auxin on some morphological, physiological and productivity parameters of potato plant cv. Sponta

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Abstract:
The present study was carried out in Homs province, Syria, during the period from 2020-2021, to study the effect of foliar application with zinc (0, 0.5, 1 g/l), and auxin IAA (0, 25, 50 ppm) and their interactions on growth and productivity of potato plant cv. Sponta. The chemical analysis was carried out in the laboratories of Faculty of Agriculture, Damascus University. The study contains 9 treatments and the data was calculated using Simple Random Design. The combination treatment of zinc (1 g/l) and IAA (50 ppm) resulted in the best morphological parameters (59.09 cm, 5.85, 168.84 cm^2 for plant height, stem number/ plant and leaf area respectively), physiological parameters (25.41 %, 18.49 %, 9.95 % for dry matter, starch, total soluble solids, respectively), and productivity parameters (6.38, 242.57 g, 36.95 ton/ hectare for tubers number/ plant, tubers weight, productivity). The lowest values for all studied parameters, however, were obtained in control plants.

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تأثير الرش الورقي بالزنك و الأوكسين في بعض المعايير المورفولوجية و الفيزيولوجية والإنتاجية لنبات البطاطا صنف Sponta

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الملخص:

أجريت هذه الدراسة في محافظة حمص، سوريا، خلال الفترة ما بين 2020 و 2021 بهدف دراسة تأثير الرش الورقي بعدة تراكيز من الزنك (0، 0.5، 1 غ/ل) و الأوكسين (0، 25، 50 ppm) و التفاعل بينهما في نمو وإنتاجية نبات البطاطا صنف سبونتا. تم إجراء التحليل الكيميائي في مختبرات كلية الزراعة، جامعة دمشق. شملت هذه الدراسة على 9 على معاملات و حللت النتائج باستخدام التصميم العشوائي البسيط. أعطت معاملة التفاعل بين الزنك (1 غ/ل) و الأوكسين (50 ppm) أفضل المؤشرات المورفولوجية (59.09 سم، 5.85، 168.84 سم ^{2} بالنسبة لارتفاع النبات، عدد السيقان، المساحة الورقية على التوالي)، المؤشرات الفيزيولوجية (25.41 %، 18.49 %، 9.95 % بالنسبة للنسبة المئوية للمادة الجافة، النشاء، المواد الصلبة الذائبة الكلية على التوالي)، والمؤشرات الإنتاجية (6.38، 242.57 غ، 36.95 طن/هكتار بالنسبة لعدد الدرنات/نبات، وزن الدرنات، الإنتاجية). وذلك، بالمقارنة مع الشاهد الذي أعطى أخفض القيم بالنسبة لجميع المؤشرات المدروسة.

الكلمات المفتاحية: البطاطا، سبونتا، الرش الورقي، الزنك، الأوكسين، مؤشرات مورفولوجية و فيزيولوجية و إنتاجية.

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1. Introduction:

Potato (Solanum tuberosum L.) considered one of the vital cultivated crops in the world besides wheat, rice and corn because of its importance as a source of minerals, carbohydrates, and vitamins. Potato tuber has a lot of nutritional energy and protein per unit (McGill *et al*., 2013, 467). It is considered as one of the major food sources in the world (Anonymous, 2008). The yearly worldwide potatoes production is around 368.25 million metric tons, reaped from a territory that came to about 17.580 million hectares (ha) (FAO, 2018).

Potato (Solanum tuberosum L.) is a leading staple food in the world's population (Mona *et al.*, 2012, 5100). It provides a part of daily caloric needs of human and delivers many essential nutrients and vitamins including potassium, phosphorus, manganese, magnesium, folate, vitamin C and vitamin B-6 (Haynes *et al*., 2012, 192). Moreover, it gives a bulk dry matter and yield per unit area in comparison with other crops such as cereals, therefore Potato is considered as a heavy nutrient requiring crop (Haynes *et al.,* 2012, 192; Bari *et al*., 2001, 1090).

The micronutrients on the other hand though are required in small amount but play a great role in plant metabolism (Katyal, 2004, 3; Kazi *et al*., 2012, 4118). Zinc is an essential micronutrient which plays a macro role in the growth and productivity of the plants, and it is an important component of enzymes that drive and increase the rate of many important metabolic reactions involved in crop growth and development (Potarzycki and Grzebisz, 2009, 519). The symptoms of zinc deficiency are visible generally in younger leaves, starting from chlorosis resulting to a decrease in shoot development and shortening of internodes, little leaf etc. (Kiran, 2006, 1). Potato plants responded positively to foliar application of zinc and produced maximum production of roots (El-Baky e*t al.*, 2010, 386).

Potato is highly responsive to fertilization. Micronutrients are essential elements for plant growth and development which are utilized in trace amounts by plants. Among Zinc (Zn) play several physiological roles in plants. Zinc activator enzymes which are responsible for the synthesis of certain proteins. It is use in the formation of chlorophyll and some carbohydrates, conversion of starches to sugars and its presence in plant tissue helps the plant to withstand cold temperature. Zinc is essential in the formation of auxin, which help with growth regulation and stem elongation. (Haynes *et al.*, 2012, 192). In spite of knowing the importance of nitrogen and physiological roles of zinc in plants, thus this trial was aimed to study the Impact of nitrogen and zinc on quality, yield and economics of potato (Solanum tuberosum L.) Cultivar *Kufri* Himsona.

Zinc maintains active state of auxin and lack of it leads ta excessive destruction of auxin due to an increase in oxidation. It is also essential for the function and structure of aldolases, dehydrogenases, phosphatases, aspartate transcarboxylase and isomerase (Auld, 2001, 89). Protein synthesis is markedly influenced through some action of Zn and also influenced in photosynthesis by the speedy release of respiratory CO2. The retardation of protein synthesis is appeared due to Zn deficiency. It is an essential element useful for carbohydrate and phosphorus metabolism and synthesis of RNA and chlorophyll formation (Pandey and Sinha, 2006, 132).

Auxin NAA is commonly used in horticultural crops to boost up the remarkable vegetative propagation and helps to promote plant growth by enhancing the cell division, cell elongation and cell differentiation which may initiate the development of plant organs and essentially required for the formation of root cambium and epicycle which may induce the formation of lateral roots. It also affects the physiological process, hasten maturity and produces better quality fruits and some other aspects such as to increase the number of branches, increased fresh weight, and yield as well as induces early flowering and prevents flower and fruit drop (Gurjar *et al*., 2018, 3157; Surendar *et al*., 2020, 5144).

The aim of this study is to investigate the effect of foliar application with zinc and auxin on some morphological, physiological and productivity parameters of potato plant.

2. Material and methods:

A field experiment was conducted during summer season of 2021-2022 on sandy, loamy soil of private farm at Homs province, Syria, to study the effect of zinc and auxin on growth and productivity of potato plant cv. Sponta (early ripening variety, drought tolerant, virus resistant, high yield with oval shaped tubers).
Chemical analysis was performed at the Laboratory of plant physiology, Faculty of Agriculture, Damascus University.
The soil was plowed up to a 0.35 cm depth, then planted in terraces form with 75×30 cm.
During the experiment period, plants were irrigated and fertilized as recommended for potato plant. Organic fertilizer was added (1 ton/donum) before planting, chemical fertilizer NPK (50 kg/ donum for sodium super phosphate added 15 days before planting, 1 kg/ donum for urea 46% added 15 days after planting) was added at a rate of 2 gm/ l for three times after planting. Cut seedy explants were used as plant material. The soil samples were taken and analyzed to be described physically and chemically as shown in table (1).

Table (1): The physical and chemical characters of the soil before experiment implementation

K_2O available	**P_2O_5 available**	**N total**	**Organic matter**	**EC Extract 5:1**	**pH suspended**	**mechanical analysis of soil (%)**		
mg/kg		%		$ds.m^{-1}$	(2.5:1)	Clay	silt	Sand
386.5	4.42	0.12	2.4	0.65	7.8	52.8	18.3	28.9

- The treatments:

Zinc soleplate was applied as foliar sprayed at three concentrations (0, 0.5, 1 g/l). Auxin IAA was sprayed at three concentrations (0, 25, 50 ppm).

- The experiment treatments were as follows:

• Un-Treated control.
• Treatment with Zn at a concentration of 0.5 g/l.
• Treatment with Zn at a concentration of 1 g/l.
• Treatment with IAA at a concentration of 25 ppm.
• Treatment with IAA at a concentration of 50 ppm.
• Treatment with Zn at a concentration of 0.5 g/l + IAA at a concentration of 25 ppm.
• Treatment with Zn at a concentration of 0.5 g/l + IAA at a concentration of 50 ppm.
• Treatment with Zn at a concentration of 1 g/l + IAA at a concentration of 25 ppm.
• Treatment with Zn at a concentration of 1 g/l + IAA at a concentration of 50 ppm.

- Treatments (with zinc and auxin)were applied three times (30, 50 and 70 days after planting).
- The study included 9 treatments, each treatment was repeated for three time, where, each replicate contains 10 plants. A Complete Random Block Design was used. Results were analyzed using the statistical analysis program (XL-STATE, 2016).
- The averages were compared according to fisher's test and calculated the least significant differences (LSD) at the level 95 % of significance.

- The Studied parameters:

1) Morphological parameters:

After 90 days of planting, Plant height (cm), number of stems per plant and leaf area (cm^2) were calculated.

2) Physiological parameters:

After 120 days of planting Total Soluble Solids (TSS %) Content in tubers was determined using digital refractometer.
tuber dry matter (%) was calculated in according to Eshu (2014) as follows:
tuber dry weight / tuber fresh weight * 100
Starch (%) was calculated as follows:
Starch (%) =17.55 + 0.891 (% dry matter – 182.24) (A.O.A.C, 1970).

3) Productivity parameters:

After harvesting (120 day from planting) Tubers number and weight (g) were determined as well as the total tubers productivity (ton/ hectare).

3. Results and discussion:

1. Effect of treatment with Zn and IAA on morphological parameters:

The effect of foliar application with zinc and auxin on growth parameters (plant height (cm), stems number/ plant and leaf area (cm^2)) is presented in Table (2).

It was obvious that all tested treatments improved growth parameters comparing with control. The highest plant height (59.09 cm), stems number/ plant (5.85) and leaf area (168.84 cm^2) were observed in the combination treatment of Zn (1 g/l) and IAA (50 ppm). Meanwhile, the lowest values (34.21 cm, 2.87 and 89.41 cm^2 for the plant height, stems number/ plant and leaf area respectively) were recorded in control plants.

Zinc is a micronutrient which is required for plant growth and development relatively in small amount. (Cakmak, 2000, 185).

It is main building part of some enzymes (Marschner, 2012, 178) and plays an important role in regulating the auxin concentration in plants which promotes the growth and development of plants. It may also be pointed out that growth and development of plants depend upon physiological and metabolic activity of plants influenced by application of zinc (Kiran, 2006). Moreover, The promotion effect of auxin that observed in the present study was in agreement with those obtained by several authors Tapdiya *et al* (2018, 2151) and Chanwala *et al.* (2019, 1846). The significant influence of NAA observed in this experiment might be attributed to the physiological effects of auxins on growth parameters of plants that induces cell division and elongation resulting in increased plant growth. The similar trend was also reported by Awati *et al* (2016, 1) studied effect of foliar application of plant growth regulators on growth and yield of potato seed tubers. The results indicated that application of 100 ppm NAA significantly affected on plant growth parameters like crop height and main shoot diameter.

Table (2): The morphological parameters of potato plant in according to studied treatments.

Treatments	Plant height (cm)	stem number/ plant	Leaf area (cm2)
Control	34.21 h	2.87 d	89.41 h
ZN=0.5 g/l	36.94 g	3.59 c	98.54 g
Zn=1 g/l	44.23 e	3.81 c	116.72 e
IAA=25 ppm	41.56 f	3.65 c	109.72 f
IAA=50 ppm	45.92 d	3.91 c	131.56 d
Zn=0.5 g/l + IAA=25 ppm	44.23 e	5.03 b	136.07 d
Zn=0.5/l + IAA=50 ppm	48.29 c	4.94 b	145.14 d
Zn=1 g/l + IAA=25 ppm	53.79 b	5.01 b	156.93 b
Zn=1 g/l + IAA=50 ppm	59.09 a	5.85 a	168.84 a
LSD 0.05	1.66	0.39	4.86

The same letters at the level of columns indicate no significant differences at the 0.05 significance level.

2. Effect of treatment with Zn and IAA on physiological parameters:

Data presented in Table (3) show the effect of treatment with zinc and auxin on dry matter (%), starch concentration (%) and total soluble solids (%). The lowest values (19.23 %, 13.63 % and 7.25 % for dry matter, starch concentration and TSS respectively) were observed in control plants. Meanwhile, the best values (25.41 %, 18.49 %, 9.95 % for dry matter, starch concentration and TSS respectively) were recorded when Zn (1 g/l) was added in combination with IAA (50 ppm).

Zinc plays a fundamental role in several critical functions in the cell such as protein metabolism, gene expression, structural and functional integrity of bio membranes and photosynthetic carbon metabolism (Cakmak, 2000, 185). Zinc also is an important co factor in chlorophyll biosynthesis, photosynthesis consequently, organic compounds formation (Ranji *at al*., 2003, 3). As well as, Zinc has an important role in

formation of amino acids, proteins, carbohydrates, ATPas, RNA, and enzymes activities. (Halvin *et al*., 2005).

This promotion effect of zinc might be due to the direct effect of zinc in regulating the auxin concentration in plants and is an essential component of enzymes which promotes the growth. (Marschner, 2012, 178).

Auxin also, is an important growth promoter that induce and enhance the vegetative growth, increase the leaf content of photosynthetic pigments. (Civello *et al.,* 1999, 1273)

Table (3): The physiological parameters of potato plant in according to studied treatments.

Treatments	Dry matter (%)	Starch concentration (%)	Total solid sugars TSS (%)
Control	19.23 e	13.63 d	7.25 d
ZN=0.5 g/l	20.28 de	14.01 d	7.90 c
Zn=1 g/l	21.36 cd	14.55 cd	8.17 c
IAA=25 ppm	21.33 cd	15.19 c	8.81 b
IAA=50 ppm	21.99 c	15.58 c	9.20 b
Zn=0.5 g/l + IAA=25 ppm	21.65 c	15.38 c	9.07 b
Zn=0.5/l + IAA=50 ppm	24.15 b	17.75 ab	9.16 b
Zn=1 g/l + IAA=25 ppm	23.85 b	17.21 b	8.97 b
Zn=1 g/l + IAA=50 ppm	25.41 a	18.49 a	9.95 a
LSD 0.05	1.2	1.1	0.59

The same letters at the level of columns indicate no significant differences at the 0.05 significance level.

3. Effect of treatment with Zn and IAA on productivity parameters:

Zn application either alone or in combination with IAA significantly increased tubers number/ plant, tubers weight (g) and productivity (ton/ hectare) (Table, 4), However, the highest values (6.38, 242.57,36.95 for tubers number/ plant, tubers weight (g) and productivity (ton/ hectare) respectively) were observed when Zn and IAA were added in combination at 1 g/l and 50 ppm respectively.

Zinc plays an important role in increasing the photosynthesis and biomass production and yield when using in small amount (Pedler*et et al.,* 2000, 120; Kiran, 2006).

Zinc also participates as a main part of many enzymes such as alcohol dehydrogenase, carbonic anhydrase, superoxide dismutase that is needed for the root development and increasing the absorption of carbon dioxide per leaf area unit and this increasing the photosynthesis and biomass production and yield (Pedler *et al.*, 2000, 120; Kiran, 2006).

Concerning auxin effect, Auxin has a direct role in improving fruits quality (weight, length, diameter) due to the improving and promoting the vegetative growth, increasing leaf area and photosynthesis, carbohydrate formation which has a positive and direct effect on fruits quality (Techawongstein, 1989, 30). Jakhar *et al*. (2018, 3402) indicated that application of NAA at 300 ppm to the sprouting broccoli significantly increased the chlorophyll content in leaves consequently increase carbohydrate concentrations and the total biomass which improve the growth and productivity. Additionally, Gurjar *et al*. (2018, 3157) found that foliar application of 25 ppm NAA produced superior growth (plant height, number of branches/ plants, number of leaves/plant and shoot girth), and productivity.

Table (4): The productivity parameters of potato plant in according to studied treatments.

Treatments	Tubers number/ plant	Tubers weight (g/ tuber)	\productivity (ton/ hectare)
Control	3.55 g	137.66 g	23.56 g
ZN=0.5 g/l	4.50 f	164.76 f	26.79 f
Zn=1 g/l	5.01 de	186.76 e	28.63 e
IAA=25 ppm	4.72 ef	185.96 e	31.11 d
IAA=50 ppm	5.87 b	199.14 d	33.39 bc
Zn=0.5 g/l + IAA=25 ppm	5.48 bc	203.32 cd	32.38 cd
Zn=0.5/l + IAA=50 ppm	5.31 cd	205.62 c	33.47 bc
Zn=1 g/l + IAA=25 ppm	5.63 bc	224.44 b	34.52 b
Zn=1 g/l + IAA=50 ppm	6.38 a	242.57 a	36.95 a
LSD 0.05	0.44	5.44	1.83

The same letters at the level of columns indicate no significant differences at the 0.05 significance level.

4. Recommendation:

This study recommends that foliar application of a combination of Zn (1 g/l) and IAA (50 ppm) promote growth, improve physiological characters and enhance the productivity parameters.

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