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THE SPRAYING EFFECT OF ZINC AND SALICYLIC ACID AND THEIR COMBINATION ON THE GROWTH AND PRODUCTION OF CHERRY TOMATO PLANT

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Abstract

The experiment was conducted at the field of horticulture and gardening engineering, College of Agriculture, University of Diyala during the autumn season of 2018-2019. The aim of this trial is to study the effect of spraying with zinc and salicylic acid on the concentration of nitrogen, phosphorus and potassium elements in plant leaves and leafy area, and the yield of cherry tomato (cultivar of BATLLE) in order to understand some physiological effects of adding zinc and salicylic acid. The experiment was set up in Randomized Complete Block Design (RCBD) and replicated thrice. Zinc element was sprayed in the form of chelated Zinc in three levels 0, 50, 100 mg.L, which are symbolized by Zn0, Zn50, Zn100 respectively. Salicylic acid was sprayed in four levels 0, 50, 100, 150 mg/L, which are symbolized by SA0, SA50, SA100, SA150 respectively. The results show that the Zn100 treatment was significantly the highest in term of concentrations of phosphorus and potassium in plant leaves and leafy area and plant yield. Spraying the plant with high levels of salicylic acid SA 150 resulted in a significant increase in all the characteristics under study when raising the concentration. Raising the concentration salicylic acid from (0) mg/L to (150) mg/L increased the concentration of nitrogen, phosphorus and potassium elements in the leaves and leafy area and the yield of the plant by 0.51%, 16.3%, 31.5%, 46.0%, 34.2%, respectively. The combination between the two treatments (Zn, SA) of the experiment significantly affected the studied research characteristics. The treatment (Zn100 + SA150) was significantly higher than other experiment parameters for all the characteristics under study.

Key words : Salicylic acid, Chelated Zinc, cherry tomato, physiological effects.

Introduction

Tomato (*Solanum lycopericum* L.) belongs to Solanum family. It is believed that the original home of tomato, South America (Peru and Mexico) entered from South America to Europe in the early sixteenth century and then to the rest of the world (Kalogeropoulos, *etal.,* 2012). In Iraq, Tomato is very important crop because of its nutritional importance as it is used fresh, cooked or in the form of manufactured food products the usual tomato Regular tomatoes are from cherry tomatoes and have an important nutritional value as they contain vitamin A, B and C. Consumption of cherry tomatoes is beneficial to the general health of man because of its contents of phytochemicals such as lycopene, B- carotene, folic acid and fructose, and many other essential nutrients such as phosphorus, potassium, magnesium and calcium (Filgueira, 2013). It is also an important source of antioxidant compounds such as polyphenols and carotenoids (Kalogero poulos *et al*., 2012) that work to prevent cancer and cardiovascular diseases. The size of cherry tomatoes ranges from thumbs to the size of a golf ball. They contain energy of 75.4 J, water of 94.5 gm, protein of 0.9 gm, fats of 3.9 gm, calcium of 10 mg, potassium of 237 mg, vitamin of A 833 J and vitamin of C 12.7 mg in 100 g (Singh *et al.*, 2017). Cherry tomato is characterized by higher productivity, high quality and enjoys excellent acceptance by the consumer because of its high sweetness and distinctive taste better than ordinary tomato (Preczenhak *et al*., 2014).

Salicylic acid is one of the hormonal organic phenolic acids, naturally extracted from the leaves and saliva of

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the *Salix* tree. It is used as a natural growth regulator. The name Salicylic is derived from the Latin word *Salix*, and is the name for the genus *Salix* spp. The chemical formula Salicylic acid (C6H4 (OH) COOH) is in the form of crystals (Khafaji 2014). Salicylic acid leads to increased plant tolerance to stresses caused by high and very low temperature and high salinity (Senaratna et al. Khan *et al.*, 2010) and plays an important role in plant resistance to pathogens (Metraux. 2001). Salicylic acid also has important effects on important physiological processes related to plant development and growth in normal conditions, including controlling the transfer and absorption of ions, speeding up the formation of carotene and chlorophyll pigments, permeability of cellular membranes, accelerating photosynthesis and increasing the activity of some important enzymes (Hayat *et al*., 2007).

Zinc is one of the most important micro nutrients in plant nutrition. It has a great morphological, physiological and biochemical effect on the plant. It is a synthetic component of a number of enzymes including Alcohol deyhdrogenase (Cu / Zn-SOD) Copper-Zinc superoxide dismutase, Carbonic anhydrase (CAH) and RNA Polymerase (Gokhan *et al*., 2003). Zinc is an auxiliary enzyme for aldolase, Isomerase, and Carboxy-peptidase (Kim *et al*., 2006). The zinc element has precise physiological functions in living systems, as it is considered the main component of thousands of proteins in the plant, and that a large number of these proteins need it to resist environmental stresses. It is an essential element in the composition of the plasma membrane, and works to protect the plant tissue from oxidation (Broadly *et al*., 2006). Zinc participates in many physiological functions within the plant, as it contributes to the formation of the amino acid (Tryptophan), which is the origin of oxins in the plant and is necessary for the elongation of cells. It is also an important and necessary component of the phosphorylation and the formation of glucose. For example, when plants suffer from a deficiency of this element, the starch formation process stops (*et al*., 2009 Akhtar). Zinc also participates effectively in other vital functions, including its role in the metabolism of nucleic acids RNA and DNA. It also increases vitamin C and a complex vitamin of B group. In addition to its contribution to the formation of pollen and the formation of chlorophyll, it also increases the plant's ability to absorb several elements from the soil (Alloway, 2008). The lack of zinc in the grain of the crops causes serious problems in human nutrition, especially child nutrition, and leads to loss of appetite, delayed growth, muscle retardation, slow wound healing and disorders of the immune system. As one of the most important physiological roles of this element in biological systems is its role in protein synthesis, since about 2,800 human proteins have the ability to bind to zinc. Therefore, its deficiency within the plant directly affects the zinc deficiency present in humans (Gibson, 2006). This is observed in different regions of the world such as India, Pakistan, China, Iran and Turkey (Brown, 2004 and Hotz). In Africa, reports of Harvest Plus (2007) show that there are 500-600 million people at risk because of their low zinc. Sillanpaa (1990) indicated in his studies of the presence of zinc in the world that all soil samples taken from separate regions of Iraq suffer from a deficiency of zinc to a degree there is almost no difference between them. He pointed out that the soil of Iraq is the lowest in terms of containing zinc from the soil of 30 countries included in the study. He explained that the agricultural crops produced in all regions of Iraq suffer from a clear shortage of this element, and this is a major problem in the agricultural field and its implications for public health, which requires Highlight and great attention.

Materials and Methods

The experiment was carried out at the fields of the College of Agriculture, Diyala University in sedimentary soils with alluvial clay textures classified as Typic Torrifluvent. Table 1 shows some of the chemical and physical properties of the soil (Page *et al.,* 1982). The experiment was carried out according to a global experiment system in the order of Randomized Complete Block Design (RCBD), with three replicates. Two factors (Salicylic acid and Zinc) were used spraying on the plant in which the first one was sprayed in four concentrations (0, 50, 100, 150) mg/L, which are symbolized by SA0, SA50, SA100, SA150 respectively. Zinc element was sprayed in the form of Chelated Zinc (Zn-EDTA), containing 14% of Zinc in three concentrations 0, 50, 100 mg/L, which are symbolized by Zn0, Zn50, Zn100 respectively. The two factors (Salicylic acid, Zinc) were sprayed three times during the plant season. The field soil was prepared in several steps, starting from removing the weeds, after which the land was ploughed, smoothed and levelled well. The experiment contained 12 beds with three replicates for each treatment. The width of the beds was 80 cm and the distance between the bed and the other (40 cm) as a walkway for the purpose of serving the crop. Two lines were planted on each bed and the distance between one plant and another was 40 cm. Urea fertilizer (46% N) and triple superphosphate fertilizer (20% P) and potassium sulphate fertilizer (41% K) were added at (200 kg N ha^{-1}), (75 kg P ha^{-1}) and (150 kg K ha^{-1}) respectively. Nitrogen and potassium fertilizers were added three times to the soil during the plant season while the triple superphosphate fertilizer was added once at planting. Drip irrigation was used in which each bed had two lines of tubes. The seeds of cherry tomato plant (BATLLE) were planted on 2018/10/15 in cork plates with a capacity (209 eye dish^{-1}) and using peatmoss as an agricultural medium for growing seedlings in a special greenhouse until the seedlings reached the age appropriate for cultivation in the permanent field. The leafy area was measured by a scanner (SCANNER LASER AREA METER) by taking five random leaves from each plant and five plants from each experimental unit, according to the average area of each leaf. Nitrogen concentration in plant leaves was determined using the method (Page, 1982). Phosphorus concentration in plant leaves was estimated using blue ammonium molybdite, using the Spectrophotometer according to (1959, Johnson). The potassium concentration in vegetable leaves was estimated using the Flame photometer (A.O.A.C., 1970), according to the total yield of one plant that was calculated by dividing the total yield of five plants by the number of used plants.

Table 1: Some of the chemical and physical characteristics of the soil before cultivation.

The characteristics	Measurement units		The values
pH 1:1	-		7.58
EC 1:1	ds.m ×¹		2.94
Available Nitrogen	mg.Kg×¹ soil		55
Available potassium	mg.Kg×¹ soil		132
Available Phosphorus	mg.Kg×¹ soil		9.5
Available zinc	mg.Kg×¹ soil		0.65
	mg.Kg×¹ soil		0.33
Gypsum	g.Kg×¹ soil		Nil
Lime	g.Kg×¹ soil		275
Organic matter	%		1.15
Soil texture	Clay	%	35
	Silt	%	40
	Sand	%	25
Texture	Clay loam		
Bulk Density	microgram.m$^{\times 3}$		1.46

Results and Discussion

The concentration of nitrogen in the plant leaves

Table 2 shows that zinc treatments significantly increased the concentration of nitrogen in the plant leaves in which the highest concentration was at the spray level Zn100 with an average 1.554%, while the lowest concentration was at the control treatment with an average 1.357%. This increase in nitrogen concentration resulted from simulating photosynthesis as a result of increasing zinc concentration (Taiz and Zeiger, 2010). For salicylic acid treatments, the highest concentration of nitrogen was observed at SA 150 with an average 1.677 %, which was higher than SA 0, SA 50 and SA 100 by 34.2 %, 18.9%, 12.1%, respectively. This may be due to the role of salicylic acid in raising the efficiency of the roots to absorb the elements, especially nitrogen, in addition to increasing CO_2 fixation and raising the percentage of dry matter. The salicylic acid has a role in maintaining the Nitrate Reductase enzyme and preserving proteins from decomposition (Abdi *et al.,* 2011).

Table 2: Effect of spraying with salicylic acid and zinc and their interaction on nitrogen concentration in cherry tomato leaves (%).

Average SA	Zinc concentrations			Salicylic Acid
	Zn_{100}	Zn_{50}	Zn_{0}	
1.249D	1.330gh	1.260ih	1.157i	SA 0
1.410C	1.517dce	1.407gfe	1.307gh	SA 50
1.495B	1.603bc	1.483dfe	1.400gf	SA 100
1.677A	1.767a	1.700ab	1.563dc	SA 150
	1.554A	1.462B	1.357C	Average Zn

* Values of averages with similar letters for each factor or their interactions, each separately, do not differ significantly according to the Duncan polynomial test under the probability level 0.05. .* Large letters indicate a comparison of the effects of major factors and lowercase letters with a comparison of averages of interference.

Interference between spray levels with salicylic acid and zinc component had a significant effect on nitrogen concentration in plant leaves. The highest average was observed at the level of interference (Zn 100 + SA 150), with an average 1.767% and the lowest average was observed at the non-spray level with an average 1.157%. Zinc influences the transport of dissolved nitrogenous compounds such as amino acids and amides between roots and leaves, which are a source of nitrogen to build most of the by-products such as alkaloids and phenolic acids. It stimulates the enzyme Dehydrogenase Glutamic acid that responsible for the conversion of glutamic acid to alpha-ketoglutaric acid which enters the Krebs cycle and contributes in the production of the energy and intermediate compounds are important for various vital activities. It has an important role in photosynthesis as it stimulates the construction of the enolase enzyme involved in the production of energy-rich compounds during the destruction of glucose in the cell cytoplasm. It also stimulates the construction of the enzyme Aldolase responsible for the demolition of carbohydrates and thus release energy in the form of ATP necessary in active transport processes. Moreover, it increases the absorption of elements whose absorption depends on the presence of Energy. Zinc also catalyses the Cytochrome oxidase enzyme, which facilitates the final oxidation process in the electron transport chain and stimulates the construction of Cytochromes, which are ion-transporting proteins, thereby increasing the entry of negatively charged ions, including phosphate ions (Yassin, 2001).

Concentration of phosphorous in plant leaves

Table 3 shows a significant increase in phosphorous concentration in plant leaves when spraying the plant with a zinc component of 100 mg. L^{-1}, with an average of 0.453%, followed by a concentration of 50 mg. L-1 with an average of 0.423% compared to the control treatment with an average of 0.366%. Zinc enhances the ability of the plant to absorb phosphorus, as it is a cofactor of the carbonic anhydrase, which has a regulatory role for the buffer pH inside the chloroplasts. Zinc also preserves proteins from losing their vital nature, in addition to the active role that zinc plays as an aid to many enzymes and an antioxidant (Davarpanah *et al.*, 2016). Salicylic acid significantly increased the phosphorous concentration in the plant leaves where the fourth level of spraying with this acid (SA 150) exceeded the level of (SA 0), (SA 50) and (SA 100) with an increase by 46.0%, 22.33%, 7.11%, respectively. Singh and Usha (2003) indicated an increase in the efficiency of water absorption and mineral elements, especially phosphorous, when adding salicylic acid to the plant, as salicylic acid plays a role in increasing root length (Kaydan *et al.*, 2007). The addition of zinc and salicylic acid positively influenced the phosphorous concentration in the plant, in which the highest concentration (0.517%) was observed at interference (Zn 100 + SA 150). The lowest concentration (0.267%) was observed at the control treatment.

Table 3: Effect of spray with salicylic acid and zinc and their interaction on phosphorus concentration in cherry tomato leaves (%).

Average SA	Zinc concentrations			Salicylic Acid concentration
	Zn_{150}	Zn_{50}	Zn_0	
0.330D	0.267h	0.353g	0.267h	SA0
0.394C	0.347g	0.400ef	0.347g	SA50
0.450B	0.403ef	0.457bdc	0.403ef	SA100
0.482A	0.447dc	0.483abc	0.447dc	SA150
	0.366C	0.423B	0.366C	Average of Zinc

* Values of averages with similar letters for each factor or their interactions, each separately, do not differ significantly according to the Duncan polynomial test under the probability level 0.05.* Large letters indicate a comparison of the effects of major factors and lowercase letters with a comparison of averages of interference.

Concentration of potassium in plant leaves

There was a significant increase in potassium concentration for all zinc treatments compared to the control (Table 4). The highest value of this property was achieved by Zn100 (2.088%) followed by Zn50 (1.997%), with an increase by 11.24% and 4.55% respectively. This can be attributed to the role of zinc in raising the efficiency of photosynthesis, increasing the accumulation of materials manufactured in the plant and raising the plant's ability to absorb elements (Akhtar *et al.,* 2009).

For salicylic acid treatments, a significant increase in potassium concentration was observed for all application rates compared to the control treatment (Table 4). The highest concentration of this property was achieved by SA 150 followed by SA100 then SA 50, recording 2.224%, 2.077% and 1.958 respectively. This was attributed to the role of salicylic acid in improving plant growth and its resistance to all stresses that the plant can be exposed to. Salicylic acid works to increase the efficiency of photosynthesis and CO2 representation and increase the accumulation of dry matter, and raise the ability of the plant to increase absorption of elements (Yazdanpanah *et al*, 2011). Hayat and Ahmed (2007) state that salicylic acid has the potential to increase the content of nitrogen, phosphorus, potassium, nucleic and amino acids within the plant and maintain its non-oxidation.

Interference between two factors had a positive effect on the potassium concentration in plant leaves, as the (Zn 100 + SA 150) treatment was the highest (2.307%) compared to the control treatment (1.557%). This indicates that the high levels of experiment factors led to a significant increase in this characteristic.

Table 4: Effect of salicylic acid and zinc and their interaction on potassium concentration in cherry tomato leaves (%).

Average SA	Zinc concentrations			Salicylic Acid concentration
	Zn_{150}	Zn_{50}	Zn_0	
1.690D	1.803g	1.710h	1.557i	SA0
1.958C	2.077d	1.953e	1.843f	SA50
2.077B	2.167c	2.100d	1.963e	SA100
2.224A	2.307a	2.223b	2.143c	SA150
	2.088A	1.997B	1.877C	Average of Zinc

* Values of averages with similar letters for each factor or their interactions, each separately, do not differ significantly according to the Duncan polynomial test under the probability level 0.05.* Large letters indicate a comparison of the effects of major factors and lowercase letters with a comparison of averages of interference.

Leafy area of the plant

Table 5 indicates that the leafy area of the plant significantly increased as the concentration of zinc increased, recording (19.20, 17.83 and 17.62) cm^2 $plants^{-1}$ for Zn100, Zn50 and Zn0 respectively. This was attributed to the large role of the zinc, whose decreased quantity within the plant leads to significant changes in the morphological and physiological composition of the plant represented by modifications in the membrane, changes in the representation of carbohydrates and the formation of cytochrome, nucleotide and chlorophyll, as well as the decrease in enzymes containing zinc (Mohammed, 2018).

There was also a significant increase in the leafy area of cherry tomato plants with increased concentrations of salicylic acid. the l SA 150 treatment was the highest with an average of (20.01) cm ^{2} and the control treatment was the lowest with an average (17.20) cm ^{2} plants $^{-1}$, which did not differ significantly from Spray level SA 50. As salicylic acid is an inhibitor of ethylene representation and has an opposite role to that of abscisic acid, this would reduce the withering and fall of leaves (Pessarakli, 2011).

The interference level Zn 100 + SA 150 was the highest mean in the leafy area of a plant with an average of 20.57 cm^{2} plant $^{-1}$, while the lowest mean was at the control treatment with an average 15.51 cm ^{2} plant $^{-1}$. Zinc is involved in the processes of metabolism of carbohydrates through its direct impact on raising the efficiency of photosynthesis. It has been observed that a lack of the element leads to a decrease in the net products of photosynthesis by 50 - 70%, and this effect may be due to a decrease in the efficiency of the performance of the enzyme (Carbonic anhydrase) that enters Zinc within the synthesis of this enzyme (*et al*., 2009 Akhtar).

Table 5: Effect of spraying with salicylic acid and zinc and their interference in the leaf area of cherry tomato plant (cm ^{2}).

Average SA	Zinc concentrations			Salicylic Acid concentration
	Zn_{150}	Zn_{50}	Zn_{0}	
17.20C	19.73c	16.36k	15.51l	SA0
17.20C	17.62h	17.20i	16.78j	SA50
18.47B	18.89e	18.47f	18.5g	SA100
20.01A	20.57a	19.31d	20.15b	SA150
	19.20A	17.83B	17.62C	Average of Zinc

* Values of averages with similar letters for each factor or their interactions, each separately, do not differ significantly according to the Duncan polynomial test under the probability level 0.05.* Large letters indicate a comparison of the effects of major factors and lowercase letters with a comparison of averages of interference.

Total yield of the plant

There was a significant increase in the plant yield for all zinc treatments (Table 6). The treatment of Zn100 was the highest in plant yield 2587.5) kg house^{-1}) compared to the control (2579.2 kg house^{-1}) and Zn50 treatments (2579.8 kg house^{-1}). Zinc is considered as one of the factors that are necessary to accelerate plant growth and production of leaves. This is due to the main role of zinc in regulating sugar and enzymes and its direct role in the production of energy compounds and the formation of amino acids (Ruttkay-Nedecky *et al.*, 2017).

Salicylic acid had a significant effect on the plant yield, as the SA 150 treatment significantly increased the plant yield compared to other treatments (Table 6). As salicylic acid is a regulating factor for the distribution of dry matter, Stabilizing agent, as well as its ability to raise the efficiency of the roots to absorb water and nutrients. Salicylic acid has the ability to bind to amino acids and its role in increasing nucleic acids, DNA and RNA (Mahmood *et al.*, 2010). These factors have a role in Increase plant weight. Significant effect appeared as a result of the interference between the two factors of the stud. The (Zn 100 + SA 150) treatment was the highest with a significant increase (2593.5 kg house^{-1}) while the control treatment was the lowest (2570.4 kg house^{-1}).

Table 6: Effect of salicylic acid and zinc and the interference between them on the yield of cherry tomato (kg. Plastic house $^{-1}$).

Average SA	Zinc concentrations			Salicylic Acid concentration
	Zn_{150}	Zn_{50}	Zn_{0}	
2577.4C	2589.2bc	2572.500hi	2570.4i	SA0
2577.7C	2582.1fe	2576.6g	2574.5gh	SA50
2582.9B	2585.1de	2582.8fe	2580.7f	SA100
2590.7A	2593.5a	2587.2dc	2591.4ab	SA150
	2587.5A	2579.8B	2579.2B	Average of Zinc

* Values of averages with similar letters for each factor or their interactions, each separately, do not differ significantly according to the Duncan polynomial test under the probability level 0.05.* Large letters indicate a comparison of the effects of major factors and lowercase letters with a comparison of averages of interference.

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