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Role Of Foliar Spray With Selenium And Urea On Growth, Flowering, And Yield Of Strawberry (*Fragaria* X *Ananassa* Duch.) Cv. Camarosa

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Abstract: The effect of foliar spray with Selenium at three levels (0, 3 and 6 mg Se. L^{-1}) and urea at two levels (0% and 1%), each alone or in combination, were studied on the growth, flowering, fruit set and yield of strawberry plants (*Fragaria x ananassa* Duch.) cv. Camarosa, which were planted in an unheated greenhouse/Department of Horticulture and Landscape Design/College of Agriculture and Forestry / University of Mosul during the growing season 2020-2021. The results obtained showed that the foliar spray with Selenium, especially at a concentration of 6 mg Se. L^{-1} and 1% urea, each separately or in combination, significantly increased all study parameters. The best treatments were the spraying strawberry plants cv. Camarosa with 6 mg Se.L^{-1} + 1% urea with each other, which recorded a significant superiority of all studied traits(leaves Chlorophyll, plant leaves area, number of flowers per plant, fruits set percentage, number of fruits per plant, fruit weight, plant yield, fruits yield per hectare) over most interaction treatments, including control treatment.

Keywords: Selenium, Urea, Strawberry, Camarosa

Introduction

The strawberry is one of the most important and widespread small fruit plants globally, which belongs to the Rosaceae family, which includes many economically important species such as ornamental roses or edible fruits such as apple, pear, peach, etc. Strawberry is a perennial herbaceous plant, and it is believed that its original home of it is North America, as it is grown in Europe, Asia, Africa and America (Habeeb and Ali, 2013); its name is derived from the Latin “fragrant” and “fragrance” and it is called in English (Strawberry) and in French (Fraise) and in Italian (Fragola), from which the name was derived in Egypt as strawberry it is called “Chillaik” in Iraq and Syria, which came from its name in Turkey as “Chillaik” (Al-Saidi, 2000).

The strawberry plant is an early-production fruit, as the first fresh crop appears in the markets in the spring, and its fruits contain a high percentage of substances that have a significant role as effective inhibitors against vascular and cardiovascular diseases as well as cancerous diseases (Al-Khayri et al., 2018). It also contains many antioxidants, including the anthocyanin dye, which is the pigment that gives the fruits their red colour. It has a distinctive taste and flavour and is used in many food industries such as jams, jelly, sweets and juices. It is used as a raw material in many food preparations for its distinctive fragrance, taste and flavour, such as in the manufacture of ice cream and pastries (Giampiri et al., 2014).

The cultivation of strawberry was introduced to Iraq by chance and planted in home gardens between the years 1946-1951 (Al-Saidi, 2000), and its cultivation in Iraq has become one of the most important fruits that were characterized by its rapid spread in central and southern Iraq (Khalil and Agah, 2018). Most of the varieties currently scattered in Iraq are European and American varieties, including the Camarosa variety, which is one of the neutral American varieties with high production and remarkable ability to produce runners and is grown in different regions of the world because of its tolerance to different climatic conditions and which distinguishes it from the rest of the varieties. Usually conical, large in size, symmetrical of high quality, resistant to circulation and dark red, distinct and marketable flavour(MuftyandTaha,2021).

Selenium is one of the essential nutrients for humans and animals, but it is not necessary for plants, although it is classified as a useful and important element for plants. It is known that the soil content of Selenium is related and emanates from the material of the origin and that its distribution in the terrestrial sector is only a strong reflection of the processes of land formation and atmospheric sedimentation from it,

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and that sandy lands developed under humid climatic conditions have the lowest content of Selenium. In contrast, calcareous and organic lands have a higher content of Selenium. It is high in Selenium, and its behaviour in the soil is controlled by many factors, including soil pH, oxidation and reduction potential, soil content of clay, organic matter, and hydroxides, and the most important forms of its presence in soil are selenite, selenite, selenides and organic Selenium (Li et al., 2016 and Yasin et al., 2016).

Selenium has many important physiological functions in plant life, including encouraging seed germination and plant growth when used in low concentrations. It also increases dry matter production by increasing the production of carbohydrates and their accumulation in the plastids, especially starch, and regulating the amount of water inside the plant. It also encourages the formation of anti-stress plant hormones, such as ethylene, jasmonic and salicylic acids, increasing the plant's ability to face oxidative stress by encouraging the plant's resistance system to antioxidants and free radicals, delaying plant ageing, protecting plants from infection with fungi, aphids, spiders, etc. plant diseases and others (Marschner, 2012; Wu et al., 2016 a & b and Zhang et al., 2016).

Several researchers stated that foliar spraying with Selenium improved the flowering, knot, and quantitative and qualitative characteristics of the strawberry yield. Santiago et al. (2018) found that there was a significant increase in the total yield of plants when foliar spraying of strawberry plants with Selenium at a concentration of 2.4 mg $Se.L^{-1}$, where five concentrations of Selenium (0, 0.3, 0.6, 1.2 and 2.4 mg Se. mg $Se.L^{-1}$) were used in the form of sodium selenite (Na2SeO3). Zahedi et al. (2019) studied the effect of foliar spraying with Selenium at two concentrations (1 and 2 mg $Se.L^{-1}$) in some quantitative characteristics of the yield of strawberry plants, as the results showed that there was a significant increase in the number of fruits formed on each plant, fruit volume and the total yield of the plant when spraying with Selenium at a concentration of 2 mg $Se.L^{-1}$. As mentioned by Narvãez-Ortiz et al. (2018), in their results on strawberry plants sprayed with Selenium in the form of sodium selenite (Na2SeO3) at three concentrations (0, 2, and 4 mg $Se.L^{-1}$), the concentration 4 mg$Se.L^{-1}$ significantly increased fruit weight. Antoniou et al. (2021) showed that foliar spraying of strawberries with Selenium at four concentrations (0, 1, 5 and 10 mg $Se.L^{-1}$) led to a significant increase in the number of flowers per plant when spraying with a concentration of 5 mg $Se.L^{-1}$; meanwhile, the spraying with 1 mg $Se.L^{-1}$ significantly increased total plant yield and the number of fruits per plant.

As for urea, ($CO(NH_2)_2$) is one of the main nitrogen fertilizers, and its content of nitrogen was 46%. N is one of the necessary elements for the plant and needs it in large quantities compared to other nutrients (Ouyang and Norton, 2020), and it works to strengthen both vegetative and root growths as it enters the composition of Chlorophyll, proteins, amino acids and in the composition of the plant cell. Nitrogenous compounds make up about 1-5% of the dry weight of the plant cell’s protoplasm. It is one of the components of the chlorophyll pigment, which is responsible for the green colour in the plant and plays a primary role in the photosynthesis process and is involved in the synthesis of nucleic acids, the synthesis of energy-carrying materials such as ADP and ATP, synthesis of cytokinins and in the formation of the natural growth hormone known as indole acetic acid (IAA), which is built from the amino acid tryptophan (Gendia, 2003 and Havlin et al., 2005).

Several researchers stated that treating strawberry plants with nitrogen, whether by foliar spraying or ground fertilization, improved the flowering and knotty characteristics and quantitative yield characteristics, including, Andriolo (2011), when nitrogen and urea were added to the Arazá strawberry plants at five concentrations (6.5, 8, 9.5, 11 and 12.5 mmol $N.L^{-1}$), Medeiros et al. (2015) when fertilizing strawberry at five levels of urea (0.16, 0.37, 0.88, 1.4, and 1.6 $g.plant^{-1}$), Chovatia and Makhmale (2017) when they sprayed strawberry plants cv. Sweet Charlie with urea at two concentrations (1.0 and 1.5%), Einizaeh and Shokouhian (2018) when fertilizing "Paros" strawberry plants with three levels of urea (50, 100 and 150 $kg.ha^{-1}$), Sadique et al. (2019) during foliar spraying strawberry plants cv.“Chandler” with NPK-Nano complex fertilizer (20:20:20) at a concentration of 6 and 8 $mg.L^{-1}$ per week, Hindersah et al. (2021) when fertilizing strawberry cultivar Festival with sulfur-coated urea at an amount of 1 and 2 g. $Plant^{-1}$, Weber et al. (2021) when urea was added to strawberry plants cv.“Clery” at four levels (0, 20, 40 and 60 kg $N.ha^{-1}$), Mohamed et al. (2021) by adding mineral nitrogen in the form of ammonium nitrate at two levels (238 and 476 kg $N.ha^{-1}$) and organic nitrogen in the form of compost at two levels (30 and 30.6 $tons.ha^{-1}$) to strawberry plants cv. Fortuna.

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Therefore, this study aims to know the effect of foliar spraying with Selenium and urea on the growth, flowering and yield of Camarosa strawberry plants grown in an unheated greenhouse.

Material and Methods

This study was carried out in one of the unheated greenhouses of the Department of Horticulture and Landscape Design/College of Agriculture and forestry, University of Mosul, with an area of 486 m^2 (length 54 m, width 9 m), during the growing season 2020-2021, and some physical and chemical properties of greenhouse soil were estimated in the laboratories of the Research Directorate and the water resources in Nineveh Governorate before planting, which are shown in Table (1).

Table (1): Some physical and chemical properties of greenhouse soil.

Pararmeter	**Unit**	**Value**
EC	(dsm. m^{-1})	0.744
pH	--------	7.69
Organic mater	gm kg^{-1}	5.28
Sand	gm kg^{-1}	610.7
Clay	gm kg^{-1}	239.6
Silt	gm kg^{-1}	156.7
Soil texture	mg kg^{-1}	Cilty Clay Loam
Available N	mg kg^{-1}	95
Available P	mg kg^{-1}	21
Available K	mg kg^{-1}	116
HCO_3	mg kg^{-1}	170.8

The strawberry plants (Camarosa) cultivar of almost homogeneous growth were selected from Halabja city in Sulaymaniyah governorate for use in this study, which was carried out using the Randomized Complete Block Design (RCBD) for factorial experiments with two factors(Selenium and urea), Selenium was sprayed with three concentrations (0, 3 and 6 mg $Se.L^{-1}$) and urea at two concentrations (0 and 1%), three replicates and ten plants for each experimental unit. The plants were planted on mastabas, 75 cm wide and covered with thick black polyethylene with holes made in the polyethylene for planting the plants with two lines. The distance between them is 25 cm, and the distance between one plant and another is 25 cm. Plants were sprayed with Selenium twice during the study period; the period between one spray and another is 20 days, as the first spray was on 12/15/2020, while the plants were sprayed with urea three times during the study period and with a period of 20 days between one spray and another, as the first spray took place on 16/12/2020.A surfactant agent (tween 20) was added to all spray solutions at a concentration of 0.025 % to reduce surface tention of solution. The following characteristics were studied:

1.Chlorophyll in leaves (mg.gm^{-1}), according to the method mentioned by (Saieed,1990).

2. Plant leaves an area (cm^2), by measuring the area of one leaf according to what was mentioned by(Patton,1984) and the number of leaves formed on each plant, and then calculating the leaf area of one plant as follows:

The leaf area of a plant = area of one leaf (cm^2) * number of leaves per plant.

3. Number of total flowers for each plant (flower.$plant^{-1}$): The number of flowers formed on each plant from the beginning until the flowering has been calculated.

4. Set percentage (%): It was calculated for all plants according to the following equation:

Set percentage = number of total flowers formed on each plant/number of fruits per plant and for all fairies * 100%

5. Number of fruits per plant (fruit. $plant^{-1}$): The number of fruits for each plant was calculated from the first harvest until the last harvest.

6. Fruit weight (gm): The average weight of the fruit (gm) was calculated for all harvests by dividing the yield of one plant by the number of fruits formed on each plant.

7. Plant yield (g. $plant^{-1}$) for all harvests**.**

8. Total yield (gm.ha^{-1}): according to the following equation:

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Average yield per hectare (kg. hectare^{-1}) = Number of plants per hectare * Plant yield (gm). All data were tabulated and statistically analyzed using the SAS program (SAS, 2002). The differences between various treatment means were tested with the Duncan Multiple Range Test at 5% level.

Result and Discussion

Leaves chlorophyll and Plant leaves area:

Data presented in table(2) showed that foliar spray with 6mg.L^{-1} selenium and 1% urea either alone or in combination significantly increased leaves Chlorophyll and plant leaves in the area as compared with the control treatment. The effect of Selenium conforms with the work of Zahedi et al.(2019 &2020) and Antoniou et al.(2021); meanwhile, the effect of urea was similar to the finding were reported by Chavatia and Makhmale (2017).

Table (2): Effect of foliar spray with Selenium and urea on leaves Chlorophyll (mg.g^{-1}) and plant leaves area (cm^2) of strawberry plants cv.Camarosa.

Treatments	**Selinium (mg Se.l^{-1})**			**Means of Urea**
	0	**3**	**6**	
Leaves chlorophyll (mg.g^{-1})				
Urea Conc. (%)				
0	8.35 f	9.72 e	10.13 d	**9.40 b**
1	10.92 c	11.72 b	13.56 a	**12.07 a**
Means of Se	**9.64 c**	**10.72 b**	**11.84 a**	
Plant leaves area (cm^2)				
Urea Conc. (%)				
0	3745.54 f	4640.26 e	5021.85 d	**4469.22b**
1	5336.96 c	5640.84 b	6142.95 a	**5706.92 a**
Means of Se	**4541.25 c**	**5140.55 b**	**5582.40 a**	

*Means of each factor and their interactions for each parameter followed by the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level.

The number of flowers per plant and fruit set:

The obtained results (Table 3) showed that the number of flowers per plant and fruit set significantly increased with the application of Selenium and urea at concentrations of 6mg.L^{-1} and 1%, respectively, each alone or with each other, so the best treatment was 6mg Se.L^{-1} + 1% urea, which it gave the highest means of flowers per plant (35.66 flower.plant^{-1}) and fruit set (91.31 %). This result was in agreement with Antoniou et al. (2021) when they sprayed strawberry plants with 5 mg Se.L^{-1} and with Chavatia and Makhmale (2017) when they sprayed strawberry plants with 1 and 1.5% urea.

Table (3): Effect of foliar spray with Selenium and urea on the number of flowers per plant and fruit set (%) of strawberry plants cv.Camarosa.

Treatments	**Selenium(mg Se.l^{-1})**			**Means of Urea**
	0	**3**	**6**	
Number of Flowers (flower.plant^{-1})				
Urea Conc. (%)				
0	27.98 f	29.03 e	31.07 d	**29.36 b**
1	32.82 c	34.74 b	37.80 a	**35.12 a**
Means of Se	**30.40 c**	**31.89 b**	**34.43 a**	
Fruit set (%)				
Urea Conc. (%)				
0	75.77 f	78.80 e	82.64 d	**79.07 b**
1	84.10 c	87.51 b	91.95 a	**88.19 a**
Means of Se	**80.43 c**	**83.15 b**	**87.30 a**	

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*Means of each factor and their interactions for each parameter followed by the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level.

Yield and Fruit quantitative traits:

Results in Table 4 show that foliar spray with Selenium at a concentration of 6mg $Se.L^{-1}$ significantly increased fruits number per plant, fresh fruit weight, plant yield, and fruit yield per hactar compared with control $plant^{-1}$, 16.39 $gm.fruit^{-1}$, 481.77 $gm.plant^{-1}$ and 364573 $km.ha^{-1}$. The same trend was obtained by other studies such as Santiago et al.(2018), Navaez-Ortiz et al.(2018), Zahedi et al.(2019) and Antonion(2021); also, urea spray at a concentration of 1% significantly dominated over control treatment in these traits (fruits number per plant, fresh fruit weight, plant yield and fruits yield per hectare). Similar findings were reported by Chavatia and Makhmale (2017).

The interaction between foliar spray with Selenium and urea significantly affected fruit number per plant, fresh fruit weight, plant yield, and fruit yield per hectare (Table 4). The best treatment was 6mg $Se.L^{-1}$ + 1% urea, which gave the highest means of fruits number per plant (32.55 fruit), Fruit fresh weight (21.02 gm.), plant yield (682.03 gm) and total fruits yield per hectare(515879 km.), and it significantly dominated over most treatment in each trait.

Table (4): Effect of foliar spray with Selenium and urea on the number of fruits per plant, fruit weight (gm), plant yield ($gm.plant^{-1}$) and total fruits yield ($kg.ha.^{-1}$) of strawberry plants cv.Camarosa.

Treatments	**Selenium(mg $Se.l^{-1}$)**			**Means of Urea**
	0	**3**	**6**	
No.Fruits ($fruit.plant^{-1}$)				
Urea Conc. (%)				
0	21.21 f	22.88 e	25.68 d	**23.26 b**
1	27.90 c	30.42 b	34.83 a	**31.05 a**
Means of Se	**24.55 c**	**26.65 b**	**30.26 a**	
Fruit Weight (gm)				
Urea Conc. (%)				
0	13.84 f	15.81 e	17.27 d	**15.64 b**
1	18.49 c	20.08 b	21.58 a	**20.05 a**
Means of Se	**16.16 c**	**17. 95 b**	**19.42 a**	
Plant Yield ($gm.plant^{-1}$)				
Urea Conc. (%)				
0	293.74 f	362.10 e	440.47 b	**365.44 b**
1	516.07 c	611.71 b	752.72 a	**626.80 a**
Means of Se	**404.98 c**	**486.86 b**	**596.59 a**	
Total Fruits Yield ($kg.ha.^{-1}$)				
Urea Conc. (%)				
0	222531 f	274324 e	333695 d	**276850 b**
1	390965 c	460697 b	570242 a	**473968 a**
Means of Se	**306748 c**	**367510 b**	**451969 a**	

*Means of each factor and their interactions for each parameter followed by the same letters are not significantly different from each other according to Duncan's multiple ranges test at 5% level.

It is clear from the results mentioned in Tables (2-4) that foliar spray with Selenium and urea with each other, especially at the high concentrations (6mg $Se.L^{-1}$ + 1% urea), gave the highest values of all studied traits (leaves Chlorophyll, plant leaves area, number of flowers per plant, fruit set, fruits number per plant, fresh fruit weight, plant yield and fruits yield per hectare). Many studies have reported the physiological functions of Selenium during plant growth and development and stress resistance (Gupta and Gupta,2016). It promotes plants from drought stress by enhancing the antioxidant defence system(Proietti et al.,2015). Also, Selenium can promote the early emergence and rapid development and increase photosynthetic rate, chlorophyll content (Peng et al.,1997) and antagonism of heavy metals(Yu,2012), Romose et al.(2010) mentioned that selenium application increased oxidant activity and consequently

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increased plants yield; meanwhile, nitrogen is a constituent of essential cellular components such as amino acids, proteins and nucleic acids(Havlin et al.,2005). Nitrogen promotes photosynthesis because it increases the amount of Chlorophyll is the only substance capable of integrating the growth of the plants and metabolic activity at the cellular level, the role of N as an osmotic agent, which allows retaining the water in the vacuoles, has been considered as important to its nutritional function (Olivar et al.,2014), all these functions of selenium and nitrogen lids to increase the number of flowers per plant and fruit set and finally plants yield. We conclude from the study that the best treatments were the spraying strawberry plants cv.Camarosa has grown in an unheated greenhouse with 6 mg $Se.L^{-1}$ + 1% urea with each other, which recorded a significant superiority of all studied traits(leaves Chlorophyll, plant leaves area, number of flowers per plant, fruits set percentage, number of fruits per plant, fruit weight, plant yield, fruits yield per hectare) over most interaction treatments, including control treatment.

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