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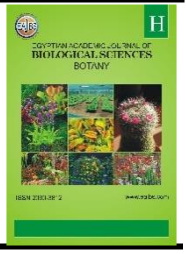

Effect of Some Nano Fertilizers on Yield and Fruit Quality of Apple

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ABSTRACT

The current study was performed through 2020 season on apple cv. Anna. The experiment was performed on fifty uniform trees, which were of the same size and vigor as possible and subjected to the same applied cultural practices in the field. The trees were sprayed three times; before flowering, during full bloom and one month later with the following treatments: control (water only), Ag NPs at 10, 12.5 and 15 mL/L, Zn NPs at 100, 200 and 300 ppm and Zn at 0.25, 0.5 and 1.00 g/L. The treatments were arranged in a randomized complete block design where each treatment was composed of five replicates (five trees). The obtained results showed that spraying Ag NPs at 12.5 and 15 mL/L, Zn NPs at 200 and 300 mL/L and Zn at 1.00 g/L on apple trees increased significantly total chlorophyll, fruit set percentages, and fruit yield. Besides, the same treatments increased also the fruit's physical and chemical characteristics compared to control and the other applied treatments.

INTRODUCTION

Spraying of nano fertilizers provides nutrients with high efficiency and low waste due to their faster and higher translocation to different parts of plants (Rico *et al*., 2011). Besides, nano-particles are atomic or molecular aggregates of size in a nano-scale range of 1- 100 nm (Rai and Ingle, 2012). Nano fertilizers can be used in small quantities rather than widespread fertilizers (Subramanian *et al*., 2015). NPs have the potential to increase the productivity of the crop (Batsmanova *et al.*, 2020). Ag NPs increased the length of vegetative traits, leaf area, chlorophyll, and carbohydrate as well as protein, and antioxidant enzyme content (Salama, 2012).

Zinc spray had a clear boost in the pomegranate fruit set compared with the untreated trees in the two seasons (Obaid and Al-Hadethi, 2013). It was noticed that any factor that can increase the concentration of endogenous Zn in plants, such as spraying NFs, can increase the synthesis of IAA and therefore shoots, berries and pollen growth and decrease undeveloped shoot berries (Arrobas *et al*., 2014). Using NFs is better than normal fertilizers in improving the growth, yield and fruit quality of different fruit crops (Refaai, 2014). Liu and Lal (2015) stated that nano fertilizers significantly improved the growth and crop yielding as compared to conventional ones. Spraying of nano-fertilizers of zinc at 636 mg Zn per tree on pomegranate yield and fruit quality one time before full bloom at a rate of

5.3 L tree^{-1}. They noticed that the foliar spraying of Zn increased the leaf content from nutrients, fruit yield in terms of the fruit number per tree, the leaf content from nutrients, enhanced fruit content from TSS, and juice sugar content as well as maturity index, while it decreased TA, comparing with control (Davarpanah *et al*., 2016). Zagzog and Gad (2017) reported that treating mango with Zn-NPs at 1 g L^{-1} before flowering increased shoots and leaves, lessened malformation by 42–55%, raised the weight of fruit by 33.74% and yield per tree by 57.36%, and boosted the concentration of nitrogen, phosphorous, potassium and zinc compared with control trees. Therefore, this study was conducted to investigate the influence of some nano fertilizers on vegetative growth, yield and fruit quality of “Anna” apple cultivar.

MATERIALS AND METHODS

This experiment was carried out during 2020 season, on "Anna" apple trees, planted at 4*4 meters apart in sandy clay loam soil under drip irrigation. Fifty uniform trees were selected in the same vigor as possible for performing this study and all of them were subjected to the same cultural practices in the two seasons. They were sprayed three times, before flowering, during the full bloom and one month later with the following treatments: control (water only), nano silver (Ag NPs) at 10, 12.5 and 15 mL/L, nano zinc (Zn NPs) at 100, 200, and 300 ppm and zinc (Zn) at 0.25, 0.5 and 1 g/L. The previously applied treatments were arranged in a randomized complete block design where each treatment was composed of five trees (five replicates). The influence of the above-mentioned treatments was investigated on the following parameters:

- Total chlorophyll Spad 502.
- Yield per Tree: was estimated in kg per each tree/each replicate at the harvest time (June)
- Yield per hectare was calculated as yield in kg per tree*number of trees per hectare.
- Fruit Quality: At the time of harvesting, ten fruits were chosen randomly from each replicate/tree to determine physical and chemical characteristics.
- Fruit weight in (g), Fruit length (cm) and Fruit diameter (cm), and Fruit size (cm^3).
- Fruit firmness (Ib/ inch^2) using a Magness and Taylor pressure tester with a 7/18 inch plunger.
- Total soluble solids (TSS %): were measured by using a hand refractometer.
- Total acidity (%): was determined by direct titrating of 0.1 N sodium hydroxide.

Statistical Analysis:

The obtained data were subjected to one-way ANOVA according to (Snedecor and Cochran, 1980) and the least significant difference (LSD) at 0.05% was used to compare the means of the treatments.

RESULTS

Results listed in Table 1 showed that the foliar addition of Ag NPs, Zn NPs and Zn improved the leaf total chlorophyll compared with control. The application of nano silver at 15 or 10 mL/L, and nano zinc at 200 and 300 pm gave the highest positive effect on total chlorophyll compared to the other applied treatments or control during our study season. Moreover, it was greatly enhanced by the foliar application of Zn at 1 g/L over control. Spraying of Zn NPs at 200 or 300 ppm, and Ag NPs at 10 or 15 mL/L boosted the fruit set percentage, fruit yield and the yield in ton per hectare compared with control. Moreover, the same measurements were ameliorated also by the application of Zn, especially at 1 g/L more than the foliar application of Zn at 0.25 or 0.5 g /L compared with the control. Additionally, the spraying of nano zinc, nano silver and conventional Zn lessened the fruit drop percentage.

The high applied concentrations from Ag NPs at 10 or 15 mL/L, Zn NPs at 200 or 300 ppm and also Zn at 1 g/L were more effective than the lowest concentration.

Table 1: Influence of spraying nano silver, nano zinc and zinc on leaf total chlorophyll, the percentages of fruit set, fruit drop and yield of "Anna" apple trees during 2020.

Treatments	Total chlorophyll Spad	Fruit set %	Fruit drop %	Yield (kg/tree)	Yield (ton/ hectare)
2020					
Control	37.92e	13.11f	47.20f	39.08f	42.98f
Nano silver 10 mL/L	43.11d	17.55e	51.43de	53.48d	58.83d
Nano silver 12.5 mL/L	47.18b	22.12bc	59.18b	60.22bc	66.24bc
Nano silver 15 mL/L	49.88a	23.67ab	62.60a	62.53ab	68.79ab
Nano zinc 100ppm	44.52cd	19.30d	51.98cde	55.00d	60.50d
Nano zinc 200ppm	49.79a	23.33ab	59.88b	60.88bc	66.97bc
Nano zinc 300ppm	50.05a	24.66a	64.14a	64.81a	71.29a
Zinc 0.25g/L	42.92d	16.41e	49.88e	49.55e	54.50e
Zinc 0.50g/L	45.72bc	21.31c	52.77cd	55.25d	60.77d
Zinc 1.00g/L	46.65b	21.94bc	54.35c	58.32c	64.15c
$LSD_{0.05}$	2.02	1.65	2.38	2.69	2.96

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability.

Results shown in Table 2 cleared that the foliar spraying of Ag NPs, Zn NPs and Zn enhanced the fruit weight, size, length and fruit diameter compared to control. Furthermore, the most obvious effect was noticed with the application of nano silver at 10 or 15 mL/L, Zn NPs at 200 or 300 ppm and zinc at 1 g/L rather than control or the rest applied treatments.

Table 2: Influence of spraying nano silver, nano zinc and zinc on fruit weight, size, length and diameter of "Anna" apple trees during 2020.

Treatments	Fruit weight (g)	Fruit size (cm^3)	Fruit length (mm)	Fruit diameter (mm)	L/D
Control	156.67e	170.00g	38.10e	35.97f	0.99c
Nanosilver 10 ml/L	174.33cd	191.00e	46.03d	49.03de	1.03bc
Nanosilver 12.5 ml/L	195.67b	210cd	60.47ab	54.68bc	1.09abc
Nano silver 15 ml/L	213.33a	225.33b	63.03a	58.01ab	1.11ab
Nano zinc 100 ppm	175.33cd	191.33e	52.30c	50.02cde	1.04bc
Nano zinc 200 ppm	198.00b	212.67c	61.17ab	54.76bc	1.11ab
Nano zinc 300 ppm	221.33a	232.00a	63.57a	61.46a	1.18a
Zinc 0.25g/L	171.33d	182.33f	52.20c	46.65e	1.03bc
Zinc 0.50g/L	180.33c	193.00e	54.23c	51.98cd	1.06bc
Zinc 1.00g/L	190.67b	204.33d	57.90b	52.72cd	1.06bc
$LSD_{0.05}$	8.26	6.20	3.45	4.33	0.1

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability.

From the data demonstrated in Table 3, it could be that the foliar application of nanosilver at 10 or 15 mL/L, Zn NPs at 200 or 300 ppm and zinc at 1 g/L increased the fruit firmness, and the percentages of total solids, compared with control. On the contrary, the same treatments minimized significantly the fruit acidity in comparison with the control.

Table 3: Influence of spraying nano silver, nano zinc and zinc on fruit firmness, TSS, and acidity of "Anna" apple trees during 2020

Treatments	Fruit Firmness (Ib/ inch^2)	TSS (%)	Acidity (%)
Control	14.00e	10.40c	0.76a
Nano silver 10 mL/L	16.80cd	12.43ab	0.68b
Nano silver 12.5 mL/L	19.67ab	13.10ab	0.62cd
Nano silver 15 mL/L	20.93a	13.67a	0.61d
Nano zinc 100 ppm	17.20cd	12.53ab	0.66bc
Nano zinc 200 ppm	20.43ab	13.27ab	0.62d
Nano zinc 300 ppm	20.93a	13.90a	0.61d
Zinc 0.25g/L	16.13d	11.90b	0.69b
Zinc 0.50g/L	18.33bc	12.53ab	0.64cd
Zinc 1.00g/L	18.87abc	13.10ab	0.63cd
$LSD_{0.05}$	1.96	1.35	0.04

Means not sharing the same letter(s) within each column, significantly different at 0.05 level of probability

DISCUSSION

Our obtained results are in the same line with the findings of Uthaichay *et al*. (2007), who reported that the foliar application of silver ions minimized the flowers and flower bud's abscission in an orchid plant. Ag NPs positively affected growth, and root elongation (Shah and Belozerova, 2009; Ma *et al*., 2010). Ag NPs increased the length of vegetative traits, leaf area, chlorophyll, and carbohydrate as well as protein, and antioxidant enzyme content (Salama, 2012). Spraying Ag NPs improved the plant's morphological attributes in plants (Shams *et al*., 2013). The spray of peach cv. Florida prince with 10, 12.5 and 15 mL/L Ag NPs improved flowering percentage, the diameter of shoots, leaf area and leaf total chlorophyll. Moreover, they increased also significantly the fruit yield per tree or per hectare, fruit weight, flesh weight, fruit firmness and the percentages of TSS (Mosa *et al*., 2021).

El-Baz (2005) noticed that the spraying of zinc sulphate at 250 ppm Zn and 500 ppm on "Balady" mandarin cultivar increased obviously the fruit number and consequently the obtained fruit yield in kg per tree as well as the fruit weight, and size, TSS percentage, while it reduced the fruit juice acidity percentage. The foliar addition of zinc sulfate showed promoting effects on the photosynthesis and berry development of vines and the accumulation of total solids, minimizing the concentration of titratable acidity in grapes (Song *et al*., 2015). Application of nano-zinc improved greatly the total chlorophyll, cane total carbohydrate percentage, cluster number, weight, length, and diameter, the weight of 100 berries, juice weight, total soluble solids percentage, the obtained yield, total, reducing and non-reducing sugars, the carbon-nitrogen ratio in the shoots, TSS/acidity as well as V.C., while it decreased the fruit content from acidity in grape cvs. Flame seedless (El-Said *et al*., 2019), and Crimson seedless (García-López *et al*., 2019).

Conclusion

- The foliar spraying of nanosilver and nano zinc could be used as good effective tools to improve the leaf chlorophyll, fruit set % and fruit yield in the apple orchard.
- 12.5 and 15 Ag NPs, 200 and 300 ppm Zn NPS gave better results in improving fruit set percentage, fruit yield and fruit quality than 10 mL/L Ag NPs, and 100 ppm Zn NPs.
- The influence of 1 g/L zn was higher than 0.25 or 0.5 g/L.
- The effect of nano zinc was better than the effect of traditional zinc.

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