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Sweet Pepper *Capsicum Annum* L. Plant Response to Spraying with Nano-NPK and Antioxidants

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Abstract

This study was conducted in one of the fields of the nursery project of the Najaf Agriculture Directorate for the spring season 2020 on the (California wonder) sweet pepper plant. The treatments included spraying the plants with NPK (20-20-20) and four concentrations (0, 1, 2, 3 gm.L^{-1}) by three sprays with a fourteen days interval, or spraying with tocopherol (vitamin E) at three concentration levels (0, 75, 150 mg. L^{-1}) two sprays 14 days interval. The period between spraying one substance and another was one week in addition to all the interactions and control treatment that sprayed its plants with distilled water. The results showed that spraying the pepper plant with single and combined studied treatments led to a significant increase in all the plant nutritional contents and yield characteristics represented by number of leaf/plant, leaf content of total chlorophyll, total carbohydrates, fruit content of Nitrogen (%), nitrates, Vita. C, number of fruits/plant, and total yield. The treatment 2g.L^{-1} NPK Nano-fertilizer+150 mg.L^{-1} tocopherol (vitamin E)) led to the highest rates for all studied traits except for fruit content of Vita. C and number of fruit/plant, which was the highest in the fertilizer combination 3g. L^{-1} NPK + 150 mg.L^{-1} tocopherol (vitamin E) compared to the control treatment, which recorded the lowest values. However, the treatment 150 mg.L^{-1} tocopherol (vitamin E) alone resulted in the lowest rate of fruit content of nitrates.

Keywords: Bell pepper, growth parameters, NPK, plant nutrition, Vitamin E

Sweet pepper (*Capsicum annuum* L.) is a fruiting vegetable of the Solanaceae family, which grows in conditions of moderate temperatures and is native to Central and South America (Bouras and Al-Basit, 2006)[1]. Pepper fruits are distinguished by their high nutritional value, as every hundred grams of fresh fruits contain about 4.8% carbohydrates and 1.2% proteins in addition to containing mineral salts such as potassium, calcium and iron and also contains fluorine, which protects the teeth from decay, vitamin C and A and E (Emmanuel-Ikpeme et al., 2014) [2]. Global production of pepper for the year 2016 was 34,497,462 tons, and China came first in the world, then Mexico (F.A.O, 2016). Pepper is grown in Iraq by open cultivation at the beginning of spring, and protected cultivation at the beginning of autumn, as Iraq produced 23,473 tons with a cultivated area of 2698.75 Hectare (ICSO, 2018) [3]. There are many local and international varieties of pepper plants in Iraq, including the California Wonder variety, which is characterized by abundant growth and abundance of production throughout the growing season and is one of the varieties approved by the Iraqi Ministry of Agriculture (Al-Akayishi, 2020) [4]

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The fact that this type of vegetable plants need to be fertilized during its growth period, so foliar fertilization has a great role to play to obtain strong plants, especially in the early stages of the plant's life. Foliar fertilization ensures that nutrients are absorbed by the leaves and other plant parts except for the roots. This avoids the loss of nutrients in stabilization processes when they are added to soils with high pH, such as Iraqi soils, and thus their readiness for plants decreases. And due to the importance of providing the nutrients, especially the major nitrogen, phosphorus and potassium, which the plant needs in large quantities, resorting to foliar fertilization with these elements to reduce the cost of fertilizers if compared to ground fertilization. As plant nutrients are very important for the growth of plants, and the lack of any component of them leads to a major imbalance in growth and yield, and thus fertilization with these nutrients leads to an improvement in the vegetative growth of the plant (Lovatt, 2013)[5]. The use of nanotechnology to add fertilizers opens new horizons and applications in the biological and agricultural fields. Nanofertilizers are innovative agricultural inputs aimed at gradually and controlled release of the necessary elements into the soil, which helped avoid potential damage to the environment from the use of traditional fertilizers and contribute to plant growth and increase the yield in quantity and quality (Janmohammadi et al., 2016) [6].

Peppers are a summer crop that needs a warm, sunny season. And that the high temperatures during the growing season lead to the weakness of the vegetative growth and yield (Bouras and Al-Basit, 2006)[1]. Therefore, some modern technologies that work to increase the plant's tolerance to heat stress must be used, including tocopherol (vitamin E), as it is found in the membranes rich in unsaturated fatty acids in the form of a dissolved lipid, and it is also found in different parts of the plant (Shao et al., 2008) [7].

Tocopherols (E-Vitamine) are important plant compounds, as they are considered antioxidants (Hess, 1983) [8] for their role in increasing membrane stability and in eliminating free radicals and free oxygen. Studies have proven the positive effect of foliar fertilization and its role in plant growth and development. In a study conducted by Al-Juthery and Al-Shami (2019) [9] on the potato plants (*Solanum tuberosum* L.) variety Arizona to study the effect of fertilizing with N, P and K Nano-fertilizer at four levels (10%, 20%, 30%, 40%), it was shown a significant effect of nanostructured fertilizer on all indicators of vegetative, chemical and yield growth of the potato plants. When treating the hot pepper *Capsicum annum* L. with fertilizer and NPK (100, 50, 50), the results showed the significant effect of the fertilizer treatments on the vegetative growth characteristics as well as their positive effect on the specific characteristics and the nutritional content (N, P, K) of the treated plants compared to untreated ones (Altaf et al. (2019) [10]. As for the role of tocopherol (vitamin E), it agreed with Neama et al. (2014) [11] in their study on the leguminous plant (Vicia faba, Cyprus class, plant response to spraying with foliar fertilizer vitamin E at a concentration of 1000 ppm in vegetative characteristics), regarding the total yield and leaf content of nutrients (N, P, K). Likewise, Taha et al. (2018) [12] spraying Capsicum annum (California wonder seedlings) with alpha-Tocopherol (α TOC) at a concentration of 1 ml.mol showed a significant increase in vegetative characteristics and the chemical and yield compared to the control treatment.

MATERIALS AND METHODS

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The experiment was conducted in one of the fields of the nursery project of the Najaf Agriculture Directorate during the spring growing season 2020 using the California Wonder sweet pepper plants. The seeds were grown in cork dishes filled with peat moss and river 1:1. The field was divided to furrows of 5 m long, 80 cm width and 75 cm between each two furrows. The planting area was covered with black plastic mulch. The seedlings were transferred to the permanent field after forming 3-4 true leaves, with a plant length of approximately 15 cm, and 35cm plant spacing with experimental unit of 3.36 square each and 14 plants in each unit. After 20 days of transferring the seedlings in the permanent field, the treatments were carried out that included two factors. The first was to spray the seedlings with NPK nan fertilizer (20-20-20) with four concentrations (0, 1, 2, 3 gm.L^{-1}) by three sprays of 14 Days between every two spurts. The second factor was spraying the tocopherol plants (vitamin E) at three concentrations (0, 75, 150 mg.L^{-1}), by two sprays, with a 14-day interval between the two sprays, while the comparison treatment was sprayed with distilled water, and a period of one week between spraying different materials. The treatments were distributed in factorial experiment according randomized complete block design (R.C.B.D). At the end of the experiment, the measurements included: number of leaf.plant^{-1}, leaf content of total chlorophyll mg.100g^{-1} FW (Ranganna, 1977) [13], total carbohydrates mg.100g^{-1}DW (Dubois et al., 1956) [14], fruit content (%) of Nitrogen (Black, 1965) [15], nitrates (Cataldo et al., 1975) [16] , Ascorbic acid (Vita. C) (A.O.A.C., 1986) [16], number of fruits.plant^{-1} and total yield. All the data were analyzed and analysis of variance ANOVA was performed using GenStat 2012 computing program. Means were compared by the least significant difference L.S.D. ($P \leq 0.05$).

RESULTS AND DISCUSSION

The results (Table 1) showed that spraying with NPK Nano-fertilizer at a concentration of 2g.L^{-1} or spraying tocopherol (vitamin E) led to a significant increase in all the vegetative growth and yield characteristics of pepper plants including number of leaf/plant, leaf content of total chlorophyll, total carbohydrates, fruit content of Nitrogen (%), nitrates, Vita. C, number of fruits/plant, and total yield compared with untreated plants in the control treatment that recorded the lowest values.

As for the interaction between the levels of NPK Nano-fertilizer and tocopherol (vitamin E), the results indicate the significant superiority of the interaction treatment with 2 gm. L^{-1} of Nano NPK and 150 mg.L^{-1} for tocopherol over the rest of the interactions by giving it the highest values for all studied traits except for Fruit content of Vita. C and number of fruit.plant^{-1}dry which was the highest in the interaction treatment 2gm. L^{-1} of Nano NPK and 150 mg.L^{-1}.

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Table1. Effect of Nano-NPK fertilizer and Tocopherol (Vita. E) in growth and yield of sweet pepper *Capsicum annum* L.

Treatments		number of leaf.plant^{-1}	Leaf content of total		Fruit content of			No. of fruit.plant^{-1}	Total yield Ton.h^{-1}
Nano-NPK	**Tocopherol (Vitamin E)**		chlorophyll mg.100g^{-1} FW	carbohydrates mg.100g^{-1}DW	Nitrogen (%)	nitrates mg.Kg^{-1}DW	Ascorbic acid (Vita. C) mg.L^{-1}		
0	**0**	**163.02**	**68.00**	**3.63**	**1.68**	**31.50**	**115.30**	**23.13**	**8.80**
	75	**213.18**	**82.50**	**3.88**	**1.88**	**31.80**	**118.23**	**26.41**	**13.59**
	150	**182.27**	**78.06**	**3.91**	**1.82**	**29.48**	**123.20**	**26.66**	**10.81**
1g	**0**	**209.55**	**79.48**	**3.85**	**1.76**	**31.63**	**118.10**	**25.00**	**11.23**
	75	**220.88**	**82.53**	**4.21**	**1.93**	**33.11**	**125.32**	**29.48**	**16.68**
	150	**247.28**	**86.10**	**4.08**	**2.10**	**32.56**	**123.53**	**27.53**	**16.34**
2g	**0**	**216.37**	**83.50**	**4.35**	**1.93**	**33.90**	**124.91**	**26.73**	**14.75**
	75	**278.63**	**89.10**	**5.10**	**2.17**	**34.10**	**130.02**	**32.81**	**16.26**
	150	**293.70**	**91.14**	**5.63**	**2.55**	**33.17**	**129.42**	**34.13**	**22.46**
3g	**0**	**227.26**	**83.91**	**4.53**	**2.04**	**34.80**	**126.40**	**29.81**	**14.67**
	75	**270.53**	**88.03**	**4.91**	**2.13**	**34.27**	**129.34**	**31.02**	**17.01**
	150	**273.90**	**89.50**	**5.12**	**2.23**	**33.08**	**130.13**	**36.49**	**21.45**
L.S.D. (*P*≤0.05)		**6.214**	**0.9755**	**0.09583**	**0.03621**	**0.06054**	**0.7714**	**0.6073**	**0.6193**

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However, the treatment 150 mg.L^{-1} tocopherol (vitamin E) in the absence of Nano-NPK resulted in the lowest rate of fruit content of nitrates (29.48 mg.Kg^{-1}DW). Generally, all the interactions and single treatments resulted in a significant increase in the studied characteristics compared to the control treatment.

Spraying with NPK nan fertilizer led to a significant increase in the vegetative growth characteristics of pepper plants represented in (plant height, average leaf area, dry weight of the shoot and root system, percentage of the node, fruit weight, fruit size and plant yield) and this is due to the effect of the fertilizer in meeting the plant's need from The macronutrients necessary for photosynthesis, respiration, and various metabolic processes that have a major role in the process of cell division and elongation, which is positively reflected on the characteristics of vegetative growth and yield (Awad and Atawia, 1995; Naseem et al., 2019) [17, 18].

Nitrogen has an effect on increasing the activity of apical meristem that increase cell division and elongation, as a result of increasing the concentration of auxins or the readiness of the basic materials needed by the plant in the building process, such as amino acids and some enzymatic adjuvants such as NAD and NADP, which include the nitrogen component in its composition. As well as the role of phosphorus, which has a key effect on vegetative growth, as phosphorous and potassium play a role in increasing the effectiveness of the plant to carry out the process of photosynthesis, which leads to an increase in the length of the branches of the plant. They are also involved in building cell membranes and forming energy compounds. In addition to the fact that potassium has an important role in the flowering process and encourages the transport of carbohydrates (Fan et al., 2001)[19] and thus increases the number of flowers and results in an increase in the number of fruits. Potassium also participates in the transfer of photosynthetic products from the leaves to the fruits and their accumulation in the fruits, which ultimately leads to an increase in the size and weight of the fruits (Ahmad and Butt, 1999; Johenson and Jones, 2004) [20, 21].

The increase in plant yield and total yield was positively reflected in the outcome indicators, and these results were in agreement with (Al-Rubeei and Azab, 2014)[22] in their study on the pepper plant, and with Gerdini (2016) [23] on squash, and Al-Sultani (2020)[24] when spraying potassium on eggplant.

The significant increase in the studied plant growth and yield indicators as a result of the tocopherol spraying can also be attributed to its role in reducing the damage caused by stress. This is through the role of tocopherol as an antioxidant that helps protect plant tissues from free radicals that may accumulate as a result of exposure to heat stress. Tocopherol works by stopping scavengers, preventing fat oxidation, maintaining the water and ionic balance in the plant, and increase the gene expression and hormonal balance of the lipid peroxy roots and free oxygen (Esterbauer et al.,1989; Ellouzi et al., 2013).[25,26] Thus, keeping continuous plant growth and improving of vegetative growth and yield indicators. This can be attributed to the role of antioxidants, including tocopherol, in controlling the selectivity of K^+/Na^+ ratio under stress conditions. The encouraging effect may also be due to Vitamin E role in improving membrane permeability as well as increasing the content of the protein that protects cell membranes and Cellular-Membrane-Associated Enzymes (Farouk, 2016)[27]. This reflected positively on the increase in vegetative growth and yield. Also, increasing the yield and improving its quality when treated with tocopherol may be due to its role in increasing the leaf area of the plant, improving the plant nutritional

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status, flower growth, and then increasing the yield and improving its quality. These results are in agreement with Mady (2009)[28] in his study on tomato plants, Neama et al. (2014)[11] in their study on Peas and Taha et al. (2018)[12] when pepper seedlings were sprayed with alpha-Tocopherol.

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