Improvement of Vegetative and Reproductive Growth of 'Camarosa' Strawberry: Role of Humic Acid, Zn, and B

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Summary

This experiment was conducted with the aim to improve vegetative and reproductive growth of strawberry *(Fragaria × ananassa* Duch. cv. 'Camarosa') using humic acid, zinc sulfate ($ZnSO_4$), and boric acid. We evaluated applications of humic acid at 0, 20 and 40 mg·L^{-1}, $ZnSO_4$ at 0, 50 and 100 mg·L^{-1}, and boric acid at 0, 50 and 100 mg·L^{-1} at 30 days after planting and blooming stage on growth of strawberry cv. 'Camarosa'. Results indicated that humic acid, ZnSo4, and boric acid application improved reproductive and vegetative characteristics compared to control treatment. The results showed, that plants treated with humic acid, $ZnSO_4$, and boric acid at higher their concentrations exhibited generally higher dry weight of roots and shoots, number of flowers and inflorescences, leaf area, length of roots and shoots, length of flowering period, yield, weight of primary and secondary fruits and number of their achenes. Total yield was significantly increased by all treatments compared to control treatment at both stages of application, especially at blooming stage. Moreover, conclusion showed that the mentioned materials could have impact on vegetative and reproductive growth of strawberry generally. In this study humic acid at 40 mg L^{-1} at blooming stage resulted in best effects on development of strawberry cv. 'Camarosa'.

Key words

humic acid, zinc sulfate, boric acid, growth

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Introduction

Strawberry is a delicious fruit with high health value and is grown almost all over the world including Iran. Strawberries are considered as one of the most important crops grown in Iran for fresh local consumption and export especially during the period from December to April (Eshghi and Jamali, 2009). Fertilizer management is a vital demand for high quality yield of organically grown strawberry. Foliar nutrition may play an important role in perennial fruit plants. Both qualitative and quantitative aspects of perennial fruit crops have been improved through foliar application of nutrients (Brown et al., 1996; Tan, 2003; Zare, 2011).

Humate is an organic substance having bio-regulatory effects. It was found that under certain conditions humic acid applied to the root zone had beneficial effects on plant development. Several studies have been reported that humic acid improved not only vegetative growth but also yield and quality. Cangi et al. (2006) indicated that the application of humic acid significantly increased the yield of grape (*Vitis vinifera* L.) cultivar Ercis. Ashraf et al. (2005) reported that growth (number and fresh weight of leaves) and yield of onion were gradually and significantly increased with increasing the level of humic acid application. Also, Habashy and Laila (2005) concluded that plant growth and yield of wheat crop were increased by fertilization with humic acid at a rate of 100 ppm. In addition, Salman et al. (2005) indicated that the application of humic acid up to 6 L per fed linearly increased total yield of watermelon crop. Zaky et al. (2006) found that the number of shoots/plant, average leaf area, total yield, average pod fresh weight and P content were increased by application of humic acid as a foliar fertilizer at a rate of 1 g·L^{-1} in been plants. Manure and compost are organic sources of nutrients that have been also shown to increase soil organic matter and improve soil quality (Wright et al., 1998).

Among nutrients, zinc and boron play an important role in pollination, fruit set, and total yield (Motesharezade et al., 2001). Boron (H_3BO_3) is an essential element required for optimal growth and development in higher plants (Marschner, 1995). Increased fruit yields in pear and sour cherry have been reported using B fertilization (Hanson, 1991; Mohamed et al., 2009; Neilson and Eaton, 1983; Wojcik and Wojcik, 2003). Even though positive responses to foliar B applications have now been observed in almond at several sites and in several years, yields were not significantly increased by time or rate of foliar B application in 1997 (Boaretto et al. 1997). High variation among trees contributed to the insignificant treatment effects, but the possibility of a residual effect of B cannot be ruled out. These results, however, are not unusual and reflect the fact that crop response to foliar B is variable. For example, Boaretto et al. (1997) reported that leaf B concentration of citrus increased linearly with higher rates of B application but there was no corresponding increase in fruit yield. Smith et al., (1997) sprayed avocado (*Persea americana* Mill.) at fully developed panicle stage and observed a 42% increase in fruit set but no significant increase in fruit retention.

Zinc has an important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes (Bowler et al., 1994). Zinc sulfate induces pollen tube growth through its role on tryptophan biosynthesis, as an auxin precursor (Chaplin and Westwood, 1980). Growth of the receptacle is controlled primarily by auxin, which is synthesized in the achenes (Dreher and Poovaiah, 1982). So, an application of $ZnSO_4$, a prerequisite of auxin, is potentially useful in increasing fruit size as well as its quality.

The objective of this research was to test the effectiveness of humic acid, zinc sulfate and boric acid on vegetative and reproductive growth of 'Camarosa' strawberry *(Fragaria × ananassa* Duch.) plants.

Material and methods

This study was carried out at commercial greenhouse of Jiroft city. Induced and rooted daughter plants of Camarosa cultivar were planted in greenhouse. The treatments were humic acid at 0, 20 and 40 mg L^{-1}, $ZnSO_4$ at 0, 50 and 100 mg·L^{-1}, and boric acid at 0, 50 and 100 mg·L^{-1}. Then, plants treated at 30 days after planting and at blooming stage and characteristics such as dry weight of roots and shoots, number of flowers and inflorescences, leaf area, length of roots and shoots, length of flowering period, yield, weight of primary and secondary fruits and number of their achenes were measured.

Statistical analysis

The experimental design was a factorial randomized complete-block with single plant experimental units and four replications. Data were analyzed by analysis of variance (ANOVA) and the means were compared ($p \le 0.05$) by Duncan's multiple rang test (DMRT). All analyses were performed by using SAS version (Ver.9.1).

Results

The results obtained on the vegetative and reproductive characteristics of strawberry plant after the application of humic acid, Zn and B as foliar spray during two stages are given in Table 1 and Table 2.

Table 1 shows the effect of humic acid, $ZnSO_4$, and boric acid on length of flowering period, weight of primary fruit, weight of secondary fruit, number of achenes of primary fruit, number of achenes of secondary fruit, yield and length of fruit. Humic acid at 40 mg·L^{-1} increased length of flowering period, weight of primary fruit, weight of secondary fruit, number of achenes of primary fruit, number of achenes of secondary fruit, yield, length of fruit more than other treatments and all treatments had significant impact on this productive characteristics compared to control in both spraying times specially at blooming stage. However, humic acid at 40 mg·L^{-1} concentration sprayed at stage of full bloom increased significantly weight of primary fruit, weight of secondary fruit and yield in comparison to control. Table 2 shows the effect of humic acid, $ZnSO_4$, and boric acid on leaf area, length of shoot, length of roots, shoot dry weight and root dry weight. Humic acid at 40 mg·L^{-1} increased leaf area, length of shoot, length of roots, shoot dry weight and root dry weight more than other treatments and all treatments had significant impact on this vegetative characteristics compared to control in both spraying time specially at blooming stage. So, results of this study showed that higher concentrations of humic acid, $ZnSO_4$, and boric acid had great effect on improvement of

Table 1. The effect of humic acid, $ZnSO_4$, and boric acid on flowering, yield and some quality characteristics of the strawberry fruits of cv. 'Camarosa'

Time of spraying	Treatment	Length of flowering period (days)	Weight of primary fruit (g)	Weight of secondary fruit (g)	Number of achenes of primary fruit	Number of achenes of secondary fruit	Yield (kg/plant)	Length of fruit (cm)
T1	C	14f*	12.55d	12.02e	120.75f	116g	1.11e	2.38f
	H1	18.75def	16.20cd	14.33cde	151ef	135g	1.47d	2.69cdef
	H2	24.25bc	20.59bc	18.36bcd	189.50bc	174.25bcd	1.74bc	2.94a-d
	B1	17f	15.76cd	13.79de	152.25def	130.25fg	1.46d	2.62def
	B2	22.50bcd	17.78bcd	15.36cde	174.75cde	160.50efg	1.64bcd	2.81b-e
	Z1	18.50def	15.82cd	14.23cde	152.25def	133.25fg	1.48d	2.49ef
	Z2	22.25bcd	17.88bcd	15.91b-e	177cde	166.5bcde	1.66bcd	2.70c-f
T2	C	15f	12.40d	12.04e	123.25f	116.75g	1.08e	2.36f
	H1	24.25bc	19.15bc	16.84b-e	191c	155c-f	1.54cd	2.83b-e
	H2	13.75a	27.54a	24.90a	237.5a	215a	1.02a	3.25a
	B1	20.50cde	17.86bcd	15.59b-e	192.25bc	148.50def	1.50d	2.72c-f
	B2	24.75bc	22.57ab	20.87ab	214.75ab	181bc	1.74bc	3.05abc
	Z1	22.25bcd	18.22bc	16.35b-e	188.75bcd	150def	1.58cd	2.67def
	Z2	26b	22b	19.49abc	220.25ab	185.50b	1.83ab	3.12ab

Means followed by same letter are not significantly different at 5% probability using Duncan's test; T1: spraying at 30 days after planting; T2: spraying at blooming stage; C: Control; H1: 20 mg L^{-1} humic acid; H2: 40 mg·L^{-1} humic acid; B1: 50 mg·L^{-1} boric acid; B2: 100 mg·L^{-1} boric acid; Z1: 50 mg·L^{-1} $ZnSO_4$ and Z2: 100 mg·L^{-1} $ZnSO_4$.

Table 2. The effect of humic acid, ZnSO4, and boric acid on some vegetative characteristics of the strawberry plants of cv. 'Camarosa'

Time of spraying	Treatment	Leaf area (cm^2)	Length of shoot (cm)	Length of roots (cm)	Shoot dry weight (g)	Root dry weight (g)
T1	C	21.30*g	13.19f	19.28e	16.22e	11.22e
	H1	33.32def	14.40def	23.91cd	17.40d	12.40d
	H2	39.15b	15.88ab	27.78abc	18.05abc	13.05abc
	B1	30.42f	14.05ef	21.08de	17.25d	12.25d
	B2	35.31cde	15.10bcd	25.23bc	17.70bcd	12.70bcd
	Z1	32.19ef	14.13def	21.21de	17.18d	12.18d
	Z2	35.65cde	15.17bc	26.35bc	18.18ab	13.18ab
T2	C	21.49g	13.20f	19.54e	16.29e	11.29e
	H1	35.30cde	15.46b	28.33ab	17.64bcd	12.64bcd
	H2	43.69a	16.54a	31.41a	18.56a	13.56a
	B1	32.27def	15.21bc	25.39bc	17.36d	12.36d
	B2	36.32bcd	15.77ab	28.57ab	18.33a	13.33a
	Z1	33.86def	15.16bc	25.06bc	17.58cd	12.58cd
	Z2	56.84bc	15.64ab	28.23ab	17.28a	13.28a

Means followed by same letter are not significantly different at 5% probability using Duncan's test; T1: spraying at 30 days after planting; T2: spraying at blooming stage; C: Control; H1: 20 mg L^{-1} humic acid; H2: 40 mg·L^{-1} humic acid; B1: 50 mg·L^{-1} boric acid; B2: 100 mg·L^{-1} boric acid; Z1: 50 mg·L^{-1} $ZnSO_4$ and Z2: 100 mg·L^{-1} $ZnSO_4$.

vegetative and reproductive growth of strawberry plant in both spraying time, but maximum was obtained when they were applied at secondary time.

Discussion

As it has been indicated in Table 1, there were considerable differences between productive characteristics of treated and non treated plants. Humic acid has a great influence on plant growth and development and many previous studies reported a promoting impact of humic acid on growth parameters. Increasing quantitative and qualitative characteristics by using humic acid have been reported by many researchers (Kamari-Shahmaleki et al., 2012; Ferrara and Brunetti, 2010; EL-Ghozoli, 2003; Sarir et al., 2005 and Shehata et al., 2011). Formation of complex between humic acid and mineral ions, catalysis of humic acid by the enzymes in plant, influence of humic acid on respiration and photosynthesis, stimulation of nucleic acid metabolism and hormonal activity of humic acid are amongst effective assumptions that have been expressed to describe the effect of humic acid on plants growth parameters. So, increase of quantitative and qualitative characteristics by using humic acid are considerable, and our findings were in accordance with previous works (Ozdamarullu et al., 2011; Turkmen et al., 2004). Some researchers (e.g. Atiyeh et al., 2002) reported that the reason behind the effectiveness of humic acid on plant growth and development is the interaction with plant growth regulators such as IAA, GAs and CKs. Moreover, some authors attributed the positive effects of humic acid to its influence on plants root, and our findings were in accordance with previous works (Adani et al., 1998; Atiyeh et al., 2002; El-Nemr et al., 2012; Mackowiak et al., 2001; Turkmen et al., 2004; Yildrim, 2007; Ozdamarullu et al., 2011). High concentrations of humic acid simulate growth of the root in hydroponic systems and cause the increase of root volume, which may be due to easier absorption and more efficient nutrients uptake. It is likely that increasing nutrient uptake by plants can particularly be associated with an increase in root growth. Also root development can be due to hormone-like activity of humic acid. However, our findings were in accordance with previous works (e.g. David et al., 1994). Cangi et al. (2006) indicated that foliar spraying of humic acid and amino acids on *Asparagus* plants increases uptake of macro and micro elements in shoot and rhizome resulting in increase of carbohydrates production, chlorophyll and carotenoids in edible stems. Enhancing the quantitative and qualitative characteristics as a result of increased respiration, photosynthesis and total protein in the plants, due to humic acid and folic acid application has also been reported by Nardi et al. (2002).

The foliar application of micronutrients such as Zn and B increase the photosynthetic compounds inside the plant tissue which ultimately reduced the leaf drop and give strength for their persistency (Puzina, 2004). The results are in conformity with Singh et al. (2002), who found that the application of Zn and B as foliar spray increased the leaf area and hastened the flowering in papaya plant, and also Francois (1984) showed that application of B on tomato increased yield, fruit size, and vegetative growth. Furthermore, the supply of B needed for reproductive growth in many crops is more that needed for vegetative growth (Brown and Hu, 1996; Brown and Shelp, 1997; Marschner, 1986; Hanson, 1991), and the same may be true in citrus and the results are in agreement with mentioned results that found that foliar application of Zn compound to severely Zn deficient citrus trees increased vigor, leaf size and shoot growth and recovery of trees resulted in increased yield. In our study yield, fruit weight and vegetative growth were significantly influenced by the foliar application of Zn and B what is in accordance with previous works. Analysis of variance showed that high concentration of Zn and B significantly increased the yield per plant as compared to untreated plants in control treatment. Maximum yield per plant was produced when plants were treated with high concentration of Zn and B. Perhaps these increases in fruit yield were due to the significant increase in leaf Zn concentration, which in turn induced more flowering and minimized the fruit drop in sweet orange trees. It was also reported that fruit drop decreased as leaf Zn and Mn content increased (Garcia et al., 1984; Hanson and Breen, 1985), also our findings were in accordance with previous works. Similar results were also reported by Leyden (1983) who obtained 95.70% increase in yield over control. The present research showed that yield was significantly increased because of increase in vegetative growth of strawberry plant due to foliar application of Zn and B. The present findings are in conformity with Jeyakumar et al. (2001) who found that the foliar application of Zn significantly increased the fruit yield in papaya (*Carica papaya* L.) cv. Co5. Parveen and Rehman (2000) obtained a significant increase in fruit yield of citrus trees when treated with Zn compound as foliar spray. The foliar application of Zn and B helps in the use of nutrients and regulate other nutrients. This aids in the production of sugars and carbohydrates that are essential for seed and fruit development. The application of micronutrients including Zn, Fe, Cu and Mn at different concentration, improve reproductive and vegetative growth that present findings are in conformity with previous researches (Atkinson, 1986; Alam, 1989; Dikshit, 1961; Hossain et al., 1998; Kanwar et al., 1963; Parveen and Rehman, 2000). The results of this experiment confirm the positive benefits of foliar B on yield and another productive characteristics of strawberry that were described previously (Littlemore, 1991; Shoeib and El sayed, 2003)., and also confirm findings that fall applied B is optimal in other *Prunus* species (Callan et al., 1978; Mart et al., 2007). According to this research, improvement of vegetative and reproductive growth of 'Camarosa' strawberry (*Fragaria* × *ananassa* Duch) by humic acid, Zn, and B application is possible and very interesting.

Conclusion

Treatments with humic acid, Zn, and B could affect the vegetative and reproductive growth and generally this influence is promising and promoting. Best results were obtained using humic acid, and this might has a great influence on over all plant growth and development. Formation of complex between humic acid and mineral ions, catalysis of humic acid by the enzymes in plant, influence of humic acid on respiration and photosynthesis, stimulation of nucleic acid metabolism and hormonal activity of humic acid are amongst effective assumptions that has been expressed to describe the effect of humic acid on plant growth parameters.

References

Adani F., Genevini P., Zaccheo P., Zocchi G. (1998). The effect of humic acid on tomato plant growth and mineral nutrition. J Plant Nutr 21: 561-575.

Alam S. (1989). Lime induced chlorosis. M.Sc (Hons). Thesis. NWFP Agric. Univ. Peshawar, Pakistan.

Ashraf M W., Saqib N., Sarfraz T. B. (2005). Biological effect of bio-fertilizer humic acid on Mung beans (*Vigna radiate* L.). J Biol Biotechnol 2: 737-739

Atiyeh R. M., Lee S., Edwards C. A. (2002). The influence of humic acids derived from earth worm processed organic wastes on plant growth. Bioresearch Technol 84: 7-14.

Atkinson D. (1986). Effects of Some Plant Growth Regulators on Water Use and the Uptake of Mineral Nutrients by Tree Crop. Acta Hort 179: 395-402.

Boaretto A. E., Tiritan C. S., Muraoka. T. (1997). Effects of foliar applications of boron on citrus fruit and on foliage and soil boron concentration, p. 121– 123. In: Bell, R.W Rerkasem,B. (eds.), Boron in soils and plants. Kluwer Academic, The Netherlands.

Bowler C., Vancamp W., Vanmontagu M., Inze D. (1994). Superoxide-dismutase in Plants. Critic Rev Plant Sci 13:199-218.

Brown G S., Kitchener A. E., McGlasson W B., Barens S. (1996). The Effect of copper and calcium foliar sprays on cherry and apple fruit quality. Sci Hort 67: 219-227.

Callan, N.W., Thompson, M.M., Chaplin, M.H., Stebbins, R.L., Westwood, M.N. (1978). Fruit set of 'Italian' prune following fall foliar and spring boron sprays. J. Amer. Soc. Hort. Sci. 103:253-257.

Cangi R., Tarakcioglu C., Yasar H. (2006). Effect of humic acid applications on yield, fruit characteristics and nutrient uptake in Ercis grape (*Vitis vinifera* L.) cultivar. Asian J Chem 18: 1493-1499.

Chaplin M. H., Westwood M. N. (1980). Relationship of nutritional factors to fruit set. J Plant Nutr 2: 477-505.

David P. P., Nelson P V., Sandres D C. (1994). A humic acid improves growth of tomato seedling in solution culture. J Plant Nutr 17: 173-184

Davis T. D., Curry E. A. (1991). Chemical regulation of vegetative growth. Crit Rev Plant Sci 10: 151-188.

Dreher T. W., Poovaiah B. W. (1982). Changes in auxin content during development in strawberry fruits. J Plant Growth Regul 1: 267-276.

EL-Ghozoli A. A. (2003). Influence of humic acid on faba bean plants grown in cadmium polluted soil. Ann Agric Sci Moshtohor 41:1787-1800.

El-Nemr M A., El-Desuki M., El-Bassiony A. M., Fawzy Z. F. (2012). Response of growth and yield of cucumber Plants (*Cucumis sativus* L.) to different foliar applications of humic acid and biostimulators. Austr J Basic Applied Scie 6: 630-637.

Eshghi S., Jamali B. (2009). Leaf and fruit mineral composition and quality in relation to production of malformed strawberry fruits. Hort Environ Biotech 50: 397-400.

Ferrara G., Brunetti G. (2010). Effects of the times of application of a soil humic acid on berry quality of table grape (*Vitis vinifera* L.) cv Italia. SpanJ Agri Resea 8: 817-822.

Francois L. E. (1984). Effect of excess boron on tomato yield, fruit size, and vegetative growth. J Amer Soc Hort Sci 10:322- 324.

Garcia, A., Haydar, N.E., Ferrer, C. (1984). Influence of Zn and Mn on the physiological behavio and yields of Valencia oranges. Institute Superior Agricola Ciego de Avila, Cuba, pp. 57-58

Habashy N. R., Laila K. M. (2005). Effects of organic growth-promoting substances as humic acids and indol-acetic acid on wheat crop with special reference to some chemical composition. Minufiy J Agric Res 30:1607-1624.

Hanson E. J. (1991). Sour cherry trees respond to foliar boron applications. J Hort Sci 26: 1142- 1145.

Hanson, E.J., Breen, P.J. (1985). Effects of fall boron sprays and environmental factors on fruit set and boron accumulation in 'Italian' prune flowers. J. Amer. Soc. Hort. Sci. 110:389–392.

Hossain B., Hirata N., Nagatomo Y., Suiko M., Takaki H (1998). Zincnutrition and levels of endogenous indol- 3-acetic acid in radish Shoots. J Plant Nutr 21:1113-1128.

Jeyakumar P., Durgadevi D., Kumar N.)2001). Effect of zinc and boron fertilization on improving fruit yields in papaya (*Carica papaya* L.) cv. Co5. J Plant Nut 356-357.

Leyden, R.F. (1983). Nutrition of young 'Star Ruby' grapefruit. Journal of Rio Grande Valley Horticultural Society 36, 67-72.

Littlemore J., Winston E. C., Howitt C. J., Farrell P. O., Wiffen D. C. (1991). Improved methods for Zinc and Boron application to mango (*Mangifera indica* L.) *cv.* Kensington Pride in the Mareeba- Dimbulah District of North Queensland. Aust J Exp Agr 31: 117-121.

Kamari-Shahmaleki S., Peivast G., Ghasemnejad M. (2012). Effect of humic acid on vegetative traits and yield of tomato cv Izabela. Hort Scie J 26: 358-363.

Khayyat M., Tafazoli E., Eshghi S., Rajaee S. (2007). Effect of nitrogen, boron, potassium and zinc on yield and fruit quality of date palm. Amer-Eura J Agric Environ Sci 2: 289-296.

Mackowiak C., Grossl P., Bugbee B. (2001). Beneficial effects of humic acid on micronutrient availability to wheat. J Amer Soc Soil Scie 65:1744-1750.

Marschner H. (1995). Mineral nutrition of higher plants. 2nd Edition, Academic Press, London, 889 PP.

Mart I. (2007). Fertilizers, organic fertilizers, plant and agricultural fertilizers. Agro Food Business Newsletter. pp: 1-4.

Mohamed A., Bakry A., Soliman Y. R. A., Moussa S. A. M. (2009). Importance of micronutrients, organic manure and bio-fertilizer for improving

maize yield and its components grown in desert sandy soil. Res J Agr Biotechnol Sci 5:16-23.

Motesharezade B., Malakuty M. J., Nakhoda B. (2001). Effects of N, ZnSO4 and B sprays on photochemical efficiency of sweet cherry. Hort Newsletter 12: 106- 111.

Nardi S., Pizzeghello D., Muscolo A., Vianell A. (2002). Physiological effects of humic substances on higher plants. Soil Biol Biochem 34: 1527-1536.

Neilson B. V., Eaton G. W. (1983). Effects of Boron nutrition upon strawberry yield components. J Hort Sci 8: 932- 934.

Ozdamarullu H. U., NluH., Karakur Y. T., PademH. (2011). Changes in fruit yield and quality in response to foliar and soil humic acid application in cucumber. Scie Res Essa 6: 2800-2803.

Parveen S., Rehman H. (2000). Effect of Zn, Mn and B in combination with urea on the yield of sweet orange. Pak J Agric Res 16: 135-141.

Pouzeshi R., Rehman M. R., Zabihi M. R., Ramezani-Moghadam M., Rajabzadeh M., Mokhtari A. (2011). Effect of foliar application of zinc, humic acid and acetic acid on yield, yield components and mineral concentration in grape cv Peikani. Hort Sci J 25:351- 360.

Puzina T. I. (2004). Effect of Zinc Sulfate and Boric Acid on the hormonal status of potato plants in relation to tuberization. Russ J Plant Physiol 51:234-240

Salman S., Abou R., Abdel H. S. D., El- Nma M. A. (2005). Fruit yield and quality of watermelon as affected by hybrids and humic acid application. Egypt J Appl Sci 20: 244-259.

Sarir M. S., Sharif M,. Ahmed Z., Akhlaq M. (2005). Influence of different levels of humic acid application by various methods on the yield and yield components of maize. Sarhad J Agr 21: 75-81.

Shehata S., Gharib A., Mohamed A. A. M., El-Mogy K. F., Gawad A., Shalaby E. A .(2011). Influence of compost, amino and humic acids on the growth, yield and chemical parameters of strawberries. J Medi Plants Res 5: 2304- 2308.

Shoeib M. M., El-sayed A. (2003). Response of "Thompson Seedless" grape vines to the spray of some nutrients and citric acid. Minia J Agric Res Dev 23: 681–698.

Smith T. E., Stephenson R. A., Asher C. J., Hetherington S. E. (1997). Boron deficiency in avocado. 1.Effects on pollen viability and fruit set, p. 131– 133. In: R.W. Bell and B. Rerkasem (eds.). Boron in soils and plants. Kluwer Academic, The Netherlands.

Tan K. H. (2003). Chemical composition of humic acid matter. In: Humic acids in soil and the environment. Principles and Controversies. Marcel and Dekker,New York. USA.

Turkmen O., Dursun A., Turan M., Erdinc C. (2004). Calcium and humic acid affect seed germination, growth, and nutrient content of tomato (*Lycopersicon esculentum* L.) seedlings under saline soil conditions. Acta Agri Scandina, Section B - Soil and Plant Science 54:168-174.

Wojcik P., Wojcik M. (2003). Effect of Boron fertilization on 'Conference' pear tree vigor, nutrition, and fruit yield and storability. Plant Soil 256:413-421.

Wright R. J., Kemper W. D., Millner P. D., Power J. F., Korcak R. F. (1998). Agricultural uses of municipal, animal, and industrial byproducts. Conservation Research Report 44. U.S. Department of Agriculture, Agric Res Serv. Retrieved June 21, 2007.

Yildrim E. (2007). Foliar and soil fertilization of humic acid affect productivity and quality of tomato. Acta Agr Scandin, Section B - Soil and Plant Sci 57: 182-186.

Zaky M. H., Zoah E. L., Ahmed M. E. (2006). Effects of humic acids on growth and productivity of bean plants grown under plastic low tunnels and open field. Egyptian J Applied Sci 21:582-596.

Zare M. (2011). Effect of foliar application of algarin, derin and humic acid on flowering, quantitative and qualitative characteristics of strawberry fruit cv Salva. M.Sc Thesis in Horticultural Sciences. 96 p.

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