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EFFECT OF HUMIC ACID ON GROWTH AND YIELD OF CUCURBITS CROPS: A REVIEW ARTICLE*

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ABSTRACT

Cucurbitaceae family comprises of prominent vegetables like cucumber, squash, melon, watermelon, and pumpkin which are valuable from medicinal and nutritional aspects. The excessive use of chemical inputs caused serious problems to public health and the environment leading to suppress soil fertility and crop palatability for consumers. Hence, utilization of humic substances including humic acid, fulvic acid, and potassium humate as natural fertilizers and bio-stimulants is a good substitute since they are enriched with nutrients, hormone and hormone like substances that activates plant to grow and yield efficiently and to combat environmental stresses. The present review article put the spotlight on the possible role of humic substances in activating growth of cucurbit foliage and yield. The possible role in improving the resistance of certain cucurbits to environmental stress is briefly discussed.

Keywords: plant growth, organic farming, bio-stimulants, Plant activation, environmental stress resistance

INTRODUCTION

The family cucrbitaceae is considered as one of the biggest family consisting of about 125 genera and 960 species of various vegetables and fruits. The vegetable members of the cucrbitaceae family are prominent component of ancient medications and traditional cooking and are rendered as the strong source for evolution of secure and active therapeutics due to their remedial significance [39].

The extensive utilization of inorganic fertilizers has brought detriments to the human, animal, plant health, deteriorated the soil structure and fecundity leading to decrease in the arable lands. Therefore, great efforts have been implemented to find out new feeding sources that are natural/organic, ecofriendly and effective to produce a crop with a unique quality and yield. A number of studies have displayed that the addition of organic fertilizers resulted in better soil fertility, reduced soil-borne diseases, boosted microbial flora structure, hence suppressed permanent obstacles that impede plant growth and development [47, 32].

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Among these sustainable sources is a prominent organic substance known as humic substance. Humic acid is an organic matter which is produced and accumulated by animal and plant wastes or residues that decomposed and changed by decomposer microbes via a chain of geochemistry operations. Humic acids can have a significant role in amelioration of the soil qualitative features, increment of rate of fertilizer utilization as well as stimulation of crop harvest and quality [2, 54].

Humic substances (HS) are counted as a key component of soil fertility traits, because they exhibit efficacy in dominating chemical and biological properties of the rhizosphere [40, 57]. It has been proven that the humic acid significantly influenced plant outgrowth parameters due to its activity in increasing permeability of cell membrane, photosynthesis and respiration, oxygen uptake, phosphate absorption and cell enlargement [6, 59]. The aim of this review is to illustrate the importance of humic substances (HS) as bio-stimulants for plant growth and soil and the effect of humic acid on cucurbits plants and environmental stresses.

Types of Humic Substances Utilized in Agriculture

Potassium Humate (KH)

Potassium humate is a useful natural matter that is widely utilized in the production of horticultural crops. It improves the physical and chemical properties of plant outgrowing medium, supporting its structure, and ultimately raising plant productivity: (KH) is provided to plants either as foliar feeding or added to the soil since it contains about 30% to 60% humic acid that is already absorbed by roots [28]. KH is an effective fertilizer that efficiently ameliorates plant performance and harvest and they do so through enhancing the rate of nutrient absorption, optimizing plant biomass and suppressing compaction of soil [43].

KH enhances membrane permeability, enzymatic and hormonal functioning and increases water holding capability of soil. Furthermore, KH also displayed capability in alleviating environmental stresses such as drought, cold and heat stress by improving plant performance, soil characteristics and nutrient mobility [27]. As consequence, KH ameliorates soil health and soil structure for plant growth and development [34].

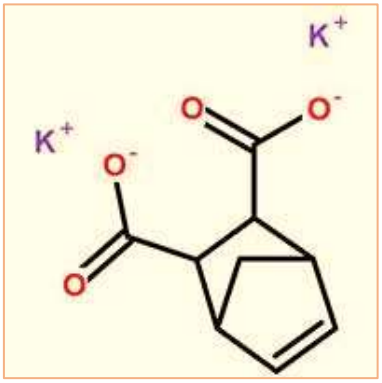

Figure 1: Structure of potassium humate (http://sk.aminoacidsfert.com/)

Fulvic acid (FA)

Fulvic acid is a bio-stimulant which is derived from biodegradable lignin containing plant organic substance [35]. Fulvic acid that is often obtainable in aqueous form remarkably participates in cation exchange capacity of the soil [60, 35]. Since fulvic acid readily dissolves in water and is easily washed out, it is

usually available in very low concentrations (0.2-1% w/v) in various sources like leonardite, peat, and compost etc. therefore, some producing companies dehydrate fulvic acid into powder forms.

Considered as an organic fertilizer, fulvic acid is a natural mineral chelating additive and water linker that upraise intake via leaves and motivated plant performance and yield. It is responsible for many beneficial activities such as attraction of water molecules, assistance of the soil to be kept moist and contribution in the mobilization of nourishing nutrients into plant roots. Fulvic acid easily makes associate or chelate minerals such as iron, calcium, copper, zinc and magnesium, as it can receive these elements to plant directly [38].

Fulvic acid is a significant component of soil organic matter. It is usually active in enhancing the rate of cell division and stimulates extra root development and ultimately makes the plant to grow more potent with excellent defense against plant disorders and ailments [31]. Fulvic acid has been applied extensively to ameliorate the physico-chemical characteristics of soil leading to better plant outgrowth. The addition of fulvic acid exhibited supremacy in raising soil organic carbon and light fraction of carbon content. The utilization of aqueous formula of fulvic acid were found to act better than the solid fulvic acid and economic rates of addition must be pointed out to give the best strategies for soil management which should not trespass 5 g kg^{-1} in the soil [51].

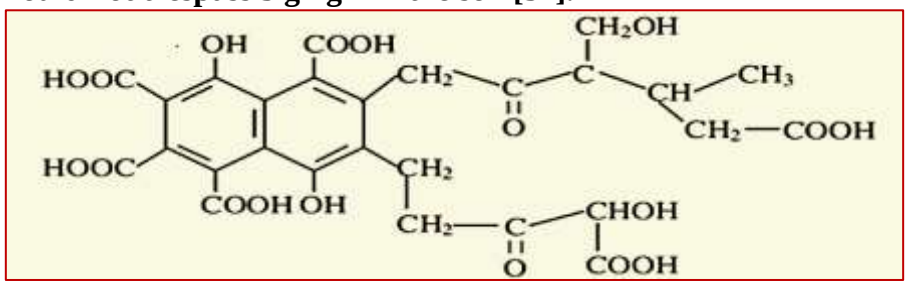

Figure 2: Structure of fulvic acid (Buffle, 5)

Humic acid (HA)

Though rendered as non-essential fertilizers, humic acid is one of the profound organic materials that enhance soil fecundity and ameliorate soil build-up. It has a unique efficiency in the modification of soil physical features and is able to promote plant outgrowth via activating microbial functioning as well as altering the fixation characteristics from chemical aspect [12, 47].

Humic acid is the terminal products of the organic wastes broken down by action of decomposer microbes and contributes in the marked reactions that take place in the soil, hence making soil more fertile via ameliorating physical and biological status and by creation of substances that are effective from physiological scope [8, 3]. Many agronomical experiments have proven that the humic acid significantly influenced nutrient intake, metabolism and plant performance [42, 58]. The potency of humic acid as a plant outgrowth stimulator was came from its vital role in initiating changes on root structure and dynamics of growth, which lead to enhanced root volume, root extension and denser root hairs with larger surface area [7].

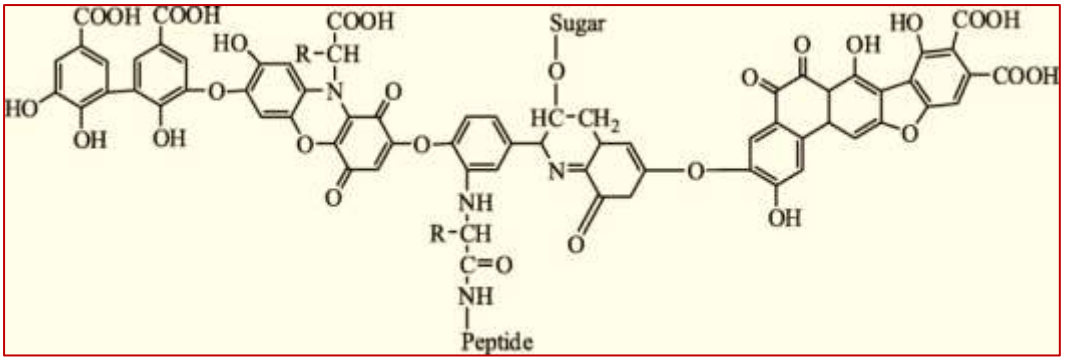

Figure 3: Structure of humic acid, Source [52]

Mechanisms of Action of Humic substances on Plant Growth and Development According to numerous studies that were implemented on the efficacy of humic substances on various plant species planted in diverse soil types and hydroponics, these natural substances importantly ameliorated plant outgrowth and harvest. Despite that, the major mechanisms of the impact of such substances remain elusive and under argument [11, 56]. Generally, two mechanisms have been hypothesized for the influence of humic substances on plant. An indirect mechanism represented by amelioration of the plant nourishment via enhancing the obtainability of nourishing elements in the soil, especially phosphorus, iron and zinc. This action of HS is potently founded on the complexion of metals by these substances drove by the existence of functional groups capable of chelation in their architecture [53, 24]. This was confirmed in studies like that executed by Garcia-Mina et al. [23] on the effect of HS-metal complexes on plant performance under restricted obtainability of microelements and they recorded an increment in plant outgrowth owed to the promotion of micronutrients uptake by these complexes.

The other proposed mechanism of HA action is the direct mechanism which is based on the presence of hormone or hormone-like materials in the structure of HS. The containment of such substances in HS might be the key activator responsible for the stimulation of plant outgrowth through organized plant hormone pathways and though the existence of these hormones and hormone-like materials in HS has not yet been proved but several research clues that boost this assumption [29]. The first clue is that the improvement in plant outgrowth and progress based on HS application resembled that obtained from the application of auxin, a common plant hormone. This was documented in raised outgrowth and surface area of roots, major morphological attributes activated by the function of auxin, resulting from the provision of HS [41]. The second clue is the identification of auxin groups in the structure of HS with the use of a mass spectrometry [9]. The humic acid may impact shoot growth via stimulating root uptake of nitrate and its transportation upward to the shoots. This action drives to improve transportation of active cytokinins from roots to shoots, hence elevating nutrient content and development of shoots [37].

Away from the auxin-like action of HS, the breakdown of seed dormancy with gibberellin (GA)-like signaling by HS was also observed. The prohibition of seed germination derived by abscisic acid (ABA) and a GA biosynthetic inhibitor (i.e., paclobutrazol) was overcome by dosing plants with HS [45].

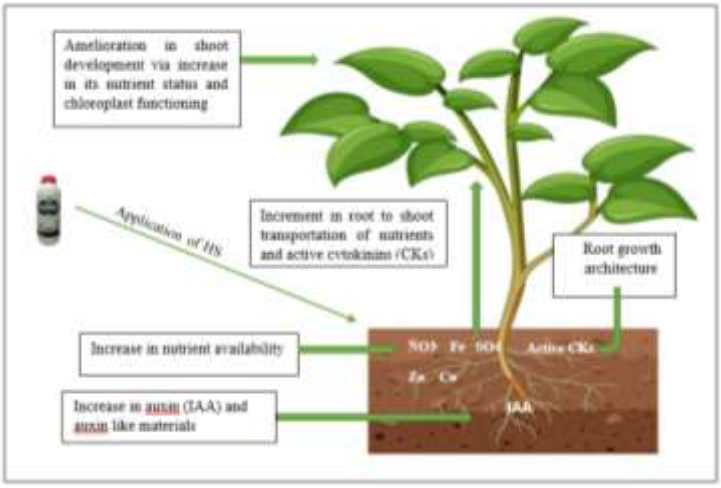

Figure 4: Mechanism of action of humic substances (HS) on plant growth

Effect of Humic acid on Foliage of Cucurbit Crop

Numerous field studies have been implemented on the response of cucurbits crop to the application of humic acid. Fahmy [22] displayed that the foliar feeding of humic acid plus other fertilizers caused a marked amelioration in the vegetation traits of cucumber and melon in terms of plant height, internode number on the main stem, leaf and branch number per plant and fresh and dry biomass when compared to control. Yaser *et al.*, [61] reported that treating greenhouse cucumber *(Cucumis sativus L.)* with humic acid was efficient in enhancing foliage parameters of the crop.

According to Mohamed and Ali [36] who examined the effects of organic and bio-fertilizer on cantaloupe plants, the combination of all fertilizers (compost + humic acid + bio-fertilizer) increased vegetative growth traits like leaf area, plant height, branch number, and plant fresh and dry weight over control.. Esho and Saeed [21] demonstrated that, compared to control and other levels, humic acid at a level of 50 mg/litter provided the greatest amount of vegetation features of three test cultivars of summer squash (*Cucurbita pepo* L.). Shalaby and El-messairy [48] found that the soil addition of humic acid at 21 l. ha^{-1} to the melon crop (*Cucumis melo* 'Galia') resulted in better foliage such as plant height, fresh and dry mass of vegetative growth and chlorophyll content (SPAD). Shafeek *et al.* [49] showed that treating cucumber plant with humic acid positively affected vegetation parameters in comparison with control.

Al-madhagi [4] observed that treating cucumber crop with a mixture of humic acid and yeast significantly improved vegetative parameters over control. El-Gazzar et al. [17] investigated the performance of watermelon (*Citrullus lantus* L.) under numerous sources of organic manures and various levels of humic and fulvic acid and found that the FYM + compost + chicken manures in presence of 4 kg humic and 4 kg fulvic acid was the best treatment in giving the maximal vegetative growth traits. The impact of organic nutrients on the growth and harvest of bitter gourd (*Momordica charantia* L.) has been investigated in field experiment. The results revealed that the T2 (vermicompost 5t + humic acid 2% + Azospirillum 2 kg ha-1) significantly ameliorated growth attributes of the crop.

Somendra Meena *et al.* [50] executed a field trial aiming to evaluate the impact of humic acid and micronutrient elements on the cucumber performance (*Cucumis sativus* L.) and they data revealed that the humic acid and micronutrients significantly increased the vegetative growth traits, namely of vine length (cm), number of branch per plant and leaf area (cm^2).

Effect of Humic acid on Yield of Cucurbit Crop

The use of humic acid as a bio-fertilizer for obtaining optimal growth and harvest of squash (*Cucurbita maxima* L) has been studied and the researchers indicated that besides improving the squash growth, the humic acid played a dominant role in providing the peak fruit yield and quality of crop [25]. Salman et al. [46] observed in another experiment that the humic acid which is provided via drip irrigation to water melon (*Citrullus lanatus*) recorded the highest quality of marketable yield which ascribed to the optimum influence of humic acid.

Kazemi [30] carried out a field study for investigating the influence of humic acid and potassium nitrate on the yield of cucumber (*Cucumis sativus* L.). The collected data displayed that the humic acid and potassium nitrate were notably excellent in elevation of yield and fruit quality. El-Masry *et al*. [18] implemented a field experiment to detect the effect of humic acid provided via soil application on squash plants (*Cucurbita pepo* L.) and displayed that giving plant humic acid made a significant increment in fruit yield and its components compared to control.

Mohammed and Ali [36] demonstrated that the cantaloupe plants received humic produced maximum yield qualitative and quantitative traits such as fruit diameter, fruit circumference and fruit fresh weight TSS %, total sugars % and total yield. Dinu et al. [14] studied the influence of humic on melon plants and the humic substance produced better crop yield i.e. the average number of fruits/plants, their average weight, and the yield/m^2 as well as the quality of fruits: soluble dry matter, total dry matter, reducing sugars, vitamin C, and carotene.

Abd El-Baky et al. [1] inspected the response of cucumber crop to and Naphthalene Acetic Acid (NAA) and they found that the biggest values of yield attributes such as number of fruits, fruit length, fruit diameter and yield per plant were recorded due to supplying plants with humic acid at level of ($3gl^{-1}$) and high level of NAA (100 ppm). Sureshkumar et al. [55] showed that the T2 (vermicompost 5 $ton.ha^{-1}$ + humic acid 2% + *Azospirillum* 2 kg. ha^{-1}) resulted in higher yield parameters of bitter gourd plant compared to other treatments including control.

Al-madhagi [4] displayed that dosing cucumber plants with humic acid at 100 mg L^{-1} significantly enhanced crop harvest while the combination of 100 humic × 4000 mg L^{-1} of yeast significantly increased harvest as compared to control. Salam et al. (2019) sprayed squash cultivars with humic acid exhibited supremacy in giving the premium flowering, yield and quality parameters over control.

Effect of Humic acid on Mineral Content of Cucurbit Crop

Demir et al. [13] treated cucumber with humic acid added to the soil enhanced micronutrient content of the crop. Salman et al. [46] showed that humic acid application up to 6 L/feddan to watermelon caused a significant enhancement in macronutrient concentration relative to control and other treatments. El-Nemr et al. [19] inspected the efficacy of humic acid on outgrowth and chemical content of cucumber and they measured the maximum percentages of N, P, K, Ca and Mg in leaves of plants received 3 g/L of humic acid. El-Masry et al. [18] studied the enhancement of nitrogen efficacy under three levels of humic acid (0.5, 1.0 and $1.5gL^{-1}$) as soil drench on squash. The data analysis the increased level of humic acid ($1.5gL^{-1}$) exhibited superiority in recording the highest percentage of N, P and K in fruits.

Ekinci et al. [16] investigated the response of cucumber crop to influence of humic acid as boron humate and calcium on mineral composition of cucumber. They noticed an increase in the macro and micronutrients in leaves and fruits of crop owed to the foliar spraying of humate substance relative to control. It has been displayed that humic when combined with 75% recommended dose of NPK fertilizers gave the greatest concentration of macronutrient (N, P, and K) in fruits of bottle gourd (*Lagenaria siceraria*) as compared to control [15].

Yasir et al. [61] reported a significant improvement in macronutrients (N, and K) of cucumber as a result of treating plants with humic acid and organic fertilizers. Mohammed and Ali [36] demonstrated that supplying cantaloupe crop with humic acid, organic fertilizers and mineral fertilizers drove to a prominent increase in plant content of macro and micronutrients (N, P, K, Ca, Mg, Fe, Zn and Mn) in comparison with control. Shalaby and El-messairy [48] showed that the melon plants delivered humic acid through soil addition and boron via foliar feeding possessed the best mineral content of nitrogen (N) and potassium (K) over control.

Abd El-Baky et al. (1) proved, in a field research, that treating cucumber crop with humic acid at dose of (3 g. L^{-1}) plus Naphthalene acetic acid (NAA) at concentration (100 ppm) significantly ameliorated mineral uptake by plants, especially N, P, K, Ca and Mg. Paulauskiene A. et al. [44] evaluated the impact of humic substance, compost and complex fertilizers on chemical composition of pumpkin fruit (*Cucurbita moschata* L). Their results illustrated that all the humic acid in combination with compost and complex fertilizer made a remarkable increase in macro and micronutrients content in fruits when compared to untreated plants.

Effect of Humic acid on environmental stress in Cucurbit Crop

Demir et al. [13] examined the effectiveness of humic acid in enhancing the harvest of cucumbers grown under three salinity levels. Due to the addition of humic acid, they noticed a partial reduction of the detrimental effects of salt stress on the harvest. Kran et al. [33] conducted research on the impact of humic acid on the drought stress applied on two melon genotypes. The findings showed that applying humic acid to both genotypes greatly boosted plant tolerance to drought stress as well as their capacity to adapt to such stress. El-Shraiy and Mostafa [20] studied the influence of some bio-regulators including fulvic acid on cucumber performance and productivity under salt conditions and found that providing plants with these bio-regulators; seaweed extract (5%) + fulvic acid (300 ppm) + glycine betaine (5 mM) significantly enhanced plant growth and harvest under salt stress.

A field experiment was conducted to assess the effects of different water stress levels and humic acid on the yield and genotypic stability of Gurma watermelon (Citrullus colocynthoides). The collected data showed that, whereas all analyzed qualities were significantly decreased when there was a water shortage, they were all significantly raised when there was a water stress [26].

The effectiveness of humic acid and boron on stress resistance in melon crop was studied by Shalaby and Messairy [48]. Their research revealed that the optimum treatment for providing the finest foliage and melon harvest under saline conditions was humic acid at 21 l. ha-1 plus boron spray at 50 ppm.

Conclusion

The production of crops following the sustainable methods through utilization of organic inputs is becoming of great interest during the last decades because the Intensive application of synthetic chemicals has deteriorated the soil architecture and the ecosystem and created serious health risks for living organisms. Therefore, the organic farming of significant vegetables with a precious nutritive value like cucurbits is very necessary to meet the local marketing demands as well as to produce organic products with prestigious quality and free of hazardous residues detrimental for human health. To achieve such sustainable agriculture, the use of natural inputs such as humic acid, fulvic acid and numerous other safe and effective products is recommended and advised since they ameliorate plant outgrowth, productivity and resistance to abiotic stresses, enhance soil fecundity and protect the environment from contamination.

REFERENCES

1- **Abd El-Baky M.M.H.; Kh. M. Abd El-Rheem; M. E. El-Azab and K. A.S. Mohammed (2016). Response of Growth, Yield and Nutritional Status of Cucumber Plants (*Cucumis sativus* L.) to Different Foliar Application of Humic Acid and Naphthalene Acetic Acid. Middle East J. Appl. Sci., 8(2): 594-598, 2018.**

2- **Ahmad, T.; R. Khan and T. Nawaz Khattak (2018). Effect of humic acid and fulvic acid based liquid and foliar fertilizers on the yield of wheat crop. J. Plant Nutr. 41, 2438–2445. doi: 10.1080/01904167.2018.1527932**

3- **Akhtar, T.; S.M. Ismail and F.S. Al-Nakhlawy (2017). Optimization of Humic acid application rate by evaluating the response of mung bean (*Vigna radiata*) yield, growth components and soil properties in western region of Saudi Arabia. Int. J. Biosci. 1(1): 240-248.**

4- **Al-madhagi, I. A. H. (2019). Effect of humic acid and yeast on greenhouse cucumber, JOURNAL OF HORTICULTURE AND POSTHARVEST RESEARCH 2019, VOL. 2(1): 67-82.**

5- **Buffle, J.A.E (1977). Les substances humiques et leurs interactions avec les ions mineraux. in Conference Proceedings de la Commission d`Hydrologie Appliquee de A.G.H.T.M.. Universte d`Orsay.**

6- **Cacco, G. and G. DellAgnolla (1984) Plant growth regulator activity of soluble humic substances. *Can. J. Soil Sci.*, 64, 25-28.**

7- **Canellas, L.P. and F.L. Olivares (2014). Physiological responses to humic substances as plant growth promoter. Chemical and Biological Technologies in Agriculture, 1(3): 1-11. https: //doi. Org/10.1186/2196-5641-1-3.**

8- **Canellas, L.P.; L.R.L. Teixeira Junior; L.B. Dobbss; C.A. Silva; L.O. Medici; D.B. Zandonadi and A.R. Façanha (2008). Humic acids cross interactions with root and organic acids. Annals of Applied Biology, 153(2): 157-166. http://dx.doi.org/10.1111/j.1744-7348.2008.00249.x**

9- **Canellas, L.P.; F.L. Olivares; A.L. Okorokova-Facanha and A.R. Facanha (2002). Humic acids isolated from earthworm compost enhance root elongation, lateral root emergence, and plasma membrane H+ -ATPase activity in maize roots. Plant Physiology. 130:1951-1957.**

10- Cha, J.Y.; T.W. Kim, J.H. Choi; K.S. Jang; L. Khaleda; W.Y. Kim and J.R. Jeon (2017). Fungal laccase-catalyzed oxidation of naturally occurring phenols for enhanced germination and salt tolerance of Arabidopsis thaliana: A green route for synthesizing humic-like fertilizers. Journal of Agricultural and Food Chemistry. 65:1167-1177

11- Chen Y.; M. De Nobili and T. Aviad (2004). Stimulatory effects of humic substances on plant growth. In F Magdoff, R Weil eds. Soil Organic Matter in Sustainable Agriculture. CRC Press, Boca Raton, Florida, p: 103- 129.

12- Chen, Y. and T. Aviad (2010). Effects of Humic Substances on Plant Growth. In: Humic Substances in Soil and Crop Sciences: Selected Readings, Mac Carthy, P., C. E. Clapp, R. L. Malcolm and P. R. Bloom (Eds.). Soil. Sci. Soc. Am., Madison, Wisconsin, USA., p: 161-186.

13- Demir, K.; A. Gunes; A. Inal and M. Al-Paslan (1999). Effect of Humic Acids on The Yield and Mineral Nutrition of cucumber (*Cucumis Sativus* L.) Grown With Different Salinity Levels. Acta Hortic. 492, 95-104

14- Dinu M. and R. Soare (2016). The influence of cultivar on thequality of fruit the species (*Cucumis melo* L.) Annals ofthe University of Craiova - Agriculture, Montanology,Cadastre Series, XLVI: 105-110.

15- Ehab, A. I. and A. E. Abd El- Kader (2015). Effect of Soil Amendments on Growth, Seed Yield and NPK Content of Bottle Gourd (*Lagenaria siceraria*) Grown in Clayey Soil. *International Journal of Soil Science,* 10*:* 186-194.

16- Ekİncİ, M.; A. EsrİngÜ; A. Dursun; E. Yıldırım; M. Turan; M. R. Karaman and T. Arjumend (2015). Growth, yield, and calcium and boron uptake of tomato (*Lycopersicon esculentum* L.) and cucumber (*Cucumis sativus* L.) as affected by calcium and boron humate application in greenhouse conditions. Turkish Journal of Agriculture and Forestry, 39(5):613-632. doi: 10.3906 /tar -1406-59.

17- El-Gazzar, T. M.; E. A. Tartoura; S. E. Farid2 and A. H. El-Kolly (2020). Effect of Different Sources of Organic Manures and Different Levels of Humic and Fulvic Acid on Growth, Flowering, Yield and its Components of Watermelon Plants. J. of Plant Production, Mansoura Univ., 11 (11):1135-1143.

18- El-Masry, T. A.; Ashraf Sh. O., M. S. Tolba1 and Y. H. Abd El-Mohsen (2014). Increasing nitrogen efficiency by humic acid soil application to squash plants (*Cucurbita pepo* L.) grown in newly reclaimed saline soil. *Egypt. J. Hort.* 41(2):17 -38.

19- El-Nemr, M.A.; M. El-Desuki; A.M. El-Bassiony and Z.F. Fawzy (2012). Response of Growth and Yield of Cucumber Plants (*Cucumis sativus* L.) to Different Foliar Applications of Humic Acid and Bio-stimulators. Aust. J. Basic & Appl. Sci., 6(3):630-637.

20- El-Shraiy, A. M. and M.A. Mostafa (2016). Enhancing Salt Tolerance of Cucumber Using Grafting and Some Bio-regulators. Middle East J. Agric. Res., 5(4):820-840.

21- Esho, K. B. and S. H. Saeed (2017). Effect of Humic acid on growth and yield of three ultivars of summer squash (*Cucurbita pepo* L.). The Egyptian Journal of Experimental Biology (Botany). 13(2):167-171.

22- Fahmy, M.A.M. (2012). Effect of some treatments on growth, yield and fruit chemical composition of melon and cucumber crops under sandy soils conditions. M. Sc. Thesis, in Agricultural Sciences (Vegetable Crops), Faculty of Agriculture, Cairo University.

23- García-Mina, JM.; M.C. Antolín and M. Sanchez-Diaz (2004). Metal-humic complexes and plant micronutrient uptake: a study based on different plant species cultivated in diverse soil types. Plant and Soil. 258, 57-68.

24- Garcia-Mina, JM.; V. Mora; M. Olaetxea; R. Baigorri; M. Fuentes; M. Garnica; S. San Francisco; J. Erro; O. Urrutia; E. Casanova; D. Lemenager and J.C. Yvin (2012). Main Mechanisms Involved In The Effects Of Humic Substances On Soil-Plant Systems. Agrociencia Uruguay, Special Issue: 188-190.

25- Hafez, M. M. (2004). Effect of some sources of nitrogen fertilizer and concentration of humic acid on theproductivity of squash plant. Egypt. J. Appli. Sci, 19, 293-309.

26- Ibrahim, E.A. (2012). Effect of different levels of water stress and humic acid application on yield, its components and genotypic stability of some new lines of gurma watermelon (*Citrullus colocynthoides*). J. Plant Production, Mansoura Univ., 3 (10):2625-2634.

27- Ibrahim, S.M. and M.A Ali (2018). Effect of potassium humate application on yield and nutrient uptake of maize grown in a calcareous soil. Alex. Sci. Exch. J., 39, 412–418. [CrossRef]

28- Idrees, M.; M.A. Anjum and J.I. Mirza (2018). Potassium humate and NPK application rates influence yield and economic performance of potato crops grown in clayey loam soils. Soil Environ. 37, 53–61. [CrossRef]

29-Jeon J.R., HY. Yoon; GI. Shin; SY. Jeong; JY. Cha; and WY. Kim (2018). Structure and action mechanism of humic substances for plant stimulations. Journal of the Korean Society of Grassland and Forage Science 38(3): 175~17.

30- Kazemi, M. (2013). Effect of Foliar Application of Humic Acid and Potassium Nitrate on Cucumber Growth. Bull. Env. Pharmacol. Live Sci. Vol. 2(11), 2013, 3-6.

31- Khaled, H. and H.A Fawy (2011). Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil Water Res., 1, 21–29. [Google Scholar] [CrossRef]

32- Khan, M. N.; M. Mobin; Z. K. Abbas and S. A. Alamri (2018). "Fertilizers and their contaminants in soils, surface and groundwater," in Encyclopedia of the Anthropocene, eds D. A. Della Sala and M. Goldstein I (Oxford: Elsevier), 225–240. doi: 10.1016/B978-0-12-809665-9.09888-8

33- Kıran S.; G. F. Baysal; M. Talhouni; Ş. Ş Ellialtıoğlu (2019). Drought stress mitigation with humic acid in two (*Cucumis melo* L.) genotypes differ in their drought tolerance. Bragantia, Campinas, v. 78, n. 4, p:490-497, 2019.

34- Kumar, D.; A.P. Singh; P. Raha; A. Rakshit; C.M. Singh and P. Kishor (2013). Potassium humate: A Potential soil conditioner and plant growth promoter. Int. J. Agric. Environ. Biotech. 6, 441–446.

35- Malan, C. (2015) Review: humic and fulvic acids. A Practical Approach in Sustainable soil management symposium. Stellenbosch, 5-6 November 2015, Agrilibrium Publisher.

36- Mohamed, M. H. M. and A. M. M. Elsayed (2016). Effect of Some Organic and Bio Fertilization Treatments in Presence of Chemical Fertilization on Growth, Chemical Composition and Productivity of Cantaloupe Plants. International Journal of Plant & Soil Science, 11 (1):1-11.

37- Mora V.; E. Bacaicoa; AM. Zamarreno; E. Aguirre; M. Garnica; M. Fuentes and JM. Garcia-Mina (2010). Action of humic acid on promotion of cucumber shoot growth involves nitrate-related changes associated with the root-to-shoot distribution of cytokinins, -polyamines and mineral nutrients. J. Plant Physiol 167: 633-642.

38- Moradi, P.; P. Babak and F. Farzad (2017). The effects of fulvic acid application on seed and oil yield of safflower cultivars. J. Central European Agriculture, 18(3): 584-593. DOI: 10.5513/JCEA01/18.3.1933.

39- Mukherjee, Pulok K. (2019). Quality Control and Evaluation of Herbal Drugs: Evaluating Natural Products and Traditional Medicine, 1st Edition - May 29, 2019.

40- Nardi S.; M. Tosoni; D. Pizzeghello; MR. Provenzano; A. Cilenti; A. Sturaro; R. Rella and A. Vianello (2005). Chemical characteristics and biological activity of organic substances extracted from soils by root exudates. Soil Sci. Soc. of Am. J. 69, 2012–2019.

41- Nardi, S.; D. Pizzeghello; A. Muscolo and A. Vianello (2002). Physiological effects of humic substances on higher plants. Soil Biology and Biochemistry. 34:1527-1536.

42- Oliveira, M.W.; V.S. Gomes da Silva; T.B.A. Oliveira; C.H.D. Nogueira; C.L. Franco; F. da Silva and G.C.S. Santos (2018). Humic substances, amino acids and marine algae extract increase sugarcane productivity. Revista de Ciências Agrárias, 41(2): 408-414.

43- Osman, M.E.H.; A.A. Mohsen; S.S. El-Feky and A.W Mohamed (2017). Response of salt-stressed wheat (*Triticum aestivum* L.) to potassium humate treatment and potassium silicate foliar application. Egypt. J. Bot., 57, 85–102.

44- Paulauskiene A.; H. Danilcenko; I. Pranckietiene and Z. Taraseviciene (2018). Effect of different fertilizers on the mineral content of pumpkin fruit. J. Elem., 23(3): 1033-1042.

45- Qin, K. and D.I. Leskovar (2019). Deficit irrigation and humic substances residuals affected watermelon yield and soil properties. Acta Hortic. 1253, 381-388.

46- Salman, S. R.; S. D. Abou-Hussein; A. M. R. Abdel-Mawgoud; and M. A. El-Nemr, (2005).Fruit yield and quality of watermelon as affected by hybrids and humic acid application. Journal of Applied Sciences Research,1(1), 51-58.

47- Selladurai, R. and J.P. Tapan (2015). Effect of humic Acid multi-nutrient fertilizers on yield and nutrient use efficiency of potato. Journal of Plant Nutrition, 12(4): 11-23.

48- Shalaby, O.A.E.-S.; M.M El-Messairy (2018). Humic acid and boron treatment to mitigate salt stress on the melon plant. Acta Agric. Slov., 111, 349–356, doi: 10.14720/aas.2018.111.2.10

49- Shafeek, M.R.; Y.I. Helmy and N. M. Omar (2016). Effect of spraying or ground drench from humic acid on growth, total output and fruits nutritional values of cucumber (*Cucumis sativus* L.) grown under plastic house conditions. International Journal of PharmTech Research, 2016, 9(12): 52-57.

50- Somendra Meena, K.D.; R.A. Ameta; Sh. L. M. Kaushik and M. Singh (2017). Performance of Cucumber (*Cucucmis sativus* L.) as Influenced by Humic Acid and Micro Nutrients Application under Polyhouse Condition. Int. J. Curr. Microbiol. App. Sci. 6(3): 1763-1767. doi: https://doi.org/10.20546/ijcmas. 2017.603.202.

51- Sootahar, K.; X. Mahendar; Sh. Su Zeng; B. YW; Ling-yu; Z. Yang L. Tao and Z. Xiaojia (2019). "The Effect of Fulvic Acids Derived from Different Materials on Changing Properties of Albic Black Soil in the Northeast Plain of China." *Molecules* 24 (38): 1535.

52- Stevenson, F.J. (1982). Humus Chemistry. Genesis, Composition, Reactions. John Wiley and Sons, New York. P. 443.

53- Stevenson, F.J. (1994). Humus Chemistry. Genesis, Composition, Reactions. Jhon Wiley and Sons, Inc., New York, pp. 496.

54- Suman, S.; R. S. Spehia and V. Sharma (2017). Humic acid improved efficiency of fertigation and productivity of tomato. J. Plant Nutr. 40, 439–446. doi: 10.1080/ 01904167.2016.1245325

55- Sureshkumar, R.; S. Deepa; M. Rajkumar and R. Sendhilnathan (2019). Effect of organic nutrients on certain growth and yield characters of bitter gourd (*Momordica charantia* L.) Ecotype "Mithipagal". Plant Archives 19(1):1013-1016.

56- Trevisan S.; O. Francioso; S. Quaggiotti and S. Nardi (2010). Humic substances biological activity at the plantsoil interface: from environmental aspects to molecular factors. Plant Signal Behav. 5: 635-643.

57- Trevisan S.; D. Pizzeghello; B. Ruperti; O. Francioso; A. Sassi K. Palme; S. Quaggiotti and S. Nardi (2009). Humic substances induce lateral root formation and expression of the early auxin-responsive IAA19 gene and DR5 synthetic element in Arabidopsis. Plant Biol. 12: 604-614.

58- Trevisan, S.; A. Botton; S. Vaccaro; A. Vezzaro; S. Quaggiotti and S. Nardi (2011). Humic substances affect Arabidopsis physiology by altering the expression of genes involved in primary metabolism, growth and development. Environmental and Experimental Botany, 74: 45-55. https://doi.org/10.1016/j. envexpbot.2011.04.017.

59- Turkmen O.; A. Dursun; M. Turan and C. Erdinc (2004). 'Calcium and humic acid affect seed germination, growth, and nutrient content of tomato (*Lycopersicon esculentum* L.) seedlings under saline soil conditions', Acta Agriculturae Scandinavica, Section B- Plant Soil Sci., 54(3): 168- 174.

60- Yamauchi, M.; S. Katayama; T. Todoroki and T. Watanable (1984) Total synthesis of fulvic acid. Journal of the Chemical Society, Chemical Communications. 23, 1565-1576.

61- Yasir, N. F.; M.W. Seheib and O. A. Hasan (2016). Effect Of Adding Different Organic Fertilizers In The Absorption Of Some Of Nutrient Elements From Soil In Properties Of Plant Growth And Yield Of Cucumber Plant. Journal of Agriculture and Veterinary Sci. 9(5):13-17.

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تأثير حامض الهيوميك في نمو وإنتاجية محاصيل القرعيات: مقالة مراجعة*

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الملخص

تتكون عائلة القرعيات من الخضراوات البارزة مثل الخيار والقرع والبطيخ واليقطين، والتي تُعّد ذات قيمة من الجوانب الطبية والغذائية. وقد تسبب الاستخدام المفرط للمدخلات الكيميائية في مشاكل خطيرة على الصحة العامة والبيئة مما أدى إلى تثبيط خصوبة التربة وتقليل استساغة المحاصيل للمستهلكين. يُعّد استخدام المواد الدبالية بما في ذلك حامض الهيوميك، حامض الفولفيك و البوتاسيوم هيوميت كأسمدة طبيعية ومنشطات حيوية بديلاً جيدًا لأنها غنية بالمواد المغذية والهرمونات والمواد الشبيهة بالهرمونات التي تنشط النبات للنمو والإنتاج بكفاءة ولمكافحة الشدود البيئية. سلطت مقالة المراجعة هذه الضوء على الآليات المحتملة التي تعمل من خلالها المواد الدبالية على تنشيط النباتات والتأثيرات المفيدة لحمض الهيوميك في أوراق الشجر والإنتاج ومقاومة الشدود لبعض القرعيات.

الكلمات المفتاحية: القرعيات، الزراعة العضوية، حامض الهيوميك ، تنشيط النبات، مقاومة الشد البيئي.

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