ARTICLE / INVESTIGACIÓN

Effect of humic acid addition and spraying with ginger rhizome extract on the growth and some chemical contents of apricot seedlings *Prunus armeniaca L.* cv.

Majid E. Hardan[1], Ahmed F. Z. Al-Dulaimy[2]*

DOI. 10.21931/RB/2022.07.04.26

[1] Anbar Province, Directorate of Anbar Agriculture, Iraq.
[2] Department of Horticulture and Landscape Gardening, College of Agriculture, University of Anbar, Iraq.
Corresponding author: ag.ahmed.fatkhan@uoanbar.edu.iq

Abstract: This study was conducted at the slat house of the Department of Horticulture and Landscaping - College of Agriculture / Anbar University, during the growing season of 2021. The effect of soil application of humic acid (H) at 0, 4, 8 ml L^{-1} and ginger rhizome extract (Z) spraying at 0, 5, 10 g L^{-1} on some growth characteristics and some chemical contents of apricot seedlings, cultivar Hamawi was studied. Eighty-one two-year-old seedlings were selected that grafted on the stock of the apricot seed. A two-factor experiment (3 x 3) was carried out according to a randomized complete block design (RCBD). The investigation included nine treatments, three replications, and three seedlings for the experimental unit. The results indicated the significant effect of adding humic acid to seedlings in all the studied traits, especially the high-level H2 (8 ml L^{-1}), which achieved the best values for the traits (Branch number, Branch diameter, Branch dry matter, Leaf area, Nitrogen, Phosphor, Potassium). Treatment Z2 (10 g L^{-1}) of spraying with ginger rhizome extract was characterized by giving it the best significant effect of the characters (Branch number, Branch dry matter, Leaf area, Nitrogen, Phosphor, Potassium). The interaction of the study factors was significant for all the studied traits except for the diameter of the branch. The highest values were for the treatments H2Z2 (8 ml L^{-1} and 10 g L^{-1}) and H2Z1 (8 ml L^{-1} and 5 g L^{-1}), where the lowest values were in the control treatment (H0Z0) for all the studied traits.

Key words: Apricot, Humic acid, Ginger, Vegetative growth, Chemical content.

Introduction

Apricot *Prunus armeniaca L.* belongs to the Rosaceae family; it may also be called Armeniaca Vulgaris[1]. Some references indicate that Apricot trees originated in northern China, where it was planted 4000 years ago[2]. There are wild types of it, the cultivation of which extends from Japan to Afghanistan, and the Romans called it the Armenian apple. That is why some scholars believe that the apricot's origin is Armenia, which is why this name[3] is called it. The word Apricot goes back to the Greeks, called AL-Praecox, which means early fruit[4].

One of the most important positive aspects of the use of natural and manufactured organic fertilizers in fertilization is their great effectiveness in plant growth and development and that they do not cause damage to the environment since they do not add substances that the plant cannot use, and that is toxic to water and soil[5]. Humic acids are among the most essential manufactured organic fertilizers, which have proven their high efficiency in increasing the growth and production of plants because they contain organic compounds, amino acids and mineral elements[6]. Humic acid improves physical, chemical and biological soil properties[7]. It also contributes to increasing the permeability of cell membranes and the absorption of nutrients. In addition, it contributes to the activation of the formation of chlorophyll pigment and the assembly of sugars, amino acids and enzymes[8]. Activate cell division, increase growth rates, shoot and root system development, and increase dry matter in plant tissues[9,10]. It also increases the ability of plants to resist diseases, and it reduces the stresses resulting from high heat and salinity that cause poisoning, which gives the plant a kind of resistance, which reflects positively on the continuation of vital processes[11-13]. (14) and (15) reported that humic acid increases photosynthesis efficiency, synthesizes carbohydrates and proteins, and reduces the breakdown of amino acids caused by stress. Thus, these effects contribute to an increase in vegetative growth rates, which is positively reflected in the yield. Plant extracts are among the materials used recently to stimulate and encourage the vegetative and flowering growth of many plants as a source of nutrients and natural growth regulators, as well as being easy to absorb and contain effective substances and natural chemical compounds.

That differs according to the species and plant parts[16-20], in addition to its significant role in the biological control of many pests that infect plants, which contributes to improving vegetative growth and thus increasing production[21,22].

Ginger (*Zingiber officinale Roscoe*) belongs to Zingiberaceae and the genus Zingiber. It is a perennial herb that is multiplied by rhizomes[23]. It is a medicinal plant that grows in hot areas, is used as a stimulant and a gas repellent, increases sweating, hypnotic, anti-emetic, cough suppressant, and is anti-inflammatory. Recent studies have also proven that it acts as an anti-cancer and is added to pickles, pastries and various foods[24,25]. Ginger contains volatile oil with

Citation: Hardan M E, Al-Dulaimy A F Z. Effect of humic acid addition and spraying with ginger rhizome extract on the growth and some chemical contents of apricot seedlings Prunus armeniaca L . cv. Revis Bionatura 2022;7(4) 26. http://dx.doi.org/10.21931/RB/2022.07.04.26
Received: 25 August 2022 / **Accepted:** 12 October 2022 / **Published:** 15 November 2022

Publisher's Note: Bionatura stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

a pungent odor and a pungent taste that includes its main compounds (Geraniol, Neral, Curcumene, Zingiberene, Zingeberol, Linallol, beta-phelanddrine and Camphor-D). It also contains the Aryl alkanes group, and the most important compounds of this group are Gingerols, which includes gingenol, the compound to which the spicy taste is attributed[26,27]. The researchers pointed to the influential role played by the extract of ginger rhizomes when sprayed on the shoots of plants in improving the vegetative growth of these plants[28-30]. Researcher[31] explained that each 100 g of ginger rhizome contains (Moisture 15.02%, Protein 5.087 g, Fat 3.72 g, soluble fiber 23.5%, In Soluble fiber 25.5%, Carbohydrate 38.35 g, Vitamin C 9.33 mg, Total carotenoids 79 mg, Ash 3.85 g, Calcium 88.4 mg, Phosphorous 174 mg, Iron 8.0 mg, Zinc 0.92 mg, Copper 0.545 and Manganese 9.13 mg).

Despite the efficiency of chemical fertilizers in improving plant growth, it has been scientifically proven that these substances are dangerous to the environment and human health. Hence, the current agricultural policy seeks to provide nutrients to improve plant growth, not harm the environment, and increase plants' tolerance of unsuitable environmental conditions[32]. Many nutrient solutions were used for development to achieve these goals, including amino acids, organic acids, plant hormones, and others. They have proven their efficiency in improving the growth and productivity of various horticultural plants[33,34].

Due to the above-mentioned and as a result of the lack of studies on the effect of both manufactured organic fertilizers and plant extracts, especially on seedlings grown in the conditions of Anbar Governorate, we decided to implement this study to investigate the effect of humic acid addition and spraying with ginger rhizome extract on some vegetative growth characteristics and some chemical contents of apricot seedlings cv. Hamawi produces vigorous seedlings with a solid structure, especially in the first years of cultivation, and the possibility of reaching the production stage early, since seedlings in the first years of their life deplete large amounts of nutrients that are used in their various vital processes. Also, both factors of the study are considered environmentally friendly materials preferred to be used in plant nutrition, especially after discovering the harmful effect of using chemical fertilizers in agriculture, both on the environment and human health.

Materials and methods

The study was conducted on Apricot seedlings cv in the lath house of the Department of Horticulture and Landscaping - College of Agriculture / University of Anbar during the growing season 2021. Hamawi, to study the effect of humic acid application and spraying with ginger rhizome extract on some vegetative growth characteristics and chemical content of seedlings. Eighty-one of the two-year-old seedlings were selected. The field operations of pest control and irrigation (drip irrigation) were conducted equally for all the treatments under study. A two-factor experiment (3 x 3) was carried out according to a randomized complete block design (RCBD). The investigation included nine treatments, three replications, and three seedlings for each experimental unit. Thus, the total number of seedlings used in the experiment was 81. In the experiment, two factors were used, the first was the addition of humic acid (0, 4, 8 ml L^{-1}) two times (1/4 and 1/6), and the above concentrations were symbolized by the symbols (H0, H1 and H2) respectively, the second factor, spraying with ginger rhizome extract in concentrations (0, 5, 10 g l^{-1}) and spraying time (1/4, 1/5, 1/6, 1/7, 1/8 and 1/10). The above extract concentrations were symbolized by the symbols (Z0, Z1 and Z2) respectively. The studied traits were: branch number (branch $plant^{-1}$), brunch diameter (mm), dry brunch matter (%), leaf area (cm^2), percentage of Nitrogen phosphor and potassium. The data were statistically analyzed, the averages were compared using the least significant difference (LSD) test at a probability level of 5%[35], and the Genstat V12.1 software did the analysis.

Results

Branch number (branch $plant^{-1}$)

The application of humic acid had a substantial impact on the rate of branch number increase (Figure 1A), particularly in treatment H2, which differed significantly from the other two treatments, H0 and H1 and yielded the highest value of 18.03 branch $plant^{-1}$. Treatment H0 had the lowest value, 13.92 branch $plant^{-1}$. The results, on the other hand, showed that spraying with ginger rhizome extract had a significant effect on the studied trait, particularly the treatment Z2, which showed a substantial difference from treatment Z0 and Z1 and achieved the highest rate of increase in branch number 17.23 branch $plant^{-1}$. At the same time, treatment Z0 had the lowest rate, 14.31 branch $plant^{-1}$. The significant effect of the interaction of the study factors followed the same path, especially for treatment H2Z2, which achieved the most critical value of 21.24 branch $plant^{-1}$. In comparison, the control treatment H0Z0 achieved the lowest value of 12.72 branch $plant^{-1}$(Table 1).

Branch diameter (mm)

The results show that the application of humic acid to apricot seedlings increased the diameter of the branch significantly, reaching a maximum of 5.79 mm for treatment H2 (Figure 1B), which differed considerably from the lowest value of 4.62 mm for treatment H0. On the other hand, spraying with ginger rhizome extract and both factors' interaction hasn't shown a significant effect in the studied trait (Table 1).

Branch dry matter (%)

The results show that the application of humic acid to apricot seedlings increased the dry matter of the branch significantly (Figure 1C), with the treatment H2 having the most significant values of 63.59% and being substantially better than treatment (H0), which had the lowest value of 51.87%. Spraying ginger rhizome extract had a substantial effect; two treatments Z2 and Z1 generated the most outstanding discounts of 60.12 and 59.51%, correspondingly, and they differed significantly from treatment Z0, which gave the lowest value of 52.97%. The interaction of the study factors had a significant effect, particularly with treatment H2Z1, which resulted in the maximum rate of increase in stem diameter of 68.75%, while the value fell to the lowest level of 48.23% when the control H0Z0 was used (Table 1). Leaf area (cm^2)

The results show that the application of humic acid to apricot seedlings increased the leaf area significantly (Figure 1D), particularly for treatment H2, which differed considerably from the other two treatments, H0 and H1 and had the highest value of 15.38 cm2. In contrast, treatment H0 had

the lowest value of 9.12cm^2. Spraying with ginger rhizome extract had a substantial effect, with the treatments Z2 and Z1 producing the maximum value of 13.94 and 13.10 cm^2, a significant difference from the treatment Z0, which made the lowest value of 9.82 cm2. The interaction of the study factors had a substantial impact, particularly with treatment H2Z1, which had the maximum value of 17.14 cm^2, while the control treatment achieved the lowest value of 7.83 cm^2 H0Z0 (Table 1).

Nitrogen (%)

The addition of humic acid had a substantial impact on the rate of Nitrogen percentage (Figure 2A), particularly in treatment H2, which differed significantly from the other two treatments, H0 and H1 and yielded the highest value of 1.94%. Treatment H0 had the lowest value of 1.79%. Spraying ginger rhizome extract had a substantial effect; the treatment Z2 had the maximum value of 1.92%, significantly different from the treatment Z0, which had the lowest value of 1.78%. The interaction of the study components had a significant effect, particularly with treatment H2Z1, which had a maximum weight of 1.97%. In comparison, the percentage fell to the lowest in the control treatment H0Z0, 1.62% (Table 2).

Phosphorus (%)

The results demonstrated that when applied to apricot seedlings, humic acid contributed to substantial changes in phosphorus percentage. Treatment H2 had the highest value of 0.46% compared with the other two treatments, H0 and H1. On the other hand, it had the lowest value of the examined characteristic (Figure 2B). Spraying with ginger rhizome extract Z2 was much better than Z0 and Z1 treatments, with the most significant value of 0.45% and the lowest value of 0.37%. The interaction of the study factors had a substantial effect, especially for treatment H2Z2, which had the maximum percentage of phosphorus at 0.51%. In comparison, the value dropped to its lowest level of 0.33% for the control treatment H0Z0 (Table 2).

Potassium (%)

The results in Figure 2C show that adding humic acid to apricot seedlings significantly increased the potassium content of leaves, particularly treatment H2, which showed a significant difference from treatment H0 and H1 and achieved the highest percentage of 1.39%. While the treatment H0 had the lowest rate, 1.29%. Spraying ginger rhizome extract had a substantial influence on the examined cha-

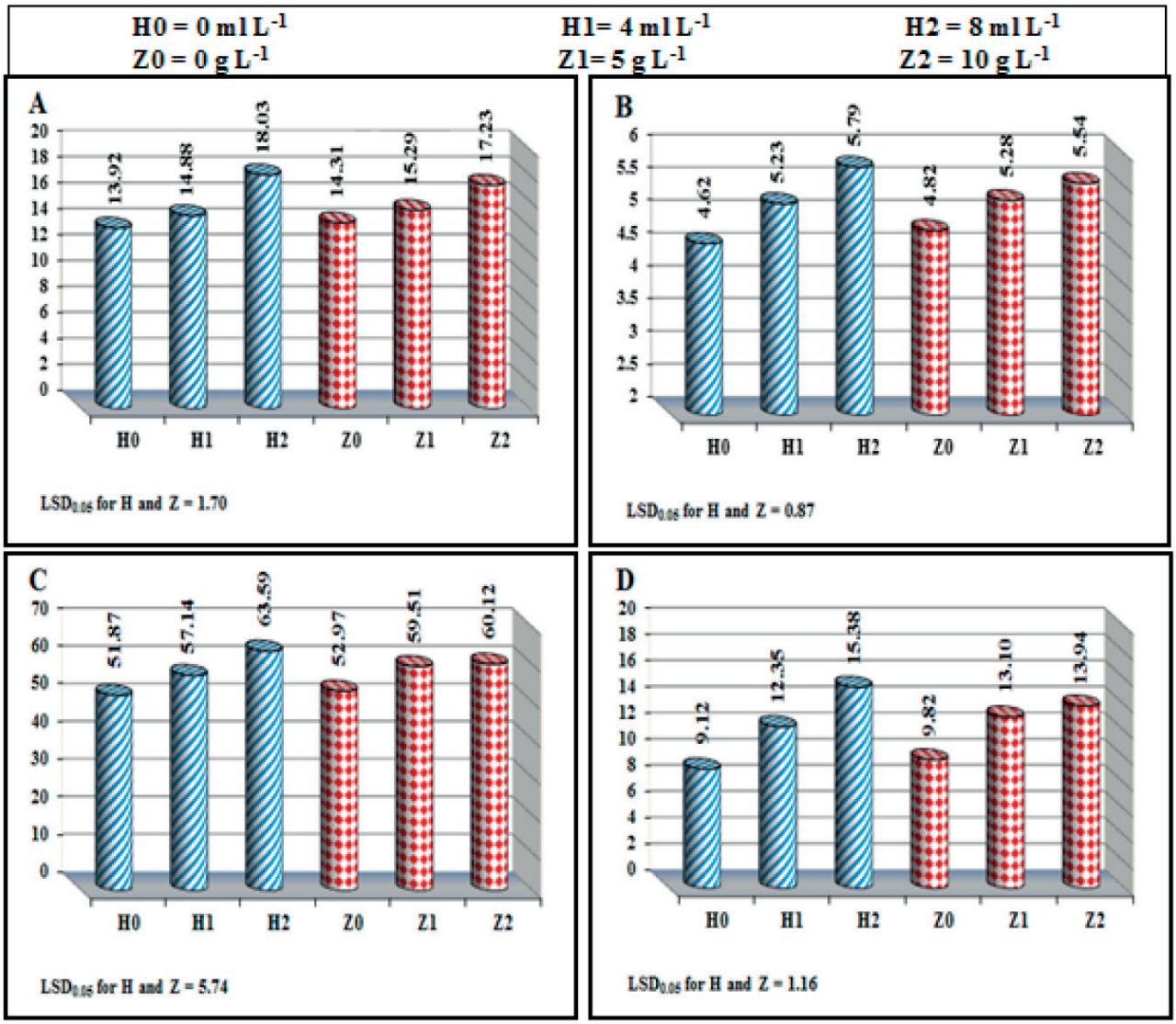

Figure 1. Effect of humic acid application and spraying with extract of ginger rhizomes on some vegetative growth traits of Apricot seedlings cv. Hamawi (A: Branch number, B: Branch diameter, C: Branch dry matter, D: Leaf area).

racteristic, as evidenced by the considerable superiority of treatment Z2 over non-spray treatment Z0, and it yielded the highest percentage of 1.38%, compared with treatments Z0 and Z1, which caused the lowest value of 1.31%. The interaction of the study components had a substantial effect, especially for treatment H2Z2, which gave the highest potassium content of 1.47%, while the value for the control treatment H0Z0 was 1.23% (Table 2).

Humic acid (ml L^{-1})	Extract of ginger rhizomes (g L^{-1})	Branch number (branch $plant^{-1}$)	Branch diameter (cm)	Branch dry matter (%)	Leaf area (cm^2)
0	0	12.72	4.46	48.23	7.83
	0	14.87	4.54	56.91	8.48
	10	14.16	4.87	50.47	11.05
4	0	12.90	5.17	57.36	9.12
	5	15.46	5.08	52.87	13.67
	10	16.29	5.44	61.18	14.26
8	0	17.31	4.82	53.30	12.51
	5	15.53	6.23	68.75	17.14
	10	21.24	6.31	68.72	16.50
LSD 5%		2.94	NS	9.93	2.00

Table 1. Effect of humic acid application and spraying with extract of ginger rhizomes interaction on some vegetative growth traits of Apricot seedlings cv. Hamawi.

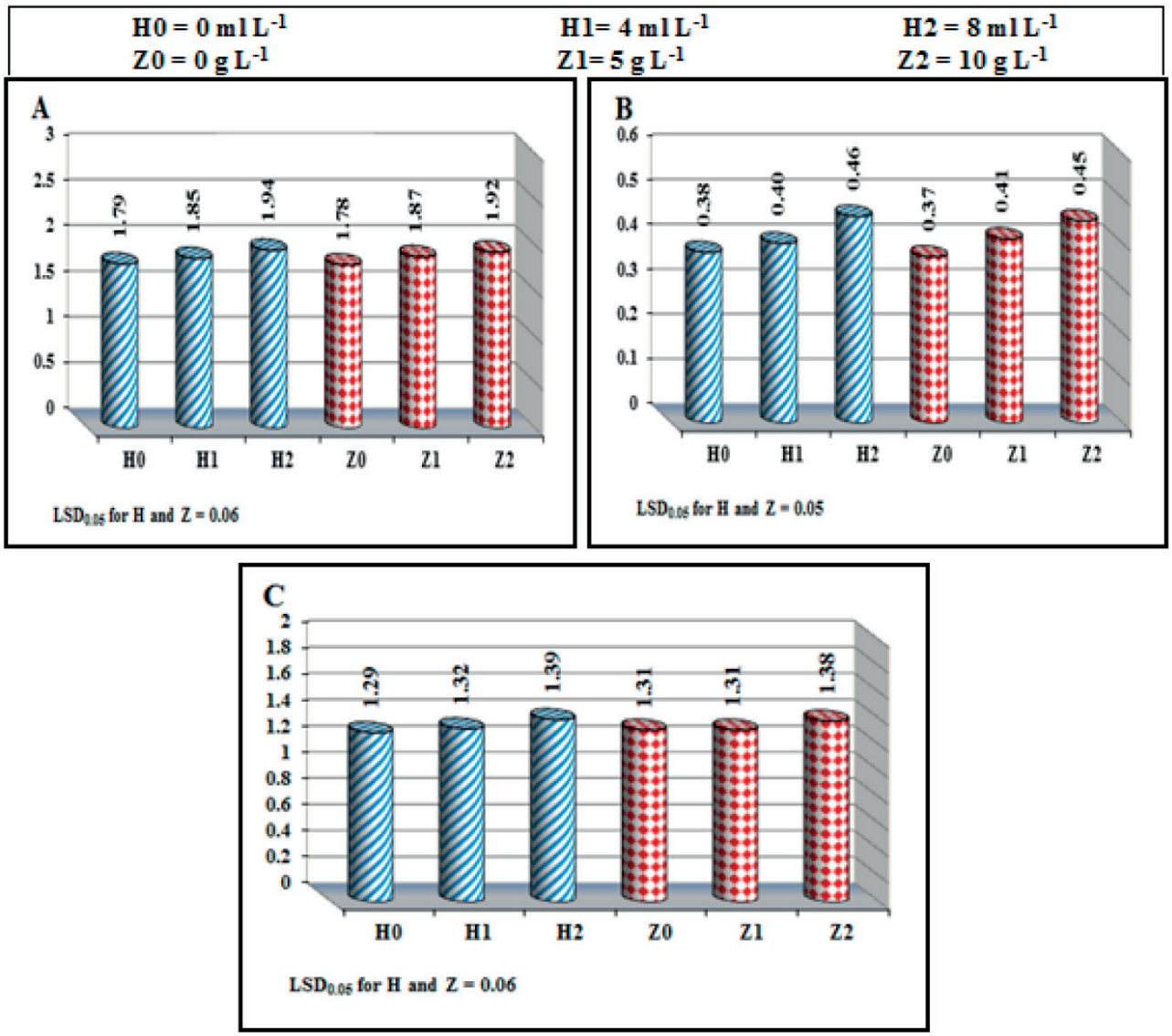

Figure 2. Effect of humic acid application and spraying with extract of ginger rhizomes on (Nitrogen, Phosphorand potassium) in leaves of Apricot seedlings cv. Hamawi. (A: Nitrogen, B: Phosphor, C: Potassium).

Humic acid (ml L^{-1})	Extract of ginger rhizomes (g L^{-1})	Nitrogen (%)	Phosphor (%)	Potassium (%)
0	0	1.62	0.33	1.23
	0	1.84	0.36	1.35
	10	1.91	0.44	1.30
4	0	1.83	0.42	1.32
	5	1.80	0.38	1.26
	10	1.92	0.40	1.38
8	0	1.89	0.37	1.37
	5	1.97	0.49	1.32
	10	1.94	0.51	1.47
LSD 5%		**0.10**	**0.09**	**0.07**

Table 2. Effect of humic acid application and spraying with extract of ginger rhizomes interaction on (Nitrogen, Phosphor and potassium) in leaves of Apricot seedlings Cv. Hamawi.

Discussion

The addition of humic acid significantly affected all vegetative characteristics and chemicals under the study of apricot seedlings (Cv. Hamawi); the reasons for this may be attributed to its role in increasing the leaf area (Figure 2D), which is positively reflected in the increase in the content of chlorophyll in leaves and thus the production of larger quantities of carbohydrates. Humic acid also contributes to the rise in the development of chlorophyll and the assembly of sugars, amino acids and enzymes[36]. It also has a similar role to auxins in increasing cell division, improving root system development, and increasing the amount of dry matter, which encourages plant growth and improves vegetative growth[37]. In addition, humic acid contributes to an increase in the formation of energy-rich compounds (ATP) and the formation of proteins within plant tissues[38]. Humic acid also plays a positive role through its content of organic acids and nutrients that contribute to plant growth[39]. Humic acid also plays an essential role in improving soil properties, root growth, increasing microbial community activity and increasing soil water retention[40,41], as well as its role in improving the chemical and physical properties of the growth medium and expanding the availability of nutrients and thus increasing plant growth[42,43]. Humic acid also contributes to increasing plant resistance to pest infestation[44]. It is also a complementary source of polyphenol, which acts as a respiratory chemical medium. This, in turn, leads to an increase in the biological activity of the plant, as the enzymatic system increases in activity and dry matter production increases[45,46].

The positive effects of spraying with ginger rhizome extract, in improving the features of vegetative growth and increasing the chemical content of seedlings, can be attributed to its role in increasing the leaf area and maybe the chlorophyll content in the leaves. This significantly impacts the manufacture of carbohydrates in the process of photosynthesis, which is used to supply the energy needed for vital processes taking place within plants. As well as the extracted content of macro- and micronutrients, vitamins, proteins and carbohydrates have an effective role in activating various physiological processes within plants[47].

Conclusions

After reviewing the study results, it can be concluded that apricot seedlings, cv. Hamawi responded by applying humic acid and spraying with ginger rhizome extract, especially at the high concentrations. Therefore, we recommend fertilizing apricot seedlings with both factors of the study, as improving the vegetative growth of plants depends primarily on balanced nutrition. That hunger has a detrimental effect on the development of seedlings.

Bibliographic references

1. Hassan, T. Encyclopedia of almond fruit. first edition. Aladdin House Publications. Syrian Arab Republic. 2002.
2. Al-Douri, A. and A. Al-Rawi. Fruit production. First Edition, House of Books for Printing, University of Mosul. 2000.
3. Punia, M.S. Wild apricot. national oil seeds and vegetable oils development board. Ministry of Agriculture, Govt. of India. 2007.
4. Janick, J. The origin of fruits, Fruit growing and fruit breeding. Plant breeding. Rev., 2005; 25: 255-230.
5. Craswell, E.T. and RDB Lefroy. The role and function of organic in tropical soils. Nutrient Cycling in Agroecosystems. 2001; 61:7–18.
6. Bama, S.K.S., S.S. Porpavai, K.G. Selvakumari and T.T. Jayaraj. Maintenance of soil quality parameters through humic acid application in an alfisol and inceptisol. Australian Journal of Basic and Applied Sciences. 2008; 2:521–526.
7. Yanan, L.. Research progress of humic acid fertilizer on the soil. Journal of Physics. J. Phys.: Conf. Ser. 2020; 1549: 1-4.
8. Luciano, P.C. and F.L. Olivares. Physiological responses to humic substances as plant growth promoter. Canellas and Olivares. Chemical and Biological Technologies in Agriculture, 2014; 1(3): 1-11.
9. Tamer, B., Ş. Akinci and A.E. Eroğlu. Effects of humic acid on root development and nutrient uptake of Vicia faba L. (Broad Bean) seedlings grown under aluminum toxicity. Communications in Soil Science and Plant Analysis, 2015; 46: 277–292.
10. Nardi, S., D. Pizzeghello, M. Schiavon and A. Ertani. Plant biostimulants: physiological responses induced by protein hydrolyzed-based products and humic substances in plant metabolism. Sci. Agric., 2016; 73(1): 18-23.

11. Abdel-Monaim, M.F., M.A. Abdel-Gaid and M.E.A. El-Morsy. Efficacy of rhizobacteria and humic acid for controlling Fusarium wilt disease and improvement of plant growth, quantitative and qualitative parameters in tomato. Journal of Plant Pathology, 2012; 1(1): 39–48.
12. Abdellatif, I.M.Y., Y.Y. Abdel-Ati, T. Abdelmageed and M.M. Hassan. Effect of Humic Acid on Growth and Productivity of Tomato Plants Under Heat Stress. Journal of Horticultural Research, 2017; 25(2): 59-66.
13. Mindari, W., P.E. Sasongko, Z. Kusuma and N. Aini. Efficiency of various sources and doses of humic acid on physical and chemical properties of saline soil and growth and yield of rice. AIP Conference Proceedings, 2018; 209: 1-8.
14. Rupiasih, N.N. and P.B. Vidyasagar. A Review: Compositions, Structures, Properties and Applications of Humic Substances. Journal of Advances in Science and Technology, 2005; 8(1-2): 16-25.
15. Olk, D.C., D.L. Dinnes, J.R. Scoresby, C.R. Callaway and J.W. Darlington. Humic products in agriculture: potential benefits and research challenges-a review. Journal of Soils and Sediments. 2018; 18: 2881–2891.
16. Pavinato, P.S., A. Merlin and C.A. Rosolem. Organic compounds from plant extracts and their effect on soil phosphorus availability. Pesq. agropec. bras., Brasília. 2008; 43(10): 1379-1388.
17. Khaled, S.M., H.A. Abbas and HH Hawass. Plant growth stimulants (environmentally friendly). Al-Nahrain University Journal. 2013; 16(4): 19-35.
18. Abd El–Hamied, S.A. and E.I. El-Amary. Improving growth and productivity of "pear" trees using some natural plants extracts under north sinai conditions. IOSR Journal of Agriculture and Veterinary Science. 2015; 8(1): 1-9.
19. Shakir, M.A. and W.A.A. Al-Rawi. Effect of garlic and licorice root extract on leaves mineral and hormonal content of pear transplants. The Iraqi Journal of Agricultural Sciences. 2017; 48: 131-143.
20. Alsalhy, B.F.J. and A.M.O. Aljabary. Effect of Moringa leaves Extracts and Licorice roots on some growth characteristics and yield of grape (Vitis vinifera L.) cv. Halawany. Plant Archives. 2020; 20(2): 2616-2623.
21. Choudhury, D., P. Dobhal, S.Srivastava, S. Saha and S. Kundu. Role of botanical plant extracts to control plant pathogens-A review. Indian Journal of Agricultural Research. 2018; 52(4): 341-346.
22. Mkindi, A.G., Y.L.B. Tembo, E.R. Mbega, A.K. Smith, I.W. Farrell, P.A. Ndakidemi, P.C. Stevenson and S.R. Belmain. Extracts of Common Pesticide Plants Increase Plant Growth and Yield in Common Bean Plants, Plants. 2020; 9(149): 1-12.
23. Han, Y.A., CW Song, W.S. Koh, G.H. Yon, Y.S. Kim, S.Y. Ryu, H.J. Kwon and K.H. Lee. Anti-inflammatory effects of the Zingiber officinale Roscoe constituent 12-dehydrogingerdione in lipopolysaccharide-stimulated raw. Cells Phytother. Res. 2013; 27: 1200–1205.
24. Kobeissi, H. A Dictionary of Medicinal Herbs and Plants, Scientific Books House, Beirut, Lebanon 2004.
25. Kanbis, A.J. Human advisor in food and medicine. Dictionary of herbal medicine and food. Dar Al-Bashaer for printing, publishing and distribution, Damascus, Syria,2007.
26. Sekiwa, Y., K. Kubota and A.V. Kobayashi. Isolation of novel glucoside-related to gingerdiol from ginger and their antioxidative activities. J. Agric.Food. Chem. 2000; 48: 373-377.
27. Iijima, Y., Y. Azawa and K. Kubota. Geaniol dehydrogenase activity related to aroma formation in ginger (Zingiber officinale Roscoe). J. Agric. Food Chem. 2001; 49: 5902-5906.
28. AL-kaisy, W.A., W.M. Rahaf and E.H. AL-Hayani. Effect of Garlic (Allium sativum)extract and root extract of Ginger (Zingiber officinale)on growth and yield of Chick plant (Cicer arietinum). Baghdad Science Journal. 2013; 10(4): 1120-1125.
29. Abd-El-Latif, F.M., S.F. El-Gioushy, A.F. Ismail and M.S. Mohamed. The impact of bio-fertilization, plant extracts and potassium silicate on some fruiting aspects and fruit quality of "Le-Conte" pear trees. Middle East J. Appl. Sci. 2007; 7(2): 385-397.
30. Mohamed, MSM. Response of "Le Conte" peer trees to bio-fertilization and antioxidants. Thesis, Faculty of Agriculture, University of Benha. 2017.
31. Sandeep, S. Commentary on therapeutic role of ginger (Zingiber officinale) as Medicine for the Whole world. Int J Pharmacogn Chin Med. 2017; 1(1):1–3.
32. Szabo, V. and K. Hrotko. Preliminary results of biostimulator treatments on Crategus and Prunus stockplants. Bull. UASVM Horticulture. 2009; 66(1): 223-228.
33. Abobatta, W.F. Plant stimulants and horticultural production. MOJ Ecology & Environmental Sciences. 2009; 5(6): 261-265.
34. Nephali, L., L.A. Piater, I.A. Dubery, V.J. Huyser, K. Burgess and F. Tugizimana. Biostimulants for Plant Growth and Mitigation of Abiotic Stresses: A Metabolomics Perspective. Metabolites. 2020; 10(12): 505-536.
35. Al-Mehmedi, S. and M.F.M. Al-Mehmedi. "Statistics and Experimental Design". Dar Usama for publishing and distributing. Amman- Jordan. 2012, pp.376.
36. Meganid, A.S., H.S. Al-Zahrani and M.S. EL-Metwally. Effect of humic acid application on growth and chlorophyll contents of common bean plants (Phaseolus vulgaris L.) under salinity stress conditions. International Journal of Innovative Research in Science. 2015; 4(5): 2651-2660.
37. Khaled, H. and H.A. Fawy. Effect of different levels of humic acids on the nutrient content, plant growth, and soil properties under conditions of salinity. Soil & Water Research. 2011; 6(1): 21-29.
38. Nardi, S., D. Pizzeghello, A. Muscolo, and A. Vianello. Physiological effects of humic substances on higher plants. Soil Biology and Biochemistry. 2002; 34(11): 1527-1536.
39. Gumus, I. and C. Seker. Influence of humic acid applications on soil physicochemical properties. Solid Earth Discuss. 2015; 7: 2481-2500.
40. Tikhonov, V.V., A.V. Yakushev, Y.A. Zavgorodnyaya, B.A. Byzov and V.V. Demin. Effects of humic acids on the growth of bacteria. Soil biology. 2010; 3: 333-341.
41. Ekin, Z. Integrated use of humic acid and plant growth promoting rhizobacteria to ensure higher potato productivity in sustainable agriculture. Sustainability. 2019; 11(12): 1-13.
42. Canellas, L.P., F.L. Olivares, N.O. Aguiar, D.L. Jones, A. Nebbioso, P. Mazzei and A. Piccolo. Humic and fulvic acids as biostimulants in horticulture. Sci. Hortic. 2015; 196: 15–27.
43. Manal, FM, A.T. Thalooth; G. Amal, M.H. Ahmed and M.H. Mohamed. Evaluation of the effect of chemical fertilizer and humic acid on yield and yield components of wheat plants (Triticum aestivum) grown under newly reclaimed sandy soil. International Journal of Chem Tech Research. 2016; 9(8): 154-161.
44. Yigit, F. and M. Dikilitas. Effect of humic acid applications on the root-rot disease caused by Fusarium Spp. on tomato. Plant Pathology Journal. 2008; 7(2): 179-182.
45. Calvo, P. L. Nelson and J.W. Kloepper. Agricultural uses of plant biostimulants. Plant and Soil. 2014; 383(1): 3-41.
46. Brown, P. and S. Saa. Biostimulants in agriculture. Front. Plant Sci. 2015; 6:671.
47. Taiz, L. and E. Zeiger. Plant Physiology. 4th ed. Sinauer Associates, Inc., Publishers Sunderland, Massachusetts 2006.