Journal of Positive School Psychology http://journalppw.com
2022, Vol. 6, No. 9, 5330-5337

Evaluation The Effect Of Biochar And Organic Materials On Nutritional Value Of Nasturtium Officinale

Rasoul Namavari[1] , Mohammad Reza Ardakani[2]* , Shahab Khaghani[3] , Mehdi Changizi[3] , Mansour Sarajoughi[4]

[1]Ph.D student, Department of Horticulture, Arak Branch, Islamic Azad University, Arak, Iran
[2]Professor, Department of Agronomy and Plant Breeding, Karaj Branch, Islamic Azad University, Karaj, Iran
[3]Associate professor, Department of Horticulture, Arak Branch, Islamic Azad University, Arak, Iran
[3]Assistant professor, Department of Horticulture, Arak Branch, Islamic Azad University, Arak, Iran
[4]Associate professor, Department of Agronomy and Plant Breeding, Karaj Branch, Islamic Azad University, Karaj, Iran
**Corresponding author Mohammad Reza Ardakani*

Abstract
Watercress has been proven in all previous scientific research as a super and healthy food and free chemicals residue products. Its leaves are the most important organ because they are the richest part in terms of nutrients, phytochemicals, and medicinal. This research is based on methods that increase watercress yield and its chemicals healthfully. The main factors included (without application: a_1, biochar: a_2) and the sub-factors were (none incubated: b_1, incubated azotobacter: b_2), (none incubated: c_1, pseudomonas fluorescence: c_2) and (without application: d_1, humic acid: d_2). Data analysis showed that four factors treatment had a significant effect on nutritional elements such as N, P, K, Fe, Ca and vitamin C amounts at 1% level. Therefore, the increasing trend in the presence of four treatments including biochar compared to the triple without biochar also shows a significant difference, which indicates the importance of the application of biochar in the culture medium.

Keywords: biochar, medicinal plants, Nasturtium officinale, nutritional value, superfoods

1. Introduction

Due to the increasing rate of the population and consequently increasing the need for food as well as the spread of nutrient poverty in most societies (even developed countries) and the consequent prevalence of various diseases resulting from the breakdown of food with unhealthy compounds, researchers decided to study food, identify mechanisms and their places of action, as well as promote them in society as much as possible to combat health poverty. In addition, due to the mechanism of action of chemical residues that are used as agricultural inputs and in food processing methods with the help of improperly used materials. The consumption of food products that can provide the essential nutrients to the body with special phytochemical materials is necessary **[1]**. Biochar is a solid compound obtained from the carbonization of biomass and may be used in soils with the intention of improving soil yield and reducing greenhouse gas emissions; otherwise, it would naturally reduce greenhouse gases. It also causes carbon sequestration, in which agricultural waste becomes a soil enhancer that can retain carbon, thus helping to increase food insecurity, increase soil biodiversity, and prevent deforestation. It can be an important tool for increasing food security and diversity of wheat fields in highly diluted soil areas, which is a scarce organic resource and a useful alternative to chemical fertilizers **[2]**. Pseudomonas is a gram-negative bacterium and a subset of the proteobacteria. Species of this genus are mainly rod-shaped, flagellate, catalase positive, oxidase positive, spore-free and motile. These bacteria are found in soil, plants, animals, and water. This bacterium, with its very high ability to dissolve phosphorus, helps to improve the growth and development of plants **[3]**. Humic acids are a mixture of weak aliphatic chains and aromatic organic acids that can be soluble in water at all pH numbers (acidic, neutral, and alkaline). As this molecule enters the plant, it can bring microelements from the plant's surface into the tissue. It is a key ingredient in high-performance foliar applications. The addition of humic acid with micro-chelate elements has a great influence on the quality of the product **[4].** However, modifiers through chelators enhance nutrient uptake in tissue and thereby improve the growth of the plant. Leaf vacuoles are major reservoirs for the accumulation and storage of metals **[5].** Azotobacter is a type of gram-negative, aerobic, and chemotrophic bacteria in various forms, including rod, elliptical, and spherical. This bacterium is a member of the gamma-proteobacteria and Pseudomonas families which have different species that are found from very tropical to polar regions. This bacterium plays an important role in the synthesis of vitamins, amino acids, exopolysaccharides, and plant growth-stimulating hormones. Improper use of nitrogen-rich fertilizers has led to ground and surface water pollution and ultimately poisoning of arable soils, causing disease to humans and animals. Biological fixation of nitrogen is only possible by certain species of prokaryotic organisms that have the ability to produce the nitrogenase enzyme **[6]**. In addition to medicine, with the change in lifestyle in developed countries and increasing attention to environmental issues and the health and hygiene of food, the tendency towards food additives of natural origin has increased. During this period, eating habits have also changed, and many of the foods present in recent years have become more pleasant with the use of products derived from plant essential oils. Furthermore, it has been found that essential oils used for flavoring food can act as antioxidant against harmful organisms **[7]**. Nasturtium officinale is a plant of the Brassicaceae family, which is one of the most important members of this family because it is the richest in terms of some nutrients, phytochemicals, and medicinal aspects. The leaves are rich in minerals and vitamins A and C, which were considered by the Romans in ancient times due to their special taste and spiciness, and today they are used in soups, salads, sandwiches, and spicy chips **[8].**

Due to the significance of medicinal plants in sustainable human health, this experiment was carried out to investigate the effect of some organic matter on the nutritional value of Nasturtium officinale.

2. Materials and methods

In order to study the effect of some organic matter on the nutritional value of Nasturtium officinale, this experiment was carried out in a factorial based on a randomized complete block design with three replications at the faculty of agriculture, Islamic Azad University, Karaj Branch. The main factors included (biochar: a_2, without application: a_1) and the sub-factors were (incubated azotobacter: b_2, none incubated: b_1), (pseudomonas fluorescence: c_2, none incubated: c_1) and (humic acid: d_2, without application: d_1).

An 8-ton ha^{-1} of vermicompost was considered a full dose. Seed inoculation liquid was applied at a rate of one liter per hectare. The watercress was treated with various treatments and transplanted to the experimental field. A distance of 1 and 2 m was maintained between plots in each replication and between blocks, respectively. All other agronomic practices (weeding, cultivation, furrow irrigation, etc.) were employed for each plot as per the recommendations.

Some factors, such as iron by the Florence method and potassium by the ammonium acetate method, were measured **[9]**. Total Ca was determined by using atomic emission spectroscopy **[10]**. Total nitrogen was determined by a LECO-device analyzer. Phosphorus (P_2O_5) was determined by the Bray method **[11]**. The level of vitamin C was recorded by the method of **[12]** as a two-stage oxidation-reduction titration.

After a normality test of residuals (Shapiro-Wilk test), based upon a statistical model plan, the data analyzed with SAS version 9.1. the means were compared using the least significant differences (LSD) at P=0.05.

3. Results and discussion

(Table 1: Analysis of variance)

S.O.V.	df	MS					
		K	Ca	Iron	Vit C	P	N
Block	3	0.3197**	11140.40**	3695.56**	153.10**	3020.51**	0.3591**
Biochar (a)	1	3.5768**	27722.25**	14020.93**	1272.44**	12656.25**	14.2601**
Error a	3	0.0124	337.50	79.39	4.73	270.71	0.0350
Azotobacter (b)	1	1.2572**	19390.56**	4575.51**	479.66**	5334.48**	5.3534**
Pseudomonas (c)	1	0.5495**	6520.56**	2299.92**	228.05**	2868.94**	1.9425**
Humic acid (d)	1	0.1754**	4522.56**	2276.24**	88.01**	1380.68*	0.3891^{ns}
a*b	1	0.1817**	1406.25*	1125.60**	91.37**	1419.03*	0.1796**
a*c	1	0.0347*	2862.25**	475.24**	27.76**	643.64^{ns}	0.4953**
b*c	1	0.1860**	517.56^{ns}	1000.30**	94.75**	1457.52*	0.0791^{ns}
a*d	1	0.0834**	2025.00*	383.87*	49.68**	929.95^{ns}	0.0395^{ns}
b*d	1	0.1016**	1580.06*	1045.88**	57.59**	1026.08*	0.0657^{ns}
c*d	1	0.0749**	1105.56^{ns}	283.92*	47.25**	898.65^{ns}	0.0791^{ns}
a*b*c	1	0.1650**	1024.00^{ns}	978.75**	84.66**	1342.86*	0.2268**

a*b*d	1	0.1216**	1369.00*	854.25**	66.04**	1126.94*	0.1416*
b*c*d	1	0.0670**	976.56^{ns}	801.17**	42.46**	838.54^{ns}	0.0395^{ns}
a*b*c*d	2	0.0495**	1703.13**	98.17^{ns}	34.41**	730.46^{ns}	0.0383^{ns}
Error		0.0085	298.73	62.42	3.37	248.864	0.0202
CV		3.6063	3.61	2.83	3.25	6.719	5.3954

The results of the analysis of variance showed that the effects of all four main treatments of biochar, azotobacter, Pseudomonas, humic acid, and their interaction on the amount of potassium at the level of 1% were significant (Table 1). By comparing the mean of the four interactions, the significant effect of biochar in the culture medium is clearly known because in biochar treated plants a remarkable change is continued at all subsequent levels (Figure 1). These results were consistent with **[13]** which stated the concentration of potassium in the shoot was increased in the presence of biochar.

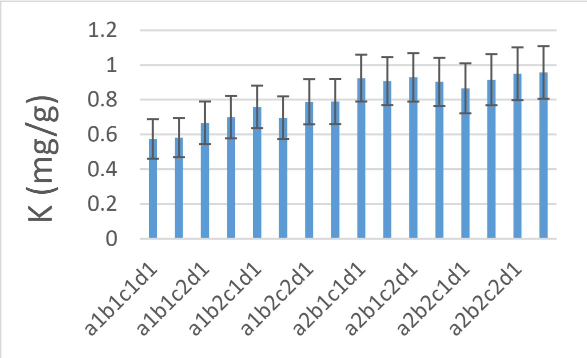
According to Table 1, nitrogen content is significantly affected by the application of biochar × azotobacter × pseudomonas × humic acid. The study of Figure 2, shows the triple interaction of biochar × azotobacter × Pseudomonas, had an increase in the percentage of nitrogen by adding each of the treatments to the culture medium. In this way, a linear and increasing trend of levels can be observed. As a result, the control level has the lowest value of 1.81 % and the highest value of 3.8 % when three treatments (biochar × azotobacter × pseudomonas) are present at the same time. In other words, these treatments increase the percentage of nitrogen and, consequently, raise the protein in the plant. However, further investigation shows that the humic acid individually did not demonstrate a significant increase in the percentage of nitrogen. According to the research **[14]**, biochar has the ability to absorb ammonium and nitrate due to its high cationic capacity.

Our results mentioned that phosphorous was significantly affected by biochar × azotobacter × pseudomonas × humic acid, while dual interactions of biochar × azotobacter, as well as quadruple interactions of biochar × azotobacter × humic acid × pseudomonas, had significant effects (Table 1). Due to the triple effect of biochar × azotobacter × pseudomonas, the highest phosphorous was found (234.74 mg/100g DM), which was a significant difference with the control (215.227 mg/100g DM) (Figure 3). Based on **[15],** biochar increases pH, total nitrogen, available phosphorus, electrical conductivity, CEC, and organic carbon. Also, the results of mean comparisons illustrated the triple interaction of biochar × azotobacter × humic acid. The highest amount of phosphorus was obtained in the presence of all treatments at the same time, which confirms the synergistic effect between the treatments. Phosphorus content was 281.9 mg/100 g DW in biochar × azotobacter × pseudomonas treatments and 279.3 mg/100 g DW in biochar × azotobacter × humic acid treatments. (Figure 4) As a result **[13]**, the use of biochar leads to an increase in phosphorus due to its high exchange levels and increased nutrient retention.

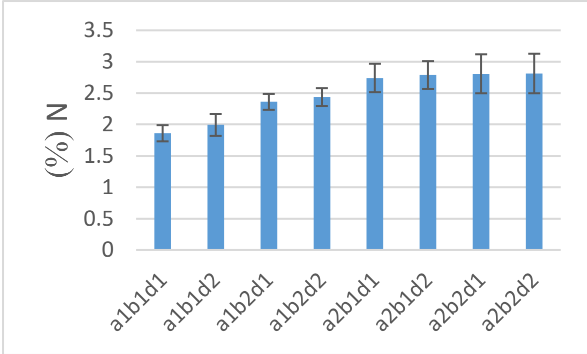
As shown in Table 1, the interaction effects of four treatments significantly affected the calcium content of the watercress plant. The calcium rate significantly increased as compared with control by dual and triple treatment interaction (Table 1). According to the comparison mean, the average of the four effects of the treatments on the mentioned trait has a significant difference with the presence of biochar along with at least two other treatments or triple (Figure 5).

The results of comparing the mean of the triple effect of Biochar on Azotobacter on Pseudomonas showed a significant difference between the media containing Biochar and Azotobacter (289.85 mg/100g DW) compared to the control (256.7 mg/100g DW). In addition, the simultaneous presence of three treatments of biochar × azotobacter × pseudomonas obtained the highest Fe value (323.02 mg/100g DW) (Figure 6). In biochar × Azotobacter × humic acid treatment, the highest rate (256.8 mg/100g DW) was obtained compared to control (322.54 mg/100g DW). The plant treated with azotobacter × Pseudomonas × humic acid has the highest iron level (313.04 mg/100g DW) (Figure 7).

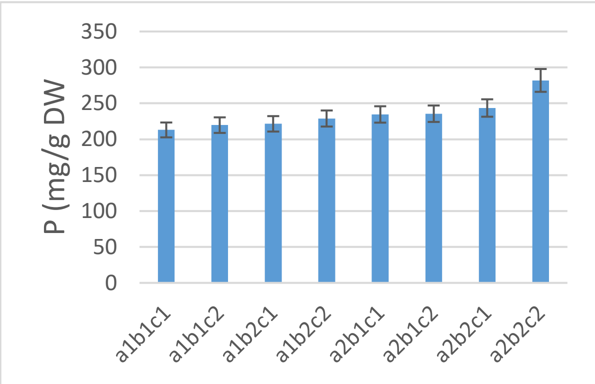
It was revealed that vitamin C significantly affected by the triple effect of Azotobacter × Pseudomonas × humic acid led to a significant difference with the control (with 55.27 and 49.19 mg/100 g FW of the plant, respectively). In other words, more discrepancy (12%) incidents related to the addition of biochar (56.52 mg/100 g FW) in the next level, despite being a single treatment, that level has led to a significant difference with the control. This increasing trend in the presence of three treatments, including biochar (60.82 mg/100g FW), compared to the triple without biochar, also shows a significant difference, which indicates the importance of application of the biochar in the culture medium (Figure 8). According to the other results, the maximum amount of this trait was recorded in the presence of all four treatments of biochar, azotobacter, pseudomonas, and humic acid, with a total of 76.89 mg/100g FW. Previous research [**16, 17**] have stated that nutritional conditions can significantly affect the growth and phytochemical interaction of the plant.



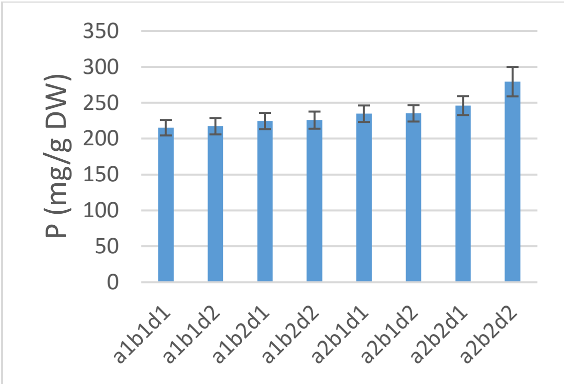
(Fig 1: potassium content)



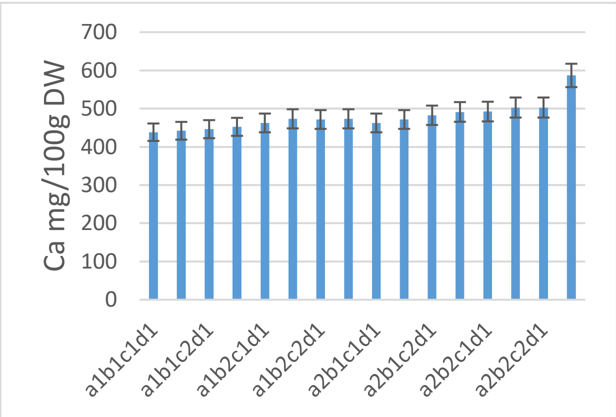
(Fig 2: nitrogen content)



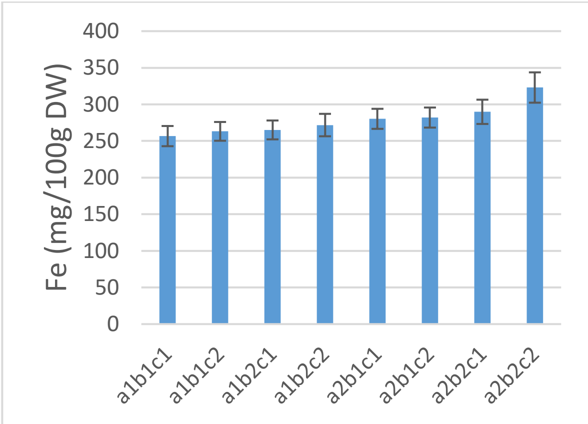
(Fig 3: phosphorus content)



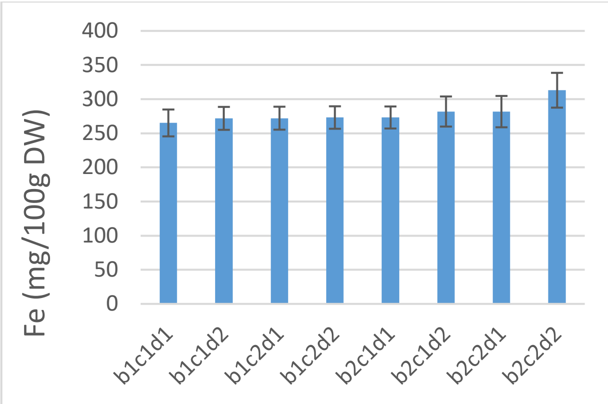
(Fig 4: phosphorus content)



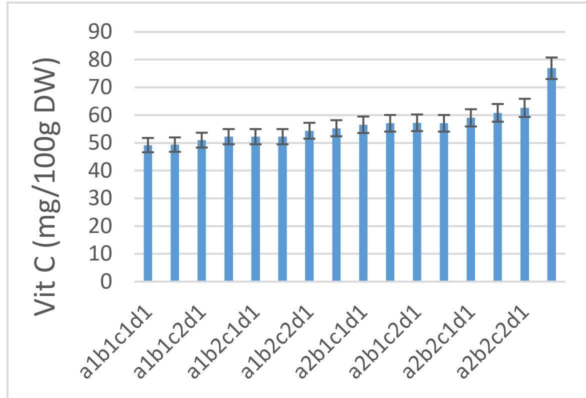
(Fig 5: calcium content)



(Fig 6: iron content)



(Fig 7: iron content)



(Fig 8: vitamin c content)

4. Conclusion

The results of this study demonstrated that biochar, azetobacter, humic acid, and pseudomonas can be applied as potential sources for watercress to improve the retention of vitamin C and increase the content of N, P, K, Fe, and Ca, which indicates the importance of application of biomaterials in the culture medium.

REFERENCE

1- Kumar, M., Puri, S., Pundir, A., Bangar, S. P., Changan, S., Choudhary, P., ... & Mekhemar, M. (2021). Evaluation of Nutritional, Phytochemical, and Mineral Composition of Selected Medicinal Plants for Therapeutic Uses from Cold Desert of Western Himalaya. Plants, 10(7), 1429.

2- Wang, J., & Wang, S. (2019). Preparation, modification and environmental application of biochar: a review. Journal of Cleaner Production, 227, 1002-1022.

3- LaBauve, A. E., & Wargo, M. J. (2012). Growth and laboratory maintenance of Pseudomonas aeruginosa. Current protocols in microbiology, 25(1), 6E-1.

4- Yang, F., & Antonietti, M. (2020). Artificial humic acids: sustainable materials against climate change. Advanced Science, 7(5), 1902992.

5- Tan, X., Li, K., Wang, Z., Zhu, K., Tan, X., & Cao, J. (2019). A review of plant vacuoles: formation, located proteins, and functions. Plants, 8(9), 327.

6- Sumbul, A., Ansari, R. A., Rizvi, R., & Mahmood, I. (2020). Azotobacter: A potential bio-fertilizer for soil and plant health management. Saudi Journal of Biological Sciences, 27(12), 3634.

7- Gavahian, M., Chu, Y. H., Lorenzo, J. M., Mousavi Khaneghah, A., & Barba, F. J. (2020). Essential oils as natural preservatives for bakery products: Understanding the mechanisms of action, recent findings, and applications. Critical reviews in food science and nutrition, 60(2), 310-321.

8- Aasim, M., Bakhsh, A., Sameeullah, M., Karataş, M., & Khawar, K. M. (2018). Aquatic plants as human food. In Global perspectives on underutilized crops (pp. 165-187). Springer, Cham.

9- DOI: 10.22069/JWSC.2017.12528.2723

10- Ogle, K. (2019). Atomic emission spectroelectrochemistry: real-time rate measurements of dissolution, corrosion, and passivation. Corrosion, 75(12), 1398-1419.

11- Jandaghi, M., Hasandokht, M. R., Abdossi, V., & Moradi, P. (2020). The effect of chicken manure tea and vermicompost on some quantitative and qualitative parameters of seedling and mature greenhouse cucumber. J. of Appl. Biolo & Biotechnol, 8(1), 33-37.

12- Adekiya, A. O., Agbede, T. M., Aboyeji, C. M., Dunsin, O., & Ugbe, J. O. (2019). Green manures and NPK fertilizer effects on soil properties, growth, yield, mineral and vitamin

C composition of okra (Abelmoschus esculentus (L.) Moench). Journal of the Saudi Society of Agricultural Sciences, 18(2), 218-223.

13- Wang, L., Xue, C., Nie, X., Liu, Y., & Chen, F. (2018). Effects of biochar application on soil potassium dynamics and crop uptake. Journal of Plant Nutrition and Soil Science, 181(5), 635-643.

14- Liu, M., Wang, C., Liu, X., Lu, Y., & Wang, Y. (2020). Saline-alkali soil applied with vermicompost and humic acid fertilizer improved macroaggregate microstructure to enhance salt leaching and inhibit nitrogen losses. Applied Soil Ecology, 156, 103705.

15- Wang, Q., Wang, B., Lee, X., Lehmann, J., & Gao, B. (2018). Sorption and desorption of Pb (II) to biochar as affected by oxidation and pH. Science of the Total Environment, 634, 188-194.

16- FUNG, V. A. C., GOBILIK, J., & DAVID, D. (2018). Effects of Fertilizer Application and Successive Harvesting on Clipping Yield, Phytochemical Contents and Antioxidant Activity of Cynodon dactylon (L.) Pers. Notulae Scientia Biologicae, 10(1), 130-136.

17- Al-Garni, S. M., Khan, M. M. A., & Bahieldin, A. (2019). Plant growth-promoting bacteria and silicon fertilizer enhance plant growth and salinity tolerance in Coriandrum sativum. Journal of Plant Interactions, 14(1), 386-396.