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ENHANCING THE ECONOMIC AND HEALTH BENEFITS OF BLACKBERRY GROWN IN SOILLESS CULTURE BY FOLIAR APPLICATION OF POTASSIUM SULFATE

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ABSTRACT

Blackberry plant is an important subject for scientific research because of their economic importance and their high content of nutrients and antioxidants essential for human health. The study was conducted at Research Station A, affiliated with the College of Agricultural Engineering Sciences, University of Baghdad, during the 2022-2023 agricultural season, aiming to improve the vegetative growth of the thornless blackberry variety grown in soilless cultivation systems using organic substrate from local plant waste (licorice root) (C_3) and imported coconut waste (C_2) compared to field soil (C_1). as well as foliar application of Potassium sulfate (S) at three concentrations (0, 2.5, 5) g l^{-1}, with 5 sprays every 20 days in a factorial experiment designed with complete randomized blocks and three replicates. The averages of the treatments were compared using the least significant difference (L.S.D.) test at a probability level of 5%. The results indicated that the treatment with cocopeat substrate and 5 g l^{-1} of potassium sulfate (C_2S_2) had the highest concentrations of nitrogen, phosphorus, total carotenoids, and total phenols at 2.497%, 0.530%, 537.44, and 10.62 mg $100g^{-1}$, respectively. Meanwhile, the treatment C_2S_1 excelled in plant height at 228.31 cm, single leaf area at 45.26 cm^2, and number of lateral branches at 5.31 branch $shrub^{-1}$. The plants in the licorice root substrate with 5 g l^{-1}, of potassium sulfate (C_3S_2) showed the highest concentration of sulfur at 1.2% and chlorophyll at 173.69 mg $100g^{-1}$ fresh weight, while the treatment C_3S_1 had the highest potassium concentration at 1.982% and a number of lateral branches at 5.31 branch $shrub^{-1}$.

Keywords: Blackberry, Organic substrate Soilless Culture systems, potassium sulfat.

* **This article is taken from the doctoral dissertation of the first researcher.**

تعزيز القيمة الاقتصادية والصحية لتوت العليق الاسود في نظم الزراعة بدون تربة بالرش بكبريتات البوتاسيوم

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الخلاصة

يعد نبات توت العليق الاسود موضوعًا مهمًا للبحث العلمي بسبب أهميته الاقتصادية ومحتواه العالي من المغذيات ومضادات الأكسدة العالية الضرورية لصحة الانسان اذ أجريت الدراسة في محطة الأبحاث A التابعة لكلية علوم الهندسة الزراعية ـ جامعة بغداد في أثناء الموسم الزراعي 2022 – 2023 ، بهدف تحسين النمو الخضري لنبات البلاك بيري صنف عديم الاشواك المزروع بأنظمة الزراعة من دون تربة في أوساط عضوية لمخلفات نباتية محلية مخلفات جذور عرق السوس (C_3) ومستوردة مخلفات قشور جوز الهند(C_2) قياسا بتربة الحقل (C_1) ، والرش الورقي بكبريتات البوتاسيوم (S) وبثلاث تراكيز(5 ,2.5 , 0)غم لتر$^{-1}$ بواقع 5 رشات كل 20 يوم في تجربة عاملية بتصميم القطاعات الكاملة المعشاة وبثلاث مكررات . تمت المقارنة بين متوسطات المعاملات باستعمال أختبار أقل فرق معنوي .L.S.D عند مستوى أحتمال 5 % واشارت النتائج الى تفوق معاملة وسط الكوكوبيت مع رش 5غم لتر$^{-1}$ من كبريتات البوتاسيوم (C_2S_2) باعلى تركيز للنتروجين والفسفوروالكاروتين الكلي والفنيولات الكلية 2.497 % ،0.530% ،10.62، 537.44 ملغم 100غم على التتابع ،فيما تفوقت المعاملة C_2S_1 في طول النبات 228.31 سم ومساحة الورقة الواحدة 45.26 سم^2 وعدد الافرع الجانبية 5.31 فرع شجرة، وتفوقت نباتات وسط مخلفات عرق السوس مع رش 5 غم لتر$^{-1}$ كبريتات البوتاسيوم(C_3S_2) باعلى تركيز للكبريت 1.2% والكلورفيل173.69 ملغم 100غم وزن طري بينما تفوق المعاملة C_3S_1 باعلى تركيز للبوتاسيوم1.982 % وعدد الافرع الجانبية 5.31 فرع شجيرة ^{1} .

الكلمات المفتاحية : توت العليق الاسود، انظمة الزراعة بدون تربة، كبريتات البوتاسيوم.

INTRODUCTION

Berries, such as (blackberries, raspberries, blueberries, and strawberries), are small-sized fruits that are widely consumed worldwide because of their delicious taste, pleasant flavor, and nutritional properties. They are used in juices, jams, and many industrial products. The blackberry plant, Rubus fruticosus L. is one of the fruit plants. The small blackberry fruit, which belongs to the Rosaceae family and the genus Rubus, is widely cultivated worldwide (**Subbiah *et al.*, 2021; Sanín *et al.*, 2020**). The blackberry fruit is an important subject of intense scientific research due to its economic importance and high content of nutrients, potent antioxidants. Studies show that this small fruit has tremendous health benefits, including reducing the risk of cancer, cardiovascular disease, diabetes, obesity, and memory loss disorders. Moreover, it has shown interesting bioactivity against esophageal, colon and oral cancer and due to its therapeutic potential and economic value makes it an attractive topic for research and development in the field of health and nutrition. (**Gil-Martínez *et al.*, 2023; Manzoor *et al.*, 2022**).

(**Mayuri *et al.*, 2023**) discovered that the blackberry plant has a unique and interesting chemical composition, making it a valuable source of medicinal and therapeutic compounds. They found that the plant contains a variety of biologically active compounds, including flavonoids, anthocyanins, tannins, and phenolic compounds. These compounds are found in

different parts of the plant, which adds to their therapeutic value. Moreover, these plant extracts have promising therapeutic properties, including... Anti-inflammatory, antioxidant and anti-wrinkle. Preserving agricultural systems using modern technologies that are environmentally friendly and with high productivity has become of great importance all over the world. The Preservation of Natural Resources and The Ecosystem Has Been Promoted and The Problems Facing Workers in The Agricultural Field Such as The Spread of Disease and Fungal Infections and The Use of Chemicals in Sterilization. Cancel The Agricultural Cycle and Obtain Year-Round Production. The World Has Turned to Search for Sustainable Agricultural Systems that are Alternative to Soil, Including the Use of Locally Produced Plant Wastes as Planting Substrate (**Rajesh *et al*., 2023; Van Os, 2017**). These Wastes are an Important Organic Media in Increasing Plant Growth and Production Because they Improve Root Growth Environment Conditions (**Mageed &Hussin, 2023**). The modern trend in agricultural research is to take advantage of agricultural areas and the distances between plants, which can be controlled using Soilless Culture systems, which **Obaid *et al*., (2022**) pointed out. Another advantage is the possibility of controlling nutritional levels, as it is possible to prepare nutrients based on requirements. The plant also provides a better growth environment for the roots (**Massa *et al.*, 2020**). With the improvement in the standard of living and the increase in demand for berry products, traditional agriculture no longer meets commercial requirements, and Soilless Culture systems using agricultural substrate, including plant waste, have become a resolution to the production and quality of berries (**Yang *et al*., 2022**). The availability and balance of essential nutrients in the growth substrate are important for optimal plant growth. A deficiency or imbalance of any of These Nutrients Can Lead to A Trouble Imbalance That Negatively Affects Growth, Both Quantitatively and Qualitatively. Potassium (K) Is an Important Nutrient That Affects the Physiological and Biological Processes in Plant Growth. It Has an Important Role in Stimulating the Photosynthesis Process by Activating Enzymes Related to The Energy Transfer Process and In Building ATP, Which Stores the Energy Needed to Metabolize CO_2 And Build Sugars, Starch, And Proteins. It Works to Regulate the Osmotic Potential in The Cells, Increases the Turgor Pressure of The Cells, Affects the Process of Opening and Closing Stomata, And Contributes to Reducing the Harmful Effect of Various Biotic and Abiotic Stresses in The Plant (**Ali *et al.*, 2014**). **Bamouh *et al*. (2019)** found in a study that foliar spraying of potassium sulfate increased the leaves' chlorophyll content and leaf area and improved the quality of strawberry, raspberry, and blueberry fruits. **Pereira *et al.* (2015**) indicated in a study on the effect of potassium on two varieties of blackberry that it improved plant vegetative growth and increased fruit production .
Therefore, the study aimed to improve the vegetative growth of blackberry shrubs through foliar application of potassium sulfate and the achievement of soilless culture techniques.

MATERIALS AND METHODS

The experiment was conducted at Research Station A of the College of Agricultural Engineering Sciences, University of Baghdad, AL-Jadira, during the agricultural season 2022-2023 on thornless blackberry plants. one-year-old homogenous seedling were selected, free of disease and insect infestations. A factorial experiment was designed according to a randomized complete block design (RCBD) With three replicates and 9 experimental units, with 2 seedlings per unit. with two factors. The first factor was soilless culture techniques using an organic substrate, coded as C:

-C1 (Control): Field soil + peat moss in a 2:1 ratio
-C2: cocopeat waste + peat moss in a 2:1 ratio
-C3: Licorice root waste + peat moss in a 2:1 ratio

A drip irrigation system was used to provide plants with nutrients and water.

A standard nutrient solution was prepared using commercial water-soluble fertilizers, with concentrations calculated according to the growth stages of the plant (vegetative and reproductive) every three days (**Sommer *et al.*, 2016**).

The second factor was a foliar application of potassium sulfate (S) at concentrations of 0, 2.5, and 5 g L-1, 5 sprays, with an interval of 20 days .

The following parameters were studied:

-Percentage of Nitrogen, Phosphorus, Potassium, And Sulfur in plant tissue
-plant height (cm)
-Number of branches per shrub
-Leaf area (cm2)
-Leaf chlorophyll, total carotenoid, and total phenols content (mg100g-1)

RESULTS AND DISCUSSION

The results in Table 1 indicate the significant effect of the interaction treatments between organic substrate and spraying with potassium sulfate, as the C2S2 treatment achieved the highest value in nitrogen concentration 2.497%, without a significant difference from the C3S2 Treatment (2.486%). The same treatment (C2S2) achieved the highest phosphorus concentration, 0.530%. Treatment C3S1 recorded the highest percentage of potassium, reaching 2.030%, and the highest concentration of sulfur was in treatment C3S2, which reached 1.200%, compared to the C1S0 .

The individual study factors indicated that the cocopeat organic substrate(C2) was superior in recording the highest concentration of nitrogen 2.458% and without a significant difference from the licorice substrate (C3) treatment, which amounted to 2.447%. The same C2 treatment gave the highest percentage of phosphorus 0.461% and the highest percentage of potassium 1.965 % without a significant difference from the C3 treatment, as it reached 1.964%. As for the highest percentage of sulfur, it was in the licorice substrate treatment(C3), which gave 1.007%, compared to the lowest values in the measurement treatment (soil C1).

The S2 spraying treatment also excelled significantly with the highest values for nitrogen and phosphorus 2.477 % and 0.424% respectively, and treatment S1 achieved the highest percentage of potassium (1.801%) while spraying treatment S2 gave the highest percentage of sulfur (1.06) compared to the (S0) for the characteristics mentioned above.

Table (1): Effect of organic Substrate and foliar application of potassium sulfate on the concentration of nutrient elements in blackberry leaves.

Treatment	N%	P%	K%	S%
C_1S_0	2.382	0.280	1.325	0.660
C_1S_1	2.484	0.371	1.384	0.750
C_1S_2	2.458	0.332	1.425	0.960
C_2S_0	2.414	0.363	1.932	0.710
C_2S_1	2.463	0.490	1.991	1.160
C_2S_2	2.497	0.530	1.973	1.020
C_3S_0	2.403	0.352	1.882	0.730
C_3S_1	2.457	0.382	2.030	1.090
C_3S_2	2.486	0.410	1.982	1.200
LSD (C×S)	0.024	0.026	0.044	0.075
C_1	2.439	0.328	1.378	0.790
C_2	2.458	0.461	1.965	0.963
C_3	2.447	0.381	1.964	1.007
LSD (C)	0.014	0.015	0.025	0.043
S_0	2.310	0.335	1.713	0.70
S_1	2.468	0.414	1.801	1.00
S_2	2.477	0.424	1.793	1.06
LSD (S)	0.014	0.015	0.025	0.043

the results in Table 2: refer to a significant effect of the interaction treatments between the organic substrate and foliar application with potassium sulfate on some indicators of vegetative growth of blackberry (Increase in plant height (cm), One leaf area(cm2), number of branches), as the treatment achieved C2S1 had the highest value for the increase in plant length and one leaf area, reaching 228.31 cm and 45.26 cm2, respectively, while treatment C2S1 and C3S1 achieved the highest value in the number of branches, 5.31 (branch. Shrub - 1) in both treatments compared to the (C1S0), and the individual study factors for the same table (2) indicated that the cocopeat substrate (C2) was superior with the highest value for the increase in plant height and the highest one leaf area, reaching 214.93 cm and 43.26 cm2, respectively, compared to the (C1). It turns out results there were no significant differences between the organic substrate in the number of branches. The S1 treatment with potassium sulfate also had the highest increase in plant height, reaching 205.99 cm. Treatment S2 achieved the highest area of one leaf, 42.80 cm2. Treatment S1 achieved the highest number of branches, reaching 5.0 (branch.shrub-1) compared with the (S0). In the characteristics mentioned above.

Table (2): Effect of organic substrate and foliar application of potassium sulfate on growth indicators of blackberry plant.

Treatment	Plant height (cm)	One leaf area (cm^2)	Number Branches
C_1S_0	158.19	38.15	3.35
C_1S_1	174.26	40.15	4.37
C_1S_2	197.16	42.20	3.50
C_2S_0	198.20	41.33	3.65
C_2S_1	228.31	45.26	5.31
C_2S_2	218.28	43.19	4.41
C_3S_0	160.20	38.24	3.23
C_3S_1	215.41	42.92	5.31
C_3S_2	198.40	43.18	4.70
LSD (C×S)	5.86	2.04	1.69

C_1	176.54	40.17	3.74
C_2	214.93	43.26	4.46
C_3	191.34	41.45	4.41
LSD (C)	3.38	1.18	0.97
S_0	172.20	39.24	3.41
S_1	205.99	42.78	5.00
S_2	204.61	42.80	4.20
LSD (S)	3.38	1.18	0.97

Chlorophyll, carotenoid, and total phenols concentration in leaves(mg100g^{-1} fresh weight)
The results in Table 3 indicate the significant superiority between the intervention treatments, as the C_3S_2 treatment had the highest concentration of chlorophyll, reaching 173.69 (mg 100 g $^{-1}$), respectively, while the C2S2 treatment achieved the highest concentration of total phenols and total carotene, 537.44, 10.62, (mg 100 g $^{-1}$), compared to the (C_1S_0). The results of the same table (3) indicate the significant effect of the individual study factors, as the licorice substrate treatment (C_3) achieved the highest concentration in chlorophyll and total carotene (149.76 mg 100g^{-1} fresh weight, 8.94 mg 100 g $^{-1}$, respectively, compared to the lowest values in (C_1). The results indicate that the spraying treatment with potassium sulfate S_2 was superior, with the highest concentration of chlorophyll, total carotene and total phenols reaching 158.85,9.74,517.47mg100gm^{-1} respectively, compared to the S_0.

Table (3): The effect of organic substrate and foliar application of potassium sulfate on chlorophyll, total carotene, and total phenols concentration in blackberry leaves.

Treatment	Chlorophyll (mg 100g-1 fresh (weight	Total Carotene (mg100g^{-1})	total phenols (mg 100g^{-1})
C_1S_0	118.38	6.20	442.52
C_1S_1	140.60	7.29	468.44
C_1S_2	154.60	8.50	486.35
C_2S_0	129.30	6.58	515.37

C_2S_1	159.30	9.19	524.44
C_2S_2	148.27	10.62	537.44
C_3S_0	129.27	7.46	510.27
C_3S_1	146.32	9.25	516.51
C_3S_2	173.69	10.11	528.63
LSD (C×S)	7.96	2.10	6.768
C_1	137.86	7.33	465.77
C_2	145.62	8.80	525.75
C_3	149.76	8.94	518.47
LSD (C)	4.60	1.21	3.908
S_0	125.65	6.75	489.39
S_1	148.74	8.58	503.13
S_2	158.85	9.74	517.47
LSD (S)	4.60	1.21	3.908

One of the advantages of soilless culture is the ability to control nutrient levels, as nutrients can be prepared based on the plant's needs. The growth substrate also provides a better growth environment for roots, and the type of substrate and its nutrient content significantly influence plant growth. The growth substrate acts as a reservoir for nutrients and water, has high air permeability, retains moisture, and provides support and fixation for the plant **(Massa *et al*., 2020; Jain *et al*., 2017)**. Therefore, the increase in element concentrations in the leaves (Table 1) of plants grown in Cocopeat substrate may be due to its very high water-holding capacity, which maintains the availability of added nutrients for the plant **(Yahya *et al*., 2009).** Additionally, as an organic material, Cocopeat can supply plants with certain elements over time, aligning with **Hameed & Khalil (2023), Obaid & Hassan (2019)**. The increase in element concentrations in plants grown in licorice waste may be attributed to the presence of numerous important chemical compounds, vitamins, and minerals, making it a nutritious and stimulating substrate **(Abdul Hadi, 2010)**. These results align with the findings **Ghehsareh *et al*. (2020).** Another advantage is reducing the effort of the plant by providing the energy necessary for absorption. The root system, which is in direct contact with these nutrients in the agricultural substrate with the appropriate ph, works to absorb the elements necessary for growth, the major and minor elements necessary for plant growth **(Taiz *et al*., 2014),** and this is achieved according to the findings of **Alkhafaji. & Khalil(2019)** and agrees with the findings of **Salman & Abdulrasool (2022)**. The increase in vegetative growth indicators in Table 2 may be attributed to the increase in organic matter resulting from the decomposition of plant residues in the organic substrate (Cocopeat and licorice waste). These organic materials contain various nutrient compounds, including elements such as carbon, hydrogen, nitrogen, oxygen, sulfur, phosphorus, and other mineral elements **(Soewardi & Laksmita, 2018)**. These organic compounds are absorbed by the roots, and their ions are easily released and rapidly transported for use in the plant's physiological processes, providing the energy required for absorption, especially during critical growth stages **(Al-Alaff, 2019)**. The increase in nutrient element concentrations in the plant, particularly major elements, that are involved in the formation of amino acids and proteins essential for the construction of chloroplasts, thereby enhancing photosynthetic efficiency and carbohydrate production **(Hassan *et al*., 1990)**. This agrees with the findings of **Khalil *et al*(2010) .** The increase in chlorophyll and total carotenoid levels in Table 3 may be attributed to the higher nitrogen content in the plant, as it is the basic component for amino acids, proteins, and nucleic acids, and it is also involved in the formation of the porphyrin ring, which is essential for chlorophyll synthesis **(Al-Hilfi, 2014; Mu *et al*., 2016)**. The increase in most growth indicators could be due to the role of potassium in enzymatic reactions, protein synthesis, photosynthesis, and water relations by regulating osmotic potential, stomatal opening and closing, and maintaining water content through transpiration **(Taiz &Zeiger, 2010)**. This agrees with the findings of **Jumaa, & Al-Sumaidai (2016); Al-Salhi *et al*. (2017).**

CONCLUSIONS:

The study results indicate no significant differences in element concentrations and some growth indicators between the organic substrate of coconut waste and licorice waste. According to the results of this study show that we can replace the imported substrate (Cocopeat) with the local substrate (licorice waste). Furthermore,there are no significant differences between the first and second concentrations of potassium sulfate in most of the studied traits.

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