Effect of foliar nutrition and adding plant waste on the chemical characteristics of three potato cultivars (*Solanum tuberosum* L)

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Abstract

A field experiment was carried out in the Al-Azzawiya region (40 km north of Babylon Governorate) during the autumn season 2023-2024 to study the effect of foliar nutrition and adding plant waste on the chemical characteristics of three potato cultivars. The experiment included three factors, as the main plots included three cultivars (Synergy, Burren and El-mundo). The sub plots included four levels of plant waste (rice waste compost), while the sub sub plots included three concentrations of foliar spraying of the microponic nutrient solution. The experiment was applied in split-split plot design according to the randomized complete block design (R.C.B.D) with three replications. The results showed that the Burren cultivar was significantly superior on the Synergy and El-mundo cultivars in the average percentage of nitrogen in the tuber (1.898)%, the percentage of phosphorus in the tuber (0.335)%, the percentage of potassium in the tuber (1.726)%, the concentration of iron in the tuber (0.026) mg kg-1 and the concentration zinc in the tuber (1.133) mg kg-1 respectively. The results also showed that the treatment of adding rice waste compost + 50% NPK fertilizer was significantly superior to the average percentage of nitrogen in the tuber (2.038) %, the percentage of phosphorus in the tuber (0.346)%, the percentage of potassium in the tuber (1.795)%, the concentration of iron in the tuber (0.027) mg kg-1 and the concentration of zinc in the tuber is (1.274) mg kg-1 compared to the control treatment respectively. The results showed that the foliar spraying treatment with the microponic nutrient solution at a concentration of 200 ml100 L-1 of water gave a significant increase in the average percentage of nitrogen in the tuber (1.681)%, the percentage of phosphorus in the tuber (0.335)%, the percentage of potassium in the tuber (1.749)%, the concentration of iron in the tuber (0.027).) mg kg-1 and the zinc concentration in the tuber is (1.103) mg kg-1 compared to the control treatment respectively. It also showed all the two-way interactions treatments a significant superiority in the chemical characteristics compared to the control treatment. The results of the three-way interaction also showed a significant effect, as the interaction treatment between the Burren cultivar and the adding of rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water gave a significant increase in the average percentage of nitrogen in the tuber (3.006)% , the percentage of phosphorus in the tuber (0.390) %, the percentage of potassium in the tuber is (2.166)%, the concentration of iron in the tuber is (0.038) mg kg-1 and the concentration of zinc in the tuber is (1.711) mg kg-1 respectively.

Keywords: Burren, Adding, Nutrient solution, Chemical.

ISSN 2072-3857

Introduction

Potato Solanum tuberosum L. is one of the important vegetable crops in the world and belongs to the Solanaceae family, which includes more than 2,000 species and 90 genus. It is the fourth crop as a basic and economic after wheat, rice, and corn [30,24]. Potato contain proteins, vitamins, fibres, fats, energy, carbohydrates, and minerals such as P, K, Fe, Ca, Mg, and ascorbic acid. It is also rich in amino acids, as it contains 18 amino acids out of 20, especially lysine, which grain crops lack, which gives them good nutritional value [22].The area allocated for potato cultivation in Iraq reached in 2023 was about (35.9) thousand dunums, and its total production reached (229.1) thousand tons and a yield of 6380.8 kg dunum-1 [20] . One of the methods adopted to increase production and improve the quality of potato is to rely on Cultivars with good specifications, high production, and appropriate environmental conditions [34]. The lack of interest in Genetic structures of high quality and high productivity, poor storage in warehouses that lack many ideal storage specifications, in adding to the prevailing weather conditions during crop growth are the reasons that stand in the way of expanding potato cultivation[28]. Adopting the organic farming system as a new and sustainable agricultural technology is due to its environmentally friendly nature and healthy products. It is more efficient in its use to save energy and provide moisture to the soil. Organic agriculture depends on the use of biosolids, crop rotation, mulching, non-synthetic fertilizers, no-tillage, integrated nutrients, and pest management to manage crops and their products [27]. Foliar nutrition is the process of supplying plants with nutrients sprayed on the shoots, which have the ability to absorb them through the stomata in the leaves, stems, cell walls and membranes. The scientific basis for nutrient absorption is similar in principle to the process of nutrient absorption by the roots. The main step in this process is Transport through cell biofilms based on the water potential difference or diffusive pressure between the spray solution and the leaf cells [21,23]. All plants also need micronutrients in relatively low quantities compared to the major nutrients, so a deficiency in one or more of them will be a determining factor in the production and quality of that crop [14 . [

The study aims to determine the effect of foliar nutrition and the adding of plant waste on the chemical characteristics of three potato cultivars.

Materials and Methods

A field experiment was carried out in the Al-Azzawiya region, north of the center of Babylon Governorate, about 40 km in the autumn season, which began from 15/9/2023 to 18/1/2024. The land was prepared for agriculture by plowing it, then smoothing it with disc harrows, leveling it, and dividing it into three sectors. One sector contains thirty-six experimental units for each, leaving a distance of 1 m between the experimental units and between one block and another to prevent the transfer of fertilizer between treatments. Planting was done on rows and on one side of the farm, with 3 gardens for each experimental unit, and the distance between one row and another was 75 cm. The number of tubers for each row was 8 tubers on one side of the row, with a distance of 25 cm between one tuber and the other. The number of tubers for one experimental unit was 24 tubers, with 108 experimental units, with an area of 4.5 m2.

ISSN 2072-3857

Random samples were taken from the field soil before planting, at a depth between 0-30 cm and from different locations. The samples were mixed together and left to dry in the air, then ground and some of their physical and chemical properties were estimated in Table (1 .(

Table (1) shows some physical and chemical characteristics of field soil.

Traits											
pH	**Ece (ds . m $^{-1}$)**	**Organic matter %**	**N (mg.kg^{-1})**	**P (mg.kg^{-1})**	**K (mg.kg^{-1})**	**CEC centmol.kg^{-1} soil**	**Bulk density gm . cm^{-3}**	**Sand %**	**Silt %**	**Clay %**	**Texture**
7.9	**3.1**	**1.15**	**23.5**	**7.4**	**162.7**	**19.28**	**1.34**	**61.0**	**24.5**	**14.5**	**Sandy loam**

The experiment was applied in split-split plot design according to the randomized complete block design (R.C.B.D) with three replications.

The experiment included three factors:

The first factor includes cultivars the main plots, which are:

A1: Synergy

A2 : Burren

A3: El- mundo

The second factor is adding plant waste (rice waste compost) at four levels. The sub-plots represent Table (2 .)

B1: the control treatment NPK 15:15:15 fertilizer produced by the Russian company Ekim (according to the fertilizer recommendation 600 kg ha-1) [17.[

B2: Adding rice waste compost (20 ton ha-1.(

B3: Adding rice waste compost + 25% NPK fertilizer.

B4: Adding rice waste compost + 50% NPK fertilizer

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Table (2): Shows the physical and chemical characteristics of organic

Traits	pH	Ece ds . m $^{-1}$	N %	P %	K %	Carbon Organic %	Organic matter %	Humic acid %	Fulvic acid %
Value	**7.43**	**3.04**	**1.12**	**1.01**	**0.61**	**44.5**	**56.2**	**14.2**	**7.1**

The third factor is foliar spraying with a nutrient solution (Microponic containing microelements) produced by the Spanish company Artal, which represents sub-sub plots with three concentrations in Table (3.(

C0: Spray with distilled water only.

C1: Spray at a concentration of 100 ml 100 L-1 of water.

C2: Spray at a concentration of 200 ml 100 L-1 of water

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ISSN 2072-3857

Table (3): Shows the chemical characteristics of the microponic nutrient solution.

B%	Cu%	%Fe	Mn%	%Mo	%Zn
0.49	0.56	4.87	3.48	0.07	4.17

Decomposed organic fertilizer (rice waste compost) was used, which was brought from the organic fertilizer production project affiliated with the Najaf Agriculture Directorate, and was added to the experimental units while preparing the land for planting according to the treatments and mixing it with the soil using a rake machine. The Microponic nutrient solution was sprayed 45 days after planting, at a rate of three sprays, and the period between one spraying to the next was 15 days, with the adding of a spreading agent (Al-Zahi) in the amount of 1 ml per liter - and the spraying process was carried out early in the morning.

Studied Traits:

-1Estimating the concentration of NPK in the tuber (%): Samples of tubers weighing 0.5 g were taken and they were digested by adding 5 ml of concentrated sulfuric acid, then 3 ml of perchloric acid was added, which is considered a strong oxidizing acid that helps complete the digestion of the sample in the presence of sulfuric acid, which works to remove The water molecules from the plant sample become brown or black. The sample continues to be heated quietly on a hot plate for half an hour with continuous shaking and stirring until the digestion process is complete and the color of the solution becomes clear and colorless as evidence of the completion of the digestion process[13. [

Nitrogen was estimated using a Micro–Kijeldahl device, according to what was mentioned in [19 .[

Phosphorus was also estimated using ammonium molybdate and ascorbic acid in a spectrophotometer at a wavelength of 882 nm, according to the method of[31] mentioned in [32.[

Potassium was estimated using a flame-photometer according to the method mentioned in [10.[

-2Estimation of the concentration of elements Fe, Zn in the tuber (mg kg-1): These elements were estimated using an atomic absorption spectrophotometer according to the method given by [8.[

The results were analyzed according to the design followed, and the L.S.D test was used to compare the means at the 0.05 probability level, and the L.S.D. program was used. Genstat in statistical analysis [11 .[

Results and Discussion

-1Nitrogen percentage in the tuber (%)

Table (4) shows that foliar spraying and adding plant waste of three potato cultivars and their interactions have a significant effect on the nitrogen percentage in the tuber in the autumn season. The Burren (A2) cultivar was significantly superior to the percentage of nitrogen in the tuber over the two cultivars (Synergy and El-mundo). It gave the highest average of (1.898)%, followed by the El-mundo cultivar (A3), which gave (1.342)%, while the Synergy (A1) cultivar gave the lowest average of (1.272.%(

The same table also shows that adding plant waste has a significant effect on the percentage of nitrogen in the tuber, as it was significantly superior to the treatment of adding rice waste compost + 50% NPK fertilizer (B4), reaching (2.038)% compared to

the control treatment (B1), which gave the lowest average of (1.046)% respectively.

It is also noted from the same table that foliar spraying with the microponic nutrient solution at a concentration of 200 ml100 L-1 of water (C2) was significantly superior, reaching (1.681)%, while the control treatment (C2) gave the lowest average, amounting to (1.289)% respectively.

The table also shows the two-way interactions between the experimental factors had a significant effect on this trait, as the interaction between the cultivars and plant waste (rice waste compost) gave a significant superiority. The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer (A2B4) was superior. It gave the highest average of (2.643)% compared to the control treatment with the Synergy cultivar (A1B1), which gave the lowest average of (0.977)% respectively.

The interaction between the cultivars and foliar spraying had a significant effect, The interaction of the Burren cultivar and foliar spraying at a concentration of 200 ml100 L-1 of water (A2C2) was superior to (2.129)% compared to the control treatment with the Synergy cultivar (A1C0) and reached (1.124)% respectively.

The interaction between plant waste and foliar spraying shows a significant effect, The interaction of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water (B4C2) was superior and gave the highest average of (2.366)% compared to the control treatment (B1C0), which recorded the lowest An average of (0.940)% respectively.

The interaction between the three factors also had a significant effect, The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water (A2B4C2) was superior and gave the highest average of (3.006)% compared to the control treatment for the Synergy cultivar (A1B1C0). which gave the lowest average of (0.869)% respectively

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Table (4) Effect of foliar spraying and adding plant waste of three potato cultivars and their interactions on the nitrogen percentage in the tuber.(%)

Plant waste	Spraying	Autumn Season			Plant waste × Spraying
		Cultivars			
		A 1 Synergy	A 2 Burren	A 3 El-mundo	
B1	C0	0.869	1.060	0.893	0.940
	C1	0.997	1.140	1.049	1.062
	C2	1.067	1.230	1.114	1.137
B2	C0	1.110	1.226	1.111	1.149
	C1	1.147	1.567	1.199	1.304
	C2	1.261	1.712	1.299	1.424
B3	C0	1.203	1.959	1.224	1.462
	C1	1.292	2.390	1.298	1.660
	C2	1.376	2.566	1.450	1.797

ISSN 2072-3857

B4	**C0**	**1.313**	**2.153**	**1.346**	**1.604**
	C1	**1.694**	**2.770**	**1.966**	**2.144**
	C2	**1.933**	**3.006**	**2.160**	**2.366**
L.S.D 0.05		**0.083**			**0.047**

Average Plant waste

Cultivars ×Plant waste	**B1**	**0.977**	**1.143**	**1.019**	**1.046**
	B2	**1.173**	**1.502**	**1.203**	**1.293**
	B3	**1.290**	**2.305**	**1.324**	**1.640**
	B4	**1.647**	**2.643**	**1.824**	**2.038**
L.S.D 0.05		**0.059**			**0.032**

Average Spraying

Cultivars × Spraying	**C0**	**1.124**	**1.600**	**1.143**	**1.289**
	C1	**1.282**	**1.967**	**1.378**	**1.542**
	C2	**1.409**	**2.129**	**1.506**	**1.681**
L.S.D 0.05		**0.048**			**0.022**
Average Cultivars		**1.272**	**1.898**	**1.342**	
L.S.D 0.05		**0.045**			

-2Phosphorus percentage in the tuber(%)

Table (5) shows that foliar spraying and adding plant waste of three potato cultivars and their interactions have a significant effect on the phosphorus percentage in the tuber in the autumn season. The Burren (A2) cultivar was significantly superior in the phosphorus percentage in the tuber to the two cultivars (Synergy and El-mundo). It gave the highest average of (0.335)%, followed by the El-mundo Cultivar (A3), which gave (0.316)%, and the Synergy (A1)cultivar, which gave the lowest average of (0.296.%(

The same table also shows that adding plant waste has a significant effect on the percentage of phosphorus in the tuber, as it was significantly superior to the treatment of adding rice waste compost + 50% NPK fertilizer (B4), reaching (0.346)% compared to the control treatment (B1), which gave the lowest average. It reached (0.286)% respectively.

The same table also indicates that foliar spraying with the microponic nutrient solution at a concentration of 200 ml100 L-1 of water (C2) was significantly superior, reaching (0.335)%, while the control treatment (C0) gave the lowest average, amounting to (0.290)% respectively.

The table also shows that the two-way interactions between the experimental factors had a significant effect on this characteristic, as the interaction between the cultivars and plant waste (rice waste compost) gave a significant superiority. The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer (A2B4) was superior. It gave the

ISSN 2072-3857

highest average of (0.367)% compared to the control treatment with the Synergy Cultivar (A1B1), which gave the lowest average of (0.271)% respectively.

The interaction between the cultivars and foliar spraying had a significant effect, The interaction between the Burren cultivar and foliar spraying at a concentration of 200 ml100 L-1 of water (A2C2) was superior and reached (0.355)% compared to the control treatment with the Cultivar Synergy (A1C0), reaching (0.272)% respectively .

The interaction between plant waste and foliar spraying shows a significant effect, The interaction of the treatment of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water (B4C2) was superior and gave the highest average of (0.368)% compared to the control treatment (B1C0), which gave The lowest average was (0.267)% respectively.

The interaction between the three factors also had a significant effect, The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water (A2B4C2) was superior and gave the highest average of (0.390)% compared to the control treatment for the Synergy cultivar (A1B1C0).) which gave the lowest average of (0.245)% respectively.

Table (5) Effect of foliar spraying and adding plant waste of three potato cultivars and their interactions on the phosphorus percentage in the tuber.(%)

Plant waste	Spraying	Autumn Season			Plant waste × Spraying
		Cultivars			
		A 1 Synergy	A 2 Burren	A 3 El-mundo	
B1	C0	0.245	0.291	0.265	0.267
	C1	0.280	0.299	0.289	0.290
	C2	0.289	0.315	0.301	0.302
B2	C0	0.263	0.295	0.271	0.277
	C1	0.288	0.314	0.299	0.300
	C2	0.295	0.345	0.325	0.322
B3	C0	0.280	0.319	0.302	0.301
	C1	0.311	0.366	0.339	0.339
	C2	0.330	0.371	0.349	0.350
B4	C0	0.301	0.332	0.309	0.314
	C1	0.333	0.381	0.359	0.357
	C2	0.335	0.390	0.378	0.368
L.S.D 0.05		0.011			0.006

Average Plant waste

Cultivars ×Plant					
	B1	0.271	0.302	0.285	0.286
	B2	0.282	0.318	0.299	0.300

ISSN 2072-3857

waste	**B3**	**0.307**	**0.352**	**0.330**	**0.330**
	B4	**0.323**	**0.367**	**0.349**	**0.346**
L.S.D 0.05		**0.005**			**0.003**

Average Spraying

Cultivars × Spraying	**C0**	**0.272**	**0.309**	**0.287**	**0.290**
	C1	**0.303**	**0.340**	**0.322**	**0.322**
	C2	**0.312**	**0.355**	**0.338**	**0.335**
L.S.D 0.05		**0.006**			**0.004**
Average Cultivars		**0.296**	**0.335**	**0.316**	
L.S.D 0.05		**0.004**			

-3potassium percentage in the tuber(%)

Table (6) shows that foliar spraying and adding plant waste of three potato cultivars and their interactions have a significant effect on the potassium percentage in the tuber in the autumn season. The Burren (A2) cultivar outperformed the two cultivars (Synergy and El-mundo), as it gave the highest average of (1.726) %, followed by the El-mundo cultivar (A3), which gave (1.621)%, while the Synergy cultivar (A1) gave the lowest average of (1.533.%(

It appears from the same table that adding plant waste has a significant effect, as the treatment of adding rice waste compost + 50% NPK fertilizer (B4) was significantly superior and gave the highest average amounting to (1.795)%, while the control treatment (B1) gave the lowest average percentage of potassium amounting to (1.498%) respectively.

The same table also shows that foliar spraying with the microponic nutrient solution at a concentration of 200 ml100 L-1 of water (C2) was significantly superior, reaching (1.749)%, while the control treatment (C0) gave the lowest average, amounting to (1.491)% respectively.

It is also noted in the table that the two-way interactions between the experimental factors had a significant impact on this trait, as the interaction between the cultivars and plant waste (rice waste compost) gave a significant superiority. The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer (A2B4) was superior. It gave the highest average of (1.970)% compared to the control treatment with the Synergy Cultivar, which gave the lowest average of (1.437)% respectively.

The interaction between the cultivars and foliar spraying had a significant effect, The interaction of the Burren cultivar and foliar spraying at a concentration of 200 ml100 L-1 of water (A2C2) was superior to (1.873)% compared to the control treatment with the Synergy cultivar (A1C0), which gave the lowest average of (1.404)% respectively.

The interaction between plant waste and foliar spraying shows a significant effect, The interaction of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a

concentration of 200 ml100 L-1 of water (B4C2) was superior and gave the highest average of (1.971)% compared to the control treatment (B1C0), which gave the lowest average of (1.417)% respectively.

The interaction between the three factors also had a significant effect, The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water (A2B4C2) was superior and gave the highest average of (2.166)% compared to the control treatment for the Synergy cultivar (A1B1C0). It gave the lowest average of (1.348)% respectively.

Table (6) Effect of foliar spraying and adding plant waste of three potato cultivars and their interactions on the potassium percentage in the tuber.(%)

lant waste	Spraying	Autumn Season			Plant waste × Spraying
		Cultivars			
		A 1 Synergy	A 2 Burren	A 3 El-mundo	
B1	C0	1.348	1.481	1.421	1.417
	C1	1.465	1.533	1.499	1.499
	C2	1.497	1.652	1.589	1.579
B2	C0	1.394	1.503	1.443	1.447
	C1	1.557	1.609	1.541	1.569
	C2	1.581	1.653	1.564	1.599
B3	C0	1.404	1.534	1.512	1.484
	C1	1.583	1.814	1.695	1.697
	C2	1.630	2.022	1.889	1.847
B4	C0	1.468	1.816	1.561	1.615
	C1	1.684	1.928	1.784	1.799
	C2	1.791	2.166	1.957	1.971
L.S.D 0.05		0.048			0.027

Average Plant waste

Cultivars ×Plant waste	B1	1.437	1.556	1.503	1.498
	B2	1.510	1.588	1.516	1.538
	B3	1.539	1.790	1.699	1.676
	B4	1.648	1.970	1.767	1.795
L.S.D 0.05		0.031			0.016

Average Spraying

Cultivars × Sprayin	C0	1.404	1.584	1.485	1.491
	C1	1.572	1.721	1.630	1.641

ISSN 2072-3857

g	**C2**	**1.625**	**1.873**	**1.750**	**1.749**
L.S.D 0.05		**0.028**			**0.013**
Average Cultivars		**1.533**	**1. 726**	**1. 621**	
L.S.D 0.05		**0.025**			

-4Iron concentration in the tuber (mg kg-1(

Table (7) shows that foliar spraying and adding plant waste of three potato cultivars and their interactions have a significant effect on the iron concentration in the tuber in the autumn season. The Burren (A2) cultivar was significantly superior in the concentration of iron in the tuber over the two cultivars (Synergy and El-mundo). It gave the highest average of (0.026) mg kg-1, followed by the El-mundo cultivar (A3), which gave (0.023) mg kg-1, and the Synergy cultivar (A1), which gave the lowest average of (0.022) mg kg-1.

It is also shown from the same table that adding plant waste has a significant effect on the concentration of iron in the tuber, as it was significantly superior to the treatment of adding rice waste compost + 50% NPK fertilizer (B4), reaching (0.027) mg kg-1 compared to the control treatment (B1), which It gave the lowest average of (0.020) mg kg-1 respectively.

The same table also indicates that foliar spraying with the microponic nutrient solution at a concentration of 200 ml100 L-1 of water (C2) was significantly superior, reaching (0.027) mg kg-1, while the control treatment (C0) gave the lowest average, amounting to (0.020) mg kg-1 respectively .

It is also noted from the table that the two-way interactions between the experimental factors had a significant effect on this characteristic, as the interaction between the cultivars and plant waste (rice waste compost) gave a significant superiority. The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer (A2B4) outperformed It gave the highest average of (0.031) mg kg-1 compared to the control treatment with the Synergy cultivar (A1B1), which gave the lowest average of (0.019) mg kg-1 respectively.

The interaction between the cultivars and foliar spraying had a significant effect, The interaction between the cultivar Burren and foliar spraying at a concentration of 200 ml100 L-1 of water (A2C2) and reached (0.030) mg kg-1 was superior compared to the control treatment with the cultivar Synergy A1C0 (0.019) mg kg-1 respectively.

The interaction between plant waste and foliar spraying shows a significant effect, The interaction of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water (B4C2) was superior and gave the highest average of (0.033) mg kg-1 compared to the control treatment (B1C0).) which gave the lowest average of (0.018) mg kg-1 respectively.

The interaction between the three factors also had a significant effect, The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water (A2B4C2) was superior and gave the highest average of (0.038) mg kg-1 compared to the control treatment for the cultivar. Synergy (A1B1C0), which gave the lowest average of (0.017) mg kg-1 respectively.

ISSN 2072-3857

Table (7) Effect of foliar spraying and adding plant waste of three potato cultivars and their interactions on iron concentration in the tuber (mg kg-1 .(

Plant waste	Spraying	Autumn Season			Plant waste ×Spraying
		Cultivars			
		A 1 Synergy	A 2 Burren	A 3 El-mundo	
B1	C0	0.017	0.019	0.018	0.018
	C1	0.018	0.021	0.020	0.020
	C2	0.020	0.025	0.022	0.022
B2	C0	0.018	0.020	0.018	0.019
	C1	0.022	0.024	0.022	0.023
	C2	0.022	0.027	0.023	0.024
B3	C0	0.020	0.024	0.020	0.021
	C1	0.022	0.026	0.023	0.024
	C2	0.026	0.030	0.028	0.028
B4	C0	0.021	0.025	0.022	0.023
	C1	0.023	0.030	0.024	0.026
	C2	0.028	0.038	0.032	0.033
L.S.D 0.05		0.0015			0.0008
Cultivars × Plant waste	B1	0.019	0.022	0.020	0.020
	B2	0.021	0.024	0.021	0.022
	B3	0.023	0.026	0.024	0.024
	B4	0.024	0.031	0.026	0.027
L.S.D 0.05		0.0008			0.0005

Average Plant waste

Average Spraying

Cultivars × Spraying	C0	0.019	0.022	0.020	0.020
	C1	0.021	0.025	0.022	0.023
	C2	0.024	0.030	0.026	0.027
L.S.D 0.05		0.0007			0.0005
Average Cultivars		0.022	0.026	0.023	
L.S.D 0.05		0.0006			

-5Zinc concentration in the tuber (mg kg-1(

Table (8) shows that foliar spraying and adding plant waste of three potato cultivars

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and their interactions have a significant effect on the zinc concentration in the tuber in the fall season. The Burren (A2) cultivar was significantly superior in the zinc concentration in the tuber to the two cultivars (Synergy and El-mundo). It gave the highest average of (1.133) mg kg-1, followed by the El-mundo cultivar (A3), which gave (0.943) mg kg-1, and the Synergy cultivar (A1), which gave the lowest average of (0.852) mg kg-1.

It also indicates from the same table that adding plant waste has a significant effect on the concentration of zinc in the tuber, as it was significantly superior to the treatment of adding rice waste compost + 50% fertilizer (B4) NPK, reaching (1.274) mg kg-1 compared to the control treatment (B1), which It gave the lowest average of (0.787) mg kg-1 respectively.

The same table also indicates that foliar spraying with the microponic nutrient solution at a concentration of 200 ml100 L-1 of water (C2) was significantly superior, reaching (1.103) mg kg-1, while the control treatment (C0) gave the lowest average, amounting to (0.826) mg kg-1 respectively .

It is also noted from the table that the two-way interactions between the experimental factors had a significant effect on this characteristic, as the interaction between the cultivars and plant waste (rice waste compost) gave a significant superiority. The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer (A2B4) outperformed It gave the highest average of (1.432) mg kg-1 compared to the control treatment with the Synergy cultivar (A1B1), which gave the lowest average of (0.708) mg kg-1 respectively.

The interaction between the cultivars and foliar spraying had a significant effect, The interaction between the cultivar Burren and foliar spraying at a concentration of 200 ml100 L-1 of water (A2C2) was superior and reached (1.279) mg kg-1 compared to the control treatment with the cultivar Synergy A1C0, reaching (0.738) mg kg-1 respectively.

The interaction between plant waste and foliar spraying shows a significant effect, The interaction of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml100 L-1 of water (B4C2) was superior and gave the highest average of (1.515) mg kg-1 compared to the control treatment (B1C0).) which gave the lowest average of (0.750) mg kg-1 respectively.

The interaction between the three factors also had a significant effect, The interaction between the Burren cultivar and the treatment of adding rice waste compost + 50% NPK fertilizer and foliar spraying at a concentration of 200 ml 100 L-1 of water (A2B4C2) was superior and gave the highest average of (1.711) mg kg-1 compared to the control treatment for the cultivar. Synergy (A1B1C0), which gave the lowest average of (0.671) mg kg-1 respectively.

ISSN 2072-3857

Table (8) Effect of foliar spraying and adding plant waste of three potato cultivars and their interactions on the zinc concentration in the tuber (mg kg-1.(

Plant waste	Spraying	Autumn Season			Plant waste ×Spraying
		Cultivars			
		A 1 Synergy	A 2 Burren	A 3 El-mundo	
B1	C0	0.671	0.862	0.717	0.750
	C1	0.710	0.876	0.763	0.783
	C2	0.743	0.929	0.813	0.828
B2	C0	0.667	0.866	0.731	0.755
	C1	0.709	0.958	0.762	0.810
	C2	0.857	1.028	0.910	0.932
B3	C0	0.743	0.983	0.892	0.873
	C1	0.787	1.355	0.930	1.024
	C2	0.959	1.447	1.003	1.136
B4	C0	0.871	0.999	0.905	0.925
	C1	1.193	1.586	1.372	1.384
	C2	1.318	1.711	1.515	1.515
L.S.D 0.05		0.072			0.043

Average Plant waste

Cultivars × Plant waste	B1	0.708	0.889	0.764	0.787
	B2	0.745	0.951	0.801	0.832
	B3	0.830	1.262	0.942	1.011
	B4	1.127	1.432	1.264	1.274
L.S.D 0.05		0.046			0.029

Average Spraying

Cultivars × Spraying	C0	0.738	0.928	0.811	0.826
	C1	0.850	1.194	0.957	1.000
	C2	0.969	1.279	1.060	1.103
L.S.D 0.05		0.034			0.020
Average Cultivars		0.852	1.133	0.943	
L.S.D 0.05		0.024			

The results of tables (4-8) showed that there were significant differences between the cultivars, The Burren cultivar excelled in the chemical content of the tubers Perhaps the reason for the resulting increase is due to the nature of the genetic structures of these cultivars, The difference between the cultivars in the characteristics of the chemical content is due to the differences in the genetic characteristics and the extent of The plant adapts to the environmental conditions surrounding it and the appropriate conditions

ISSN 2072-3857

available to it for growth and metabolic processes [36,18] These results also agree with what [15,16,26] found on potato.

As for the plant waste treatments, the treatment (B3 and B4) had a significant effect on the chemical content in the tubers of potato plants. This increase may be due to the role of organic waste, as it works to increase the availability of nutrients in the soil as a result of the decomposition of organic matter and the absorption of nutrients through the roots [12]. The increase in the percentage of nitrogen in the tubers may be due to the organic and chemical fertilizers containing a high percentage of nitrogen, which leads to the formation of a strong vegetative system and works to increase the efficiency of the photosynthesis process and increase the percentage of proteins in the leaves and their transfer to the tubers [3,6]. Organic fertilizers also prepare phosphorus by forming chelating compounds that prevent phosphorus from fixing in the soil and provide it in a form ready for absorption [29]. The increase in the percentage of potassium in the tubers is due to its increased absorption through the root system to increase its readiness in the soil solution and the plant's construction of the various compounds that require its formation, but it is not included in their composition as it helps in their movement from the source, the leaves, to the storage places in the tubers, The availability of potassium during the tuber formation stage is important and essential for the transfer of substances manufactured in the leaves, especially carbohydrate substances, to the tubers, which are stored in the form of starch [5] These results are consistent with [33] on potato.

As for the foliar spraying treatments with the microponic nutrient solution at a concentration of 200 ml100 L-1 of water (C2), it had a significant effect on the chemical content in the tubers of potato plants, and the increase in the percentage of nitrogen in the tubers may be due to the important role of potassium in increasing plant growth and its efficiency in Absorption of nutrients to meet the needs of its vital activities, including nitrogen [3]. The increase in the percentage of phosphorus in tubers may be due to the important role played by potassium in transferring phosphorus from leaves to tubers, as nitrogen participates with phosphorus in the formation of energy compounds and enzymatic accompaniments that support enzymatic activity in starch formation, as it participates with potassium in the responsible enzymatic activities. On the transport and storage of starch in tubers [37]. or the increase may be due to the content of the nutrient solution and the microelements it contains (Appendix 3). This may be due to the direct absorption of the contents of the nutrient solution when spraying on the leaves, in adding to the role of the microelements, especially iron, as it is the catalyst in the formation of the two compounds, amino Laevalinic A. The Protochloro pyhic They are two basic compounds in building chlorophyll, which leads to increased rates of photosynthesis and then increased production and accumulation of dry matter, thus increasing growth rates. This is clearly reflected in the number of aerial stems, plant height, dry weight of the shoots, and tuber yield [9,35]. As well as zinc, as one of the components of the nutrient solution, and its role in growth processes that require greater absorption of nutrients to meet growth requirements, and its role in absorbing water, increasing respiration, and the assimilation of carbohydrates and proteins. It activates a number of enzymes, including carbonic anhydrase, which is found in chloroplast,

which regulates the pH and thus works to protect proteins from changing their nature. And synthase starch enzyme It is necessary in the manufacture of starch and is necessary in the construction of the plant hormone indole acetic acid (IAA), which is necessary in cell division, expansion and elongation [1,25] These results are consistent with [4,2,7 .[

Conclusions and Recommendations

It is concluded from this study that the Burren cultivar showed a significant superiority on the Synergy and El-mundo cultivars in the chemical characteristics of potato tubers. The treatment of adding rice waste compost + 50% NPK fertilizer gave a significant increase in the chemical characteristics of potato tubers, and the foliar spraying treatment with a microponic nutrient solution at a concentration of 200 ml 100 L-1 of water gave a significant increase in the chemical characteristics of potato tubers .

We also recommend using the Burin cultivar and conducting other studies with new varieties that suit the environmental conditions of the region. We recommend conducting other studies on the potato plant using levels higher than those used in the study because the response was positive with increasing levels used in the study factors

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ISSN 2072-3857