FIELD AND STORAGE PERFORMANCE OF INDUSTRIAL POTATOES TREATED WITH COBALT AND SILICON

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ABSTRACT

Two field and storage experiments were conducted at a Research Station affiliated with the College of Agricultural Engineering Sciences / University of Baghdad during the 2023 and 2024 season. To investigate the effect of cobalt chloride at three concentrations 0, 5, and 15 mg. L^{-1} (C0, C1, C2) and silica gold at four concentrations 0, 5, 10, and 15 ml.L^{-1} (Si0, Si1, Si2, Si3) to increase tubers production and quality and raise the storage capacity of industrial potato hybrid Hermes as factorial experiment within R.C.B.D. with three replicates. The storage experiment was conducted in the refrigerated warehouse belongs to private sector, following the same design of field experiment, the results revealed that the C1 treatment recorded the highest percentage of ascorbic acid and total phenols in tubers for both seasons while C2 treatment recorded the highest plant productivity and tuber weight in both season and lowest percentage of microbial contamination. The Si2 treatment resulted in the highest activity of catalase enzyme and the lowest weight loss percentage.

Keywords: phenols, weight losing, catalase, ascorbic acid, strategic crop, food security.

الاداء الحقلي والمخزني للبطاطا الصناعية المعاملة بعنصري الكوبلت والسليكون

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المستخلص

أجريت تجربتين حقلية وخزنية في احد المحطات البحثية التابعة لكلية علوم الهندسة الزراعية / جامعة بغداد اثناء الموسم 2023-2024 ، لدراسة تأثير ثلاث تراكيز من كلوريد الكوبلت 0 ، 5 ، 15 ملغم لتر$^{-1}$ ورمز لها (C0، C1، C2) وأربع تراكيز من المغذي silica gold ‎0، 5 ، 10 ، 15مل لتر$^{-1}$ ورمز لها (S0، S1، S2، S3) والتداخل بينهما في زيادة انتاج وجودة الدرنات ورفع مقدرتها التخزينية لهجين البطاطا الصناعية Hermes كتجربة عاملية بأتباع تصميم القطاعات الكاملة المعشاة R.C.B.D وبثلاث مكررات ، أما التجربة الخزنية فأجريت في أحد المخازن المبردة التابعة للقطاع الخاص وبحسب التصميم التجريبي ذاته المتبع بالتجربة الحقلية. أظهرت النتائج تسجيل المعاملة (C1) اعلى نسبة من حامض الاسكوربيك والفينولات الكلية في الدرنات ولكلا الموسمين، وأقل نسبة في التلف المكروبي، بينما سجلت المعاملة (C2) اعلى انتاجية للنبات ووزن الدرنة ولكلا الموسمين، وسجلت المعاملة (S2) اعلى فاعلية لانزيم Catalase وأقل نسبة فقد بالوزن.

الكلمات المفتاحية: فينولات، فقد وزني، كتاليز ،حامض الاسكوربيك، محصول أستراتيجي، أمن غذائي.

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INTRODUCTION

The demand for potato (*Solanum tubersum* L.) produced for industrial purposes potatoes such as crisps and finger chips is increasing due to the spread of this consumer culture globally, which requires hybrids with high-quality standards for tubers, especially concerning their chemical content or quantitative production specifications (4, 19, 36). Potato consumption methods have witnessed major transformations from fresh consumption to processed consumption (chips and fast food), as many factories have emerged in Iraq, which has achieved remarkable development in this sector in recent years with the entry of many hybrids into the country for processing and manufacture industries. Balancing the high fertilizer requirements of this crop, reducing environmental pollution, stress, and maintaining product quality and safety are some challenges facing crop producers and farmers (2, 5, 10, 28). Recently, potatoes for manufacturing purposes have become the focus of scientific research as an attempt to delve deeper into this aspect and determine the best nutritional and environmental factors to increase the productivity of their hybrids used in agriculture, as changing the levels of fertilization with macro elements NPK can significantly increase the morphological and productive characteristics of this crop during both the fall and spring production seasons (21). However, some nutrients, like Cobalt have not received sufficient research and investigation in this field, since it has essential physiological properties in crop growth, especially those of economic importance, such as stopping the deterioration of chlorophyll and activating many enzymes, including catalase, and effectively contributing to nitrogen fixation and cell development, delaying tissue aging and reducing ethylene production, which reduces damage to plant cells, which would reflect in boosting plant productivity due to the vigor of its vegetative growth and then increasing food manufacture and its transfer to its accumulation sites, in addition to extending its consumption and storage life after harvest (12, 13). The results obtained by (6) demonstrated the extent of the contribution of foliar spraying with cobalt sulfate in improving vegetative growth and increasing of potato yield. Foliar feeding with organic cobalt (1 and 2 ml L^{-1}) also improved the vegetative growth paths and quantitative production, as well as boosted the nutritional values of potato tubers produced in the spring and fall seasons (7). Concerning Silicon, it works as a nutritional element to improve crop productivity, especially in a foliar application. Silicon fertilizers affect the plant's bio-system as a result of its regulatory function for water relations and the biosynthesis of various hormones, its activation of the enzyme system, and its improvement of carbon assimilation performance, and nutrient absorption and distribution, especially K and Na, as well as it has a role in reducing the effect of biological and fungal stresses (24, 26, 30, 31, 34). Moreover; Silicon increased the productivity and quality in plants (2 ,16, 22, 29, 32, 33, 35). In the same context, (27) concluded that the foliar addition of this element increased potato tubers number and their marketing weight; and thus increased the amount of the produced crop and improved its marketability. As for foliar spray with potassium silicate (1.25 ml L^{-1}), it improved the productive characteristics of the strawberry fruits, in addition to preserving the quality of the stored fruits represented by the percentage of total soluble solids and ascorbic acid and reducing the fruit spoilage percentage (17). Given the advantage of the industrial potato hybrids in their low yield compared to the consumer potato hybrids, this experiment aimed to increase the production capacity and nutritional values of tubers produced in the spring and improve their storage capacity for use as seeds for planting in the following fall season by using foliar nourishment with cobalt and silicon and the interaction between them.

MATERIALS AND METHODS

The experiment was conducted at the research station (A) affiliated with the College of Agricultural Engineering Sciences, University of Baghdad, using the potato hybrid Hermes as a factorial field experiment (4x3) with three replicates for each treatment, following the randomized complete block design (R.C.B.D.). The tubers were planted on rows of 0.75 m wide and with a planting distance of 0.25 m between one tuber and another on 2/1/2023 for the spring season and 9/5/2023 for the fall season. The foliar spray included cobalt chloride $CoCl_2.6H_2O$ as a source of cobalt at three concentrations (0, 5, and 10 mgL^{-1}) symbolized by C0, C1, and C2, respectively, constituting the first factor in the experiment. The second factor involved foliar spray with the nutrient silica gold as a source of silicon (Si = 3%, K_2O = 1.3) and at four concentrations (0, 5, 10, and 15 ml L^{-1}) symbolized by Si0, Si1, Si2, and Si3, respectively, in addition to foliar spray with a combination of the interaction between the levels of two factors. The time interval between one spray and another was 15 days, according to the growth stages, noting that all experimental units were chemically fertilized according to the fertilization recommendation mentioned in (1). After tubers had been harvested on 15/5/2023 for the spring season and on 11/1/2024 for the fall season, the following data were recorded: leaf area ($dm^2.plant^{-1}$), number of aerial branches (aerial branch. $plant^{-1}$), plant yield (g. $plant^{-1}$), number of tubers (tuber $plant^{-1}$), tuber weight (g $tuber^{-1}$), tuber firmness (kg cm^{-1}), ascorbic acid (mg 100 g^{-1} fresh weight), total phenolics (%) (15, 23) and catalase activity (absorption unit. g^{-1} protein) (18). Furthermore, a storage experiment was conducted in a private-sector refrigerated warehouse to evaluate the effectiveness of treatments used in a field experiment and their interaction impact on increasing the storage capacity of tubers produced in the spring season to be used as seeds for the fall season. The experiment relied on the randomized complete block design (R.C.B.D). A sample of specified weight was taken from each experimental unit for the three replicates, kept in plastic mesh bags, and preserved in the refrigerated store at a temperature of 4±1°C and a relative humidity of 90±5 for three months. At the end of the storage period, the tubers were adapted by placing them in a shaded place for ten days. The percentage of weight loss (%), microbial spoilage (%), and total soluble solids (%). The data were analyzed using the software Genstat to compare the differences between the means based on the least significant difference test at a probability level of 5% (10).

RESULTS AND DISCUSSION

Vegetative growth traits: Table 1 illustrates the significant effect of all nutritional treatments under spring production conditions. Treatments C1 and C2 led to their plants recording the highest number of aerial branches and the largest leaf area compared to the control treatment C0, whose plants recorded the lowest values for these two parameters (6.033 ,3.86 aerial branches. $plant^{-1}$; 134.49 and 110.21 dm^2 $plant^{-1}$) respectively. The treatments Si2 and Si3 achieved significant superiority by producing the highest number of aerial branches and the largest leaf area, attaining 5.79, 3.926 aerial branches. $plant^{-1}$, 129.92 and 117.61 dm^2 $plant^{-1}$, respectively compared to the treatment Si0. The interaction between the two experimental factors for the spring season improved these two traits, as the plants of the interaction treatments C1XSi3 and C1XSi0 recorded their highest averages, reaching (7.00 aerial branches $plant^{-1}$ and 148.37 dm^2plant^{-1}) respectively, compared to the control treatment C0XSi0, which its plants recorded the lowest (2.67 aerial branches $plant^{-1}$ and 84.50 dm^2 $plant^{-1}$) respectively. It is also evident from the same table that treatment C1 could record the highest number of aerial branches and leaf area during the fall production season compared to the control treatment C0 (3.42 ,2.46 aerial branches $plant^{-1}$; 90.47 and 77.10 dm^2plant^{-1}) for the two treatments respectively. On the other hand, the treatment Si1 produced the highest number of aerial branches in the plants, while the treatment Si3 led to increasing leaf area, in comparasion, with control treatment Si0 which recorded the lowest rates for these two traits (3.53 and 2.16 aerial branches $plant^{-1}$; 92.67 and 67.53 dm^2 $plant^{-1}$ respectively). Regarding the interaction between the two experimental factors, the treatment C1XSi1 exhibited the highest number of aerial branches (4.33 branches. $plant^{-1}$) and the treatment C1XSi3 produced the largest leaf area (108.9 dm^2plant^{-1}) compared to the control treatment C0XSi0, which recorded the lowest values of these traits (1.33 aerial branches $plant^{-1}$ and 48.20 dm^2 $plant^{-1}$) respectively.

Table 1. Effect of foliar nutrition with cobalt and silicon and their interaction on some vegetative growth traits (the upper numbers refer to the spring season of 2023, and the lower numbers refer to the fall season of 2024)

Si	Number of aerial branches (aerial branches $plant^{-1}$) Co			Si Means		Leaf area (dm^2 $plant^{-1}$) Co			Si Means
	C0	C1	C2		Si	C0	C1	C2	
Si0	2.67 1.33	4.33 2.83	4.78 2.33	3.926 2.16	Si0	84.50 48.20	148.37 80.8	123.96 73.60	117.61 67.53
Si1	4.33 3.07	5.36 4.20	6.67 3.33	5.45 3.53	Si1	132.84 106.5	126.73 90.30	127.19 77.3	128.92 91.36
Si2	5.02 2.76	6.33 3.33	5.70 3.05	5.68 3.05	Si2	131.82 68.8	135.80 81.90	122.02 100.5	129.88 83.73
Si3	3.40 2.69	7.00 3.33	6.98 3.00	5.79 3.01	Si3	115.68 85.00	128.86 108.9	144.60 84.60	129.71 92.67
Co Means	3.86 2.46	5.76 3.42	6.03 2.93		Co means	110.21 77.10	134.49 90.47	129.44 83.88	
$L.S.D_{5\%}$	Co	Si	CoxSi		$L.S.D_{5\%}$	Co	Si	CoxSi	
	0.865 0.706	0.998 0.815	1.729 1.411			2.815 5.24	3.250 6.05	5.63 10.48	

Production traits

Table (2) shows the positive path that all nutritional treatments led to in the yield amount, as treatment C2 was able, under the conditions of the spring season, to produce the highest plant yield (910 g) and weight of the produced tubers (115.87 g $tuber^{-1}$). As for the highest number of tubers, it was reached by the plants of the treatment C1 (8.303 tubers $plant^{-1}$) compared to the control treatment C0, which recorded the lowest (711 g $plant^{-1}$, 99.47 g $tuber^{-1}$, and 7.38 tubers $plant^{-1}$) respectively. Besides, the treatment Si1 recorded the highest plant yield (995 g $plant^{-1}$) tubers weight (118.72 g $tuber^{-1}$), while the plants of the treatment Si3 produced the highest number of tubers (8.69 tubers $plant^{-1}$) compared to the control Si0 treatment (626 g. $plant^{-1}$, 91.54 g. $tuber^{-1}$, and 6.75 tubers. $plant^{-1}$), respectively. In contrast, compared to the control treatment, the interaction treatments C1XSi1, C2XSi2, and C2XSi1 were able to produce the highest rates of the studied production parameters (1063 and 442 g $plant^{-1}$; 9.17; and 5.80 tubers $plant^{-1}$; and 124.8 and 75.05 g $tuber^{-1}$) respectively. Under the conditions of the fall season, as shown in Table (2), the nutritional treatment C2 was superior, recording the highest averages for all production traits, which amounted to 411 and 281 g. $plant^{-1}$; 5.05 and 4.25 tubers. $plant^{-1}$; and 78.5 and 65.2 g $tuber^{-1}$, respectively compared to the control treatment C0. The treatment Si3 could achieve the highest averages of quantitative production traits compared to the control treatment Si0, (394 ,253 g $plant^{-1}$; 5.10 ,3.82 tubers $plant^{-1}$; 74.9 and 64.57 g $tuber^{-1}$) respectively. The interaction between the two experimental factors resulted in the interaction treatment C2XSi1 recording the highest plant productivity and tuber weight and the plants of the interaction treatment C1XSi3 produced the highest number of tubers, and compared to the control treatment C0XSi0, the recorded results were (531, 189 g $plant^{-1}$; 91.5 ,60.10 g $tuber^{-1}$; 5.80 and 3.10 tubers $plant^{-1}$) respectively.

Table 2. Effect of foliar nutrition with cobalt and silicon and their interaction on some production traits (the upper values refer to the spring season of 2023, and the lower values refer to the fall season of 2024)

	Plant yield (g plant^{-1}) Co			Mean Si	No. of tubers (tubers plant^{-1}) Co			Mean Si	Tuber weight (g.tuber^{-1}) Co			Mean Si
Si	C0	C1	C2		C0	C1	C2		C0	C1	C2	
Si0	422 189	707 278	728 293	626 253	5.80 3.10	8.02 4.30	6.43 4.07	6.75 3.82	75.05 60.1	87.34 64.3	112.2 69.3	91.54 64.57
Si1	924 285	1063 287	988 531	995 367	7.35 4.35	8.97 4.53	8.06 4.87	8.06 4.87	113.4 65.4	117.8 62.9	124.8 91.5	118.7 73.3
Si2	912 348	843 308	894 391	883 349	8.07 5.07	7.23 4.67	9.17 5.43	8.16 5.06	98.69 68.1	114.4 66.0	108.4 71.2	107.1 68.43
Si3	565 305	1004 449	1018 429	862 394	8.30 4.53	8.99 5.80	8.80 4.96	8.69 5.10	110.7 67.0	112.5 75.9	117.9 81.9	113.7 74.9
Mean Co	711 281	904 330	910 411		7.38 4.25	8.30 4.83	7.92 5.05		99.47 65.2	108.0 67.3	115.9 78.5	
L.S.D 5%	Co	Si	CoX Si		Co	Si	CoXSi		Co	Si	CoXSi	
	196.6 62.7	227.1 72.40	393.3 125.3		0.883 0.546	1.020 0.630	1.766 1.092		3.553 6.92	4.103 7.99	7.106 13.83	

Tuber quality traits

Table (3) demonstrates that tubers produced from the C2 nutritional treatment had the highest hardness and activity of the CATALASE enzyme under the conditions of the spring season in comparison with the control treatment CO, attaining 11.51and 11.38 kg.cm^{-2}; and 25.11 and 19.51 absorption units gm^{-1} protein, respectively. Whereas the treatment Si2 produce tubers with the highest quality for the mentional traits compared to tubers produced from the control treatment Si0, recording12.33 and 10.27 kg cm^{-2}; and 25.23 and 21.74 absorption unitsg^{-1} protein, respectively. The interaction between the two study factors had a positive effect on the mentioned qualitative parameters, as the tubers produced from the interaction treatment C2XSi2 exhibited the highest hardness versus the lowest hardness for tubers produced from the interaction treatment C0XSi0 recording 12.97 and 9.40 kg cm^{-2}, respectively, besides, the interaction treatment C2XSi3 produced tubers with the highest activity of the CATALASE enzyme of 9.58 units g^{-1} protein, compared to the lowest activity of this enzyme had by the tubers produced from the interaction treatment C0XSi0 recording 14.50 absorption units g^{-1} protein. For the fall season, tubers produced from nutritional treatment C1 had the highest rates of hardness and enzyme activity trails, compared to the lowest that were displayed by the tubers produced from control treatment C0 (11.07 and 9.62 kg cm^{-2}; and 20.41 and 16.27 absorption units g^{-1} protein), respectively. Similarly, the nutritional treatment Si2 produced tubers with the highest hardness and activity of the catalase enzyme; compared to tubers produced from the control treatment Si0 they had 11.89 and 9.243 kg cm^{-2}; and 21.78 and 17.26 absorption units g^{-1} protein respectively. The tubers produced from the interaction treatment C2XSi2 exhibited the highest hardness compared to the C0XSi0 measurement treatment, recording 12.33 and 6.70 kg cm^{-2} respectively; yet, it did not differ statistically significantly from the interaction treatment C0XSi2 in its effect on this parameter. The highest activity of the catalase enzyme was shown in tubers produced from the interaction treatment C1XSi2, contrary to the lowest activity of this enzyme displayed by the tubers produced from the interaction treatment C0XSi0, as there were 23.49 and 11.18 absorption units. g^{-1} protein, respectively.

Table 3. Effect of foliar nutrition with cobalt and silicon and their interaction on some tuber quality parameters (the upper number refer to the spring season of 2023, and the lower number refer to the fall season of 2024)

Si	Tuber hardness (kg.cm^{-2}) Co C0	C1	C2	Means Si	Si	Catalase enzyme activity (absorption units g^{-1} protein) Co C0	C1	C2	MeansSi
Si0	9.40 6.70	11.30 11.13	10.10 9.90	10.27 9.242	Si0	14.50 11.18	23.85 19.63	26.86 20.99	21.74 17.26
Si1	12.80 11.23	11.23 10.50	11.24 10.97	11.76 10.90	Si1	20.18 16.31	21.85 17.84	23.42 19.08	21.82 20.41
Si2	12.57 12.30	11.47 11.03	12.97 12.33	12.33 11.89	Si2	22.24 19.50	26.80 23.49	26.43 22.35	25.23 21.78
Si3	10.77 8.23	11.90 11.63	11.73 10.90	11.47 10.25	Si3	20.91 18.09	24.67 20.43	29.58 23.40	25.05 19.65
Co means	11.38 9.62	11.48 11.07	11.51 11.02		Co means	19.51 16.27	24.29 20.41	25.11 19.93	
L.S.D 5%	Co	Si	CoxSi		L.S.D 5%	Co	Si	CoxSi	
	0.828 0.910	0.956 1.051	1.656 1.821			1.383 1.552	1.597 1.792	2.766 3.103	

Antioxidants traits

The results in Table (4) reveal the superiority of the nutritional treatment C1 in its effect on the concentration of ascorbic acid and total phenols produced in the tubers compared to these two antioxidants produced from tubers of the control treatment C0, as they were 16.74 and 14.21 mg100 g^{-1} F.W; and 0.433 and 0.358%, respectively and under the conditions of the spring season. The treatment Si3 was superior in, producing tubers with the highest content of antioxidants compared to the control treatment Si0, their values were 5.97 and 12.91 mg100 g^{-1} F.W; and 0.407 and 0.340%, respectively. The interaction treatment C1XSi2 was superior in, producing tubers with the highest concentration of ascorbic acid and total phenols followed by the interaction treatment C1XSi1. In contrast, the lowest concentration of these two antioxidants was contained by tubers produced from the control treatment C0XSi0, as they recorded 17.73 and 12.91 mg100g^{-1} fresh weight; and 0.477 and 0.272%, respectively, for the spring production season. It is evident from the same table that the nutritional treatment C1 continued to have a significant superiority. Its tubers had the highest content of the studied antioxidants, compared to the lowest content recorded by tubers produced from the control treatment C0 under fall season conditions, reaching 14.90 and 13.01 mg100 g^{-1} F.W; and 0.342 and 0.239%, respectively. The treatment Si2, with no significant difference from treatment Si3, was able to produce tubers containing the highest concentration of ascorbic acid and total phenols compared to the lowest concentration recorded by the control treatment Si0, 14.40 and 13.26 mg.100 g^{-1} F.W; and (0.311 and 0.212%), respectively.

The interaction between the two experimental factors under fall season production conditions continued to have a positive effect on these two traits, as the tubers resulting from the interaction treatment C1XSi1 were able to exhibit the highest percentages of ascorbic acid and total phenols, contrary to the tubers resulting from the interaction treatment C0XSi0, as their contents were (16.01 ,11.41 mg100 g^{-1} F.W.; 0.391 and 0.117%) respectively.

Table 4. Effect of foliar nutrition with cobalt and silicon and their interaction on antioxidants (the upper values refer to the spring season of 2023, and the lower values refer to the fall season of 2024)

Si	Ascorbic acid (mg100 g^{-1} F. W) Co C0	C1	C2	Means Si	Si	Total phenols (%) Co C0	C1	C2	Means Si
Si0	12.91	15.23	17.18	15.11	Si0	0.272	0.407	0.340	0.340
	11.41	13.87	14.50	13.26		0.117	0.309	0.209	0.212
Si1	14.19	17.53	16.04	15.92	Si1	0.381	0.477	0.312	0.390
	12.85	16.01	14.34	14.40		0.221	0.391	0.208	0.273
Si2	13.91	17.73	15.18	15.61	Si2	0.434	0.410	0.372	0.405
	13.16	15.89	13.47	14.17		0.329	0.291	0.274	0.298
Si3	15.82	16.47	15.63	15.97	Si3	0.433	0.438	0.440	0.407
	14.64	13.85	13.96	14.15		0.288	0.378	0.268	0.311
Co	14.21	16.74	16.01		Co	0.358	0.433	0.366	
Means	13.01	14.90	14.07		means	0.239	0.342	0.240	
$L.S.D_{5\%}$	Co	Si	CoxSi		$L.S.D_{5\%}$	Co	Si	CoxSi	
	0.543	0.627	1.086			0.017	0.020	0.035	
	0.821	0.948	1.641			0.020	0.024	0.041	

Storage traits

Table (5) shows the significant role of nutritional treatments in improving the storage performance of tubers produced in the spring season used as seeds. The stored tubers resulting from treatment C1 displayed the lowest percentage of weight loss and the lowest microbial spoilage, compared to the highest values of these two parameters recorded by the stored seeds resulting from the comparison treatment C0; besides, the stored tubers resulting from the treatment, C2 contained the highest percentage of total soluble solids (T.S.S.) compared to the control treatment (1.39, 1.94, 0.73, 1.00, 6.10 and 5.62%) respectively. In the same context, the stored tubers resulting from the nutritional treatment Si1 exhibited the lowest percentage of microbial spoilage and the highest percentage of total soluble solids found; on the other hand, the tubers resulting from the nutritional treatment Si2 had the lowest percentage of weight loss compared to the comparison treatment Si0, which tubers used as seeds had the highest percentage of microbial spoilage, the lowest percentage of total dissolved solids and the highest percentage of weight loss (0.75, 6.29, 1.37, 1.31, 5.54 and 1.82%) respectively. The interaction between the two study factors took the same positive path in affecting the storage studied trails of the storage experiment. The interaction treatment C1XSi2 recorded showed the lowest percentage of weight loss in its tubers, the tubers resulted from the interaction treatment C0XSi3 had the lowest microbial spoilage percentage, and the highest content of total soluble solids was recorded in the stored tubers resulting from the interaction treatment C1XSi3, reaching (1.08, 0.51, and 6.57%), respectively; in contrast, the highest percentage of weight loss and microbial spoil, and the lowest content of total soluble solids was recorded by the stored tubers resulting from the interaction treatment C0XSi0 reaching (2.36, 2.36, and 4.48%) respectively.

Table 5. Effect of foliar nutrition with cobalt and silicon and their interaction on some storage parameters

Si	Weight loss percentage (%) Co C0	C1	C2	Mean Si	Microbial spoilage (%) Co C0	C1	C2	Mean Si	T.S.S(%) Co C0	C1	C2	Mean Si
Si0	2.36	1.42	1.70	1.82	2.36	0.67	0.91	1.31	4.48	5.74	6.41	5.54
Si1	2.01	1.70	1.61	1.75	0.60	0.70	0.94	0.75	6.56	5.91	6.40	6.29
Si2	1.77	1.08	1.25	1.37	0.54	0.73	1.01	0.76	5.72	5.92	6.02	5.89
Si3	1.62	1.36	1.78	1.59	0.51	0.84	1.08	0.81	5.71	6.57	5.59	5.96
Mean Co	1.94	1.39	1.58		1.00	0.73	0.98		5.62	6.03	6.10	
L.S.D 5%	Co	Si	CoXSi		Co	Si	CoXSi		Co	Si	CoXSi	
	0.20	0.23	0.40		0.26	0.30	0.53		0.23	0.27	0.47	

The positive field and storage performance of the studied potato hybrid under the conditions of foliar nutrition with cobalt chloride is likely due to the essential physiological functions of this element within plant tissues, perhaps most notably the stimulating and activating role of cobalt for several natural hormones related to improving the morphological characteristics of the plant, including cytokinins and gibberellins, which showed an increase in the number of vegetative branches and leaf areas contributing to photosynthesis and carbon assimilation (Table1). Additionally, cobalt chloride is involved in the compound Combanmine construction, which is essential in enzyme systems and plays a significant role in nitrogen fixation and plant metabolic pathways, ultimately leading to increased productivity in individual plants (Table 2), by enhancing the plant's ability to produce nutrients and transport them to where they are needed, resulting in improved quantitative crop yield traits (12 and 13). These findings are consistent with those previously reported by (7). Cobalt also has the delaying senescence property by inhibiting the activity of ACC-oxidase and reducing the production of ethylene, thus reducing damage to plant cells (14) that can explain the positive path taken by the nutritional treatments belong to this element in improving the condition of stored tubers, especially the percentages of microbial contamination and weight loss. In the same context, the positive effects of silica gold concentrations on the targeted parameters in this experiment, both in the field and in storage, can be attributed to the role of silicon. Silicon regulates water relations and the biosynthesis of plant growth hormones improves the process of photosynthesis and carbon assimilation, and enhances nutrient absorption, particularly potassium. It also activates the enzyme system, which was positively reflected in increasing the effectiveness of the catalase enzyme and the production of ascorbic acid and total phenolic materials, the synthesis of which is affected by the nutritional status of the plant, in addition to reducing the effect of biological stresses such as bacterial infections (24 and 26). Due to silicon's role in cell wall composition, it can effectively prevent water loss through transpiration and protect from microbial infections (11). This could be the cause of the beneficial effects of this nutrient on tubers that have been preserved. These findings concur with the observations made by (17).

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