Effect of nano-fertilizer on growth traits of potato cultivars grown under water stress

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Abstract

The experiment was conducted in the field of the Plant Production Techniques Department at the Technical College of Musayyib for autumn season of 2020. The first experiment included three factors. The first factor was the use of four cultivars (Burren, Sifra, Arizona, Royal) and symbolized by the symbol (C1, C2, C3, C4).), the second factor has four levels of water stress (without water stress, water stress during the germination stage starting from the date of planting to 30 days of planting, water stress during the vegetative growth stage starting from the end of the germination stage until 45 days of planting, water stress during The stage of tuber formation and starts from the end of the vegetative growth stage until 60 days of planting) and is symbolized by the symbol (W0, W1, W2, W3). The third work included spraying three levels of nano fertilizer (khazra) which are (0, 1, 2) g. L^{-1} and its symbol (S0, S1, S2), and the experiment was implemented according to the RCBD (Randomized complete block design) with three replicates, and the transactions were distributed randomly within each replicate. The results were analyzed according to the Least Significant Difference (L.S.D) test at the level of probability. 5%The cultivars had a significant effect on the studied traits, the two Burren cultivars significantly excelled on the other cultivars and gave the highest values for traits of plant height 57.70 cm, number of leaves 48.00 leaves. $plant^{-1}$, chlorophyll 50.39 spade, number of tubers 10.16 tubers. $plant^{-1}$, The fresh weight of the tubers was 511.29 gm, the dry weight of the tubers was 132.94 gm.The two treatments of stress during the tuber formation stage (W3) and stress during vegetative growth (W2) had a negative effect on reducing the values of most of the studied traits, while a treatment without stress (W0) was recorded, and gave the highest values for most of the traits.The triple interaction treatment consisting of (Burren variety, treatment without stress, and spraying at a concentration of $2g.l^{-1}$) excelled significantly and recorded the highest values for the characteristics of plant height 66.33 cm, number of leaves 54.95 leaves, $plant^{-1}$, chlorophyll 51.44 spad, number of tubers 12.54 $tubers.plant^{-1}$, the fresh weight of the tubers 828.31 gm, the dry weight of the tubers 215.36 gm

Introduction

Potato (Solanum tuberosum L.) is one of the most important food crops and belongs to the Solanaceae family. It is believed that the origin country of potatoes is South America and ranks fourth after wheat, rice and corn in terms of cultivation, production, and economic importance. It constitutes about 75-90% of the daily food for some countries of the world. Its nutritional importance is due to the fact that it contains some vitamins such as thiamine, riboflavin and vitamin C. It is also a rich source of energy. It contains high amounts of carbohydrates and minerals, as well as being very rich in amino acids, as it contains 18 out of 20 amino acids, which increases its nutritional value [1] and potatoes have a major role in the human economic and food system by securing suitable food, which, along with other strategic crops, contributes to covering the growing requirements of humans who [2])Also, the cultivar is affected by the environmental conditions negatively or positively, and with the methods of rationing and guidance in the use of water, it was necessary to test the new cultivar in their tolerance to the conditions of stress and the

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lack of water in a way that fits with the environmental conditions located in the scarcity of water and the lack of rain [3] . Therefore, the nutritional status of the plant must be improved to resist water stress, so compensation is made by supplying the plants with nutrients despite the importance of adding fertilizers for plant growth and development, where most of the added fertilizer elements deteriorate their readiness due to many factors, including leaching, adsorption, and sedimentation, so it is necessary to limit the loss of nutrients In fertilization, and increasing crop productivity by adopting new applications and with the help of nanotechnology and nanomaterials, it was noted that nano fertilizer particles have a positive effect on plant growth and development[4]. explained that the interaction between the plant cell and the nanoparticles leads to the modification of gene expression, which leads to biological pathways that affect the growth and development of the plant. Surface structure, size, shape, chemical composition, concentration, solubility and aggregation of nanomaterials.Also, the response of plants to metal nanoparticles differs according to the mineral, plant type and growth stage. In view of the above, the research aims to

1. Studying the vegetative and root indicators of the most tolerant cultivars of water stress.

2. Studying the effect of nano-fertilizer to reduce the damage caused by water stress on the potato cultivars used in the study.

3. Studying the interaction between the study factors and their impact on the growth and productivity of potato cultivars under the influence of water stress.

Materials and Methods

The experiment was carried out in the field of the Department of Plant Production Techniques at the Technical College of Al-Musayyib for autumn season of 2020, where the land was prepared by conducting two orthogonal plows using the Moldboard plows for each experimental unit, which contains three corridors with a length of 4 m and a width of 75 cm, and the distance between one corridor and the last is 1 m.A distance of 1 m was left between the units.

Seeds were planted on 9/15/2020, on both sides of a furrow, alternately, with a distance of 30 cm between one tuber and another (72 plants. Experimental unit^{-1}).The service operations were carried out from weed control whenever needed, and the experiment was implemented according to RCBD (Randomized complete block design) with three replicates, and the treatments were distributed randomly within each replicate. The results were analyzed according to the Least Significant Difference L.S.D test at the level of probability 5% [6] and the experiment included the following factors:

The first factor: cultivars:

This experiment included three factors, the first factor using four brands (BURREN, Sifra, ARIZONA, Royal), the second factor three levels of water stress are)

BURREN The Irish cultivar from IPM is registered and approved by the Iraqi Ministry of Agriculture

The cultivar is produced by the method of natural selection, and the genetic crossing method (GMO) was not used in its production, and it is symbolized by the symbol (C1).

2- Sifra (Dutch cultivar from HZPC company, registered and approved by the Iraqi Ministry of Agriculture, the cultivar produced by natural selection and did not use the GMO method in its production) and is designated by the symbol (C2)

3- (ARIZONA) Dutch cultivar from Agrico Company registered and accredited in the Iraqi Ministry of Agriculture. The cultivar was

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produced by natural selection method, and the genetic crossing method (Gmo) was not used in its production, and it is designated by the symbol (C3).

4- Royal (Danish cultivar produced by Danespo company, registered and approved by the Iraqi Ministry of Agriculture, the cultivar produced by natural selection method, and the genetic crossing method (GMO) was not used in its production, and it is designated by the symbol (C4).

Table (1) Components of the nanocomposite (khazra)

percentage	**components**
%8	**iron**
%1.5	**zinc**
%0.5	**magnesium**
%0.5	**copper**
%0.5	**Boron**
%0.5	**molypodium**

Soil samples were taken from the two experiments, and soil analysis was conducted in the laboratories of the Directorate of Agriculture of Babylon to find out some of its physical and chemical properties, which are shown in Table (1).

Table (2) some physical and chemical properties of the experimental soil

values	**units**	Traits	
7.29	-	(pH) 1:1	
2.67	$DS.m^{-2}$	The electrical conductivity degree (EC) is 1:1	
16.43	cmolc.kg-1	Cation exchange capacity (CEC)	
8.11	g.kg-1 soil	organic matter	
28.11		Calcium carbonate	
77	$g.kg^{-1}$ soil	nitrogen	available element
5.60		phosphorous	
123.0		potassium	
5.47		zinc	
616	$g.kg^{-1}$ soil	sand	Soil separation
240		silt	
144		clay	
Sandy loam	texture		

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studied traits

Plant height (cm): It was calculated from the area of contact of the plant with the soil to the highest peak of the plant, then the average was taken.

Number of leaves ($leaf.plant^{-1}$): I calculated all the leaves of the plant and then took the average.

Leaves chlorophyll content: The chlorophyll content of the leaves was measured using a SPAD-502 chlorophyll meter during the flowering stage by taking three leaves and three readings for each reading, then the average was calculated[6]

Number of tubers: It was calculated from the number of tubers of five plants, divided by their number and the average taken.

The fresh and dry weights of the tubers (gm): The tubers of five plants were randomly taken from the experimental units, the dust was removed from them, their fresh weight was measured and divided by their number to extract the average fresh weight, then they were dried in the oven at a temperature 70 m until the weight is stable and from it according to the average dry weight of the tubers.

Results and discussion

Plant Height (cm)

The results in Table (3) showed that the cultivars showed significant differences in plant height. The Burren cultivar was significantly excelled on the rest of the other cultivars and gave the highest plant height of 56.70 cm, while the Sifra cultivar gave an average plant height of 54.84 cm, while it was the lowest plant height. At Royal cultivar, a plant height of 49.99 cm was recorded.The results also showed that water stress had a significant effect on plant height, where the stress treatment during the vegetative growth stage (W2) recorded the lowest average plant height of 48.14 cm.While the highest plant height was when treated without stress and gave 58.91 cm, followed by the stress treatment during the germination stage and recorded a plant height of 54.96 cm.The results also showed that nano-fertilizer had a significant effect on the rate of plant height, where spraying with a concentration of $2g.L^{-1}$ was superior and gave the highest rate of plant height, which reached 55.44 cm.This was followed by the spraying treatment with a concentration of $1g.l^{-1}$, which gave an average plant height of 54.49 cm, while the treatment without spraying recorded the lowest average plant height of 51.40 cm.The data of Table (3) also showed that the triple interaction between cultivars, water stress, and spraying with nano-fertilizer had a significant effect on the rate of plant height (cm).The triple interaction treatment consisting of (Burren cultivar, without stress and spraying with a concentration of 2 $g.l^{-1}$) was significantly excelled on the rest of the other triple interaction treatments and gave the highest average plant height, which was 66.33 cm, while the interaction treatment consisting of (Royal cultivar and stress) recorded During the vegetative growth stage and without spraying), the lowest average plant height was 41.38 cm.

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Table (3) Effect of cultivars, water stress, and spraying with nano-fertilizer and the interaction between them on potato plant height (cm)

W x C	Nano fertilizer spraying (S(			water stress) W(	cultivars) C(
	2g.L-1(S(2	1g.L-1(S1(	Without spraying (S0(		
61.71	66.33	60.33	58.46	without stress W0)(	**Burren (C1)**
56.93	53.68	62.65	54.46	Stress during the germination stage (W1(	
48.24	43.46	51.90	49.36	stress during vegetative growth stage (W2(	
57.26	59.90	49.58	62.28	Stress during tuber formation (W3(	
60.13	57.40	65.30	57.68	without stress W0)(	**Sifra(C2)**
56.25	53.45	63.68	51.60	Stress during the germination stage (W1(	
46.29	43.53	52.65	42.68	stress during vegetative growth stage (W2(	
56.69	59.90	48.58	61.58	Stress during tuber formation (W3(	
56.69	57.30	64.40	48.35	without stress W0)(	**Arizona(C3)**
54.67	51.58	63.33	49.09	Stress during the germination stage (W1(	
49.69	46.90	51.48	50.68	stress during vegetative growth stage (W2(	
55.78	59.58	47.10	60.65	Stress during tuber formation (W3(	
57.13	56.90	64.12	50.36	without stress W0)(	**Royal(C4)**
51.98	62.88	49.78	43.28	Stress during the germination stage (W1(	
48.33	52.30	51.30	41.38	stress during vegetative growth stage (W2(	
42.51	43.58	42.19	41.74	Stress during tuber formation (W3(	
0.38	0.76			**L.S.D 0.05**	
cultivars)C(	The interaction between cultivars and nanofertilizers				
56.70	58.12	56.14	55.85	**Burren (C1)**	
54.84	57.56	53.39	53.57	**Sifra(C2)**	
54.21	56.58	52.20	53.84	**Arizona(C3)**	
49.99	55.47	48.56	45.93	**Royal(C4)**	
0.22	0.38			**L.S.D 0.05**	
water stress) W(	The interaction between water stress and nanofertilizer				
58.91	63.54	59.49	53.72	without stress W0)(	
54.96	63.14	50.50	51.24	Stress during the germination stage (W1(	
48.14	51.84	46.55	46.03	stress during vegetative growth stage (W2(	
53.06	56.68	55.28	47.21	Stress during tuber formation (W3(	
0.22	0.38			**L.S.D 0.05**	
	55.44	54.49	51.40	water stress) W(	
	0.19			**L.S.D 0.05**	

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Number of leaves (leaf.plant^{-1})

The results showed in Table (4) that the cultivars showed significant differences in the number of leaves. The Burren cultivar was significantly excelled over the rest of the other cultivars and gave the highest average number of leaves amounting to 48.00 leaves. Plant^{-1}, while the Sifra cultivar gave an average number of leaves amounting to 46.79 leaves. Plant$^{-1.}$ while the lowest number of leaves was in the Royal cultivar, which recorded 44.62 leaves. Plant^{-1}.The results also showed that water stress had a significant effect on the number of leaves, where the treatment without stress recorded the highest rate of the number of leaves and gave 50.62 leaves. plant^{-1},Followed by the stress treatment during the germination stage, and the number of leaves reached 48.61 leaves. Plant^{-1}. As for the stress treatment during the vegetative growth stage, it recorded the lowest average number of leaves, amounting to 40.72 leaves. Plant^{-1}.The results also showed that the nanofertilizer had a significant effect on the average number of leaves.The spraying was excelled with a concentration of 2 g.l^{-1} and gave the highest average number of leaves amounted to 47.71 leaves. plant^{-1}, followed by the spraying treatment with a concentration of 1 g.l^{-1} and gave an average number of leaves amounted to 46.27 leaves. plant^{-1}, while the treatment without spraying recorded less Average number of leaves reached 45.03 leaves. Plant^{-1}.The data of Table (4) also showed that the triple interaction between cultivars, water stress and spraying with nano-fertilizer had a significant effect on the average number of leaves (leaf.plant^{-1} significantly on the rest of the other triple interaction treatments and gave the highest average number of leaves and recorded 54.95 leaves. Plant^{-1}, while the interaction treatment consisting of (Royal cultivar and stress during the vegetative growth stage and without spraying) recorded the lowest average number of leaves amounting to 35.41 leaves Plant^{-1}.

chlorophyll content in leaves (spad)

The results in Table (5) showed that the cultivars showed significant differences in the chlorophyll content in the leaves. The Burren cultivar was significantly excelled on the rest of the other cultivars and gave the highest rate of chlorophyll content in the leaves amounting to 50.39 spad, while the Sifra cultivar gave an average content of chlorophyll in the leaves amounted to 49.12 spad. , while the lowest plant height was at Royal cultivar, which reached 45.83 spad.The results also showed that the water stress had a significant effect on the chlorophyll content in the leaves, where the treatment without stress recorded the highest rate of chlorophyll content in the leaves and gave 54.16 spad, followed by the stress treatment during the germination stage and recorded a plant height of 51.42 spad, while the stress treatment during the vegetative growth stage recorded the lowest. The average chlorophyll content in the leaves was 40.76 spad.The results also showed that the nano-fertilizer had a significant effect on the average chlorophyll content in the leaves, as the spraying with a concentration of 2g.l^{-1} excelled and gave the highest average content of chlorophyll in the leaves amounted to 50.29spad, followed by the spraying treatment with a concentration of 1g.l^{-1} and gave an average content of chlorophyll in the leaves It reached 48.37 spad, while the treatment without spraying recorded the lowest average content of chlorophyll in the leaves amounted to 47.46 spad.The data in Table (5) also showed that the triple interaction between cultivars, water stress and spraying with nano-fertilizer had a significant effect on the rate of chlorophyll content in the leaves (spad).) significantly over the rest of the other triple interaction treatments and gave the highest average content of chlorophyll in the leaves and recorded 57.02 spad, while the interaction treatment consisting of (Royal cultivar and stress during the stage of tuber formation and without spraying) recorded the lowest average content of chlorophyll in the leaves amounted to 33.99 spad.

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Table (4) the effect of cultivars and water stress spraying with nano-fertilizer and the interaction between them on the number of leaves in potato leaves (leaf.plant^{-1})

W x C	Nano fertilizer spraying (S(			water stress) W(	cultivars) C(
	2g.L-1(S1)	1g.L-1(S1(	Without spraying (S0(		
52.24	54.95	52.37	49.42	without stress W0)(	Burren (C1)
49.98	51.09	50.13	48.74	Stress during the germination stage (W1(	
47.72	48.127	47.987	47.057	stress during vegetative growth stage (W2(	
42.05	43.977	43.127	39.047	Stress during tuber formation (W3(	
49.89	52.057	50.117	47.487	without stress W0)(	Sifra(C2)
49.28	51.167	48.393	48.267	Stress during the germination stage (W1(	
46.99	47.067	47.697	46.197	stress during vegetative growth stage (W2(	
41.00	42.167	42.857	37.97	Stress during tuber formation (W3(	
50.35	51.887	50.057	49.117	without stress W0)(	Arizona(C3)
47.07	50.967	42.057	48.197	Stress during the germination stage (W1(	
44.22	46.417	43.267	42.967	stress during vegetative growth stage (W2(	
42.13	41.017	45.417	39.947	Stress during tuber formation (W3(	
50.00	51.337	49.777	48.887	without stress W0)(	Royal(C4)
48.12	50.797	45.287	48.263	Stress during the germination stage (W1(	
42.66	46.093	44.197	37.697	stress during vegetative growth stage (W2(	
37.70	39.337	38.367	35.407	Stress during tuber formation (W3(	
0.43	0.74			**L.S.D 0.05**	
cultivars)**C**(	The interaction between cultivars and nanofertilizers				
48.00	49.27	48.44	46.30	**Burren (C1)**	
46.79	47.90	47.11	45.36	**Sifra(C2)**	
45.94	46.78	45.12	45.92	**Arizona(C3)**	
44.62	46.89	44.41	42.563	**Royal(C4)**	
0.21	0.37			**L.S.D 0.05**	
Nano fertilizer(S(	The interaction between water stress and nanofertilizer				
50.62	52.56	50.58	48.73	without stress W0)(	
48.61	51.00	46.47	48.37	Stress during the germination stage (W1(	
45.40	45.65	45.59	44.95	stress during vegetative growth stage (W2(	
40.72	41.62	42.44	38.093	Stress during tuber formation (W3(	
0.21	0.37			**L.S.D 0.05**	
	47.710	46.269	45.034	water stress) W(	
	0.19			**L.S.D 0.05**	

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Table (5) Effect of cultivars and water stress, spraying with nano-fertilizer, and the interaction between them on the chlorophyll content in the leaves of potato leaves (spad)

W x C	Nano fertilizer spraying (S(			water stress) W(	cultivars) C(
	2g.L-1(S2(	1g.L-1(S1(	Without spraying (S0(		
55.37	57.02	56.13	52.96	without stress W0)(	**Burren (C1)**
53.73	54.81	54.24	52.14	Stress during the germination stage (W1(	
50.19	49.45	50.69	50.44	stress during vegetative growth stage (W2(	
42.29	44.49	43.94	38.44	Stress during tuber formation (W3(	
54.05	55.77	53.94	52.44	without stress W0)(	**Sifra(C2)**
52.71	55.02	51.76	51.34	Stress during the germination stage (W1(	
49.22	48.24	49.19	50.24	stress during vegetative growth stage (W2(	
40.50	42.24	43.24	36.02	Stress during tuber formation (W3(	
53.70	55.45	53.32	52.34	without stress W0)(	**Arizona(C3)**
48.99	54.51	41.44	51.03	Stress during the germination stage (W1(	
46.68	48.45	42.74	48.86	stress during vegetative growth stage (W2(	
43.21	41.49	47.12	41.02	Stress during tuber formation (W3(	
53.51	55.24	53.05	52.24	without stress W0)(	**Royal(C4)**
50.24	54.45	45.44	50.84	Stress during the germination stage (W1(	
42.53	48.04	34.52	45.02	stress during vegetative growth stage (W2(	
37.04	40.02	37.12	33.99	Stress during tuber formation (W3(	
1.05	2.36			**L.S.D 0.05**	
cultivars)**C**(	The interaction between cultivars and nanofertilizers				
50.39	51.44	51.25	48.49	**Burren (C1)**	
49.12	50.32	49.53	47.51	**Sifra(C2)**	
48.14	49.97	46.15	48.31	**Arizona(C3)**	
45.83	49.44	45.52	42.53	**Royal(C4)**	
0.9	1.05			**L.S.D 0.05**	
water stress)**W**(	The interaction between water stress and nanofertilizer				
54.16	55.87	54.11	52.49	without stress W0)(	
51.42	54.70	48.22	51.34	Stress during the germination stage (W1(	
47.15	48.54	44.28	48.64	stress during vegetative growth stage (W2(	
40.76	42.06	42.85	37.37	Stress during tuber formation (W3(	
0.9	1.12			**L.S.D 0.05**	
	50.29	48.37	47.46	water stress) W(	
	0.8			**L.S.D 0.05**	

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number of tubers (tuber.plant^{-1})

The results showed in Table (6) that the cultivars showed significant differences in the number of tubers, the Burren cultivar was significantly excelled on the rest of the other cultivars and gave the highest rate of the number of tubers amounted to 10.16 tubers plant^{-1}, while the cultivar Sifra gave an average number of tubers amounted to 9.42 tubers plant$^{-1,}$ while the lowest number of tubers was in the Royal cultivar, which recorded 9.09 tubers. Plant^{-1}.The results also showed that water stress had a significant effect on the number of tubers, as the treatment without stress recorded the highest average number of tubers and gave 11.03 tubers. plant^{-1}, followed by the stress treatment during the germination stage and recorded the number of tubers reached 10.14 tubers. plant^{-1}, while the stress treatment during the plant stage Formation of tubers, the lowest rate of the number of tubers was 8.11 tubers. Plant^{-1}.The results also showed that the nano-fertilizer had a significant effect on the rate of the number of tubers, as the spraying with a concentration of 2g.l^{-1} excelled and gave the highest rate of the number of tubers amounted to 10.08 tubers.plant-1, followed by the spraying treatment with a concentration of 1g.l^{-1} and gave an average number of tubers of 9.25 Tuber plant^{-1}, while the treatment without spraying recorded the lowest average number of tubers, amounting to 9.21 tuber plant^{-1}.The data of table (6) also showed that the triple interaction between cultivars, water stress and spraying with nano-fertilizer had a significant effect on the average number of tubers (tuber.plant^{-1}). significantly over the rest of the other triple interaction treatments and gave the highest average number of tubers and recorded 12.54 tubers. Plant^{-1}, while the interaction treatment consisting of (Royal cultivar and stress during the vegetative growth stage and without spraying) recorded the lowest average number of tubers amounted to 7.35 tubers Plant^{-1}.

Tuber fresh weight (g)

The results showed in Table (7) that the cultivars showed significant differences in the fresh weight of tubers, the Burren cultivar was significantly excelled on the rest of the other cultivars and gave the highest average fresh weight of tubers amounted to 511.29 g, while the Sifra cultivar gave an average fresh weight of tubers amounted to 433.95 g, while it was The lowest dry weight of tubers was in the Royal cultivar, which was 341.19 gm.The results also showed that the water stress had a significant effect on the fresh weight of the tubers, as the treatment without stress recorded the highest rate of the fresh weight of the tubers and gave 624.42 g, followed by the stress treatment during the germination stage and recorded the dry weight of the tubers amounted to 469.86 g, while the stress treatment during the vegetative growth stage recorded the lowest rate The fresh weight of the tubers reached 303.56 g.The results also showed that nano-fertilizer had a significant effect on the average fresh weight of tubers, as spraying with a concentration of 2g.l^{-1} excelled and gave the highest average fresh weight of tubers amounted to 504.11g, followed by the spraying treatment with a concentration of 1g.l^{-1} and gave an average fresh weight of tubers amounted to 441.56g. While the treatment without spraying recorded the lowest average fresh weight of tubers was 326.93 g.The interaction between the Burren cultivar and without stress also excelled and gave the highest rate of fresh weight of tubers compared to other interaction treatments and recorded 723.41 g. It was 195.34 gThe results also showed the superiority of the binary interaction coefficient consisting of (Burren cultivar and spraying at a concentration of 2 g.L^{-1}) and gave the highest average fresh weight of tubers amounting to 605.56 gm, while the treatment (Royal cultivar without spraying) recorded the lowest average fresh weight of tubers amounting to 336.44 gm Also, the binary interaction treatment consisting of (treatment without stress and

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spraying at a concentration of 2g.L-1) was recorded and gave the highest rate of fresh weight of tubers amounted to 530.90 gm, while the treatment (stress during the stage of tuber formation without spraying) was recorded and gave the lowest rate of fresh weight of tubers. It amounted to 223.07 g.The data of Table (11) also showed that the triple interaction between cultivars, water stress and spraying with nano-fertilizer had a significant effect on the average fresh weight of tubers (g). Significantly superior to the rest of the other triple interaction treatments and gave the highest rate of fresh weight of tubers and recorded 828.31 gm, while the interference treatment consisting of (Royal cultivar and stress during the tuber formation stage and without spraying) recorded the lowest rate of fresh weight of tubers amounted to 132.94 gm.

Table (6) the effect of cultivars, water stress, and spraying with nano-fertilizer and the interaction between them on the number of tubers in potato leaves (tuber.plant-1)

W x C	Nano fertilizer spraying (S(			water stress) W(	cultivars) C(
	2g.L-1(S2(	1g.L-1(S1(	Without spraying (S0(		
11.69	12.54	11.99	10.55	without stress W0)(	**Burren (C1)**
11.02	11.29	11.50	10.29	Stress during the germination stage (W1(	
9.58	9.40	9.70	9.65	stress during vegetative growth stage (W2(	
8.35	8.65	8.51	7.91	Stress during tuber formation (W3(	
10.92	11.65	10.70	10.40	without stress W0)(	**Sifra(C2)**
10.39	11.40	9.98	9.80	Stress during the germination stage (W1(	
8.24	9.20	5.96	9.55	stress during vegetative growth stage (W2(	
8.12	8.32	8.39	7.67	Stress during tuber formation (W3(	
10.81	11.50	10.50	10.43	without stress W0)(	**Arizona(C3)**
9.53	10.90	8.04	9.65	Stress during the germination stage (W1(	
8.91	9.15	8.55	9.04	stress during vegetative growth stage (W2(	
8.34	8.23	8.77	8.01	Stress during tuber formation (W3(	
10.72	11.50	10.51	10.15	without stress W0)(	**Royal(C4)**
9.63	10.76	8.67	9.45	Stress during the germination stage (W1(	
8.38	8.95	8.68	7.50	stress during vegetative growth stage (W2(	
7.63	7.88	7.65	7.35	Stress during tuber formation (W3(	
0.78	1.36			**L.S.D 0.05**	

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cultivars)**C**(	The interaction between cultivars and nanofertilizers			
10.16	10.47	10.42	9.597	**Burren (C1)**
9.42	10.14	8.76	9.352	**Sifra(C2)**
9.40	9.95	8.97	9.283	**Arizona(C3)**
9.09	9.77	8.88	8.613	**Royal(C4)**
0.39	0.68			**L.S.D 0.05**
Nano fertilizer(S(	The interaction between water stress and nanofertilizer			
11.03	11.80	10.92	10.382	without stress W0)(
10.14	11.09	9.55	9.796	Stress during the germination stage (W1(
8.78	9.17	8.22	8.933	stress during vegetative growth stage (W2(
8.11	8.27	8.33	7.733	Stress during tuber formation (W3(
0.39	0.68			**L.S.D 0.05**
	10.081	9.255	9.211	water stress) W(
	0.34			**L.S.D 0.05**

Table (7) Effect of cultivars, water stress, spraying with nano-fertilizer and the interaction between them on the fresh weight of tubers in potato leaves (gm)

W x C	Nano fertilizer spraying (S(			water stress) W(	cultivars) **C**(
	2g.L-1(S2(	**1**g.L-1(S1(	Without spraying (S0(		
723.41	828.31	787.38	554.54	without stress W0)(	**Burren (C1)**
595.25	686.71	605.18	493.86	Stress during the germination stage (W1(	
382.81	372.36	393.06	383.01	stress during vegetative growth stage (W2(	
343.71	524.22	282.33	224.58	Stress during tuber formation (W3(	
600.51	757.51	585.04	458.97	without stress W0)(	**Sifra(C2)**
516.12	706.40	479.19	362.78	Stress during the germination stage (W1(	
289.32	362.87	339.73	165.37	stress during vegetative growth stage (W2(	
329.83	514.09	227.68	247.72	Stress during tuber formation (W3(	
608.73	808.23	584.99	432.96	without stress W0)(	**Arizona(C3)**
413.20	666.42	352.59	220.58	Stress during the germination stage (W1(	
274.19	350.13	261.47	210.96	stress during vegetative growth stage (W2(	
345.37	503.69	313.74	218.67	Stress during tuber formation (W3(	
565.02	716.46	575.24	403.36	without stress W0)(	**Royal(C4)**
354.86	615.31	306.63	142.63	Stress during the germination stage (W1(	

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249.55	321.78	293.92	169.96	stress during vegetative growth stage (W2(	
195.34	209.86	206.21	132.94	Stress during tuber formation (W3(	
6.88	11.91			**L.S.D 0.05**	
cultivars)**C**(	The interaction between cultivars and nanofertilizers				
511.29	605.56	516.99	411.33	**Burren (C1)**	
433.95	375.30	507.83	418.71	**Sifra(C2)**	
410.37	375.05	510.86	345.20	**Arizona(C3)**	
341.19	221.28	465.85	336.44	**Royal(C4)**	
3.44	5.96			**L.S.D 0.05**	
water stress)**W**(	The interaction between water stress and nanofertilizer				
624.42	530.90	767.40	574.95	without stress W0)(	
469.86	386.18	648.33	375.06	Stress during the germination stage (W1(	
298.97	351.18	322.66	239.00	stress during vegetative growth stage (W2(	
303.56	437.05	234.63	223.07	Stress during tuber formation (W3(	
3.44	5.96			**L.S.D 0.05**	
	504.11	441.56	326.93	water stress) W(	
	2.97			**L.S.D 0.05**	

Tuber dry weight (g)

The results showed in Table (8) that the cultivars showed significant differences in the dry weight of tubers, the Burren cultivar was significantly excelled on the rest of the other cultivars and gave the highest average dry weight of tubers amounted to 132.94 g, while the Sifra variety gave an average dry weight of tubers amounted to 54.84 g, while it was The lowest dry weight of tubers was in the Royal cultivar, which was 92.04 gm.The results also showed that the water stress had a significant effect on the dry weight of the tubers, where the treatment without stress recorded the highest rate of the dry weight of the tubers and gave 162.35 g, followed by the stress treatment during the germination stage and recorded the dry weight of the tubers amounted to 122.17 g, while the stress treatment during the vegetative growth stage recorded the lowest rate The dry weight of the tubers was 77.73 g.The results also showed that the nano-fertilizer had a significant effect on the average dry weight of the tubers, where the spraying with a concentration of 2g.l^{-1} excelled and gave the highest average dry weight of the tubers amounted to 144.43g, followed by the spraying treatment with a concentration of 1g.l^{-1} and gave an average dry weight of the tubers amounted to 105.85g. While the treatment without spraying recorded the lowest average dry weight of tubers was 84.29 g.The interaction between the Burren variety and without stress also excelled and gave the highest rate of dry weight of tubers compared to other interaction treatments and recorded 188.09 g, while the dry weight of tubers decreased when the two-overlap treatment consisting of (Royal variety and stress during the tuber formation stage) recorded dry weight of tubers It was 62.77 g.The results also showed the excelled of the bi-interaction treatment consisting of (Burren variety and spraying at a concentration of 2 g.L^{-1}) and gave the highest rate of dry weight of tubers amounted to 157.45 gm, while the treatment (Royal variety without spraying) recorded the lowest rate of dry weight of tubers amounted to 67.53 gm Also, the binary overlap treatment consisting of (treatment without stress and spraying at a concentration

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of 2g.L-1) was recorded and gave the highest rate of dry weight of tubers amounted to 199.52 g, while the treatment (stress during the vegetative growth stage and without spraying) was recorded and gave the lowest rate of dry weight of tubers. It amounted to 58.00 g.The data of Table (7) also showed that the triple interaction between cultivars, water stress and spraying with nano-fertilizer had a significant effect on the average dry weight of tubers (g). Significantly excelled on the rest of the other triple interaction treatments and gave the highest rate of dry weight of tubers and recorded 215.36 gm, while the interference treatment consisting of (Royal variety and stress during the vegetative growth stage and without spraying) recorded the lowest rate of dry weight of tubers amounted to 50.50 gm.

Table (7) Effect of cultivars, water stress, and application of nano-fertilizer and their interactions on the dry weight of tubers in potato leaves (gm)

W x C	Nano fertilizer spraying (S(			water stress) W(	cultivars) **C**(
	2g.L-1(S2	**1**g.L-1(S1(	Without spraying (S0(		
188.09	215.36	204.72	144.18	without stress (W0)	**Burren (C1)**
154.76	178.54	157.35	128.40	Stress during the germination stage (W1(	
99.53	102.20	99.58	96.81	stress during vegetative growth stage (W2(	
89.37	136.30	73.41	58.39	Stress during tuber formation (W3(	
156.13	196.95	152.11	119.33	without stress W0)(	**Sifra(C2)**
134.19	183.66	124.59	94.32	Stress during the germination stage (W1(	
79.00	94.35	88.33	54.32	stress during vegetative growth stage (W2(	
85.76	133.66	64.41	59.20	Stress during tuber formation (W3(	
158.27	210.14	152.10	112.57	without stress W0)(	**Arizona(C3)**
107.43	173.27	91.67	57.35	Stress during the germination stage (W1(	
71.29	91.03	67.98	54.85	stress during vegetative growth stage (W2(	
89.79	130.96	81.57	56.85	Stress during tuber formation (W3(	
146.90	186.28	149.56	104.87	without stress W0)(	**Royal(C4)**
97.48	159.98	79.72	52.74	Stress during the germination stage (W1(	
70.19	83.66	76.42	50.50	stress during vegetative growth stage (W2(	
62.77	73.61	60.56	54.19	Stress during tuber formation (W3(	
1.79	3.10			**L.S.D 0.05**	
cultivars)**C**(	The interaction between cultivars and nanofertilizers				

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132.94	157.45	134.42	106.95	**Burren (C1)**
112.83	132.04	108.86	97.58	**Sifra(C2)**
106.69	132.82	89.75	97.51	**Arizona(C3)**
92.04	121.12	87.47	67.53	**Royal(C4)**
0.89	1.55			**L.S.D 0.05**
water stress)**W**(	The interaction between water stress and nanofertilizer			
162.35	199.52	149.49	138.03	without stress W0)**(**
122.17	168.57	100.41	97.52	Stress during the germination stage (W1**(**
77.73	91.31	83.89	61.01	stress during vegetative growth stage (W2**(**
78.93	113.63	62.14	58.00	Stress during tuber formation (W3**(**
0.89	1.55			**L.S.D 0.05**
	144.43	105.85	84.29	water stress**)** W**(**
	0.78			**L.S.D 0.05**

It is noted from the results of tables (3-7) that the cultivars showed significant differences between them. The plants of the Burren cultivar were significantly superior to the rest of the other cultivated cultivars in all traits of vegetative growth, yield and chemical traits. Stress conditions[8] Or it is due to the nature of the genetic traitsof each cultivar, or the existence of genetic variation between them, and this is due to the dominance of genetic factors related to the genotype to show the trait [9] . The quantitative and qualitative indicators of potato tubers depend on several factors, including cultivar, environmental conditions and nutrition. Therefore, the variation in the effect of cultivars in the indicators studied in the experiment may be due to their significant influence on the genetic makeup, which was reflected in the length of the growing season and the strength of the vegetative parts of the plant and its positive role in an efficient representation of the carbon that It works to manufacture a large amount of carbohydrates that accumulate in the areas of storage and consumption in tubers[10] . This is consistent with the findings [11,12] In their experiments when studying the effect of different potato cultivars on vegetative growth, yield and chemical traits.

The results also showed the superiority of the treatment without stress in most of the traits, while the stress treatments during the vegetative growth stage and the tuber formation stage gave the lowest rate for the studied traits, due to the role of water stress, which leads to a decrease in the water content of plant cells[11] and that the elongation of the cells does not occur until after the occurrence of pressure from the inside to the outside of the cells, which is known as bulging pressure, and that the lack of pressure causes a lack of water and leads to a slowdown in elongation and division of the cells and a reduction in their size[8] and thus affecting of plant height, number of leaves and leaf area Tables (3-5), while the decrease in the chlorophyll content of the leaves (Table 6) can be due to water stress, which negatively affected the effectiveness of photosynthesis, which is very sensitive to water stress as a result of the partial or total closure of stomata, which caused a lack of gas exchange, especially CO_2, which It negatively affected the growth of chloroplasts[13] and this in turn was reflected negatively on the chlorophyll content, or the decrease in photosynthesis processes may be due to the role of dehydration in the decomposition of proteins responsible for the manufacture of chlorophyll

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a and b, which caused a decrease in nitrogen absorption from the roots in addition to stress. water, which caused a shortage in the readiness of soil water and nutrients, their absorption, and their transmission into the plant[8] and cells exposed to water stress need to spend a lot of energy, and this energy causes an imbalance in the water balance inside the cells, which negatively affected all structural processes within the tissues plants, which are closely associated with nutrient solubility and availability in the soil solution [14] and this negatively affected fresh and dry weight of tuber (Tables 6 and 7). This agrees with [15,16] in their experiments to investigate the effect of water stress on potato plants.

References

1. Muthoni, J., & Nyamongo, D. O. (2009). A review of constraints to ware Irish potatoes production in Kenya. *Journal of horticulture and forestry*, *1*(7), 98-102.
2. Nasir, M. W., & Toth, Z. (2022). Effect of drought stress on potato production: A review. *Agronomy*, *12*(3), 635.
3. Taha, Farouk Abdel Aziz. 2007. Effect of potassium fertilizer and soil mulching on three potato cultivars, Solanum tuberosum L, grown in Basra province. Master's Thesis in Agricultural Sciences, Department of Horticulture. College of Agriculture, University of Basra. Iraq.
4. Guillén-Enríquez, R. R., Zuñiga-Estrada, L., Ojeda-Barrios, D. L., Rivas-García, T., Trejo-Valencia, R., & Preciado-Rangel, P. (2022). Effect of nano-biofortification with iron on yield and bioactive compounds in cucumber. Revista mexicana de ciencias agrícolas, 13(SPE28), 173-184.
5. Hazarika, A., Yadav, M., Yadav, D. K., & Yadav, H. S. (2022). An overview of the role of nanoparticles in sustainable agriculture. Biocatalysis and Agricultural Biotechnology, 102399.
6. Al-rawi, Mahmoud Khasha'a, and Abdel-Aziz Mohamed Khalafallah. 2000. Design and analysis of agricultural experiments. faculty of Agriculture. University of Al Mosul. Iraq.
7. Jemison, J. and M. Williams. 2006. potato-grain study project report water quality office. university of maine, cooperation extension.
8. Al-Hamzawy, Majid Kazem Abbas. (2016). Abiotic stress in plants. First edition. National Library for Publishing and Distribution. 587 pages.
9. Al-Fayyad, Diaa Zaim Yasser. ((2019. Effect of several potato genotypes and water stress by PEG-8000 and irrigation periods on growth and yield. Master thesis. Ministry of Higher Education and Scientific Research. Al-Furat Al-Awsat Technical University. Technical College / Musayyib . The Republic of Iraq
10. Khairallah, Hossam Saad El Din Mohamed Wahba Ahmed Jawad. 2017. Evaluation of the response of eight potato cultivars grown ex vivo under the influence of salt stress. Iraqi Agricultural Sciences Journal. 48(6): 1612-1623.
11. Kulkarmi,M. and U. Deshpande. 2007.In vitro screening of tomato genotypes for drought resistance using polyethylene glycol. Afr J. Biotechnol. 6(6): 691-696.
12. Addai, Hussein Awwad and Marwan Mahmoud Hamad. 2017. Effect of spraying with humic acid and iron on some growth and yield characteristics of two potato cultivars, Solanum tuberosum L.. Anbar Journal of Agricultural Sciences, Volume 15 (conference special issue). Pages 233-243.

ISSN 2072-3857

13. Al-Saadi, Abbas Jassem Hussein. 2016. The relationship between water stress, calcium and dacinolide hormone in some indicators of vegetative growth and element content in coriandum sativum L. Coriandnum Ibn al-Haytham Journal of Pure and Applied Sciences 29 (2): 376-385
14. Zhai, H. , F.wang , z.si ,J. Hao ; L.xing ;Y. An; S. He and Liu a.2016. Amgo-inositol -1- phosphate synthase gene , Ibips1 .enhances salt and drought tolerance and stem nematode resistance in transgenic sweet potato. Plant Biotechnology Journal., 14: 592-602.
15. Tabrizi. . F . M . Yarnia . M . Farajzadeh . N and V. Ahmadzadeh . 2011. Effect of Different irrigation level on yield of potato .*Annals of Bio Research* .2(6):269-273.
16. Al-Janabi, Muhammad Ali Abboud Fares. 2012. Effect of drip irrigation, organic fertilization and mulching on the growth and yield of sweet potato (Solanum tuberosum L.). PhD thesis, College of Agriculture, University of Baghdad.

ISSN 2072-3857