Original Article

Response of Potato Cultivars to Spraying With Calcium Nano Particles and the Amino Acid Proline in Characteristics of Vegetative Growth

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Abstract

The study was carried out in the field of vegetable crops, Department of Horticulture and Landscape Engineering, College of Agriculture and Forestry, University of Mosul, Iraq. To study the response of potato varieties to spraying with calcium nano particles and the amino acid proline on vegetative growth labels during the spring 2022 agricultural season. Seeds of three potato varieties produced from tissue culture were used in the tissue culture laboratory, University of Duhok, College of Agricultural Engineering Sciences (Hermes-620, JIP16). -001-620 and SM12-124-15) and three concentrations of calcium nano-fertilizer (0, 1.5 and 3 gm / liter) and three concentrations of the amino acid proline (0, 150 and 300 ppm). The study was organized by sectoral design. Randomization by split-split system with three replications for each experimental unit (treatment). The items were placed in the main plots, the calcium nano-fertilizer in the subplot, and the amino acid proline was placed in the sub-plot. The data were analyzed according to the Duncan test at the 5% probability level. Genetic features were recorded in the study. The results showed that the cultivar JIP16-001-620 was significantly superior to the other two cultivars in the characteristics of the main stem length and in the total leaf area of the plant, while the cultivar Hermes -620 was superior in the characteristic of one leaf area and in the total chlorophyll content. The treatment of a concentration of 1.5 g / liter of calcium nano-fertilizer achieved the highest significant values in the characteristics of stem length, in the area of one leaf, in the total leaf area per one, and in the percentage of dry matter in vegetative growth, while the concentration of 300 parts per million of the amino acid proline produced the highest values. Significant in the characteristics of the main stem length, in the number of aerial stems for each plant, in the total leaf area, and in the percentage of dry matter in vegetative growth, as produced by the treatment of two-way interaction between cultivar JIP-16-001-620 with 1.5 or 3 g / liter of calcium nano fertilizer The best results were in the characteristics of stem length, the number of aerial stems per plant, and the total leaf area, while the two-way interaction between the same cultivar and concentrations of 150 or 300 ppm of the amino acid achieved the best values in most of the vegetative growth characteristics. As for the treatment of interaction between calcium nano fertilizer 3 g / liter with 300 parts per million of amino acid, the best significant values were in the characteristics of stem length, in the number of aerial stems for each plant, in the total leaf area, in the total chlorophyll content, and in the percentage of dry matter in vegetative growth. The values of the genetic parameters were high for the traits of genetic and phenotypic variation and the coefficient of genetic and phenotypic variation for the traits of the main stem length and the

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total leaf area, and the heritability rate in the broad sense was high above 50% for all the studied traits, and the expected genetic improvement was high for the trait of stem length and in the total leaf area.

Key words: Cultivars, Nano fertilizers, Amino acid, Proline, Vegetative growth, Genetic parameters.

INTRODUCTION

The potato (Solanum tuberosum L.), is one of Solanaceae family, is a very important vegetable crops worldwide, coming in fourth after wheat, rice and maize (Taha, 2007) and topping the tuber crops (Hassan, 2003). Scientists agree that the habitat land of potato is South America and then moved to Europe by Spanish explorers during the sixteenth century, and spread quickly in all European countries and became one of the most important foods on which the peoples of this region depend for their livelihood, and then moved to North America by Scottish and Irish immigrants (Hassan, 1999)The genetic factor of a variety grown in a specific area varies greatly in the quantity and quality of the crop so that the variety is controlled by the genetic and environmental factor in general, and genetic factors control a large degree in growth and development of the plant, and many methods are used to breed and improve the plant, and the method of entry is considered one of the most important and The easiest way to improve the growth of the cultivar, especially in countries where there is little agricultural and

scientific experience in this field (Kumar et al., 2000). One of the most important things that plant breeders should take into account is estimating the overlap between genetic factors and environmental conditions. Therefore, the breeding process for a particular variety takes place in different locations and seasons so that the varieties that give more resistance under different environmental conditions are important for plant breeders to determine the extent of their resistance and adaptation to environmental conditions. It is also taken into account that the response of varieties to different environmental conditions is considered one of the most difficult things for a breeder to determine which variety is superior to them, so it has become necessary for plant breeders and those interested in this variety in any country to work on developing adapted and new varieties that are similar to and superior to imported varieties and meet the demands of modern agriculture it is characterized by high production and good quality (Khokha et al., 2006). There are also many potato varieties that are grown in large regions of the world, while the varieties grown in Iraq and the Arab regions belong to European varieties (Hassan, 2011). Al-Hayali (2019) in Iraq, found that the variety Amarin was significantly superior to the other two cultivars in most of the vegetative traits and the highest number of aerial branches in The Barcelona cultivar produced the highest leaf area of the plant and was significantly superior to the rest of the cultivars, while the cultivar Labadia gave the highest values in the length of one plant compared to the other cultivars. Al-Baydawi (2019) concluded in an evaluation study of two potato cultivars (Riviera and Arizona) during the 2018 growing season in Babylon province that the Riviera variety was significantly superior to the cultivar Arizona with most of the vegetative growth characteristics (plant length and number of aerial stems per plant), Panthi et al. (2019) found in a study on two potato cultivars (Local and Candinal) during the 2016 growing season in Nepal that the Candinal variety was significantly superior to the Local variety in plant height. And the number of total aerial stems reached (45.54 cm and 5.50 branch.plant-1 each, respectively). Al-Jabbawy (2019) in a study he conducted in Babylon Governorate for the fall season of 2018-2019 on five potato varieties Arnova, Arizona, Riviera, Sifra, and Burren, the Arizona variety was significantly superior in most of the studied vegetative growth characteristics, including the number of total aerial stems and the leaf area, , while the Burren variety was superior in leaves, plant height, total chlorophyll in leaves, and dry matter in leaves. While Al-Bayati and others (2020) confirmed in their experiment on three potato varieties: Arizona, Volar, and Sylvana, the Sylvana variety was superior in the percentage of total chlorophyll in the leaves over the rest of the varieties. Al-Abdali (2021) confirmed in his experiment that he conducted in Nineveh Governorate during the spring growing season on two potato cultivars: Arizona and Montreal, he found that the Montreal variety had a significant superiority in each of the number of aerial stems, chlorophyll in leaves, plant height, and total leaf area of the plant. During a study conducted by Esho et al., (2021) to study the genetic parametres of some genotypes of six potato cultivars (Florence, Liberia, Arizona, Montreal, Desiree, and Latona) under the conditions of the city of Mosul, where the Arizona cultivar was significantly superior in each of the number of tubers per plant over the rest. cultivars, while the Iberia cultivar excelled in the number of aerial stems. Calcium plays an important physiological role in the plant life cycle through elongation of cells and in the processes of secondary representation through the messenger and the main in the cell plasma membrane. Cytoplasm, vacuoles, dynamics of microtubules, cell divisions, chromosome segregations, cell elongation, top growth, and morphological characteristics (Reddy, 2001).

Nano fertilizer has a larger surface area in relation to the same mass of materials manufactured in a larger area, which makes it highly chemically active and affects its strength or electrical properties, meaning that materials that are inactive are sometimes active in their formation on nano materials, that is, when there are a few particles in the materials, then A very large percentage of the atoms are on the surfaces, which differ from those on the inside (Fan et al., 2003). Fertilization is one of the important factors in the technology of producing the quantitative and qualitative yield in potatoes, and the potato plant needs macronutrients to improve the green material, plant height, and the quantity and quality of tubers per unit area. Among these elements are N, P, K, Mg, Ca, in addition to the trace elements (Fit and Hangan, 2010). The technology of nano-fertilizers can be explained by several explanations, including that the careful construction of small blocks and attention to the small stage leads to pure materials free from impurities and a higher level of quality. Also, the properties of materials can be changed dramatically if they are divided into smaller and finer parts, especially when they reach the nano scale at the time. Nano particles begin to show new, unexpected and previously unknown properties that do not exist in the properties of the parent material (Dutta and Hofmann, 2005 and Al-Obeidi, 2012). Nanotechnology is the ingenious manipulation of matter at the molecular or atomic level, generally to scales of less than 100 nanometers. This technology is promising in improving the ongoing agricultural processes through improving management, maintenance and sustainability of inputs in agricultural production. The research carried out in the last two decades focused on metal nano, the subject of nano particles of metal such as nano scale calcium and other metals (Monreal et al.2015) to improve the growth of agricultural crops and yield, increase the quality and quantity, and reduce the use of other fertilizers in large quantities. Nano fertilizers are very effective for managing macro and micro nutrients and increase crop growth, thus increasing photosynthesis and increasing dry matter as well as preventing Abiotic and biotic stress (Meena et al. 2017). Moddisane (2007) showed that when increasing calcium levels from 44 mg.L-1 as compared to 176, 352 and 704 mg.L-1 of calcium sulfate, it caused significant effective increases on the potato yield of the indicators of vegetative growth. El-Hadidi et al. (2017) indicated in a study conducted at Mansoura University in Egypt when they used calcium and magnesium foliar spray on potato crop, with three concentrations of magnesium fertilizer (0, 0.2 and 0.4%) pure magnesium from magnesium sulfate and three levels of calcium nitrate (0 and 0.6 and 0.8%) pure calcium that there are significant increases in plant growth represented in wet weight, leaf area, total chlorophyll. Al Juthery et al., (2018) concluded from their study at the University of Al-Qadisiyah for the autumn growing season to show the effect of

foliar spraying with nano-fertilizers (S, Mo, P) using four levels (100, 75, 50, 25 g.L-1) that all levels of nano-fertilizer It showed a significant superiority in the content of total chlorophyll and dry matter in the leaves. Abbas and Hawraa (2019) found that, in their study, adding nano-fertilizer (macro nutrient + micro nutrient) to five potato varieties (Arizona, Arnova, Rivera, Sifra, Burren) with a concentration of (0, 1, 2) gm.L-1 gave a concentration of 2 gm L -1 had the highest leaf area , and the binary interaction between Revera cultivar and 2gm L-1 gave the highest leaf area for the plant and the highest percentage of starch, and the binary interaction between Burren cultivar. Amino acids are biological substances that absorb and move in all parts of the plant because they have a direct effect on the enzymatic activity in the plant and are also included in nucleotides, vitamins and growth hormones. An experiment was conducted on the effect of spraying the amino acid Proline on tomato plants at a level of (25, 75, 150 mg. L-1), where the level of (150 mg.L-1) gave a significant superiority over the comparison treatment and the rest of the treatments in plant height, leafy area and number of leaves (Al-Saadi, 2001). Al-Morjani and Abdel-Wahab (2011) When spraying tomato plants with the amino acids Arginine, Proline, and Tyrosine at a level of (200,100.0 mg.L-1), the treatment of (200 mg.L-1) led to a significant superiority in plant height and leaf area, compared to the comparison of tomato plants. Gouda et al. (2015) in Egypt obtained from their study of the growth response of potato cultivar Falor to some amino acids (Proline 400 ppm, riboflavin 100 ppm) and trace elements of iron and zinc (75ppm). Their results indicated that each of the plant height, number of aerial stems, number of leaves, dry weight and leaf area It increased significantly by using amino acids.

Al khafaji and Oliwi (2020) explained from their study of the effect of spraying with amino acids and the ground addition of potassium on the growth and proline content of potato plant leaves, where (0, 150, 300 ppm) of proline and arginine were used with potassium concentrations (0,120,240 kg.ha-1 that spraying with amino acids at a concentration of 300 ppm gave a significant superiority in the studied characteristics represented by plant height, number of aerial stems, total yield ton.ha-1, dry and wet weight, leaf area and chlorophyll content.

The research paper aims to study the response of cultivars and spraying with calcium nano-fertilizer and the amino acid proline in the vegetative growth characteristics of potato plant.

MATERIALS AND METHODS

The study was carried out in the vegetable field of the Department of Horticulture and Landscape Engineering, College of Agriculture and Forestry, University of Mosul, during the spring 2022 growing season, to study the response of potato varieties to spraying with nano calcium and the amino acid proline in terms of vegetative growth and tuber yield. tissue cultures (micro tubers) which are (Hermes-620, JIP16-001-620 and SM12-124-15) from the tissue culture laboratory of the University of Duhok, College of Agricultural Engineering, and three concentrations of calcium nano fertilizer (0, 1.5 and 3 gm L-1 Fertilizer and three concentrations of the amino acid proline (0, 150 and 300 ppm) were used. The tubers of potato varieties were planted on 2/17/2022, at a distance of (20) cm between each other ( ), and on lines. The experimental unit consisted of two lines, and the number of tubers in each line was (7), and for the experimental unit (14), the drip irrigation system was used in the experiment. The experiment was carried out. By designing complete random plots with a splinter system, where the cultivars were placed in the main plot and nano calcium fertilizer in the sub plot, and the amino acid Proline was placed in the sub sub plot, with three replications for each experimental unit, the experiment included 27 experimental units (3 x 3 x 3 , Al-Rawi and Khalaf Allah, 2001), the data were analyzed statistically with the electronic calculator program using the (SAS, 2001) system, and the averages were compared at a probability level of ≥ 5% (Steel and Torrie 200). In the productive fields of potato seeds (Matloob et al. 1989), a preventive program was set up until the end of the growing season. Genetic variation was calculated according to the fixed model with the equation presented by (Steel and Torrie, 1980) and the coefficient of genetic and phenotypic variation was estimated according to (Panse and Sukhatme, 1984), and the percentage of heritability in the broad sense was estimated from the equation provided by Falconer and Mackay, 1996), and the values of heritability in the broad sense were expressed within the limits that were explained by (Baho, 1997) which is H2(B.S) less From 40% to low, between 40-60% medium, more than 60% high, as the expected genetic improvement values were adopted according to (Kempthorne, 1969). Data were recorded on five intermediate plants from plot for each treatment and included: Plant length (cm), Number of aerial stems, area of leaf (cm2), total leaf area of the plant (cm2), total chlorophyll content in leaves (mg/g wet tissue weight). The percentage of dry matter in vegetative growth.

RESULTS AND DISCUSSION

Table 1. indicate effect of spraying with calcium and the amino acid proline on the stem length characteristic of potato cultivars, and the interaction between the three factors resulted in the JIP16-001-620 cultivar having a significant superiority in the plant length characteristic compared with the other two cultivars, as it produced 103.815 cm, and the least length produced was from the cultivar SM12-124-15. It reached 55.135 cm. The concentration of 1.5 and 3 gm L-1 of calcium nano-fertilizer produced the highest reading in that amounted to 77.098 and 76.826 cm, respectively, and they differed significantly with the comparison treatment 0 gm of nano-calcium, and the concentration of 300 ppm of the amino acid proline produced the highest plant length of 77.469 cm and differed significantly with the other two concentrations.

As for the effect of the interaction between the studied factors, the treatment of the binary interaction between cultivar and the two concentrations 1.5 and 3 gm L-1 produced calcium nano fertilizer with variety JIP16-001-620 the highest length in that reached 105.852 and 104.740 cm respectively and differed significantly with The rest of the binary overlap coefficients. The treatment of binary interaction between the JIP-16-001-620 variety with a concentration of 150 ppm of the amino acid proline produced the highest length (105.851) cm in that, and it differed significantly with all the treatments of the binary interaction between the acid Amino proline and calcium nano fertilizer concentrations, and produced a binary interaction treatment between the variety SM-12-124-15 with 150 ppm of the amino acid, the least length of which was (51.368) cm.

Table (1) Effect of cultivars and spraying with nano scale calcium, acid and proline on stem length (cm) in potatoes during growing season spring 2022 *.

Varieties	Calcium nano(gm L^{-1})	Amino acid (proline) ppm			Nano calcium x variety
		0	150	300	
Hermes -620	0	64.447 i	70.143gh	72.113h	68.901d
	1.5	68.890h	71.553g	75.997f	72.146c
	3	67.777h	68.443h	67.887h	68.035d
JIP-16-001-620	0	101.780c	106.890c	93.890g	100.853b
	1.5	103.557c	112.887a	101.113c	105.852a
	3	102.777c	97.777d	113.667aأ	104.740a
SM 12-124-15	0	56.777jk	51.330L	55.113jk	54.406f
	1.5	57.113j	48.443L	54.333k	53.297f
	3	ي55.667k	54.333K	63.110i	57.703e-
Variety x proline		0	150	300	Effect of variety
	Hermes -620	67.037e-	70.046d	71.998c	69.694b
	JIP-16-001-620	102.704b	105.851aأ	102.89b	103.815a
	SM 12-124-15	56.518g	51.368g	57.520f	55.135c
Calcium x proline		0	150	300	Effect of calcium
	0	د74.334e-	76.121bc	73.705e	74.720b
	1.5	76.520b	77.627b	77.148b	77.098a
	3	ج75.406d	73.517e-	81.554a	76.826a
Effect of proline		0	150	300	
		75.420b	75.755b	77.469a	

* Means that share the same letter of the alphabet are not significantly different from each other according to Duncan's multiple range test at a probability level ≥5%.

The treatment of the binary interaction between a concentration of 300 ppm of the amino acid proline and 3 gm L-1 of nano crystalline calcium produced the highest length in the plant amounted to 81.554 cm. gm L-1 nano particles of calcium reached 73.517 cm. As for the effect of the triple interaction between the studied factors, the treatment of the interaction between the cultivar JIP 16-001-6230 with 3 g L-1 nano calcium and 300 ppm of the amino acid proline produced the highest plant length of 113.667 cm, and this differed significantly with most of the triple interaction treatments. While the least length was 48.443 cm from the triple overlap treatment between SM-12-124-15, 1.5 gm L-1 nano-calcium and 150 ppm of the amino acid proline. As for the characteristic of the number of aerial stems for each plant, it may appear from Table 2 that there were no significant differences between the individual factors affecting this characteristic, as for the binary interaction between the JIP16-001-620 variety and the concentrations of nano-gm L-1 nano-calcium and the interaction Between cultivar SM-12-124-15 and nano calcium concentrations produced the highest number of stems for each plant, and it differed significantly with the interaction treatment between cultivar Hermes -620 and nano calcium concentrations. The treatment of interaction between the cultivar SM-12-124-15 with 300 ppm of the amino acid proline produced the highest number of 2.75 stems per plant, but it did not reach the significant level with the rest of the two-way treatments, but it differed significantly with the treatment of the two-way interaction between The cultivar Hermes-620 and 0 ppm of the amino acid, which produced the lowest number of 1.258 stems per plant. The treatment of binary interaction between nano scale calcium 3 gm L-1 with a concentration of 300 ppm of the amino acid proline produced the highest number of 1.888 stems per plant and differed significantly only with the treatment of binary interaction 3 gm L-1 nano calcium with 150 ppm amino acid , which produced the lowest number of 1.443 stems plant-1 The treatment of the triple overlap between the cultivar SM-12-124-15 with 3 gm L-1 nano calcium with 300 ppm of the amino acid proline produced the highest number in that amounted to 2.333 stems plant-1 and this differed significantly with some triple overlap treatments, and the lowest number resulted From the treatment of the triple interaction between the cultivar Hermes-620 with 0 gm of nano calcium and 300 ppm of the amino acid proline it reached 1.11 stems plant-1. As for the area of leaf, it appears from Table 3 that the area of leaf was significantly affected by the studied factors, as the Hermes-620 variety was significantly superior to the rest of the cultivars in this characteristic, which produced the highest leaf area of 90.972 cm2, and it did not reach the significance limit for the two varieties JIP16- 001-620 and SM12-124-15. The concentration of 1.5 gm L-1 of calcium nano particles produced the highest leaf area of 87.022 cm2 and it differed significantly with the two concentrations of 0 and 3 gm L-1. The concentration of 0 ppm of the amino acid produced the

highest leaf area of 87.291 cm2 and it differed significantly with the two concentrations of 150 and 300 ppm of the amino acid. As for the effect of the interaction between the Hermes-620 variety and 0 gm L-1 of nano-calcium, the highest leaf area reached 100.372 cm2, and it differed significantly with the rest of the coefficients of the bilateral interaction between the varieties and nano-calcium. The treatment of the bilateral interaction between the Hermes -620 variety and spraying with a concentration of 0 ppm of the amino acid proline at the top of the leaf area reached 96.301 cm2 and differed significantly with most of the treatments of the bilateral interaction of these two factors, while the treatment of the bilateral interaction between calcium nano particles excelled at a concentration of 0 gm. L-1 with 150 ppm of the amino acid proline had the highest leaf area of 92.343 cm2 and differed significantly with all the binary interaction coefficients for these two factors. As for the effect of the triple interaction between the studied factors, as it appears from the same table that the triple interaction treatment between the Hermes-620 variety with 0 gm L-1 of nano scale calcium and 150 ppm of the amino acid proline has achieved the highest value in the area of one leaf, which It reached 113.764 cm2 and this differed significantly with all the triple overlap treatments, and the triple overlap treatment produced between the variety JIP-16-001-620 with 0gm L-1 of nano-calcium fertilizer and with 0 ppm of the amino acid proline, the lowest area in that amounted to 70.344 cm2. As shown in Table 4, the potato variety JIP16-001-620 achieved the highest value in the total leaf area of the plant, which amounted to 4636.7 cm2 and was significantly superior to the other two cultivars. Significantly outperformed with the other two concentrations. The concentration of 300 ppm of the amino acid proline achieved the highest reading in the leaf area, which amounted to 3817.5 cm2, and was significantly superior compared to the other two concentrations.

Table (2) Effect of cultivars and spraying with calcium nano particles, amino acid and proline on the number of aerial stems in potatoes during growing season spring 2022 *.

Varieties	Calcium nano(gm L^{-1})	Amino acid (proline) ppm			Nano calcium x variety
		0	150	300	
Hermes -620	0	1.220cd	1.663a-d	1.110d	1.331c
	1.5	1.333cd	1.553a-d	1.443b-d	1.443bc
	3	1.223cd	1.333cd	1.443b-d	1.333c
JIP-16-001-620	0	1.4433b-d	1.780a-d	2.000a-c	1.741ab
	1.5	1.553a-d	1.780a-d	2.220ab	1.851a
	3	2.223ab	1.443bc	1.890a-d	1.852a
SM 12-124-15	0	1.666a-d	1.780a-d	2.223ab	1.890a
	1.5	1.670a-d	1.776a-d	1.670a-d	1.705a-c
	3	1.666a-d	1.553a-d	2.333a	1.850a
Variety x proline		0	150	300	Effect of variety
	Hermes -620	1.258c	1.516bc	1.332bc	1.369a
	JIP-16-001-620	1.740ab	1.667a-c	2.036a	1.814a
	SM 12-124-15	1.667a-c	1.703ab	2.75a	1.815a
Calcium x proline		0	150	300	Effect of calcium
	0	1.443b	1.741ab	1.777ab	1.650 a
	1.5	1.518ab	1.703ab	1.777ab	1.666a
	3	1.74ab	1.443b	1.888a	1.678a
		0	150	300	
Effect of proline		1.555 b	1.629ab	1.814a	

* Means that share the same letter of the alphabet are not significantly different from each other according to Duncan's multiple range test at a probability level ≥5%

Table (3) Effect of cultivars and spraying with calcium nano particles, amino acid and proline on the leaf area (cm2) in potatoes during growing season spring 2022 *.

Varieties	Calcium nano(gm L^{-1})	Amino acid (proline) ppm			Nano calcium x variety
		0	150	300	
Hermes -620	0	100.520d	113.764a	86.832g-i	أ 100.372
	1.5	84.329i	72.594 no	86.133hi	هـ 81.021
	3	104.056c	80.683kl	89.865f	ج 91.535
JIP-16-001-620	0	70.344 o	82.255jk	65.318p	ز 72.639
	1.5	88.636fh	108.245b	89.288f g	ب 95.390
	3	71.170 o	75.393m	86.936 g-i	و 77.833
SM 12-124-15	0	79.015 l	81.010kl	74.499mn	و 78.175
	1.5	94.512e	72.154no	87.330f-h	د 84.666
	3	93.042e	80.078kl	82.173jk	د 85.098
Variety x proline		0	150	300	Effect of variety
	Hermes -620	96.301a	89.013b	87.603b	أ 90.972
	JIP-16-001-620	76.716d	88.631b	80.513c	ب 81.953

	SM 12-124-15	88.856b	77.747d	81.334c	ج 82.646
Calcium x proline		0	150	300	Effect of calcium
	0	83.293d	92.343a	75.549f	ب 83.728
	1.5	89.159b	78.717e	87.576c	أ 87.022
	3	89.422b	71.78 e-	86.324c	ب 83.821
		0	150	300	
Effect of proline		87.291aأ	85.130b	83.150c	

* Means that share the same letter of the alphabet are not significantly different from each other according to Duncan's multiple range test at a probability level ≥5%

As for the double and triple overlap treatments, from the same table it appears that the double overlap treatment between the JIP16-001-620 variety with 1.5 gm L-1 of nano calcium has achieved the highest total paper area of 5997.0 cm 2 and is significantly superior with all the double overlap treatments for these two factors. And produced the treatment of binary overlap between the variety SM12-124-15 with 0 gm L-1 nano calcium, which reached the lowest value of 2139.4 cm2. As for the treatment of binary interaction between the variety JIP-16-001-620 with 150 and 300 ppm of the amino acid proline, it achieved the highest leaf area of 4642.4 and 5004.8 cm2, respectively, and it differed significantly with the rest of the treatments of binary interaction.

The treatment of binary interaction between calcium nano-fertilizer at a concentration of 1.5 gm L-1 with 0 and 300 ppm of the amino acid proline, and 3 gm L-1 with 300 ppm of the amino acid achieved the highest paper area, and these treatments were significantly superior with the rest of the overlap treatments. The combination of these two factors, and the interaction treatment between 0 gm L-1 nano particles calcium with 300 ppm amino acid yielded the least value in that amounted to 3240.9 cm2. As for the triple interaction coefficients between the three factors with their effect on the characteristic of the total leaf area for each plant, the triple interaction treatment between each of the cultivar JIP-16-001-620 with 1.5 gm L-1 nano particles and with all concentrations of the amino acid proline achieved the highest leaf area for the plant It outperformed significantly with most triple overlap treatments. Table 5 shows the effect of each of the cultivar, calcium nano fertilizer, and the amino acid proline, and the interaction between them, on the total chlorophyll content.

Table (4) The effect of cultivars and spraying with nano scale calcium, acid and proline on the total leaf area (cm2) of potato plants during the growing season spring 2022 *.

Varieties	Calcium nano(gm L^{-1})	Amino acid (proline) ppm			Nano calcium x variety
		0	150	300	
Hermes -620	0	3921.5 e-j	3830.6e-h	4174.6d-f	3975.6b
	1.5	3906.0e-j	3111.3gi	3865.5ei	3627.6b
	3	4445.0cd	3733.8ei	4009.8fg	4062.9b
JIP-16-001-620	0	3395.0f-1	4945.6b-d	3549.3e-1	3963.3b
	1.5	5853.5ab	5846.8ab	6290.7a	5997.0a
	3	3540.9ei	3134.8gi	5174.3bc	3950.0b
SM 12-124-15	0	2875.9 ij	1543.4k	1998.7jk	2139.4d
	1.5	2926.2hj	1890.3k	2020.3jk	2278.9d
	3	2930.6hj	3036.5gi	3273.9f-1	3080.3c
Variety x proline		0	150	300	Effect of variety
	Hermes -620	4090.8c	3558.5d	4016.7c	3888.6b
	JIP-16-001-620	4263.1bc	4642.4ab	5004.8a	4636.7 a
	SM 12-124-15	2910.9e-	2156.7f	2431.0ef	ج 2499.5
Calcium x proline		0	150	300	Effect of calcium
	0	3397.5c	3439.9c	3240.9c	3359.4c
	1.5	4228.6a	3616.1bc	4058.9 ab	3967.9a
	3	3638.8bc	ج 3301.7	4152.7a	3697.7b
		0	150	300	
Effect of proline		3755.0a	3452.6b	3817.5a	

* Means that share the same letter of the alphabet are not significantly different from each other according to Duncan's multiple range test at a probability level ≥5%.

It appears that the two cultivars Hermes -620 and JIP-16-001-620 achieved the highest content of chlorophyll in the leaf, which amounted to 1.307 and 1.128 mg gm-1 wet weight of plant tissue -1, and differed significantly with cultivar SM12-124-15, which produced the lowest content. In that it reached 0.860. The two concentrations 1.5 and 3 gm L-1 nano calcium produced the highest content in that amounted to 1.184 and 1.192, and they differed significantly with the concentration 0 gm L-1 nano calcium which achieved the lowest content in that. It also did not reach a significant level of the effect of proline amino acid concentrations on this trait. And it appears from the same table that the highest content of chlorophyll in the leaf resulted from the binary interaction treatment between the Hermes-620 variety and 1.5 gm L-1 nano-calcium, which amounted to 1.486 and differed significantly with the variety SM12-124-15 with all concentrations of nano-calcium, and with The binary

overlap treatment between the JIP16-001-620 variety, which produced the lowest content in that amounted to 0.638. It also did not differ significantly with the two cultivars Hermes -620 and jip-16-001-620 and the concentrations of calcium nano particles 1.5 and 3 gm L-1.

Table (5) Effect of cultivars and spraying with calcium nano particles, the amino acid and proline, on the total chlorophyll content of potato plants during the growing season spring 2022 *.

Varieties	Calcium nano(gm L^{-1})	Amino acid (proline) ppm			Nano calcium x variety
		0	150	300	
Hermes -620	0	1.283a-d	0.843b-d	1.473a-d	1.200a-c
	1.5	1.483a-d	1.593a-c	1.383a-d	1.486a
	3	1.426a-d	0.903a-d	1.380 a-d	1.236abc
JIP-16-001-620	0	0.903a-d	0.553cd	0.460 d	0.638d
	1.5	1.810ab	1.060a-d	1.030 a-d	1.300ab
	3	1.060a-d	1.356a-d	1.923 a	1.446a
SM 12-124-15	0	1.380a-d	0.790b-d	0.593cd	0.921bcd
	1.5	0.883a-d	0.810b-d	0.606cd	0.766cd
	3	0.466d	1.183a-d	1.033a-d	0.894bcd
Variety x proline		0	150	300	Effect of variety
	Hermes -620	1.397a	1.113ab	1.412a	1.307a
	JIP-16-001-620	1.257ab	0.990ab	1.137ab	1.128ab
	SM 12-124-15	0.910ab	0.927ab	0.744b	0.860b
Calcium x proline		0	150	300	Effect of calcium
	0	1.188a-c	0.728c	0.842bc	0.920b
	1.5	1.392ab	1.154a-c	1.006a-c	1.184a
	3	0.984a-c	1.147a-c	1.445a	1.192a
		0	150	300	
Effect of proline		1.1885a	1.010a	1.098a	

* Means that share the same letter of the alphabet are not significantly different from each other according to Duncan's multiple range test at a probability level ≥5%.

The treatment of the binary interaction between the variety Hermes-620 and the concentration of 300 parts per million of the amino acid proline achieved the highest reading in that amounted to 1.412. Significantly different with the rest of the binary interference coefficients for these two factors. The treatment of binary interaction between calcium nano-fertilizer at a concentration of 3 gm L-1 with 300 ppm of proline acid achieved the highest content in that and differed significantly with the treatments of binary interaction between a concentration of 0 nano-calcium and 150 and 300 ppm of proline acid - but it did not reach the limit of significance with the rest of the two-way interaction coefficients. The triple interaction treatment between JIP-16-001-620 and 3 gmL-1 nano-calcium and 300 ppm of amino acid achieved the highest content of 1.923, and it differed significantly with the triple-interference treatment between the same variety with 0 gm L-1 nano-calcium and 300 ppm. Of proline acid, which produced the lowest content in that amounted to 0.460

Table (6) Effect of cultivars and spraying with proline and calcium on the percentage of dry matter on the vegetative growth of potatoes during growing season spring 2022*

Varieties	Calcium nano(gm L^{-1})	Amino acid (proline) ppm			Nano calcium x variety
		0	150	300	
Hermes -620	0	12.925bcd	11.596e-g	12.391c-f	12.304b
	1.5	12.949bcd	12.629c-g	12.533cde	12.704b
	3	11.882d-g	12.301c-f	13.223abc	12.468b
JIP-16-001-620	0	10.762g	14.184a	12.540cde	12.495b
	1.5	12.074d-g	12.445c-f	12.732c-f	12.417b
	3	11.555e-g	11.557e-g	13.873ab	12.328b
SM 12-124-15	0	12.407c-g	12.235c-f	12.358c-f	12.328b
	1.5	12.316c-f	14.302a	13.254abc	13.290a
	3	14.051ab	11.313fg	12.256c-f	12.540b
Variety x proline		0	150	300	Effect of variety
	Hermes -620	12.585ab	12.175b	12.716ab	12.492a
	JIP-16-001-620	11.464c	12.729ab	13.048a	12.413a
	SM 12-124-15	12.924a	12.617ab	12.622ab	12.721a
Calcium x proline		0	150	300	Effect of calcium
	0	12.031cd	12.672abc	12.430bc	12.377b
	1.5	12.446cd	13.125a	12.839ab	12.804a
	3	12.496abc	11.724d	13.117a	12.446b

	0	150	300	
Effect of proline	12.324b	12.507ab	12.795a	

* Means that share the same letter of the alphabet are not significantly different from each other according to Duncan's multiple range test at a probability level ≥5%

. From Table 6 it appears that the percentage of dry matter in vegetative growth did not reach a significant level of being affected by cultivars, while the concentration of 1.5 gm L -1 of nano calcium fertilizer achieved the highest content of matter in vegetative growth which amounted to 12.804 and this differed significantly with concentrations 0 and 3gm L-1 of nano fertilizer, as it appears from the same table that two concentrations of the amino acid proline 150 and 300 ppm achieved the highest dry matter content in vegetative growth and reached 12.507 and 12.795 and it differed significantly with the treatment of concentration 0 ppm of the amino acid . As for the treatment of the bilateral interaction between the variety and calcium nano-fertilizer, the treatment of the bilateral interaction between the variety SM 12-124-15 and 1.5 gm of calcium nano-fertilizer achieved the highest content in that amounted to 13.290, and this differed significantly with all the treatments of the bilateral interaction. The treatment of binary interaction between JIP16-001-620 and spraying with a concentration of 300 ppm of the amino acid Proline achieved the highest dry matter content of 13.048, and this differed significantly with the treatment of the binary interaction between the variety Hermes-620 and the concentration of the amino acid of 150 ppm, and with The treatment of binary interaction between JIP16-001-620 and 0 ppm amino acid, which achieved the lowest value of 12.175 and 11.464, respectively. There were also no significant differences between the rest of the two-way interaction treatments. It appears from the same table that the treatment of bilateral interaction between calcium nano fertilizer 1.5 mg L-1 produced the highest content in that amounted to 13.125 and differed with some of the treatments of binary interaction, including the treatment of bilateral interaction between a concentration of nano-calcium 3 gm L-1 with 150 ppm of amino acid proline, which produced the lowest content, was 11.724. As for the treatment of triple interaction between the studied factors, the treatment of triple interaction between cultivar SM 12-124-15 and spraying with a concentration of calcium nano fertilizer 1.5 with 150 ppm of the amino acid proline produced the highest content in that amounted to 14.302, and this differed significantly with some interaction treatments. The triple, and the lowest dry matter content in vegetative growth resulted from the triple interaction treatment between the JIP 16-001-620 variety and 0 gm L-1 nano concentration of calcium and 0 ppm of amino acid, which amounted to 10.762.

Through the obtained results, we noticed that potato cultivars differed significantly among themselves in the characteristics of stem length (cm), single leaf area (cm2), total leaf area, and total chlorophyll content (Tables 1, 3, 4, 5). This is due to the influence of the genetic factors carried by each genotype under study, which differ among themselves in the location of the gene, which has a major role in its impact on these traits. Which results in discrepancies between the varieties under study, and our results were consistent with the results of each of the researchers who concluded that the varieties and genotypes of potatoes differ significantly among themselves in the characteristics of vegetative growth (Hassan et al., 2017, Ibrahim, 2018, Al-Qaisi and Al-Bayati 2010, and Al-Bidawi 2019, Al-Hayali, 2019, Al-Jabbawi 2019, Panthi et al, 2019, Al-Bayati et al. 2020, Al-Abdali 2021, Esho et al., 2021, Al-Ajely, 2021, and Al-Zebari, 2021) indicating that there are differences. Significant in some vegetative growth traits of cultivars that were used in our study this is. As it appears from the results (1, 2, 4, 5, 6) that the concentration of calcium nano particles used up to 3 gm L-1 produced the highest significant values in the characteristics of vegetative growth in the study, these results may explain the large physiological role played by the element calcium In the life cycle of the potato plant through elongation of the cells and in the processes of secondary representation through the messenger and the main in the plasma membrane of the plant cell and it has a major role in regulating the balance between nutrients, and the element calcium is necessary for the formation of protein, which is like a valve in a number of cell contents and in the density of the cytoplasm vacuoles, the dynamics of microtubules, cell division, chromosomal isolation, cell elongation and its effect on meristematic cells in developing apices and morphological characteristics (Reddy 2001), and nano-calcium fertilizer is one of the important things in the growth stages of potato, which needs nutrients to complete the plant life cycle (Hangan and Fit 2010, and Monareal et al., 2015), calcium also increases plant metabolism through photosynthesis, which in turn It causes an increase in dry matter content and prevents biotic and abiotic stress (Meena et al., 2017), as well as the unique properties of nano-fertilizers due to the small size of their particles from plant cells with better efficiency, which increased the absorption surface and direct entry into cells plant and perform the required functions (Sabir et al., 2014), our results came with what was obtained by (Moddisane 2007; El-Hadidi et al., 2017, Al-Juthery et al., 2018 ; Abbas and Hawraa, 2019; Al-Ajely, 2021, and Al-Zebari, 2021) that the vegetative growth characteristics of potato plants within our study were significantly affected by the increase in the concentrations of calcium used on them. It is also noted that the concentrations of the amino acid proline caused a significant increase in the characteristics of stem length and total leaf area. The enzymatic activity also interferes in building nucleotides, vitamins and growth hormones in the plant and has a major role in the life of the cytoplasm and activates the energy in the vegetative growth, which therefore caused significant increases in the characteristics studied in our research, and also has a major role in the growth and activity of the roots to absorb the available elements in the root zone (Abdel Aziz and Balba, 2007, and Morteza et al., 2013). In the tomato plant, Mona et al., 2015; Goud et al., 2015; Al-Juthery et al., 2019; and Alkhafaji and Oliwi, 2020, and Kumar et al., 2020,Lateef et al.2021) that the vegetative growth characteristics of potato plants increase significantly due to the effect of spraying with the amino acid proline.

As for the effect of the binary interaction between the studied factors on the vegetative growth characteristics of the genotypes of potatoes, the cultivar JIP-16-001-620 interwoven with 1.5 and 3gm L-1 of nano-calcium achieved the highest significant values in the characteristics of stem length and number of aerial stems. and total leaf area of the plant (Tables 1, 2, 3), while the two-way treatment between the cultivar Hermes-620 with (0 and 1.5 gm L-1) of calcium nano particles had the highest content of total chlorophyll (Table 5), but from On the other hand, the treatment of the interaction between the cultivar SM-12-14-15 with 1.5 gm L-1 of calcium had a significant superiority in the percentage of dry matter in vegetative growth. As for the effect of the triple interaction between the studied factors on the characteristics of vegetative growth, it appeared The results presented in Tables (1 to 6) indicate different significant effects between the three factors on these traits, which may explain these different results in their effects on the vegetative growth traits to the cumulative and additive effect of the studied factors on these traits. These results are consistent with what was found by (Al-Ajely, 2021, and Al-Zebari, 2021) That the vegetative growth characteristics were significantly affected by the effect of the binary interaction between potato cultivars and nano-fertilizers on the vegetative growth characteristics of potato plants

Genetic parameters

Through the data of Table 7, it appears that the genetic parameters of the stem length trait were high in genotypic and phenotypic variation, the coefficient of genetic and phenotypic variation, heritability, and the expected genetic improvement. As for the characteristic of the number of aerial stems for each plant, the heritability rate in the broad sense was high, amounting to 78.30%, as well as the genetic parameters. The characteristic of the area of one leaf and the total leaf area of the plant has high genetic and phenotypic variation in the values of the heritability ratio in the broad sense and the expected genetic improvement, as the values of the heritability ratio in the broad sense were high.

Table (7) Genetic parameters of potato cultivars during growing season 2022*.

Genetic parameter	X1	X2	X3	X4	X5	X6
mean	75.681	1.629	86.209	3693.550	12.607	1.140
$\delta^2 g$	635.438	0.095	44.802	1187985.648	0.022	0.076
$\delta^2 p$	635.971	0.121	48.282	1191374.090	0.042	0.092
gcv	33.308	18.882	7.764	29.509	1.170	24.253
pcv	33.322	21.345	8.060	29.552	1.618	26.587
H^2 B.S.	99.9	078.3	92.8	99.7	52.3	83.2
GA	51.907	0.561	13.282	2242.097	0.220	0.520
Mean of GA	68.586	34.410	15.407	60.703	1.743	45.576

* X1=stem length(cm) , x2=number of stem /plant , 3=leave area(cm2), x4=total leaves area/plant (cm2), x5= percentage of dry mater (%) , x6= total chlorophyll (mg/g fresh tissue)

Through that, it appears that the studied traits showed a wide range of studied genetic parameters of potato cultivars, where they were high for most of the studied parameters of the traits, except for the percentage of dry matter and total chlorophyll content in relation to genetic and phenotypic variation. This may be explained by the fact that these traits are quantitative traits that are greatly affected by the environmental conditions in the study area. Therefore, selection is effective on the basis of the values of external phenotypic traits (Al-Mukhtar 1988). The heritability ratio in the broad sense of the studied vegetative growth traits may indicate the importance of additional influences. And the non-additional genes controlling the inheritance of these traits (Mather and Jinks, 1982) and the high percentage of heritability is an indication that the individual has a great relationship with the genotype and this is also an indication of the possibility of making direct improvements to these traits in the following seasons according to the special breeding programs that Therefore, it is developed as it can be used in the use of the appropriate program for breeding and improvement (Allard, 1960). Our results were consistent with Fekadu et al. (2013) for leg length, Ozturk and Yildirim 2014, and Asefa et al. (2016). For stem length and leaf area, and with Ramachandra and Srinivasa, (2017), the percentage of heritability in the broad sense was high for stem length, leaf area, and total chlorophyll content, and also with Patel et al., 2018, for vegetative growth traits, with (Singh and Chaudhary, 1985) and Singh, et al, 2020 for the heritability of the stem length trait, and with Moussa, 2013 for the genetic improvement of the number of aerial stems trait, and with (Singha and Ullah, 2020; Al-Zebari, 2021) for the vegetative growth traits of potato cultivars, that The high percentage of heritability in the broad sense, which was compatible with the high values of genetic improvement for these traits, gives evidence for prediction that we can get from the selection method (Welsh, 1981).

CONCLUSION

Through the study, we conclude that the cultivars varied among themselves in the characteristics of vegetative growth, that the cultivar JIP16-001-620 produced the best results in the characteristics of vegetative growth, and that increasing the levels of calcium nano particles and the amino acid proline achieved the best results in the characteristics of vegetative growth, and that the bilateral interaction between JIP16-001-620, the levels of the amino acid proline and the levels of calcium nano particles achieved the best results, and the genetic and phenotypic variance was high for the main stem length characters, in the area of one leaf and the total leaf area, and the heritability rate in the broad sense was high for all the traits that were studied

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