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EFFECT OF ADDITION OF PACLOBUTEROL AND COUMARIN ON THE PRODUCTION OF MICROTUBERS OF FOUR POTATO CULTIVARS IN VITRO

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Abstract:

A field experiment was carried out in the plant tissue culture laboratory of the Nakheel Paradise Company for Tissue Agriculture Ltd., Baghdad, for the period from March 2022 to November 2022. Its purpose was to study the effect of adding different concentrations of paclobutrazol and coumarin on the production of micro tubers and four varieties of potatoes, as the experiment included four treatments of All paclobutrazol and coumarin, which are as follows: four levels of paclobutrazol in concentrations (0, 3, 6, and 9 mg/L, respectively), and four levels of coumarin in concentrations (0, 10, 15, and 20 mg/L), respectively, and four varieties of potatoes, which are as follows: Arizona, Burren, and Spuntas Hermiz. The data from the first experiment was analyzed as a factorial experiment using a completely randomized design (CRD). Adding paclobutrazol at a concentration of 3 mg. Addition of paclobutrazol at a concentration of 9 mg. liter to the nutrient medium led to an increase in the proline content in the tubers, and adding coumarin at a concentration of 10 mg liter 1 to the MS nutrient medium led to a significant increase in the weight of the micro-tuber, the number of micro-tubers, and the diameter of the micro-tubers, and adding coumarin at a concentration of 20 mg liter to the nutrient medium led To increase the proline content in tubers, the interaction between paclobutrazol and coumarin, paclobutrazol and varieties, coumarin and varieties, and the triple interaction led to a significant increase in most of the traits studied.

Keywords: potato, in vitro, micro-tubers

1. INTRODUCTION

Potato (Solanum tuberosum L.) belongs to the Solanaceae family, which includes more than (2000) species and (90) genera. It is one of the most important and widely used vegetable crops and tops the list of tuber crops (Hassan, 1999). I used modern methods for the production of potato seeds, the most important of which was the technology of plant tissue culture, and thanks to this technology it became possible to secure the foundation seeds represented by micro-tubers as a result of their important characteristics in addition to being free from viral causes, as these tubers are characterized by being small in size and having diameters of 10-23 mm With a weight of 0.2 - 2 g, it is more suitable for commercial purposes and is easy to store and transport (Nivaa, 2001). The formation of microtubers is affected by various factors, as plant growth regulators are among the means that play an important role in the formation of microtubers, and the hormonal effect varies according to the varieties and the type of hormone used. Increasing and reducing costs, as it is possible to produce seedlings and accurate tubers in a large number and at a specific time (Al-Maari, 2019). The study aims to determine the best level of growth inhibition paclobetrazole and coumarin and to find out the best interaction between them in increasing some of the qualitative characteristics of microtubers outside the living body.

2. MATERIALS AND METHODS

The tissue experiment was carried out in the plant tissue culture laboratory of the Palm Paradise Company for Tissue Agriculture Ltd., Baghdad, for the period from March 2022 to November 2022. The purpose of the study was the production of micro tubers. Four varieties of potatoes were used in the study, two of which were taken from the tissue. Available in Paradise Palms Company and widely cultivated in the country, they are the Arizona and Burren cultivars. The texture of the other two cultivars, Spuntas Hermiz, was obtained from a Dutch company and included four levels of paclobuterol with concentrations (0, 3, 6, and 9 mg liters), respectively, and four levels of coumarin with

concentrations (0, 10, 15, and 20 mg L), respectively, and measurements of the number of tubers per plant, the average weight of one tuber, and the average diameter of the tuber were taken by taking (9) replicates from each treatment and for each variety, and after completing the tuber harvest, the proline content was estimated in microtubers by following the method of Bates et al.) (1973).

3. RESULTS

1. Average weight of the microtuber (g tuber)

The results in Table 1 indicate that the paclobutrazol addition treatments are significantly superior in terms of the average weight of the micro tuber, as the highest micro tuber weight of 2.972 grams is observed when 3 mg per liter is added compared to the 9 mg treatment. liters, which gave the lowest weight of the micro tuber. There were significant differences when adding coumarin in terms of the average weight of the tuber, as the addition treatment at a concentration of 10 mg per liter excelled in giving the highest average weight of the micro tuber, amounting to 2.924 compared to the treatment | 20 mg L which gave the lowest weight of the micro tuber. In the same table, the two varieties Spunta and Hermiz were significantly superior in the average weight of the micro tuber, as the highest weight of the micro tuber was observed for the two varieties Spunta and Hermiz, which did not differ from each other significantly and amounted to 2.720 grams and 2.702 grams compared to the variety Burren, which gave the lowest weight of the micro tuber. The interaction treatment of paclobutrazol at a concentration of 3 mg/L with coumarin at a concentration of 10 mg/L was superior in recording the highest average weight of the microtuber, which amounted to 3.303 grams, compared to the treatment without the addition, which gave the lowest weight of the microtuber. In the interaction between paclobutrazol and the varieties, the treatment of adding 3 mg/L of paclobutrazol with the Spunta variety excelled in recording the highest weight of the micro tuber, reaching 3.026 grams, compared to the interaction treatment between paclobutrazol at a concentration of 9 mg/L with the Burren variety, which gave the lowest weight of the micro tuber. As for the interaction of coumarin with the varieties, the treatment excelled. Interaction between coumarins at a concentration of 10 mg. liter, with the Spunta variety recording the highest weight per minute tuber, which amounted to 2.985 grams, compared to the coumarin interaction treatment at a concentration of 20 mg per liter, with the Burren variety, which gave the lowest tuber weight. In the triple interaction between paclobutrazol and coumarin and the varieties, the interaction treatment between paclobutrazol at a concentration of 3 mg/L with coumarin at a concentration of 10 mg/L with the Spunta variety was superior in recording the highest microtuber weight of 3.347 grams compared to the treatment without adding paclobutrazol with coumarin with the Spunta variety, which gave Minimum tuber weight.

Table1.Effect of adding different concentrations of Paclobutrazol and coumarin and their interaction on the average weight of microtubers of four potato varieties (g tuber-^{1})

Interaction Varieties and Paclobutrazol	Coumarin (mg l^{-1})				Paclobutrazol (mg l^{-1})	Varieties
	20	15	10	0		
2.743 g	3.064 q	2.974 u	2.900 x	2.035 k^{--}	0	Arizona
2.941 c	2.577 j^{-}	3.148 l	3.204 i	2.835 c^{-}	3	
2.633 k	2.204 x^{-}	2.428 m^{-}	3.110 n	2.789 e^{-}	6	
2.377 m	2.154 b^{-}	2.277 u^{-}	2.339 q^{-}	2.736 f^{-}	9	
2.689 h	2.989 t	2.883 z	2.800 d^{-}	2.084 i^{--}	0	Burren
2.930 d	2.384 n^{-}	3.343 c	3.315 d	2.677 h^{-}	3	
2.554 l	2.115 g^{-}	2.289 t^{-}	3.145 m	2.666 i^{-}	6	
2.234 p	2.100 h^{-}	2.152 d^{-}	2.203 y^{-}	2.481 l^{-}	9	
2.832 f	3.163 j	3.085 p	3.033 s	2.045 j^{--}	0	Hermiz
2.991 b	2.356 p^{-}	3.298 e	3.346 b	2.965 v	3	
2.641 j	2.116 f^{--}	2.320 s^{-}	3.237 g	2.892 y	6	
2.344 o	2.117 e^{--}	2.189 z^{-}	2.222 w^{-}	2.848 b^{-}	9	
2.835 e	3.161 k	3.100 o	3.052 r	2.029 l^{--}	0	Spunta
3.026 a	2.503 k^{-}	3.296 f	3.347 a	2.959 w	3	
2.655 i	2.184 a^{--}	2.358 o^{-}	3.213 h	2.868 a^{-}	6	
2.364 n	2.154 c^{--}	2.250 v^{-}	2.329 r^{-}	2.724 g^{-}	9	
Averages Varieties	Coumarin (mg l^{-1})				Interaction Varieties and Coumarin	
	20	15	10	0		
2.673 B	2.500 m	2.707 g	2.888 c	2.599 k	Arizona	| Varieties
2.601 C	2.397 p	2.667 i	2.866 d	2.477 n	Burren	
2.702 A	2.438 o	2.723 f	2.959 b	2.688 h	Hermiz	
2.720 A	2.500 l	2.751 e	2.985 a	2.645 j	Spunta	
Averages Paclobutrazol	Coumarin (mg l^{-1})				Interaction Paclobutrazol and Coumarin	
	20	15	10	0		
2.774 B	3.094 d	3.011 e	2.946 f	2.048 p	0	Paclobutrazol (mg l^{-1})
2.972 A	2.455 j	3.272 b	3.303 a	2.859 g	3	
2.620 C	2.155 n	2.349 k	3.176 c	2.804 h	6	
2.329 D	2.131 o	2.217 m	2.273 l	2.698 i	9	
	2.458 D	2.712 B	2.924 A	2.602 C	Averages Coumarin	

Numbers with similar symbols and letters are not significantly different from each other according to the Duncan test at the 5% probability level.

2. Average number of microtubers (plant tuber - 1)

The results of Table 2 that there are significant effects of the paclobutrazol addition treatments on the number of micro tubers, as the highest number of micro tubers of 3.23 tubers was found when 3 mg L was added compared to the addition treatment at a concentration of 9 mg L - 1, which gave the lowest number, and there were significant effects when adding coumarin in terms of the number of micro tubers. The treatment with the addition of coumarin at a concentration of 10 mg per liter excelled in recording the highest number of 3.13 tubers compared to the treatment with 20 mg per liter of coumarin, which gave the lowest number. In the same table, the variety outperformed the variety. Burren was significantly superior to the rest of the varieties in recording the highest number of tubers, which reached 2.80 compared to the Hermiz variety, which gave the lowest number. In the interaction between paclobutrazol and coumarin, the interaction treatment of paclobutrazol at a concentration of 3 mg/L with coumarin at a concentration of 10 mg/L was superior in recording the highest average number of micro tubers, which amounted to 3.69 tubers. With the non-add treatment that gave the lowest number. In the interaction between paclobutrazol and the varieties, paclobutrazol at a concentration of 3 mg/L outperformed the variety Burren in recording the highest number of micro tubers, amounting to 3.29 tubers, compared to the treatment of adding paclobutrazol at a concentration of 9 mg/L with the variety Hermiz, which gave the lowest number. As for the interaction of coumarin with the varieties, the treatment

of adding coumarin at a concentration of 10 mg/L with the variety Burren excelled in recording the highest number of micro tubers, amounting to 3.19 tubers, compared to the treatment of adding coumarin at a concentration of 20 mg/L with the variety Hermiz, which gave the lowest number. In the triple interaction between paclobutrazol, coumarin, and the varieties, the interaction treatment excelled. Between paclobutrazol at a concentration of 3 mg. L $^{-1}$ with coumarin at a concentration of 10 mg per liter with the Arizona variety, which recorded the highest number of micro tubers, amounting to 3.74 tubers, compared to the treatment without the addition of paclobutrazol with coumarin, with the Spunta variety, which received the addition of gave the lowest number.

Table 2. The effect of adding different concentrations of paclobutrazol and coumarin and their interaction on the average number of microtubers for four potato varieties (tuber plant^{-1})
Numbers with similar symbols and letters are not significantly different from each other according to the Duncan test at the 5% probability level.

Interaction Varieties and Paclobutrazol	Coumarin (mg l^{-1})				Paclobutrazol (mg l^{-1})	Varieties
	20	15	10	0		
2.81 f	3.26 n	3.24 o	3.19 r	1.55 f^{--}	0	Arizona
3.26 b	2.70 i^{-}	3.62 g	3.74 a	3.00 x	3	
2.72 h	2.00 y^{-}	2.59 l^{-}	3.45 j	2.85 d^{-}	6	
2.26 n	1.94 a^{--}	2.06 v^{-}	2.29 q^{-}	2.77 h^{-}	9	
2.81 e	3.27 m	3.24 o	3.22 p	1.53 g^{--}	0	Burren
3.29 a	2.62 k^{-}	3.66 d	3.72 b	3.18 t	3	
2.77 g	2.09 u^{-}	2.58 m^{-}	3.50 i	2.92 a^{-}	6	
2.31 m	1.97 z^{-}	2.13 t^{-}	2.33 p^{-}	2.82 e^{-}	9	
2.69 i	3.22 q	3.11 u	3.00 y	1.45 h^{--}	0	Hermiz
3.14 d	2.35 o^{-}	3.61 h	3.69 c	2.91 c^{-}	3	
2.58 l	1.92 b^{--}	2.23 r^{-}	3.42 l	2.78 g^{-}	6	
2.18 p	1.90 d^{--}	2.03 x^{-}	2.20 s^{-}	2.59 m^{-}	9	
2.68 j	3.18 s	3.08 v	3.01 w	1.44 i^{--}	0	Spunta
3.22 c	2.68 j^{-}	3.63 e	3.62 f	2.93 z	3	
2.67 k	1.90 c^{--}	2.43 n-	3.43 k	2.91 b^{-}	6	
2.25 o	1.85 e $^{--}$	2.06 w^{-}	2.29 q^{-}	2.80 f^{-}	9	
Averages Varieties	Coumarin (mg l^{-1})				Interaction Varieties and Coumarin	
	20	15	10	0		
2.76 AB	2.47 m	2.88 f	3.17 b	2.54 j	Arizona	Varieties
2.80 A	2.49 l	2.90 e	3.19 a	2.61 i	Burren	
2.65 B	2.34 p	2.74 h	3.08 d	2.43 n	Hermiz	
2.70 AB	2.41 o	2.80 g	3.09 c	2.52 k	Spunta	
Averages Paclobutrazol	Coumarin (mg l^{-1})				Interaction Paclobutrazol and Coumarin	
	20	15	10	0		
2.75 B	3.23 d	3.17 e	3.10 f	1.49 p	0	Paclobutrazol (mg l^{-1})
3.23 A	2.59 j	3.63 b	3.69 a	3.00 g	3	
2.69 B	1.97 n	2.46 k	3.45 c	2.86 h	6	
2.25 C	1.91 o	2.07 m	2.28 l	2.74 i	9	
	2.43 C	2.83 B	3.13 A	2.53 C	Averages Coumarin	

3. Mean Tuber Diameter (mm)

The results showed in Table 3 that the treatments of adding paclobetrazole were significantly superior in the characteristic of the average microtuber diameter, as the highest microtuber diameter was 5.99 mm when adding 3 mg. liters compared to the addition treatment of 9 mg per liter, which gave the lowest diameter. There were significant differences when adding coumarin in the characteristic of the average diameter of the tuber, as the addition treatment with a concentration of 10 mg per liter excelled in giving the highest average diameter of the minute tuber reaching

5.96 mm, compared to the treatment without adding 0 mg per liter, which gave the lowest diameter. In the same table, the Spunta variety was significantly superior in The average diameter of the micro tuber, as the highest diameter of the micro tuber of Spunta cultivar was 5.91 mm compared to the Arizona variety, which gave the lowest diameter. The treatment of interfering with paclobetrazole at a concentration of 3 mg/l with coumarin at a concentration of 10 mg/l excelled in recording the highest average diameter of the microtuberculus, which reached 6.27 mm, compared to the treatment without addition, which gave the lowest diameter. In the interaction between paclobetrazole and the cultivars, the treatment of adding 3 mg L - 1 paclobetrazole with Spunta cultivar excelled in recording the highest diameter of the minute tubercle reaching 6.18 mm, compared to the treatment of interaction between paclobetrazole at a concentration of 9 mg L with the variety Arizona, which gave the lowest diameter. As for the interaction of coumarins with cultivars, the interaction treatment between coumarins at a concentration of 10 mg L with Spunta cultivar excelled in recording the highest diameter of the minute tubercle and reached 6.14 mm, compared to the treatment of interaction between coumarins at a concentration of 20 mg L with the cultivar Arizona, which gave the lowest diameter. In the triple interaction between paclobetrazole and coumarin and cultivars, the interaction treatment between paclobetrazole at a concentration of 3 mg L with coumarin at a concentration of 10 mg L with Spunta cultivar was superior in recording the highest diameter of the micro-tuber reached 6.35 mm, compared to the treatment without adding paclobetrazole with coumarin with the cultivar Arizona, which gave the lowest diameter.

Table 3. The effect of adding different concentrations of paclobetrazole and coumarin and the interaction between them on the average microtuber diameter of four potato cultivars (mm)

Interaction Varieties and Paclobutrazol	Coumarin (mg l^{-1})				Paclobutrazol (mg l^{-1})	Varieties
	20	15	10	0		
5.59 l	6.02 t	5.99 v	5.82 f^{-}	4.45 i^{--}	0	Arizona
5.88 d	5.26 w^{-}	6.17 k	6.28 d	5.89 b^{-}	3	
5.45 n	4.90 d^{--}	5.20 y^{-}	6.11 n	5.60 m^{-}	6	
5.08 p	4.76 f^{--}	5.00 c^{--}	5.11 a^{--}	5.45 q^{-}	9	
5.59 k	5.94 y	5.83 e^{-}	5.74 h^{-}	4.83 e^{--}	0	Burren
5.85 e	5.49 o^{-}	6.08 p	6.17 j	5.67 j^{-}	3	
5.55 l	5.17 z^{-}	5.40 s^{-}	6.02 u	5.61 l^{-}	6	
5.30 o	5.00 b^{--}	5.28 v^{-}	5.35 t^{-}	5.58 n^{-}	9	
5.71 i	6.11 m	6.24 e	6.04 r	4.47 h^{--}	0	Hermiz
6.06 b	5.74 h^{-}	6.22 g	6.30 b	5.98 x	3	
5.78 f	5.34 u^{-}	5.67 i^{-}	6.19 i	5.91 a^{-}	6	
5.53 m	5.23 x^{-}	5.46 p^{-}	5.58 n^{-}	5.85 d^{-}	9	
5.75 h	6.19 h	6.14 l	6.11 n	4.55 g^{--}	0	Spunta
6.18 a	5.99 w	6.29 c	6.35 a	6.08 o	3	
5.97 c	5.65 k^{-}	5.93 z	6.23 f	6.06 q	6	
5.77 g	5.43 r^{-}	5.75 g^{-}	5.86 c^{-}	6.03 s	9	
Averages Varieties	Coumarin (mg l^{-1})				Interaction Varieties and Coumarin	
	20	15	10	0		
5.50 D	5.24 p	5.59 k	5.85 e	5.33 o	Arizona	| Varieties
5.57 C	5.40 n	5.65 i	5.82 f	5.42 m	Burren	
5.77 B	5.61 j	5.90 d	6.02 c	5.55 l	Hermiz	
5.91 A	5.81 g	6.03 b	6.14 a	5.68 h	Spunta	
Averages Paclobutrazol	Coumarin (mg l^{-1})				Interaction Paclobutrazol and Coumarin	
	20	15	10	0		
5.66 B	6.07 d	6.05 e	5.94 f	4.58 p	0	Paclobutrazol (mg l^{-1})
5.99 A	5.62 j	6.19 b	6.27 a	5.89 g	3	
5.69 B	5.26 n	5.55 k	6.13 c	5.80 h	6	
5.42 C	5.11 o	5.37 m	5.47 l	5.72 i	9	
	5.51 C	5.79 B	5.96 A	5.50 C	Averages Coumarin	

Numbers with similar symbols and letters are not significantly different from each other according to the Duncan test at the 5% probability level.

4.Proline content in the micro tubers (mmol g^{-1})

The results in Table 4 show that the paclobutrazol addition treatments significantly outweigh the proline content in the micro tubers, as the highest proline content in the micro tubers is observed at 7.57 mmol g^{-1} when adding 9 mg per liter compared to The treatment without addition gave the lowest proline content. There were significant differences when coumarin was added at a concentration of 20 mg/L in recording the highest proline content in the micro tubers, which amounted to 7.22 mmol $g1^{-1}$, compared to the treatment without the addition, which gave the proline content. In the same table, the Spunta variety was significantly superior in proline content in the micro tubers, as the highest proline content was observed in the micro tubers of the Spunta variety, which amounted to 5.82 mmol g^{-1}, compared to the Burrrn variety, which gave the lowest content. The interaction treatment of paclobutrazol at a concentration of 9 mg per liter with coumarin at a concentration of 20 mg per liter was superior. It recorded the highest content of proline in the micro tubers, reaching 9.60 mmol g^{-1}, compared to the treatment without addition, which gave the lowest content. In the interaction between paclobutrazol and the varieties, the treatment of adding 9 mg liter of paclobutrazol with the Arizona variety was superior in recording the highest proline content in the micro tuber, amounting to 7.96 mmol g^{-1}, compared to the interaction treatment between paclobutrazol at a concentration of 0 mg liter 1 of the Arizona variety, which gave the lowest content...proline. As for the interaction of coumarin With the varieties, the coumarin interaction treatment at a concentration of 20 mg/L with the Arizona variety excelled in recording the highest proline content in the micro tubers, which amounted to 7.29 mmol g^{-1}, compared to the coumarin interaction treatment at a concentration of 0 mg/L with the Burren variety, which gave the lowest content. And in the triple interaction between paclobetrazole and coumarin and the classes The interaction treatment between paclobutrazol at a concentration of 9 mg L^{-1} and coumarin at a concentration of 20 mg L^{-1} with the Arizona variety excelled in recording the highest proline content in the micro tubers, reaching 985 mmol gm, compared to the treatment without the addition of paclobutrazol with coumarin with the Burren variety, which gave Lowest proline content.

Table 4. Effect of adding different concentrations of paclobutrazol and coumarin and their interaction on the proline content of fine tubers of four potato varieties (mmol g^{-1})

Interaction Varieties and Paclobutrazol	Coumarin (ملغم لتر$^{-1}$)				Paclobutrazol (ملغم لتر$^{-1}$)	Varieties
	20	15	10	0		
4.42 p	4.45 u^{-}	4.73 q^{-}	5.00 l^{-}	3.53 j^{--}	0	Arizona
4.82 k	6.22 v	4.12 c^{--}	3.66 g^{--}	5.27 h^{-}	3	
6.23 f	8.65 e	6.62 q	4.25 z^{-}	5.42 e^{-}	6	
7.69 a	9.84 a	7.85 i	7.24 n	5.83 a^{-}	9	
4.48 n	4.63 s^{-}	4.84 o^{-}	5.02 k^{-}	3.43 k^{--}	0	Burren
4.81 l	6.14 w	4.22 a^{--}	3.74 f^{--}	5.14 i^{-}	3	
6.08 h	8.28 h	6.44 t	4.34 w^{-}	5.28 g^{-}	6	
7.43 d	9.51 c	7.46 l	7.03 p	5.74 b^{-}	9	
4.43 o	4.50 t^{-}	4.64 r^{-}	4.97 n^{-}	3.62 h^{--}	0	Hermiz
4.84 j	6.14 x	4.13 b^{--}	3.81 e^{--}	5.30 f^{-}	3	
6.21 g	8.59 f	6.56 s	4.26 y^{-}	5.45 d^{-}	6	
7.65 b	9.74 b	7.76 j	7.21 o	5.90 z	9	
4.61 m	4.84 p^{-}	4.97 m^{-}	5.13 j^{-}	3.59 i^{--}	0	Spunta
4.92 i	6.31 u	4.27 x^{-}	3.83 d^{--}	5.27 h^{-}	3	
6.23 e	8.49 g	6.57 r	4.43 v^{-}	5.45 c^{-}	6	
7.50 c	9.30 d	7.53 k	7.26 m	5.91 y	9	
Averages Varieties	Coumarin (ملغم لتر$^{-1}$)				Interaction Varieties and Coumarin	
	20	15	10	0		
5.79 B	7.29 a	5.83 f	5.03 m	5.01 o	Arizona	الاصناف
5.70 C	7.14 d	5.74 h	5.03 n	4.90 p	Burren	
5.78 B	7.24 b	5.775 g	5.06 k	5.06 j	Hermiz	
5.82 A	7.21 c	5.83 e	5.16 i	5.06 l	Spunta	
Averages Paclobutrazol	Coumarin (ملغم لتر$^{-1}$)				Interaction Paclobutrazol and Coumarin	
	20	15	10	0		
4.49 D	4.58 l	4.79 k	5.03 j	3.54 p	0	Paclobutrazol (ملغم لتر$^{-1}$)
4.85 C	6.20 f	4.18 n	3.76 o	5.24 i	3	
6.19 B	8.50 b	6.55 e	4.32 m	5.40 h	6	
7.57 A	9.60 a	7.65 c	7.18 d	5.84 g	9	
	7.22 A	5.79 B	5.07 C	5.01 D	Averages Coumarin	

Numbers with similar symbols and letters are not significantly different from each other according to the Duncan test at the 5% probability level.

The results Tables 1, 2, 3, and 4 that low levels of growth retardants led to an increase in the average tuber weight, the number of tubers, the average tuber diameter, and the average tuber weight. This increase occurs with a decrease in the concentration of the growth retardants paclobutrazol and coumarin. With increasing concentrations, it decreases. This is due to the fact that most The processes that occur in the plant give a response to the obstacle under this tension, and these processes change due to the tension and lead to the state of rapid aging of the Sahuki plant, 2013). The increase in the number of tubers and their weight and diameter in the low and control treatments may be due to the state of equilibrium that the plant experiences without stress, which leads to an increase in cell division and expansion and the formation of tubers. As for the decrease in the number of fine tubers, their weight and diameter at high concentrations, this is due to the catabolism of proteins by ROS. The inability of protective mechanisms to repair the damage caused to the cell by these oxidizing compounds. It was found that the diameter of the fine tubers decreased with increasing concentrations of inhibiting substances compared to the low treatment and the control treatment. This may be due to the inhibition of a number of genes affecting the size of the tubers under tension, and then a decrease in all characteristics with increasing concentrations that cause tension. (2007) put it Bray drew a diagram about the involvement of groups of genes that are induced by genes, both stimulatory and inhibitory, and noted that a large number of genes contribute to each case. This means that the genes that control the trait are large in number. The increase in the fresh weight of the fine tubers in the low-concentration treatments and the comparison treatment compared to the high-concentration treatments is due to the fact that the plants growing under high stresses will suffer from the disassembly, aggregation, or dissolution of proteins, and then disturbance of the osmotic tension in the cell,

and a number of processes intertwined with the occurrence of the aforementioned damages. ABA includes instructions related to the synthesis of protective proteins by stimulating certain genes that synthesize soluble compounds such as sugars and proline, which encourage cells to withdraw water, as well as inhibiting genes that remove ROS that are harmful to cell activities, as well as activating genes encoding for the production of important enzymes such as peroxidase and SOD and (2003 Catalase Moon). Another reason that may be due to the diameter and weight of the fine tuber is the increase in the level of ABA in the tissues, which reduces its GA3 content and then the effect of Glutathione and In DNA and RNA formed where with gibberellin As well as reducing the representation of proteins and thus cell division, which leads to a decrease in the diameter and weight of the tuber (Pandey, Sinha 1995) and an increase in proline concentrations in microtubers when using growth retardants pacloprazole and coumarin at high concentrations, and this may be due to the tension caused by these obstacles, and thus its concentration increases and proline By activating antioxidant enzymes that have an important effect in getting rid of free radicals, and thus the accumulation of proline under stress is an important biochemical indicator through which plant species can be identified under stress conditions (Hasanzumman et al. 2013), and it also explains the increased concentration of proline as a protective factor for cellular organelles in the cytoplasm as well It is a storage compound for carbon and nitrogen and removes free radicals and its contribution to the stability of membranes and protein (Chinnusamy et al., 2005). And the results are consistent with (1991) (Simko and Kozak (2002), Nuraini et al. (2018), Al-Jubouri (2004), EL-swy et al. (2007), Al-Amri (2007), Suharjo et al. (2019) and Mustikasari (2023).

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