



IRAQI  
Academic Scientific Journals



العراقية  
المجلات الأكاديمية العلمية

TJAS

Tikrit Journal for  
Agricultural  
Sciences

ISSN:1813-1646 (Print); 2664-0597 (Online)

*Tikrit Journal for Agricultural Sciences*

Journal Homepage: <http://www.tjas.org>

E-mail: [tjas@tu.edu.iq](mailto:tjas@tu.edu.iq)

## Response of different potato cultivars to treatment with some growth regulators during the fall season

Abrar A. Naser 

Horticulture and Landscaping Department, College of Agriculture, Tikrit University, Salah Al-Din, Iraq.

Correspondence email: [abrarakeel@tu.edu.iq](mailto:abrarakeel@tu.edu.iq)

### KEY WORDS:

Gibberellic acid, Cppu,  
Cultivars, Potato

Received: 10/01/2024

Revision: 14/08/2024

Proofreading: 22/09/2024

Accepted: 22/10/2024

Available online: 31/12/2024

© 2024. This is an open access article under the CC by licenses

<http://creativecommons.org/licenses/by/4.0>



### ABSTRACT

This experiment was conducted to study the response of tubers of different potato cultivars to treatment with growth regulators gibberellic acid before planting and spraying with growth regulator CPPU on vegetative growth using three levels for each (0, 5, 10) mg L<sup>-1</sup> and its effect on vegetative and yield traits, the experiment was carried out using a split-split plot design within the randomized complete plot design (R.C.B.D.) with three replications, the cultivars put in main plot, GA<sub>3</sub> in sub plot and spraying with CPPU in sub-sub plot as more important. The results showed that Laperla cultivar gave significant increase in two characteristics Leaves number, sprouting percentage, reached to (81.94 leaf plant<sup>-1</sup> and 2.60%), respectively, while Barcelona cultivar was superior in protein percentage in tubers, which gave 5.32%. As for the CPPU spraying 5 mg L<sup>-1</sup>, was superior in protein percentage in tubers, which gave 4.92%, while the concentration 10 mg L<sup>-1</sup> was superior in leaves number, which reached 75.14 leaf plant<sup>-1</sup>. As for the effect of treatment with gibberellic acid, it was clear in two characteristics, leaves number and protein percentage gave (72.58 leaf plant<sup>-1</sup> and 4.21%) at 5 mg L<sup>-1</sup>. As for the binary and triple interactions, they caused significant differences for all traits, except unmarketable tubers number didn't have any significant differences.

## استجابة اصناف مختلفة من البطاطا للمعاملة ببعض منظمات النمو خلال العروة الخريفية

ابرار عقيل ناصر

قسم البيستنة وهندسة الحدائق ، كلية الزراعة ، جامعة تكريت ، العراق

### الخلاصة

اجريت هذه التجربة لدراسة مدى استجابة درنات اصناف مختلفة من البطاطا للمعاملة بحامض الجبرليك قبل الزراعة والرش بـ CPPU على المجموع الخضري للنبات وبأستخدام ثلاث مستويات لكل منهما ( 0 ، 5 ، 10 ) ملغم لتر<sup>-1</sup> وتأثيرها على الصفات الخضرية وصفات الحاصل الكمية والنوعية ، تم تنفيذ التجربة بأستخدام تصميم القطع المنشقة – المنشقة - Split plot design ضمن تصميم القطاعات العشوائية الكاملة ( R.C.B.D. ) وبثلاث مكررات ، فكانت الاصناف ضمن القطع الرئيسية Main plot وهي الاقل اهمية والمعاملة بمنظم النمو حامض الجبرليك ضمن القطع الثانوية Sub plot والرش بمنظم النمو CPPU ضمن القطع الثانوية – الثانوية Sub-sub plot بأعتبارها اكثر اهمية . وقد بينت النتائج تفوق الصنف لايرلا في صفتي عدد الاوراق ونسبة التزريع للدرنات واعطى النتائج التالية ( 81.94 ورقة نبات<sup>-1</sup> و 2.60% ) على التوالي ، اما الصنف برشلونة فقد تفوق في صفة نسبة البروتين في الدرنات والذي اعطى قيمة بلغت 5.32% . اما الرش بمنظم النمو CPPU فقد تفوق التركيز 5 ملغم لتر<sup>-1</sup> في صفة نسبة البروتين في الدرنات والتي بلغت 4.92% ، اما التركيز 10 ملغم لتر<sup>-1</sup> فقد تفوق في صفة عدد الاوراق والتي بلغ عددها 75.14 ورقة نبات<sup>-1</sup> . اما تأثير المعاملة بحامض الجبرليك فقد كان واضحاً في صفتي عدد الاوراق ونسبة البروتين في الدرنات عند التركيز 5 ملغم لتر<sup>-1</sup> واعطى القيم التالية ( 72.58 ورقة نبات<sup>-1</sup> و 4.21% ) على التوالي . اما التداخلات الثنائية والثلاثية فقد احدثت فروق معنوية لجميع الصفات عدا في صفة عدد الدرنات غير الصالحة للتسويق فلم يكن للتداخلات الثنائية اية فروق معنوية.

الكلمات الافتتاحية : حامض الجبرليك ، CPPU ، الاصناف ، البطاطا .

### INTRODUCTION

Potato plant is one of the most important plants of the Solanaceae family, its scientific name is *Solanum tuberosum* L. It is one of the most widespread economic crops in the world because it contains starch and vitamins B and C (Hassan , 1999) . Potato crop is planting during the spring and autumn seasons in Iraq , Iraqi farmer suffers from cultivating potato crop in fall season because of several problems, the most important which is the phenomenon apical dominance which caused few the number of ground stems that leads to a fewer of production, and this in turn negatively affects the quantity and quality of production (Haverkort , 1991). The production of potato crop is affected by many factors, the most important of which is the appropriate cultivars, environmental conditions surrounding the plant, and agricultural service operations. found (Ibrahim , 2018 ) in his study on two cultivar of potato, Universa was significantly superior to the Latona in fresh and dry weight of the plant and leaf area. It was also shown (Al- Mohammadi and Al- Jumaili , 2018 ) that Arizona cultivar gave the highest number of main stems of the plant and the highest percentage of protein and was significantly superior in these two traits, amounting to (4.74 stems<sup>-1</sup> and 1.70%), respectively, while the cultivar Rivera gave (2.92 stems<sup>-1</sup> and 1.68%). (Al-Shammari and Al-Zobaai , 2018 ) confirmed that the Everist cultivar was significantly superior to the Rivera cultivar in the protein percentage in tubers, which gave (1.41%).

Gibberellic acid affects plant growth physiologically and has an important role in activating vital activities within the cell such as the process of photosynthesis. It also works to stimulate division cells and increase their elongation and thus increase plant height, leafy area, vegetative and root growth, and this in turn increases productivity (Al-Khafaji , 2014 ) . (Al-Assaf and others , 2013 ) was found that spraying with gibberellic acid at 100 mg L<sup>-1</sup> led to a significant increase in plant height, branches number, tubers number, average tuber weight, single plant yield and total yield compared to no spraying. (El-Hamady , 2017 ) showed that Sponta cultivar treats with several concentrations of GA<sub>3</sub> (0, 10, 20, 30) mg L<sup>-1</sup> exceeded the concentration of 30 mg L<sup>-1</sup> in some vegetative growth characteristics, including fresh and dry weight of the total vegetative compared to the control treatment. In another study by ( Zain al-Din and Abd al-Rasol , 2017 ) , spraying potato plants of Rodolf cultivar with gibberellic acid (0, 50, 100, 200) mg L<sup>-1</sup>, the percentage of NPK in leaves gave significantly superior comparison with control treatment at 100 mg L<sup>-1</sup>, in addition to the tubers number and one plant yield.

As for the effect of CPPU, it acts like cytokinin, and as it is known, cytokinin stimulates cell division, delays aging, and activates the action of enzymes (Wasfi , 1995 ) . (Al-Mohammadi and Al-Essawi , 2015 ) showed that spraying potato plants with cytokinin at 5 , 10 mg L<sup>-1</sup> gave the highest rates. In quality yield characteristics, including starch percentage in tubers, specific density, dry matter percentage in tubers, and dissolved solids percentage ,compared to other treatments. It was also found (El-Shray and Hegaze , 2010 ) that spraying with CPPU on potato plants with different concentrations (0, 10, 20) mg L<sup>-1</sup>, that the 10 and 20 mg L<sup>-1</sup> had a significant superior with control treatment in leaves number, fresh and dry weight of the shoots. Also, (El-Areiny and others , 2019 ) confirmed that spraying different levels of cytokinin (0, 0.04, 0.08, 0.12) mmol L<sup>-1</sup> on potato plants , was gave significant differences to the control treatment in tuber content of NPK elements at 0.12 mmol L<sup>-1</sup>.

The aim of this research is to study and evaluation of three potato cultivars to choose the best cultivar suitable for cultivation under the conditions of Salah al-Din Governorate in terms of productivity and quality and determine the best combination of study factors.

## **MATERIAL AND METHODS**

The experiment was carried out for the fall season 2019 at the Horticulture Research Station of Agriculture College / Tikrit University, and its soil is characterized as gypsum soil. Samples of field soil were taken from the soil surface to a depth of 30 cm and analyzed in Soil and Water sciences laboratories / Agriculture College / Tikrit University, Table (1) Explain some chemical and physical properties soil. The field land was cultivated and prepared for cultivation on 8/22/2019 by using a reversible disc plow, it was divided using the split-split plot design within the (R.C.B.D) according to the design(Al-Mohammadi and Al-Mohammadi , 2010 ) . The experimental length unit was 2 m, the width was 3 m, the distance between one plant and another was 0.3 m, between one treatment and another was 0.3 m, and each cultivar contained 6 hole The experimental unit includes 24 hole. The land was fertilized before planting with compound fertilizer NPK according to the fertilizer recommendation (240:120:400) as mentioned

(Mahmoud and Others, 2013 ). The irrigation system used is drip irrigation. The tubers were prepared in a place with room temperature for 10 days before planting to stimulate the sprout for growth. The tubers were treated with gibberellic acid, according to the treatments, and were planted on 8/28/2019. Two months after planting the plants was sprayed with CPPU, as two sprays between them two weeks, the tubers were harvested on 12/21/2019.

Table 1: Some chemical and physical properties of field soil before planting

Traits	Gypsum g.kg <sup>-1</sup>	Lime g.kg <sup>-1</sup>	Ec Ds.m <sup>-1</sup>	pH	Sand g.kg <sup>-1</sup>	Silt g.kg <sup>-1</sup>	Clay g.kg <sup>-1</sup>	Texture	Organic Matter %
Value	13.8	21.2	2.21	8.1	540	339	121	sandy loam	0.85

\*Field soil was analyzed in Soil and Water Sciences laboratories / College of Agriculture / Tikrit University.

#### Measurements:

- Leaves number (leaf plant<sup>-1</sup>): The average leaves number was calculated for five plants randomly from each experimental unit.
- Root Weight to Vegetative Growth Weight (%): It was calculated as a percentage between roots weight and vegetative group weight.
- Unmarketable tubers number (tuber plants<sup>-1</sup>): It was calculated for tubers that deformed, infected and weighing less than 10 gm.
- Unmarketable tubers yield (ton h<sup>-1</sup>): This calculated by taken tubers that deformed infected and less than 5.5 cm.
- Sprouting percentage at harvest (%): This is taken by a percentage of sprouting tubers number and total tubers number.
- Protein percentage in tubers (%): 0.4 g of dried potato powder was taken and placed in glass dishes. 10 ml of H<sub>2</sub>SO<sub>4</sub> concentrated acid was added. After 24 hours, perchloric acid was added to carry out the digestion process until the solution became clear white. Then the percentage of nitrogen in the sample was estimated using a micro Kjeldahl device and the percentage of protein was calculated according to the following equation: Protein percentage = Total nitrogen percentage x 6.25 (Michael , 2013 ) .

## RESULTS AND DISCUSSION

It is clear from table (2) that Laperla cultivar has superior at the other cultivars and gave highest results for leaves number, which gave 81.94 leaf in plant, while Barcelona cultivar, gave 60.94 leaf plant<sup>-1</sup> which was the lowest . As for the effect of CPPU, 10 mg L<sup>-1</sup> was superior gave 75.14 leaf, and when we not treated with CPPU reached to 66.92 leaf plant<sup>-1</sup>. GA<sub>3</sub> at levels 5 and 10 mg L<sup>-1</sup> were superior to the comparison treatment, which gave the lowest leaves number 60.43 leaf plant<sup>-1</sup>, while the highest results were at 10 mg, which reached to 76.43 leaf.

In same table the interaction between treatments led to significant increases, when spraying 10 mg L<sup>-1</sup> CPPU on Laperla cultivar, it gave highest value compared with other

treatments, but a lowest results when we spraying on Barcelona cultivar, which gave 59.00 leaf. The interaction of GA<sub>3</sub> and cultivars were significant differences when treating Laperla cultivar with 5 and 10 mg L<sup>-1</sup>, the results reached 90.68 and 88.21 plant leaf<sup>-1</sup>, and these two treatments outperformed the rest of the other treatments, the lowest leaves number at untreated Barcelona cultivar which gave 53.02 leaf plant<sup>-1</sup>. The interaction between 10 mg L<sup>-1</sup> for each GA<sub>3</sub> and CPPU was superior to the rest of the other treatments, as it gave the highest leaves number 85.45 leaf, compared with control treatment, which gave 56.60 leaf plant<sup>-1</sup>. We also note from the same table the effect of the triple overlap between the treatments, as the differences were significant in the treatment Laperla cultivar at 10 mg L<sup>-1</sup> CPPU and 5 mg L<sup>-1</sup> GA<sub>3</sub> gave the highest leaves number reaching 109.90 leaf plant<sup>-1</sup>, compared with other treatments, but untreated Barcelona cultivar with mentioned growth regulators, the value reached 44.84 leaf plant<sup>-1</sup>.

Table (2): Effect of CPPU and GA<sub>3</sub> in three cultivars on leaves number (leaf plant<sup>-1</sup>).

Cultivar	GA3	CPPU 0	CPPU 5	CPPU 10	Cultivars+ GA3	
Barcelona	0	44.84 j	55.19 hij	59.04 ghi	53.02 d	
	5	69.61 eh	66.82 ei	53.58 ij	63.34 c	
	10	75.28 def	59.77 ghi	64.38 ei	66.47 bc	
	0	59.35 ghi	69.03 eh	72.45 dg	66.94 bc	
	5	75.75 de	86.40 cd	109.90 a	90.68 a	
	10	97.74 abc	76.45 de	90.44 bc	88.21 a	
Laperla	0	65.61 ei	57.05 hij	60.55 fi	61.07 cd	
	5	60.17 ghi	66.55 ei	64.43 ei	63.72 c	
	10	53.95 ij	68.33 ei	101.52 ab	74.60 b	
			Cultivars+ CPPU			Effect of cultivar
	Barcelona		63.24 c	60.59 c	59.00 c	60.94 c
	Laperla		77.61 b	77.29 b	90.93 a	66.64 a
Montreal		59.91 c	63.98 c	75.50 b	81.94 b	
		GA3+CPPU			Effect of GA3	
0		56.60 d	60.42 d	64.01 cd	60.35 b	
5		68.51 Bc	73.25 b	75.97 b	72.58 a	
10		75.66 b	68.18 bc	85.45 a	76.43 a	
Effect of CPPU		66.92 b	67.29 b	75.14 a		

\*Different letters within column indicating of significant differences ( $p < 0.05$ )

In Table (3) we note the effect of individual treatments on this characteristic that the cultivars and treatment with CPPU did not have a significant effect, while gibberellic acid had a significant effect that was shown when treating potato tubers with 10 mg L<sup>-1</sup>, which was superior to the concentration 5 mg L<sup>-1</sup>, which gave 11.55%, while the other concentration gave 9.74%. The same table also shows the effect of the bilateral interaction between the treatments, as the interaction between Barcelona cultivar and spraying with 5 mg L<sup>-1</sup> CPPU had a significant effect compared to the treatment of Montreal cultivar at all concentrations. 9.09%, respectively. As for the effect of the interaction between the cultivars and gibberellic acid, the differences were significant when Barcelona cultivar was treated with 10 mg L<sup>-1</sup>, which gave highest values and superior at all other treatments except for untreated Laperla cultivar with GA<sub>3</sub>, while the lowest results were when Montreal cultivar was treated with 5 mg. L<sup>-1</sup>, which gave 14.52, 9.20%, respectively. As for the interaction effect between growth regulators, it gave significant differences at level 5 mg L<sup>-1</sup> for each GA<sub>3</sub> and CPPU, reached to 12.75%, which gave significant differences compared with other treatments, while the lowest values in treatments 5 mg L<sup>-1</sup> for both growth regulators, which gave 9.57%.

It is also clear from the table the effect of the triple interaction between the treatments, as the differences were significant when treating and untreated Laperla cultivar with gibberellic acid and CPPU, which gave 15.49% compared to most other treatments, while the lowest values were Montreal cultivar was treated with the same concentration of gibberellic acid and CPPU, which is 5 mg L<sup>-1</sup>, at which was 8.22%.

Table (4) shows the effect of treatments on unmarketable tubers number. Cultivars and gibberellic acid had no significant differences in this characteristic. The spraying with CPPU, it had a negative effect on this trait, as spraying treatments with 5 and 10 mg L<sup>-1</sup> gave the highest value unmarketable tubers number, and outperformed the comparison treatment, which reached to 0.62 tubers .

The binary interaction coefficients, they did not have a significant effect on this trait. As for the triple interaction, when Laperla cultivar was not sprayed by CPPU and treated with 5 mg L<sup>-1</sup> GA<sub>3</sub>, reached to 0.20 tubers plant<sup>-1</sup> compared to most other treatments, and unmarketable tubers number was the lowest at the same time. cultivar and the same concentration of gibberellic acid, but when spraying at 10 mg L<sup>-1</sup>, which reached 1.87 tubers.

Table (3) : Effect of CPPU and GA<sub>3</sub> in three cultivars on root weight ratio to vegetative growth weight (%)

Cultivar	GA3	CPPU 0	CPPU 5	CPPU 10	Cultivars+ GA3	
Barcelona	0	10.03 d-g	14.18 abc	10.02 d-g	11.41 b	
	5	10.03 d-g	8.70 fg	10.17 d-g	9.64 b	
	10	13.48 a-e	15.30 a	14.77 ab	14.52 a	
	0	12.71 a-f	13.96 a-d	15.49 a	14.05 a	
	5	9.77 efg	11.81 a-g	9.60 Efg	10.39 b	
	10	10.80 c-g	9.18 fg	11.46 b-g	10.48 b	
Laperla	0	8.94 fg	10.11 d-g	9.27 Fg	9.45 b	
	5	9.89 efg	8.22 g	9.51 efg	9.20 b	
	10	10.42 c-g	10.08 d-g	8.50 g	9.67 b	
			Cultivars+ CPPU			Effect of cultivar
	Barcelona		11.18 abc	12.73 a	11.66 ab	11.86 a
	Laperla		11.09 abc	11.65 ab	12.18 a	11.64 a
Montreal		9.75 bc	9.47 c	9.09 c	9.44 a	
		GA3+CPPU			Effect of GA3	
0		10.56 b	12.75 a	11.59 ab	11.63 a	
5		9.90 b	9.57 b	9.76 b	9.74 b	
10		11.57 ab	11.52 ab	11.58 ab	11.55 a	
Effect of CPPU		10.64 a	11.28 a	10.98 a		

\*Different letters within column indicating of significant differences ( $p < 0.05$ )

Table(4):Effect of CPPU and GA<sub>3</sub> in three cultivars on unmarketable tubers number(tuber plant<sup>-1</sup>)

Cultivar	GA <sub>3</sub>	CPPU 0	CPPU 5	CPPU 10	Cultivars+ GA <sub>3</sub>
Barcelona	0	0.73 b	0.47 b	0.60 b	0.60 a
	5	0.98 ab	1.20 ab	0.60 b	0.93 a
	10	1.00 ab	0.98 ab	0.43 b	0.80 a
Laperla	0	0.27 b	0.60 b	1.27 ab	0.71 a
	5	1.87 a	0.73 b	0.20 b	0.93 a
	10	0.87 ab	1.33 ab	0.80 ab	1.00 a
Montreal	0	1.07 ab	1.20 ab	0.67 b	0.98 a
	5	0.47 b	1.27 ab	0.73 b	0.82 a
	10	0.73 b	0.80 ab	0.27 b	0.60 a
		Cultivars+ CPPU			Effect of cultivar
Barcelona		0.90 a	0.88 a	0.54 a	0.78 a
Laperla		1.00 a	0.89 a	0.76 a	0.88 a
Montreal		0.76 a	1.09 a	0.56 a	0.80 a
		GA <sub>3</sub> +CPPU			Effect of GA <sub>3</sub>
0		0.69 a	0.76 a	0.84 a	0.76 a
5		1.10 a	1.07 a	0.51 a	0.89 a
10		0.87 a	1.04 a	0.50 a	0.80 a
Effect of CPPU		0.89 ab	0.95 a	0.62 b	

\*Different letters within column indicating of significant differences ( $p < 0.05$ )

We note from table (5) that there are no significant differences in cultivars, as well as when treated with gibberellic acid, while there were significant differences when spraying with CPPU, but the effect was negative, as the comparison treatment gave 0.77 ton h<sup>-1</sup> compared with 5 , 10 mg L<sup>-1</sup>, which gave the highest unmarketable tubers yield at 5 mg l<sup>-1</sup>, it gave 1.80 ton h<sup>-1</sup>. It is evident from the same table the interaction between the treatments in unmarketable tubers yield, as there were significant differences when Laperla and Montreal cultivars were untreated with CPPU, the value for each treatments was 0.63 tons. H<sup>-1</sup>, but the highest unmarketable tubers yield when Barcelona cultivar treated by 5 mg L<sup>-1</sup>, it reached to 2.36 tons H<sup>-1</sup>. The effect of other bilateral interactions, there were no significant increases and differences between the treatments.



As for the effect of the triple interaction, it was the lowest unmarketable tubers yield when the interaction Montreal cultivar + 0 CPPU + 10 mg L<sup>-1</sup> GA<sub>3</sub> gave 0.11 ton h<sup>-1</sup>, while when we untreated Montreal cultivar by GA<sub>3</sub> and sprayed by 10 mg L<sup>-1</sup> CPPU, gave 4.07 tons h<sup>-1</sup>.

Table (5): Effect of CPPU and GA<sub>3</sub> in three cultivars on unmarketable tubers yield (ton h<sup>-1</sup>).

Cultivar	GA3	CPPU 0	CPPU 5	CPPU 10	Cultivars+ GA3	
Barcelona	0	0.77 bc	0.64 bc	1.00 bc	0.80 a	
	5	0.65 bc	3.09 abc	0.45 bc	1.40 a	
	10	0.67 bc	3.35 ab	1.72 abc	1.91 a	
	0	0.20 c	0.89 bc	0.89 bc	0.66 a	
	5	1.69 abc	0.68 bc	0.33 bc	0.90 a	
	10	2.73 Abc	1.45 abc	0.65 bc	1.61 a	
Laperla	0	4.07 a	2.22 abc	0.69 bc	2.33 a	
	5	1.67 abc	3.00 abc	1.08 abc	1.92 a	
	10	0.37 bc	0.89 bc	0.11 c	0.46 a	
			Cultivars+ CPPU			Effect of cultivar
	Barcelona		0.70 ab	2.36 a	1.06 ab	1.37 A
	Laperla		1.54 ab	1.01 ab	0.63 b	1.06 A
Montreal		2.04 ab	2.04 ab	0.63 b	1.57 A	
		GA3+CPPU			Effect of GA3	
0		1.68 a	1.25 a	0.86 a	1.27 A	
5		1.34 a	2.26 a	0.62 a	1.41 A	
10		1.26 a	1.90 a	0.83 a	1.33 A	
Effect of CPPU		1.42 ab	1.80 a	0.77 b		

\*Different letters within column indicating of significant differences ( $p < 0.05$ )

Table (6) shows the effect of individual factors on the Sprouting percentage at harvest, as we note that Laperla cultivar gave the lowest sprouting percentage 2.60%, while Montreal cultivar gave the highest percentage 9.97%. As for GA<sub>3</sub> and CPPU they didn't have any significant differences. We also note from the table that the bilateral interactions gave significant differences in sprouting percentage . The bilateral interaction between cultivars and spraying with CPPU had a significant effect in giving the highest sprouting percentage in tubers, which is

a non-positive trait, when spraying 5 mg L<sup>-1</sup> CPPU on Montreal cultivar gave 10.75% compared to the lowest sprouting percentage when Laperla cultivar not sprayed with CPPU, sprouting percentage was 1.82%. The binary interaction cultivars and gibberellic acid, gave lowest sprouting percentage when we untreated Montreal cultivar by gibberellic acid, which gave 11.42%. The interaction spraying CPPU with gibberellic acid, there were no significant differences or increases.

As we can see from the table, the triple interaction effect in the treatments Laperla cultivar + 0 CPPU + 0 GA<sub>3</sub>, and the other Laperla cultivar + 10 mg L<sup>-1</sup> CPPU+ 0 GA<sub>3</sub>, the lowest sprouting percentage 0.00% for both treatments. Compared with interaction between Montreal cultivar and 5 mg L<sup>-1</sup> from CPPU and GA<sub>3</sub>, which gave sprouting percentage 12.02%.

Table (6):Effect of CPPU and GA<sub>3</sub> in three cultivars on sprouting percentage at harvest (%).

Cultivar	GA3	CPPU 0	CPPU 5	CPPU 10	Cultivars+ GA3
Barcelona	0	3.75	8.10	6.37	6.07
		fj	ag	bi	c
	5	5.38	5.11	5.70	5.39
		cj	cj	ci	c
	10	5.72	5.66	9.51	6.97
		ci	ci	ad	bc
Laperla	0	0.00	3.17	0.00	1.06
		j	fj	j	d
	5	1.85	1.52	2.73	2.03
		hij	ij	gj	d
	10	7.11	4.24	2.74	4.70
		ag	dj	gj	c
Montreal	0	11.89	11.86	10.51	11.42
		a	a	abc	a
	5	7.19	9.19	12.02	9.46
		ah	ae	a	ab
	10	7.38	11.21	8.50	9.03
		ah	ab	af	ab
		Cultivars+ CPPU			Effect of cultivar
Barcelona		4.95	6.29	7.19	6.15
		cd	bc	bc	b
Laperla		2.99	2.98	1.82	2.60
		de	de	e	c
Montreal		8.82	10.75	10.34	9.97
		ab	a	a	a
		GA3+CPPU			Effect of GA3
0		5.21	7.71	5.63	6.18
		a	a	a	a
5		4.81	5.27	6.82	5.63
		a	a	a	a
10		6.74	7.04	6.91	6.90
		a	a	a	a
Effect of CPPU		5.59	6.67	6.45	
		a	a	a	

\*Different letters within column indicating of significant differences ( $p < 0.05$ )

Table (7) shows cultivars effect on protein percentage in tubers, Barcelona cultivar gave significant increase protein percentage in tubers reached to 5.32%, compared with lowest percentage in Montreal cultivar it gave 3.80% protein. For CPPU also had a significant difference in increasing the protein percentage in tubers at 5 mg L<sup>-1</sup> CPPU exceeded the control treatment and 10 mg L<sup>-1</sup> it was gave 4.92%, while the control treatment gave 4.42% while it was lowest protein percentage in tubers at 10 mg L<sup>-1</sup> reached 4.29%. As for the effect of gibberellic acid, the control superior on 5 , 10 mg L<sup>-1</sup>, protein percentage in tubers reached 4.86%. The protein percentage in tubers at a concentration 5 mg L<sup>-1</sup> gave a value 4.57%, and a concentration of 5 mg L<sup>-1</sup> gave a value 4.21%.

The same table shows the effect of the bilateral interaction between the treatments. The interaction between Barcelona cultivar spraying with 5 mg L<sup>-1</sup> , superior over all other treatments and gave the highest protein percentage in tubers reached to 6.13% compared to the lowest protein percentage when Montreal cultivar spraying with same concentration of CPPU, which gave 3.40. %. The interaction between gibberellic acid and cultivars, the interaction Barcelona cultivar + 0 or 10 mg L<sup>-1</sup> gave the highest value of protein percentage, which gave 6.02% and 5.99%, respectively, compared to other treatments and significantly differences them, the lowest values when we treated Laperla cultivar by 10 mg L<sup>-1</sup> gibberellic acid, reached to 3.40%. The bilateral interaction GA<sub>3</sub> and CPPU , the treatments 0 and 10 mg L<sup>-1</sup> gibberellic acid with 5 mg L<sup>-1</sup> CPPU were significantly differences to the rest of the other treatments, and the protein percentage in tubers of these two treatments reached 5.48% for both, while the treatment 10 mg L<sup>-1</sup> CPPU + 5 mg L<sup>-1</sup> GA<sub>3</sub>, gave 3.78%.

It is clear from the same table that the triple interaction between the treatments had a significant effect on this characteristic when we were treated Barcelona cultivar by 10 mg L<sup>-1</sup> GA<sub>3</sub> and 5 mg L<sup>-1</sup> CPPU gave. 8.98% protein in tubers, compared when we treated Montreal cultivar + 10 mg L<sup>-1</sup> CPPU + 0 mg L<sup>-1</sup> gibberellic acid, gave 3.06%.

The reason superiority of Laperla and Barcelona cultivars in some characteristics may be return to genetic factors for this cultivar and the extent to which it is affected by the environmental factors surrounding it during the growing season (Haverkort , 1991). The reason of increase in leaves number and protein percentage in tubers when spraying with CPPU may be due to cytokinins in delaying leaf aging , stimulating cell divisions by activation RNA and protein, as it has an important role in linking both the tRNA and the mRNA, and thus the proteins formation (Wasfi , 1995 ) . The increasing in leaves number and protein percentage when treated with gibberellic acid may be due to its role in stimulating , cell division and elongation, which return the increases in vegetative growth ( Al-Khafaji , 2014 ), and limited growth lateral sprout through its effect on the enzyme IAA-oxidase activity. This in turn auxin preserves and increases auxin proportion ( Al-Khafaji , 2014 ) (Wasfi , 1995 ) . The superiority of interactions bilateral and triple may be due to the effect of one single factors or their combined, and thus caused this superiority in those treatments compared to other treatments.

In this study, we recommend conducting further studies to test new potato cultivars and their suitability to the conditions of Salah Al-Din Governorate, and using higher concentrations of gibberellin and CPPU than those used in this study.

Table (7): Effect of CPPU and GA<sub>3</sub> in three cultivars on protine percentage in tuber (%).

Cultivar	GA <sub>3</sub>	CPPU 0	CPPU 5	CPPU 10	Cultivars+ GA <sub>3</sub>
Barcelona	0	7.66 b	5.62 e	4.80 fg	6.02 a
	5	3.37 m	3.78 jkl	4.70 fg	3.95 d
	10	4.49 gh	8.98 a	4.49 gh	5.99 a
Laperla	0	3.78 jkl	7.25 c	4.08 ij	5.04 b
	5	4.08 ij	5.00 f	6.23 d	5.10 b
	10	3.47 lm	3.47 lm	3.27 mn	3.40 f
Montreal	0	3.06 n	3.57 klm	3.88 ijk	3.51 ef
	5	3.88 ijk	2.65 o	4.19 hi	3.57 e
	10	4.80 fg	3.98 ij	4.19 hi	4.32 c
		Cultivars+ CPPU			Effect of cultivar
Barcelona		5.17 b	6.13 a	4.66 c	5.32 a
Laperla		3.78 e	5.24 b	4.53 c	4.51 b
Montreal		3.91 e	3.40 f	4.08 d	3.80 c
		GA <sub>3</sub> +CPPU			Effect of GA <sub>3</sub>
0		4.83 c	5.48 a	4.25 d	4.86 a
5		3.78 f	3.81 f	5.04 b	4.21 c
10		4.25 d	5.48 a	3.98 e	4.57 b
Effect of CPPU		4.29 c	4.92 a	4.42 b	

\*Different letters within column indicating of significant differences ( $p < 0.05$ )

## CONCLUSION

We conclude from this study that Laperla cultivar gives the highest leaves number and lowest sprouting percentage in tubers, while Barcelona cultivar gave highest protein percentage in tubers. The treatment with 5mg L<sup>-1</sup> GA<sub>3</sub> significantly affected the leaves number and protein percentage in tubers. The spraying with CPPU caused significant increases in leaves number, and

protein percentage in tubers. The bilateral and triple interaction caused significant increases in most of vegetative and yield traits taken for the study. and the best combination were giving the lowest yield of unmarketable tubers was Montreal cultivar treated by 10 mg L<sup>-1</sup> GA<sub>3</sub> + 0 mg L<sup>-1</sup> CPPU, which It gave 0.11 tons H<sup>-1</sup>.

## ACKNOWLEDGMENTS

The author gratefully acknowledges the staff of the Horticulture dep., Agriculture College ,Tikrit University for their technical and general support.

## REFRANCES

- Al- Mohammadi, Omar Hashem Musleh and Muhammad Sami Abdullah Al- Jumaili (2018) *effect of some foliar nutrients on the nitrogen content of potato yield of two cultivars in the spring harvest in Abu Ghraib* Third International Scientific Conference of Agricultural Sciences Kirkuk University Agricultural Sciences Journal special issue P:334 -340. <https://www.iasj.net/iasj/download/faeaf326108c3ed8>.
- Al-Assaf, Muhammad Ali, Zainal Saeed Abbas, and Ibtisam Nazim Hazim. (2013). *Effect of gibberellic acid spraying and nitrogen fertilizer application on two cases of Alaska potato seed*. Diyala Journal of Agricultural Sciences, 5 (2) P:384-395. (At Arabic). <https://journal.djas.uodiyala.edu.iq/index.php/dasj/article/view/2761/2278>
- Al-Khafaji, Maki Alwan. (2014). *Plant growth regulators and their applications and horticultural uses*. Baghdad . Iraq .(At Arabic).
- Al-Mohammadi, Omar Hashim Musleh and Ali Khalif Husein Al-Essawi (2015) *Spraying potato plants Solanum tuberosum L. Burin cultivar with some nutrients and their effect on growth and production* Al-Anbar Journal of Agricultural Sciences 13 (1) P:362 -372. (At Arabic). <https://www.iasj.net/iasj/pdf/93809b9c1dd51f64>
- Al-Mohammadi, Shaker Musleh and Fadel Musleh Al-Muhammadi (2010) *Statistics and experimental design* Dar Osama for publication and distribution. Amman Jordan P: 376.
- Al-Shammary, Mhammed Abraham Abbas and Al-Zobaai , Hussin Adday Awad . (2018) . *Response of two Varieties of potatoes Solanum tuberosum L. for inoculation with nonbivalent bio-fertilizers* . Journal of Education and Scientific Studies . vol.1(13) P:29-42. (At Arabic). <https://www.iasj.net/iasj/pdf/5d731ba7e0518ef2>
- El-Areiny , A.A.R. A.A. Alkharpotly A.A.A. Gabal and A.I.A. Abido (2019) *Potato yield and quality as affected by foliar application with cytokinin and salicylic acid* Journal Adv. Agric. Res. 24 (1) P: 1-34 . [https://journals.ekb.eg/article\\_163008\\_e2859ddd1e98a2b17b67590aa0dbabc2.pdf](https://journals.ekb.eg/article_163008_e2859ddd1e98a2b17b67590aa0dbabc2.pdf)

- El-Hamady , M.M. (2017) . *Growth and yield of potato (Solanum tuberosum L.) as influenced by soaking in GA<sub>3</sub> and potassium fertilizer rates* . Canadian Journal of agriculture and crops . 2 (1) P:50 – 59.  
[.https://www.onlinesciencepublishing.com/index.php/cjac/article/view/379/570](https://www.onlinesciencepublishing.com/index.php/cjac/article/view/379/570)
- El-Shray , A.M. and A.M. Hegaze (2010) *Influence of JA and CPPU on growth yield and  $\alpha$ -Amylase activity in potato plant Solanum tuberosum L.* Australian Journal of Basic and Applied Sciences 4(2) P:160-170.(At Arabic).  
<http://www.ajbasweb.com/old/ajbas/2010/160-170.pdf>
- Hassan, Ahmed Hassan Abdel Moneim. (1999). *Potatoes production*. Cairo University . Arab House for Publishing and Distribution. Cairo . The Egyptian Arabic Republic . P: 25-32 (At Arabic).
- Haverkort A. J., D. I. Langerak and M. Van de. (1991) . *Effects of gamma-irradiation of seed potatoes on numbers of stems and tubers*. Netherlands Journal of Agricultural Science (39) P:81-90 <https://library.wur.nl/ojs/index.php/njas/article/view/16543/15957>
- Ibrahim, Fadel Ragab (2018) . *Responses of two potato cultivars to humic acid fertilization*, Al-Rafidain Agriculture Journal, 46(2) P:54-61.  
[https://magrj.mosuljournals.com/article\\_161443\\_fad519739a91c1b4525ea5b3cae6e6be.pdf](https://magrj.mosuljournals.com/article_161443_fad519739a91c1b4525ea5b3cae6e6be.pdf)
- Mahmoud, Jawad Taha Hamid Khalaf Al-Salmani, and Ismail Khalil Ibrahim (2013) *Effect of organic and mineral fertilization on nitrogen phosphorus and potassium concentrations in potato leaves* Diyala Journal of Agricultural Sciences 5 (1) P: 61- 72.
- Michael, Nawzad Rashid Ali (2013) *The effect of plant cover and some seed treatments on the growth and production of potato crop Solanum tuberosum L. Cultivar Desiree in gypsum soil*. Master Thesis faculty of Agriculture Tikrit University Iraq (At Arabic).
- Wasfi, Imad Eddin (1995) *Growth and flowering regulators and their use in agriculture*. First edition. Academic library Dokki Cairo Egyptian Arabic Republic . 343-347. (At Arabic).
- Zain al-Din, Mohammad Ali and Iman Jaber Abd al-Rasol (2017) *Growth and production response potato plant Rudolph cultivar to spraying with gibberellin and nutrients* Al Furat Journal of Agricultural Sciences 9 (4) P:525- 536 (At Arabic).  
<https://jcoagri.uobaghdad.edu.iq/index.php/intro/article/view/232/167>