

## Response of two broccoli hybrids to spraying with selenium and brassinolide on some chemical properties

Lanja Muhammed shukur<sup>1</sup> Omar Hashim Muslah ALmohammedi<sup>2</sup>

<sup>1</sup>College of Agricultur. Kirkuk University

<sup>2</sup>College of Agricultur. Anbar University

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### Abstract

The experiment was carried out during the agricultural season (2021-2022) in one of the agricultural fields at the village of Tarjeel, Laylan district, Kirkuk governorate, and the experiment included the study of three factors, where the first factor was spraying with the element selenium in concentrations (20, 30, 40 mg L<sup>-1</sup>), the second factor was spraying with the hormone brassinolide in concentrations (50, 100, 150 mg.L<sup>-1</sup>) and the third factor was consisted of two hybrids (Parasio and Jassmine F1). The plants were sprayed in two batches, the first spray was 20 days after planting the seedlings on September computer, 2021 and the second spray was 20 days after the first spray. The experiment had three replicates, each with 14 experimental units. The experiment was conducted according to the Split Plot Design System within the R.C.B.D. The data were analyzed statistically according to the least significant difference L. S. D. and Duncan's multiple range test (P≤0.05) to compare the averages.

1. The results showed that spraying with the element selenium was not significantly effective, while the hormone brassinolide at a concentration of (100 mg L<sup>-1</sup>) was significantly superior in the characteristics of fresh and dry weights of the shoot, which amounted to (1.625 and 0.300 g), respectively, also the superiority of the brassinolide concentration (150 mg.L<sup>-1</sup>) was significant in the characteristics of percentages of carbohydrates, nitrogen, protein and selenium in the pink tablets with (7.528, 2.274, 14.065 and 0.207%), respectively.

2. It was revealed that Jassmine F1 hybrid was significantly superior, especially in the traits of shoot fresh weight (1.244 g), shoot dry weight (0.291 g), and the percentage of carbohydrates in the pink discs (6.789%), while Parasio hybrid was only significant in the trait of main disc fresh weight (0.756 g).

3. The bilateral interaction between Parasio hybrid and spraying with brassinolide at 150 mg L<sup>-1</sup> gave the superiority in shoot fresh weight (1.623 g), while the interaction between Parasio hybrid and selenium at 40 mg.L<sup>-1</sup> caused the superiority in shoot dry weight (0.329 g), whereas the hybrid Jassmine F1 interacted with selenium at 40 mg.L<sup>-1</sup> led to the superiority of weight of the main disc of the pink discs (0.930 g).

**Keywords:** Broccoli, brassinolide, selenium, chemical characteristics.

## استجابة هجينين من البروكلي للرش بالسليينيوم والبراسينولايد على بعض الصفات الكيميائية

نجه محمد شكور      عمر هاشم مصلح المحمدي

جامعة كركوك / كلية الزراعة      جامعة الانبار / كلية الزراعة

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## الخلاصة

تم تنفيذ التجربة في الموسم الزراعي (2021 – 2022) في احد الحقول الزراعية في قرية الترجيل ناحية ليلان في محافظة كركوك وتضمنت التجربة دراسة ثلاثة عوامل تضمن العامل الأول الرش بالسليينيوم بتركيز (20,30,40 ملغم لتر<sup>-1</sup>) والعامل الثاني الرش بالبراسينولايد بتركيز (50,100,150 ملغم لتر<sup>-1</sup>) والعامل الثالث الهجينين (Jasmine F1, Parasio). تم رش المعاملات بدفعتين الرش الأولى بعد 20 يوم من زراعة الشتلات في 2021/9/1 والرش الثانية بعد 20 يوم من الرش الأولى وتضمنت التجربة ثلاث مكررات ولكل مكرر 14 وحدة تجريبية وتم تنفيذ التجربة وفق نظام الألواح المنشقة ( Split Plot Design) ضمن تصميم القطاعات العشوائية الكاملة R.C.B.D و حللت البيانات احصائيا وفقا ل فرق معنوي L.S.D وعلى مستوى احتمال 0.05

1. وأظهرت ان الرش بعنصر السليينيوم لم يتفوق معنوياً في الصفات المدروسة أعلاه، في حين تفوق البراسينولايد بتركيز (100 ملغم لتر<sup>-1</sup>) بشكل معنوي في صفات الوزن الطري و الوزن الجاف للمجموع الخضري حيث بلغت (1.625 غم و0.300 غم) وايضاً تفوق البراسينولايد بتركيز (150 ملغم لتر<sup>-1</sup>) معنوياً في النسبة المئوية للكربوهيدرات والنسبة المئوية للنتروجين والنسبة المئوية للبروتين والنسبة المئوية للسليينيوم في الأقراص الزهرية (7.528% و2.274% و14.065% و0.207%) على التتابع .

2. ان الهجين Jasmine F1 تفوق معنوياً وسجل اعلى قيمة في (الوزن الطري للمجموع الخضري وبلغ 1.244 غم و الوزن الجاف للمجموع الخضري بلغ 0.291 غم والنسبة المئوية للكربوهيدرات في الأقراص الزهرية 6.789% في حين تفوق الهجين Parasio معنوياً في وزن القرص الرئيسي وبلغ 0.756 غم.

3. تفوق معاملة التداخل الثنائية بين الهجين Parasio والرش بالبراسينولايد بتركيز 150 ملغم لتر<sup>-1</sup> لصفة الوزن الطري للمجموع الخضري وبلغ 1.623 غم بينما تفوق الهجين Parasio والرش بالسليينيوم بتركيز 40 ملغم لتر<sup>-1</sup> في صفة الوزن الجاف للمجموع الخضري وبلغ 0.329 غم، في حين تفوق الهجين Jasmine F1 و معاملة المقارنة في وزن القرص الرئيس للأقراص الزهرية وبلغ 0.930 غم.

الكلمات المفتاحية: البروكلي، البراسينولايد، السليينيوم، الصفات الكيميائية.

## INTRODICTION

Broccoli *Brassica oleracea* var. *Italica*, is a winter vegetable, belongs to the cruciferous family Brassicaceae. It is an annual herbaceous plant which is morphologically similar to cauliflower. It is one of the few plants spread in Iraq. It was known more than 2,700 years ago in the Mediterranean region and in the regions of Asia Minor. The Romans knew it since ancient times. The Italians planted it and crossed it. It is believed that broccoli was transferred to the United States of America in 1806 AD (Ouda and Mahadeen, 2008). Broccoli is grown for its inflorescences, as it is the part that is eaten in the phase of the vegetative flowering buds with their thick, smooth stalks and is one of the richest vegetable crops of this family with high nutritional value and mostly used in therapeutic terms (Thapa and Rair, 2012).

The demand for the crop by consumers has increased recently, as the demand for it in the global markets because of its high nutritional value and distinctive taste, which was proven by the increase in the cultivated area of the crop and the increase in production significantly in all global markets (Zange *et al.*, 2011) as one of the crops with nutritional value. Each 100 gm of the fresh weight of the pink disc contains 5.9 gm of sugars, 0.3 gm of fat, 3.6 gm of protein, 32 calories and 89.1 gm of water. It is low in free fats, sodium, and calories. It works to protect the human body from the risk of cancer because it contains Glucoraphanin against stomach cancer, as well as the compound Indole-3-carbinol that prevents breast and colon cancer, in addition, that it improves liver function when eating more than one meal per week, to enhance the body's immunity and reduce the risk of cancer diseases by 45% (Griffin, 2006). The demand for the crop by consumers has increased recently, as this demand has been witnessed in the global markets due to its high nutritional value and distinctive taste, this was proven by the increase in the cultivated area of the crop and the significant increase in production in all global markets (Zange *et al.*, 2011).

Plant breeders aim to obtain hybrids and varieties with desirable agricultural characteristics for important agricultural crops through breeding and improvement programs and to know the extent to which they are adapted to the environmental conditions prevailing in that area in which the plant grows, so it requires the provision of new hybrids or varieties.

Selenium is one of the rare elements that have an effective role in raising the activity of the enzymatic antioxidants of water. It is also characterized by its association with amino acids and the formation of what is known as selenium proteins, which have the extraordinary ability to withstand cell membranes to water stress (Hassanuzzaman *et al.* 2010). Brassinolide is a plant steroid compound and is one of the latest discovered plant hormones, as it was previously believed that steroid hormones are found only in the animal kingdom as it is a complex hormonal system, but recent studies have proven its presence in concentrations in plants of the cruciferous family Brassicaceae, where many types of steroid hormones were found, which are similar to the structure of the hormone Testosterone in the watercress plant (Islam, 2014). Therefore, the aim of this study is to identify the effect of spraying with selenium and brassinolide on the growth characteristics and yield of two hybrids of broccoli; Parasio and Jasmine F1 in Kirkuk governorate.

### **Materials and methods:**

The experiment was carried out during the agricultural season (2021-2022) in one of the private agricultural fields in the village of Tarjeel, Laylan district, in Kirkuk governorate, which is located on the longitude (44.526016 E) and latitude (35.382831 N), and for the period September 1 to December 3, 2021.

### **Preparing the land and planting seedlings:**

The soil of the field was prepared by removing the growing bushes and large stones and then irrigating the field abundantly for the purpose of accelerating the growth of the remaining bushes and weeds and then removing them. Then the field land was divided into three replicates, each replicate contained the two hybrids randomly so that every 14 meters includes one hybrid, and each plant is considered an experimental unit. Between the blocks, 40 cm was left, and then animal manure was added to all experimental units. The drip irrigation system was used to irrigate the plants in the field. The experiment was conducted according to a split-plot design in a randomized complete block design R.C.B.D.

**Study treatments:**

1. Spray solutions The shoot systems of broccoli plants were sprayed with selenium and brassinolide in the following manner:

(a) T1: Selenium / Brassinolide 0 mg.L<sup>-1</sup> (Control)

(b) T2: Selenium 20 mg.L<sup>-1</sup>

(c) T3: Selenium 30 mg.L<sup>-1</sup>

(d) T4: Selenium 40 mg.L<sup>-1</sup>

(e) T5: Brassinolide 50 mg.L<sup>-1</sup>

(f) T6: Brassinolide 100 mg.L<sup>-1</sup>

(g) T7: Brassinolide 150 mg.L<sup>-1</sup>

2 . Broccoli hybrids:

(a) V1: Camel (Paraiso), the Japanese hybrid.

(b) V2: Camel (Jasmine), the American hybrid.

**Studied parameters:**

1. **Total shoot fresh weight (g):** Three of the selected plants were cut from the soil contact area with a knife after harvesting the side flower discs and then their vegetative sum for all plants was weighed by an electronic scale.
2. **Shoot dry weight (g):** The dry weight of the three cut plants was measured after drying their vegetative mass, weighed and then the average weight was calculated.
3. **Main syphilitic disc weight (g):** This was done by collecting the weights of the main syphilitic discs of each experimental unit and extracting their averages.
4. **Total carbohydrates% in the syphilitic discs:** The total carbohydrates in the syphilitic discs were estimated and the readings were recorded using a spectrophotometer type v-1 labEMC100 at a wavelength of 490 nm, according to (Dubois *et al.*, 1956).
5. **Total nitrogen% in the syphilitic discs:** The fruits were taken from each treatment and then cut into small pieces. The tablets were dried after being placed in perforated paper bags, and they were placed in an electric oven at a temperature of (65±5 °C) for 48 hours, after then, the fruits were crushed well and took 0.2 g of the dried samples, digested with concentrated sulfuric acid H<sub>2</sub>SO<sub>4</sub> and pyrochloric acid HClO<sub>4</sub> at a ratio of 1:4, respectively, according to (Johnson and Ullich 1959), the nitrogen was estimated using the microkiel Dahl device, according to (A. O. A. C., 1980).
6. **Protein% in the syphilitic discs:** The percentage of protein was estimated using the following equation:

Percentage of protein = % nitrogen x 6.25 (Mitrus *et al.*, 2003).

**7. Selenium% in the syphilitic discs:** Selenium was determined by Atomic Absorption Spectrophotometry

(Tracy and Möller, 1990 and Al-Wahaibi *et al.*, 2006).

**Results and discussion:**

**Shoot fresh weight (g)**

Table (1) shows the effect of selenium, brassinolide and their interactions on fresh weight (g) of broccoli plants. The results indicate that spraying with brassinolide at a concentration of 100 mg.L<sup>-1</sup> significantly increased the fresh weight of the shoot, which recorded the highest values (1.625 g).

Compared to hybrid computer, hybrid 2 showed significant superiority, in which the highest average shoot fresh weight (1.447 g) was recorded, while hybrid 1 recorded the lowest rate for this trait which amounted to 1.276 g.

In the binary interaction between hybrids and spraying, the significant effect of hybrid 1 and spraying with brassinolide at a concentration of 150 mg.L<sup>-1</sup> was shown, which recorded the highest value (1.623 gm) compared to hybrid 1 and spraying with brassinolide at a concentration of 50 mg.L<sup>-1</sup>, which recorded the lowest value (1.100 gm).

**Table (1) Effect of spraying with selenium and brassinolide and their interaction on average shoot fresh weight (g) in two hybrids of broccoli.**

Treatments	Level	Varieties		Average
		Hybrid 1	Hybrid 2	
Control		1.214	1.513	1.364
Selenium (mg.L <sup>-1</sup> )	20	1.263	1.338	1.301
	30	1.216	1.058	1.137
	40	1.139	1.441	1.290
Brassinolide (mg.L <sup>-1</sup> )	50	1.100	1.365	1.233
	100	1.379	1.871	1.625
	150	1.623	1.546	1.585
		0.176**		0.124**
Average Hybrid		1.276	1.447	
		0.169*		

**Shoot dry weight (g):**

Table (2) shows the effect of spraying selenium, brassinolide and their interaction effect on average shoot dry weight of two broccoli hybrids. It is clear that the effect of spraying with

brassinolide at a concentration of 100 mg.L<sup>-1</sup> on this trait was significant, which recorded the highest rate of 0.300 g compared to spraying with brassinolide at a concentration of 50 mg.L<sup>-1</sup> which recorded the lowest rate (0.207 g).

Regarding the effect of hybrid, the hybrid 2 outperformed by recording the highest rate shoot dry weight (0.291 g) compared to hybrid 1 giving the lowest rate for this trait (0.240 g).

In the bilateral interaction between hybrids and spraying with selenium, the significant effect was shown by hybrid 1 and spraying with selenium at a concentration of 40 mg.L<sup>-1</sup>, which recorded the highest value (0.329 g) compared to hybrid 2 and spraying with brassinolide at a concentration of 50 mg.L<sup>-1</sup>, which recorded the lowest rate (0.187 g).

**Table (2) Effect of spraying with Selenium, brassinolide and their interaction on average shoot dry weight (g) in two hybrids of broccoli.**

Treatments	Level	Varieties		Average
		Hybrid 1	Hybrid 2	
Control		0.258	0.253	0.255
Selenium (mg.L <sup>-1</sup> )	20	0.236	0.291	0.264
	30	0.285	0.312	0.299
	40	0.192	0.329	0.261
Brassinolide (mg.L <sup>-1</sup> )	50	0.187	0.228	0.207
	100	0.277	0.322	0.300
	150	0.241	0.299	0.270
		0.038**		0.027**
Average Hybrid		0.240	0.291	
		0.030*		

### Main syphilic disc weight (g)

As shown in (Table 3), the results indicate that the control treatment gave the highest average for the main syphilic disc weight (g), which amounted to 0.864 g, compared to spraying with brassinolide at a concentration of 50 mg.L<sup>-1</sup>, which amounted to 0.691 g. The results also show that the hybrid 1 was significantly superior, as it recorded the highest rate of 0.756 g, compared to hybrid 2 which recorded the lowest rate for this trait (0.740 g).

The effect of the binary interactions between treatments and hybrids showed a significant effect of the control treatment and hybrid 2, which gave the highest rate (0.930 g), compared to spraying with brassinolide at a concentration of 50 mg.L<sup>-1</sup> and hybrid 2 which recorded the lowest value (0.525 g).

**Table (3) The effect of spraying with Selenium, brassinolide and their interaction on main disc weight (g) in the two hybrids of broccoli.**

Treatments	Level	Varieties		Average
		Hybrid 1	Hybrid 2	
Control		0.797	0.930	0.864
Selenium (mg.L <sup>-1</sup> )	20	0.640	0.735	0.688
	30	0.824	0.872	0.848
	40	0.759	0.654	0.706
Brassinolide (mg.L <sup>-1</sup> )	50	0.856	0.525	0.691
	100	0.716	0.821	0.769
	150	0.700	0.645	0.673
		0.102**		0.072**
Average Hybrid		0.756	0.740	
		Ns		

#### Total carbohydrates% in the syphilic discs

The results of Table (4) show a significant increase in the percentage of total carbohydrates in the syphilic discs when the plants were sprayed with a concentration of 150 mg.L<sup>-1</sup> of brassinolide, and the highest rate for this trait was 7.528%, compared to the comparison treatment, which recorded the lowest rate for this trait (5.693%).

In the same table, we can see that hybrid 2 is significantly superior in this trait, amounting to 6.789%, compared with hybrid 1, which recorded the lowest rate of this trait which amounted to 6.582 %. The dual interaction between the two hybrids agent and spraying with brassinolide that hybrid 2 and spraying with brassinolide at a concentration of 150 mg.L<sup>-1</sup> had a significant effect on the total carbohydrate trait which gave the highest average for this trait amounted to (7.724 %) compared with hybrid 1 and the comparison treatment which recorded the lowest value amounted to (5.267%).

**Table (4) Effect of spraying with Selenium, brassinolide and the interaction on total carbohydrates% in two hybrids of broccoli.**

Treatments	Level	Varieties		Average
		Hybrid 1	Hybrid 2	
Control		5.267	6.118	5.693
Selenium (mg.L <sup>-1</sup> )	20	6.171	6.700	6.436
	30	6.899	6.357	6.628
	40	6.776	6.725	6.751
Brassinolide (mg.L <sup>-1</sup> )	50	6.706	7.082	6.894
	100	6.925	6.819	6.872
	150	7.332	7.724	7.528
		0.284**		0.201**
Average Hybrid		6.582	6.789	
		0.207*		

#### Total nitrogen% in the syphilic discs

The results of table (5) show that brassinolide at a concentration of 150 mg.L<sup>-1</sup> had a significant effect on this trait, as the highest rate of nitrogen (2.274%) in plants was recorded, while the comparison treatment recorded the lowest value (1.211%). No significant differences were observed between the two hybrids due to selenium and brassinolide. The results of the binary interaction between the two hybrids and sprays showed the significant superiority of hybrid 2 and spraying with brassinolide at a concentration of 150 mg.L<sup>-1</sup>, which recorded the highest rate of this trait (2.557%) compared with hybrid 1 and the comparison treatment that recorded the lowest rate (1.199%).

**Table (5) Effect of spraying with Selenium, brassinolide and their interaction on total nitrogen% in two hybrids of broccoli.**

Treatments	Level	Varieties		Average
		Hybrid 1	Hybrid 2	
Control		1.199	1.223	1.211
Selenium (mg.L <sup>-1</sup> )	20	1.523	1.570	1.547
	30	1.644	1.674	1.659
	40	1.857	1.758	1.808
Brassinolide (mg.L <sup>-1</sup> )	50	1.757	1.735	1.746
	100	1.912	1.804	1.858
	150	1.991	2.557	2.274
		0.124**		0.088**
Average Hybrid		1.698	1.760	
		Ns		

### Protein% in the syphilic discs

It is clear from the results of Table (6) that spraying the vegetative parts of the plants had significantly affected on protein% of the discs, when brassinolide at a concentration of 150 mg.L<sup>-1</sup> was used, which gave the highest rate (14.065%) compared to the comparison treatment, which recorded the lowest rate for this trait that amounted to (8.195%).

Selenium and brassinolide sprays solely caused no significant differences in protein% values of broccoli discs. The dual interaction between the two hybrids and sprayings caused significant differences, both hybrids were significantly interacted with brassinolide at a concentration of 150 mg.L<sup>-1</sup>. The highest value for this trait was 15,690% compared with what was recorded by hybrid 1 and the comparison treatment that gave the lowest rate for this trait, which was 7.490%.

**Table (6) Effect of spraying with Selenium, brassinolide and their interaction on protein% of the syphilitic discs in two hybrids of broccoli.**

Treatments	Level	Varieties		Average
		Hybrid 1	Hybrid 2	
Control		7.490	8.900	8.195
Selenium (mg.L <sup>-1</sup> )	20	9.180	10.270	9.725
	30	10.280	10.460	10.370
	40	11.600	10.990	11.295
Brassinolide (mg.L <sup>-1</sup> )	50	10.980	10.840	10.910
	100	11.580	11.950	11.765
	150	12.440	15.690	14.065
		1.153**		0.815**
Average Hybrid		10.507	11.300	
		Ns		

### Selenium% in the syphilitic discs

The results of Table (7) indicate that spraying the vegetative parts of plants is significantly affected when using brassinolide at a concentration of 150 mg.L<sup>-1</sup>, which recorded the highest average for the percentage of selenium in the syphilitic disc which was 0.207% compared to the comparison treatment, which recorded the lowest value for this trait as 0.087%. While no significant differences were observed between the two hybrids for all the concentrations of selenium and brassinolide used.

As for the bilateral interaction between the hybrids and sprays, the effect of the hybrid and brassinolide at the concentration of 150 mg.L<sup>-1</sup> was significant in the percentage of selenium, where the highest rate (0.213%) was recorded compared to the hybrid 2 and the comparison treatment, which recorded the lowest rate for this trait that amounted to 0.084%.

**Table (7) Effect of spraying with Selenium, brassinolide and their interaction on selenium% of pink discs in two hybrids of broccoli.**

Treatments	Level	Varieties		Average
		Hybrid 1	Hybrid 2	
Control		0.089	0.084	0.087
Selenium (mg.L <sup>-1</sup> )	20	0.129	0.122	0.125
	30	0.111	0.113	0.112
	40	0.137	0.139	0.138
Brassinolide (mg.L <sup>-1</sup> )	50	0.179	0.189	0.184
	100	0.162	0.196	0.179
	150	0.201	0.213	0.207
		0.014**		0.010**
Average Hybrid		0.144	0.151	
		Ns		

The results indicate that the Jassmine hybrid was superior in the characteristics of the fresh and dry weight of the vegetative group and the percentage of carbohydrates in the syphilitic disc, the reason may be due to the difference between the hybrids in the genetic factors that control these traits and their susceptibility to respond to the environmental conditions prevailing in the experimental area (Zaki *et al.*, 2015). It should be noted that the genetic content of the hybrid varies. Each hybrid expresses the trait differently depending on the genes responsible for the absorption of nutrients, and these elements are: nitrogen, phosphorous and potassium. These traits are positively related to the traits of nutrients in the vegetative system, which means that the increase in the percentage of nutrients in the leaves led to an improvement in the characteristics of vegetative growth, which in turn provides the heads with nutrients and makes them contain a high percentage of dry matter, soluble solids, protein, sulfur, amines and acids these results agreed by Abd Al-Shammary *et al.* (2019) and Mahmood and Salihi (2020)

It is believed that the effect of spraying with selenium and brassinolide has a role in the production of glycoprotein compounds called glucosinolate similar to isoprenoid compounds. Which is involved in the pathway of the synthesis of mevalonic acid and the production of gibberellins, and selenium as an antioxidant has an interfering role in protecting gibberellin from the oxidation process, which worked to influence most of the chemical properties measured (sams *et al.*, 2011) and these results agreed by Shahbaz and Ashraf (2007) and Hussein and Hussein (2016) and Al-Shammari (2017) Muhammad *et al.* (2019).

**CONCLUSION:**

- Through the experiment, we reached that the use of selenium in these concentrations did not have a significant effect on the above studied traits in both hybrids.
- As well as the behavior of the hormone brassinolide in a positive and significant effect on the characteristics studied above, and it was recommended to use the brassinolide in different concentrations to get better results.

The results indicate that we obtained a good yield in terms of both quantitative and qualitative terms, which indicates the importance of relying on the two hybrids Jassmine and Paraiso for the cultivation of the broccoli crop in Kirkuk Governorate, with a recommendation to conduct another future trust to approach this hybrid with another new hybrid entering the country for the first time

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