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Response of two cauliflower cultivars *Brassica oleracea* var. botrytis to foliar spray of growth stimulant Atonic in growth and yield

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Abstract: The study was conducted at the Agricultural Research Station, College of Agriculture, University of Basrah, in the Karmat Ali area during the winter agricultural season of 2022-2023. To study the response of two cauliflower cultivars Alnahar and White flake to spray with the growth stimulant Atonic at the concentrations 0, 1.5, and 3 ml L^{-1} on the growth and yield. The results showed that the Alnahar cultivars were significantly superior in leaf area, curd weight and total yield, in contrast, the White flake cultivars were significantly superior in the fresh and dry weights of the plant, its content of chlorophyll and carotene pigments, curd diameter, dry matter percentage and total soluble solids in the curd. Spraying with the growth stimulant Atonik at a concentration of 3 ml L^{-1} led to a significant increase in the plants number of leaves, fresh and dry plant, curd weight, total yield, dry matter percentage and total soluble solids in the curd. The interaction between the two factors significantly affected some growth traits. Vegetative and quantitative and qualitative yield components: Alnahar plants sprayed with Atonik growth stimulant at a concentration of 3ml L^{-1} gave the highest curd weight and total yield of 2.012 kg and 53.11 tons ha^{-1}, respectively.

Keywords: Atonik growth stimulant; Cauliflower; Cultvars; Yield.

Introduction

Cauliflower (*Brassica oleracea* var. botrytis) is an important winter vegetable crop from the Brassicaceae family. It is grown for its curd, the edible part of the plant. It consists of the flower buds before they open, along with the fleshy, enlarged flower stalks, and has a high nutritional and medicinal value due to its content of vitamins (B6, B5, K, C), fiber, folic acid, and minerals (P, Mg, Fe, Zn, K) (Kemble *et al.,* 2024). It also contains polyphenolic antioxidantcompounds (Ahmed & Ali ,2013). To help increase production per unit area, attention must be paid to agricultural service operations and cultivating of new cultivate and genetic compositions with high productivity and good quality.

Several studies were conducted on the extent of the effect of cauliflower cultivars and the differences between them in many characteristics such as vegetative growth and yield. Abdullah & Al-Maliki (2013) obtained when planting Two cauliflower cultivars, Ponderet and Neblina, under desert conditions in the Al-Zubair district, the Ponderet cultivar was significantly superior in the

diameter of the inflorescence curd and the Neblina cultivar, Al-Hayaly & Ibrahim (2023) obtained when planting two cauliflower cultivars, Ice ball and Narges, under the conditions of Mosul city, the Narges cultvar was significantly superior in the number of leaves, leaf area, percentage of dry matter and Chlorophyll content of leaves, while the Ice ball cultivar was significantly superior in plant height. Hafez *et al.,* (2023) When planting five cauliflower hybrids under Egyptian conditions (Raoul, Fargo, Mexico, Solid snow, Barkha),the hybrid Fargo was significantly superior in plant height, number of leaves, leaf area and total yield compared to other hybrids for both seasons of the experiment, while the hybrid Mexico was significantly superior in leaf content of total chlorophyll and carotene compared to other hybrids for both seasons of the experiment. Yousif & Saeid (2023) noted when planting two broccoli cultivars *Brassica oleracea* var.italic, namely Ajjasi, Wisdom under the conditions of Dohuk city in Iraqi Kurdistan, the Wisdom cultivar was significantly superior in total yield, yield per plant and early yield compared to Ajjasi cultivar.

Foliar feeding with artificial growth regulators improves growth and production in quantity and quality. One of them is the growth regulator Atonik. This aromatic nitrogen compound causes an increase in vital and biochemical activities without causing any deformity or toxicity on the surfaces of the plants treated with it. Chemically, it consists of Sodium ortho-nitrophenolate at a concentration of 2%, Sodium para-nitrophenolate at a concentration of 3%, and Sodium 5-nitroguaiacolate at a concentration of 1%, according to the Japanese producing company Asahi Chemical. The plant parts easily absorb it and have the property of accelerating the formation of roots, their growth and branching, and increasing production, as it increases the flow of plant juice, which gives additional strength and vitality to the plant cells. It also increases the absorption of nutrients by the plant, such as potassium, calcium, and magnesium, and increases the process of photosynthesis (Przybysz *et al.,* 2014).

Many studies have indicated the role of atonic in increasing the growth and productivity of vegetable crops. El shabrawy (2009) indicated that spraying zucchini plants Cucmis sativus with different concentrations of atonic (0, 0.25, 0.5) ml L^{-1} caused both concentrations a significant increase in plant height, number of leaves, fresh and dry weight of the plant, fruit weight and total yield compared to the control treatment. Abdalla *et al.,* (2015) noted spraying cabbage plants *Brassica oleracea* var.Capitata with different concentrations of atonic (0,100, 200)ml L^{-1} caused the high concentration of 200ml L^{-1} to increase the number of leaves and theie weight significantly, and both concentrations caused a significant increase in head weight and total yield, However, they did not significantly affect the percentage of total soluble solids.

Zrar *et al.,*(2022) showed that foliar spraying of pea plants Pisum sativum with different concentrations of atonic (0,0.2, 0.4, 0.8, 1)ml L^{-1} resulted in a significant increase in the number of leaves, while the concentration of 0.2ml L^{-1} caused a significant increase in the fresh weight of the plant, the total chlorophyll content of the leaves, and the total yield. Almusawi (2023) obtained when spraying sweet pepper plants Capsicum annuum with concentrations of atonic (0, 25, 50, 75) mg L^{-1}, the high concentration of 75 mg L^{-1} caused a significant increase in plant length, number of branches, leaf area, dry weight of the plant,

and leaf content of Chlorophyll Spad. Due to the lack of studies on the effect of atonic stimulants on the growth and yield of cauliflower, this study was conducted.

Materials & Methods

The field experiment was carried out at the Agricultural Research Station of the College of Agriculture - University of Basra, Karma Ali site, during the winter season 2022-2023, to study the response of two cauliflower cultivars to foliar spraying with the growth stimulant Atonik in growth and yield. The planting was carried out after preparing the land, levelling it and preparing it into three lines with a length of 15 meters and a distance between one line and another of 0.80 meters. The seedlings were transferred after 45 days on 10/25/2023, as the line was divided into 6 experimental units with a length of 2.5 meters. The planting lines were covered with a black polyethylene cover to maintain soil moisture, prevent weed growth and warm the soil (Alhamrani *et al*., 2019). The seedlings were planted at a distance of 50 cm between one seedling and another. All agricultural operations required for crop cultivation, including weeding, irrigation, fertilization and control, were carried out on all experimental units. The experiment was implemented as a factorial according to the design of complete randomized sectors and with three replicates. (R.C.B.D.) Complete Block Design Randomized.

The experiment included two factors, the first factor included two cauliflower cultivars (Alnahar, White Flake),while the second factor included spraying with three concentrations of the growth stimulant Atonik at concentrations of(0, 1.5, 3) ml L^{-1}, so the number of treatments became 6 factorial treatments, which are the interaction between the two cauliflower cultivars with foliar spraying with three concentrations of Atonik and with three replicates, so the number of experimental units is 18 experimental units. The treatments began three weeks after planting and three times, with every two weeks between one spray and another.

Table (1): Some chemical and physical characteristics of the study soil

Attribute		Value	Unit
pH		7.7	
ECE		5.22	ds m-¹
Available Phosphorus		38.8	mg kg-¹
Total Nitrogen		0.23	g kg-¹
Ready Potassium		101.20	mg kg-¹
solube positive ions	Calcium	16.5	millimoles l-¹
	Magnesium	11	
	Sodium	21.3	
	Bicarbonates	13.6	
	Sulfates	18.5	
	Chlorides	28.0	
Soil separators	Sand	593	G kg^{-1}
	Silt	271.5	
	Clay	135.5	
Soil texture		sandy loam	

Experimental measurements were taken at the end of the season and included vegetative growth traits including plant height, number of leaves, leaf area Dm^2 the total area measured according to the method described by Weston & Weston 1953, fresh and dry weight of the plant, total chlorophyll and carotene mg 100 g^{-1} fresh weight, total chlorophyll pigment in green leaves was estimated according to the method described by Goodwin (1976) and carotene mg 100 g^{-1} fresh weight, according to Zealander *et al*.,(1974). Also, the dry matter of the floral curd and the percentage of total dissolved solids in the floral curd was measured by placing a part of it in a hand press and then several drops of the juice were taken and placed in a Hand refractometer. Also, the diameter of the floral curd and its weight and the total yield of the plant were measured.

The average results were analyzed statistically using the statistical program GenStat, V. 10.3 (2011), and the modified Least Significant Differences Test (L.S.D.) was used to compare the averages at a probability level 0.05.

Results & discussion

Table (2) showed that the two cultivars differed significantly in leaf area and fresh weight of the vegetative group, as the Alnahar cultivar was significantly superior in increasing leaf area and by an increased rate of 9.37 compared to the White flake cultivar At the same time the latter cultivars were significantly superior in fresh weight of the vegetative group and by an increased rate of 13.45 compared to the Alnahar cultivars. The difference between the two cultivars may be attributed to the genetic factors specific to them and their response to the environmental factors surrounding the plants (Al-Furtuse *et al*., 2019). These results are consistent with what was obtained by (Alhaly & Ibraheem, 2023, Hafez *et al*., 2023). The same table shows that foliar spraying of the growth regulator Atonik had a significant effect on all the traits under study, as spraying at a concentration of 1.5ml L^{-1} caused a significant increase in plant height and leaf area and by an increased rate of (20.30, 5.88). (5.89,17.70) % compared to the comparison treatment and a concentration of 3 ml L^{-1}, respectively, while spraying with concentration 3 ml L^{-1} significantly increased the number the vegetative groups leaves and dry weight compared to the comparison treatment and an increased rate of (7.12,91.61) %, respectively. The spraying treatment with a concentration of 1.5ml L^{-1} did not differ significantly from the number of leaves, in contrast the concentration of 1.5ml L^{-1} significantly exceeded the dry weight of the vegetative group compared to the comparison treatment and had an increase rate of 86.29. As for the fresh weight of the vegetative group, the effect increased significantly with increasing the spray concentration, as the concentration 3ml L^{-1} significantly exceeded the concentration and an increased rate of (23.16,6.87)% compared to the comparison treatment and concentration 1.5 ml L^{-1}, respectively, and in turn, the concentration 1.5ml L^{-1} significantly exceeded the comparison treatment and an increased rate of 15.24%.

The moral superiority of spraying with Atonik growth regulator in vegetative growth indicators may be attributed to the chemical composition of the regulator, which includes compounds with the ability to divide plant cells and increase their chlorophyll content, which in turn increases the efficiency of the photosynthesis process and the speed of plant sap flow, in addition to its ability to increase the level of internal hormones (Haron, 2001). It also helped absorb necessary nutrients, which led to increased cell division (Guo *et al.,* 1994), which was positively reflected in increasing vegetative growth indicators. These results are consistent with what was obtained by (El-Shabrawy, 2009 in zucchini, Abdalla *et al*., 2015 in cabbage, AL-Rikabi & AL-Zubaidy,2021 in cucumber, Zara *et al*., 2022 in peas, and Almusawi 2023 in sweet pepper). The interaction between the two factors showed a significant effect on the leaf area and the fresh and dry weights of the vegetative group, as the sprayed Alnahar cultivar plants gave Atonik at a concentration of 1.5ml L^{-1} the largest leaf area of 59.48 Dcm^{-2}, while the White flake plants sprayed at a concentration of 3ml L^{-1} gave the lowest leaf area of 41.68 Dcm^{-2} The Alnahar plants sprayed at a concentration of 3ml L^{-1} gave the largest values for the fresh and dry weights of

the vegetative group, reaching 1.451 kg and 102.12 g, respectively, In contrast the unsprayed Alnahar plants gave the lowest values of 0.901 kg and 39.54 g, respectively.

Table (2): Effect of cultvars and spraying with Atonik growth regulator and their interaction on some vegetative growth indicators of cauliflower plants

Treatments			Plant height (cm)	numbers of leaves (cm)	Leaves area (dm^2)	Fresh weight of vegetative group (kg)	Dry weight of vegetative group (g)
Average cultvars effect		Nahar	60.78	19.33	49.60	1.241	80.41
		White flake	61.78	19.22	45.35	1.408	82.30
LSD 0.05			N. S	N. S	1.29	0.051	N.S
Average effect of Atonik concentrations gL^{-1}		0	55.00	18.67	48.14	1.174	51.07
		1.5	66.17	19.17	50.98	1.353	95.14
		3.0	62.67	20.00	43.31	1.446	97.86
LSD 0.05			3.053	0.88	1.58	0.063	2.80
Effect of interaction between cultivar and Atonik concentrations	Nahar	0	54.67	18.67	44.37	0.901	39.54
		1.5	65.33	19.33	59.48	1.369	99.56
		3.0	62.33	20.94	44.94	1.451	102.12
	White flake	0	55.33	18.67	51.90	1.446	62.59
		1.5	67.00	19.00	42.48	1.338	90.71
		3.0	63.00	20.00	41.68	1.441	93.59
LSD 0.05			N. S	N. S	2.24	0.089	3.97

Table (3) shows that the two cultivars differed significantly in the content of their leaves of total chlorophyll and carotene pigments, as the White Flake cultivar was significantly superior in increasing these two pigments by an increased rate of (6.51, 8.57) %, respectively. This may be attributed to the genetic factors specific to the cultivars and their response to environmental factors. This result is consistent with what was obtained by (Mijwel & Ridha 2021, Alhaly & Ibraheem, 2023, Hafez *et al.,* 2023).

Table (3): Effect of cultvars and spraying with Atonik growth regulator and their interaction on Photosynthetic pigments of cauliflower plants

Treatments			Total chlorophyll in mg $100g^{-1}$ fresh weight	Carotene in leaves mg $100g^{-1}$ fresh weight
Average cultvars effect		Nahar	8.75	0.1481
		White flake	9.32	0.1608
LSD 0.05			0.36	0.0066
Average effect of Atonik concentrations gL^{-1}		0	8.90	0.1482
		1.5	9.10	0.1582
		3.0	9.10	0.1570
LSD 0.05			N. S	0.0082
Effect of interaction between cultivar and Atonik concentrations	Nahar	0	8.90	0.1482
		1.5	8.88	0.1533
		3.0	8.88	0.1480
	White flake	0	9.31	0.1533
		1.5	9.32	0.1650
		3.0	9.33	0.1660
LSD 0.05			N. S	N. S

The same table shows that spraying with the growth regulator Atonik had a significant effect on increasing the content of the leaves of the carotene pigment, as both

concentrations of 1.5 and 3ml L^{-1} caused a significant increase in this pigment of (6.74, 5.93) % compared to the comparison treatment, respectively. The increase may be due to the role of Atonik in activating the photosynthesis process, which leads through a series of reactions to Formation of Isoprenoids, which are units of Isoprene, several of which combine through a series of reactions to form carotene (Kazem,1985). The interaction between the two factors did not significantly affect these two pigments.

Table (4) indicates that the two cultivars differed significantly in the components of the quantitative and qualitative yield, as the White flake cultivar was significantly superior in increasing the diameter of the flower disc, the percentage of dry matter, and the percentage of total dissolved solids in it, with an increased rate of (3.82, 33.47, 14.77)% compared to the Alnahar cultivar, respectively, while the Alnahar cultivar was significantly superior in increasing the weight of the curd and the total yield, with an increased rate of 19.85% for each of them compared to the White flake cultivars. The difference between the two cultivars may be attributed to the genetic factors specific to the cultivars and its response to environmental factors. This result is consistent with what was obtained by (Mijwel & Ridha 2021, Yousif & Saeid 2023, Hafez *et al*., 2023). It appears from the same table that foliar spraying with the growth regulator Atonik had a significant effect on all the traits under study, except for the diameter of the flower disc, as the spray concentration of 3ml L^{-1} caused a significant increase in The weight of the curd and the total yield compared to the comparison treatment and with an increased rate of 20.14% for each of them. The spraying treatment with a concentration of 1.5ml L^{-1} did not differ significantly from them, At the same time the effect increased significantly with increasing the spraying concentration in the characteristic of the percentage of dry matter in the flower curd, as the concentration of 3ml L^{-1} was significantly superior and with an increased rate of (25.98, 11.56)% compared to the comparison treatment and the concentration of 1.5 ml L^{-1}, respectively

Table (4): Effect of cultvars and spraying with Atonik growth regulator and their interaction on Quantitative and qualitative components of cauliflower plants.

Treatments			Curd diameter (cm)	Curd weight (kg)	Total yield t ha^{-1}	Dry matter content (%)	Total dissolved solids content (%)
Average cultvars effect		Nahar	18.84	1.636	43.06	7.11	4.67
		White flake	19.56	1.365	36.03	9.49	5.36
LSD 0.05			**0.59**	**0.105**	**2.77**	**0.53**	**0.18**
Average effect of Atonik concentrations gL^{-1}		0	18.84	1.375	36.29	7.35	4.86
		1.5	19.56	1.475	38.74	8.30	4.83
		3.0	19.40	1.652	43.61	9.26	5.36
LSD 0.05			**N. S**	**0.129**	**3.39**	**0.65**	**0.22**
Effect of interaction between cultivar and Atonik concentrations	Nahar	0	18.58	1.233	32.54	5.88	4.66
		1.5	20.17	1.664	43.53	7.02	3.83
		3.0	20.49	2.012	53.11	8.43	5.53
	White flake	0	19.11	1.517	40.05	8.81	5.06
		1.5	18.95	1.286	33.95	9.57	5.83
		3.0	18.31	1.292	34.11	10.09	5.20
LSD 0.05			**1.02**	**0.182**	**4.80**	**N.S**	**0.31**

In turn, the concentration of 1.5ml L^{-1} was significantly superior compared to the comparison treatment with an increase of

12.92%. As for the percentage of total dissolved solids in the curd, the spray concentration of 3ml L^{-1} was significantly superior compared to the comparison treatment and the concentration of 1.5ml L^{-1} and by an increase of (10.28, 10.97) %, respectively. The significant increase may be attributed to the role of the growth regulator Atonik in increasing the vegetative growth indicators in the plant Table (2) and increasing the products of the photosynthesis process, which was positively reflected in increasing the quantitative and qualitative yield. These results are consistent with what was obtained by (El-Shabrawy,2009 in zucchini squash, Abdalla, *et al.,* 2015 in cabbage, Zara *et al.,* 2022 in peas, and Almusawi, 2023 in sweet pepper). As for the interaction between the two factors, showed an effect Morally, in the studied traits, except for the percentage of dry matter in the curd, as Alnahar plants sprayed with Atonik at a concentration of 3ml L^{-1} gave the highest values for the diameter of the floral curd and its area and the total yield reached (20.49 cm, 2.012 kg, 53.11 tons ha^{-1}), respectively, while White flake plants gave the highest percentage of total soluble solids in the curd, reaching 5.83%. The lowest diameter of the floral curd was in White flake plants sprayed at a concentration of 3 ml L^{-1}, reaching 18.31 cm, and the lowest weight of the floral curd and the total yield were in Alnahar plants that were not sprayed, reaching 1.233 kg and 32.54 tons ha^{-1}, respectively, while Alnahar plants sprayed with Atonik at a concentration of 1.5ml L^{-1} gave the lowest percentage of total soluble solids in the curd, reaching 3.83%.

Conclusions

Can conclude from this study that to obtain abundant production of cauliflower plants grown in Basrah City, we recommend planting the Alnahar cultivars and spraying it with the growth regulator Atonik at a concentration of 3 ml $L^{-1.}$

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Contributions of authors

Z.A. Al-sudani: Conceptualization, experimental design, fieldwork supervision, data collection, and writing – original draft.

O.A. Ibrahim: Laboratory analysis , resources management, and critical revision of the manuscript.

A.A. Abdulla: Statistical analysis, interpretation of results, data visualization, and writing – review & editing.

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استجابة صنفين من القرنابيط *Brassica oleracea* var.botrytis للرش الورقي بمحفز النمو Atonik في النمو والحاصل

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المستخلص: اجريت الدراسة في محطة البحوث الزراعية التابعة لكلية الزراعة جامعة البصرة في منطقة كرمة علي خلال الموسم الزراعي الشتوي 2022–2023 لدراسة استجابة صنفين من القرنابيط Alnahar و White flake للرش بمحفز النمو Atonikبتراكيز (0,1.5.3)مل لتر$^{-1}$ في النمو والحاصل.اظهرت النتائج تفوق صنف Alnahar معنويا في المساحة الورقية و وزن القرص الزهري و الحاصل الكلي و تفوق الصنف White flake معنويا في الوزنين الطري و الجاف للنبات ومحتواه من صبغتي الكلوروفيل و الكاروتين و قطر القرص الزهري ونسبة المادة الجافة والنسبة المئوية للمواد الصلبة الذائبة الكلية في الاقراص, كما ادى الرش بمحفز النمو Atonik بتركيز 3 مل لتر$^{-1}$ زيادة معنوية في عدد الاوراق والوزنين الطري و الجاف للنبات و وزن القرص الزهري و الحاصل الكلي ونسبة المادة الجافة والنسبة المئوية للمواد الصلبة الذائبة الكلية في الاقراص و اظهر التداخل بين العاملين تاثيرا معنويا في بعض صفات النمو الخضري ومكونات الحاصل الكمي و النوعي اذ اعطت نباتات صنف Alnahar المرشوشة بمحفز النمو Atonik بتركيز 3 مل لتر$^{-1}$ اعلى وزن للقرص الزهري و الحاصل الكلي بلغ 2.012 كغم و 53.11 طن هكتار$^{-1}$ وعلى التوالي.

الكلمات المفتاحية: نبات القرنابيط، اصناف، محفز النمو Atonik, الحاصل.