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Effect of foliar application of seaweed extract and cytokinin on growth and yield of cauliflower plant (*Brassica oleracea var. botrytis*)

ABSTRACT

The experiment was conducted at the research station of the Department of Horticulture and Landscape - College of Agriculture - Tikrit University for the 2019-2020 season, to study the effect of spraying organic fertilizer (seaweed extract) and growth regulator (cytokinin) on the growth and yield of the cauliflower plant. The experiment included two factors: spraying seaweed extract in three levels, (S0) 0 ml l-1 as a control, (S1) 3.3 ml l-1, (S2) 6.6 ml l-1. The second factor was spraying cytokinin in three levels: (G0) 0 mg l-1 as a control, (G1) 10 mg l-1, (G2) 40 mg l-1. The experiment was carried out according to the Randomized Complete Block Design R.C.B.D with three replications and the averages were compared according to Duncan's multiple range tests at a probability level of 5%.The results showed that spraying seaweed extract (S2) increased the percentage of phosphorus, potassium and boron significantly compared with all other treatments. Meanwhile, the application of cytokinin did not affect significantly on all the studied characteristics. The interaction traetments caused significant effect in fresh weight of leaf, phosphorus%, and potassium% with S0G0, S2G2, and S2G0 respectively compared with S2G0, S0G0, and S0G2 treatments which had the lowest values for previous characteristics respectively.

INTRODUCTION

The Botrytis group of *Brassica oleracea* which most commonly called cauliflower belongs to the mustard family (Brassicaceae). It is a cool-season crop that does not resist heat very well, so it is grown in Iraq in winter. Cauliflower considers as two stages grown period like other several plants in this family, it is annual herbal plant with some varieties, and biannual (vegetation growth in first stage and flowering in second stage) in other varieties sometimes depends on region and environment in field area (Viliam and Alana, 2007). Cauliflower characterized by its high nutritional value such as vitamins magnesium, calcium, zinc, sodium, iron, and high quality proteins (USDA, 2013). Moreover, the edible part in this plant is the curd which may called "head", Each 100 g of the curd contains: 9.10 g moisture, 27 calories, 2.7 g proteins, 0.2 g fat, 5.2 g carbohydrates, 0.1 g fibers, 0.9 g water, 56 mg phosphorus, 25 mg calcium and 1.1 mg iron, as well as vitamin A, C and E, and ascorbic acid (Watt and Merril, 1963), enzymes (Abdul–Rahman, 2009), and antioxidants such as glutathione, which helps protect against cancer diseases, especially bladder cancer (Jamal Al-Din, 2010).The annual report of Central Statistical Agency and Information Technology (2019) refer that cultivated areas average, yield and productivity of cauliflower in Iraq for 2019 were 989 hectare, 7276 kg h^{-1}, and 7187 tons respectively. In general, the variability in production of cauliflower correlates highly on many different factors such as environmental

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conditions during the grown period, genotypes, date of harvest, mulching, and application of fertilizers and growth regulators, as well as many other factors (Siciliano et al., 2017).

Statistics show that planted area in cauliflower dwindled in the last decade, meanwhile the production developed rapidly. This improvement in production has been achieved as a result to use many different factors which reflected positively on growth and yield of cauliflower plants (Tawfeeq and Abdulrhman, 2021). However, the availability of chemical fertilizers and using modern agricultural methods led to practice that turned out to be detrimental to the natural environment (Carson, 2002). Recent attention on the harmful impact of chemical fertilizers and their negative long-term effects on agriculture and on human beings has yielded in a marked pressure for low input and organic approaches (Abdelaziz et al., 2007). Choice of fertilizer, some lower input techniques were subjects of controlled experiments in order to reduce the negative impacts on human and environment equally (Shanahan et al., 2011; Singh and Guleria, 2013; Mechergui et al., 2016).Nevertheless, the integrated supply of nutrients to plants through a variety of organic sources became one of the most important aspects of environmentally sound in agriculture (Singh and Guleria, 2013). Seaweed extract is one of the ways using to supply nutrients and became used widely with a huge range of crops (Khan, et al. 2009; Selvam and Sivakumar, 2014). It is biodegradable, generates low pollutant levels, non-toxic, and non-hazardous. It is also containing good amount of plant nutrients such as macro and micro elements, and equipped with good level of fatty acids, vitamins, organic matter, and natural growth regulators (Dhargalkar and Pereira, 2005; Gurusaravanan et al., 2010; Neish and Bourgougnon, 2014). Accordingly, most of the results obtained with seaweed extract were similar to those spotted by applying hormones on plants. Furthermore, bioactivity of organic compounds forming seaweed extract can be used to improve the productivity of plant in agricultural systems due to its high percentage contains of growth regulators which play an active role in promoting the activity and vitality of the plant (Rayorath *et al.*, 2008, Tawfeeq, 2017).Growth regulators in plants stimulate growth in a wide number of plants, which result in valuable changes in production (Prins et al., 2010). Cytokinins are group of the plant growth substances in plants that stimulates cell division in plant shoots and roots. They are playing an important role in cell growth, specialization, and differentiation, but it also affects axillary bud growth, apical dominance and leaf senescence (Tawfeeq, 2017).While there have been several investigations on the effect of chemical fertilizer on the growth and yield of cauliflower, there is a shortage of information available on the effect of organic fertilizer, and cytokinin as a growth regulator on this crop. This experiment reports the influence on growth, yield of cauliflower using a seaweed extract fertilizer and compares this with different levels of cytokinin (growth regulator).

MATERIALS AND METHODS

Site and experimental design

The experiment has been conducted out at the researches station of the Department of Horticulture and Landscape, College of Agriculture, Tikrit University for the agricultural season of 2019-2020.The experiment was laid out in a Randomized Complete Block Design (RCBD) as a factorial experiment. Cauliflower plants treated with three levels of seaweed extract (Table 1) sprayed into three levels which were (S0: 0, S1: 3.3, and S2: 6.6 ml l^{-1}) as a first factor. The second factor was sprayed growth regulator into three concentrations of cytokinin trans-zeatin-riboside (zr): (G0: 0, G1: 4mg l^{-1}, and G2: 10mg l^{-1}). Each treatment had three replications distributed randomly across experimental units and the plants were sprayed three times every four weeks during the growth stage.

Table (1) Physics and chemical characteristics of field soil

Characteristic	Soil texture	O.M	Gypsum g kg^{-1}	EC ds m^{-1}	pH	mg kg^{-1}			Soil texture calculator g kg^{-1}		
						N	P	K	Clay	Sand	Silt
Values	Sandy loam	0.9	13.4	2.1	7.6	11.0	9.0	35.0	12.0	53.0	35.0

The plants have been prepared on 15th September 2019; the seeds were placed in Seedling trays. On 21st October 2019 when the plants approached about 10 cm (5 true leaves appeared), the plants transplanted in the field. Seedlings planted in ridge in the top with 2 meters length and 40 cm between each plant and 75 cm between each line. The plants in this experiment were watered with equal amounts of water by a drip irrigation system. SAS program was used to analyses variance. Duncan's test at 0.05 probability levels was employed to separate mean values (SAS, 2001).

Organic fertilizer

The product ‘Seasol’ produced by Seasol International Pty Ltd. (Australia) used as an organic fertilizer. 'Seasol' obtained from an alga source in a liquid form extracted from unique species *Durvillaea potatorum* that includes naturally occurring carbohydrates, growth regulators, trace elements, alginates and vitamins.

Table (2) Nutrient contents of seaweed extract 'Seasol'

N%	P_2O_5%	K_2O%	Mg%	Ca%	Fe %	Cu%	S%	I%	Na%	Cl ppm	B ppm
0.22	0.58	4.3	0.04	0.098	0.03	0.000064	0.2	0.012	0.9	0.33	0.0013

This product used in this study like a source of organic fertilizer due to the presence of many elements as well as the presence of identified cytokinins: trans-zeatin (Z) (0.7 mg l^{-1}), trans-zeatin-riboside (Zr) (7.0 mg l^{-1}), isopentenyl adenosine (IPA) (2.0 mg l^{-1}), and isopentenyl adenine (IP) (16.0 mg l^{-1}).

Observed traits of plant

Plant height (cm), total fresh weight of leaf (g), leaf area (cm^2), total leaves number (leaf $plant^{-1}$), curd length (cm), curd diameter (cm), yield per plant, total yield (ton ha^{-1}) as well as percentage of nitrogen, phosphorous, potassium, and boron in the leaves of plants.

RESULTS

Effect of spraying seaweed extract on growth, yield and chemical content of cauliflower

The results in Table 3 showed that spraying with seaweed extract at different concentrations (0, 3.3, 6.6 ml l^{-1}) did not affect significantly on plant height, fresh weight of leaf, leaf area, total leaf number, curd length, curd diameter, curd weight, total yield, and percentage of nitrogen. Whereas, plants treated with spray seaweed extract at a concentration of 6.6 ml l^{-1} increased the concentration of phosphorous, potassium, and boron significantly 0.395, 3.696, 63.043 % respectively, compared with other treatments. On the other hand, the comparison treatment (S0) gave the lowest values of phosphorous, potassium, and boron 0.217, 2.42 and 58,060%, respectively.

Table (3) Effect of spraying seaweed extract on growth, yield and chemical content of cauliflower

Treatments	Plant length (cm)	Fresh weight of leaf (g)	Leaf area (cm^2)	Total number of leaves	Curd length (cm)	Curd diameter (cm)	Curd weight (g)	Total yield (ton ha^{-1})	N%	P%	K%	B ppm
S0	24.856 a	21.300 a	200.95 a	10.603 a	8.624 a	13.642 a	400.61 a	13.353 a	1.307 a	0.217 c	2.426 b	58.060 c
S1	24.711 a	18.559 a	174.44 a	10.396 a	7.814 a	12.276 a	321.35 a	10.711 a	3.988 a	0.312 b	2.932 b	62.061 b
S2	24.144 a	18.683 a	167.34 a	10.794 a	8.061 a	12.622 a	319.35 a	10.645 a	2.093 a	0.395 a	3.696 a	63.043 a

a, b, c: means in the same Rows with different superscripts differ significantly according to Duncan's multiple test

Effect of spraying cytokinin on growth, yield and chemical content of cauliflower

It is clear from Table (4) that treatments with different levels of cytokinin (0, 40, 10 mg l^{-1}) did not show any significant difference in all the characteristics.

Table (4) Effect of spraying cytokinin on growth, yield and chemical content of cauliflower

Treatments	Plant length (cm)	Fresh weight of leaf (g)	Leaf area (cm^2)	Total number of leaves	Curd length (cm)	Curd diameter (cm)	Curd weight (g)	Total yield (ton.ha^{-1})	N%	P%	K%	B ppm
G0	24.233 a	19.447 a	187.73 a	10.403 a	8.395 a	12.476 a	356.06 a	11.868 a	1.659 a	0.297 a	3.114 a	61.041 a
G1	24.656 a	19.169 a	182.90 a	10.460 a	7.956 a	12.921 a	326.56 a	10.885 a	4.076 a	0.316 a	3.0078 a	61.068 a
G2	24.822 a	19.927 a	171.89 a	10.931 a	8.956 a	13.143 a	358.70 a	11.965 a	1.653 a	0.311 a	2.933 a	61.054 a

a, b, c: means in the same Rows with different superscripts differ significantly according to Duncan's multiple test

Effect of interaction treatment between seaweed extract and cytokinin on growth, yield and chemical content of cauliflower

It appears from Table 5 that the interaction treatments between spraying seaweed extract and growth regulator (cytokinin) has no significant effect on plant height, leaf area, total number of leaves, curd length, curd diameter, curd weight, total yield, and percentage of nitrogen in leaves. On the other hand, a significant effect of the S0G0 treatment was noticed on the fresh weight of leaf 23.013 g compared to the lowest value with S2G0 treatment which was 16.940 g. Whereas, the treatments S2G2, S2G0, and S2G1 distinguished significantly in percentage of phosphorous, potassium, and boron 0.406%, 3.781%, and 63.146 ppm, respectively, compared with control (S0G0) which were 0.203 and 2.537% for both percentages of phosphorous and potassium respectively, and S0G2 which was 57.940 ppm for born.

DISCUSSION

The review of results showed that there are no significant differences in most of the vegetative and yield (productive) characteristics of the cauliflower when treated with seaweed extract and growth regulator (cytokinin) sprayed on the leaves. The reason why the plant is not affected by both solutions may be attributed to the inability of the leaves to absorb them due to the increase in the specific contact angle between the surface of the leaf and both solutions (Fernández and Brown, 2013). As it is known, the specific contact angle plays an important role in the plant ability to absorb solutions through its vegetative parts, especially leaves. The specific angle of contact considers the indicator which determines the ability of plant to absorb solutions through their shoot. So, even there is an increase in angle value, that leads to more disharmonies between them and less absorption of the solution which means less benefiting (Macedo et al, 2021). This is due to the abundance and density of alkaloid substances that cover the cauliflower leaves, which prevent or reduce the absorption of many of the liquids that are sprayed on their leaves surfaces. Furthermore, the reason for not being the plant affected significantly (especially the vegetative characteristics) is attributed to the specialization of cytokinin, as well as most of the growth regulators contained in seaweed extract, encouraging the apical dominance of the plant as well as reducing the growth of buds and lateral growths (Kummar and Sahoo 2011). According to the fact that cauliflower is one of the plants with limited growth and there is no apical dominance or branches, the effect of this type of solutions (growth regulators solutions) considered like a limited efficacy on the plant (Cline, 1994). These results were being exceptional from what was shown by

the analysis of the elements concentrations in the leaves. The results showed significant differences when the plant was treated with seaweed extract. The response of cauliflower plants in this experiment in terms of elemental concentrations to different levels of seaweed extract is likely to be due to the high content of this extract of elements.

Table (5) Effect of interaction treatment between seaweed extract and cytokinin on growth, yield and chemical content of cauliflower

Treatments	Plant length (cm)	Fresh weight of leaf (g)	Leaf area (cm^2)	Total number of leaves	Curd length (cm)	Curd diameter (cm)	Curd weight (g)	Total yieldn ($ton.ha^{-1}$)	N%	P%	K%	B ppm
S0G0	24.267 a	23.013 a	238.51 a	11.053 a	9.443 a	13.950 a	419.76 a	13.992 a	1.253 a	0.203 d	2.537 c	58.120 b
S0G1	27.300 a	20.847 ab	156.70 a	10.063 a	8.057 a	13.623 a	401.70 a	13.390 a	1.360 a	0.240 cd	2.381 c	58.120 b
S0G2	23.000 a	20.040 ab	207.63 a	10.693 a	8.373 a	13.353 a	380.36 a	12.678 a	1.307 a	0.210 d	2.362 c	57.940 b
S1G0	24.467 a	18.387 ab	155.34 a	10.367 a	7.720 a	11.693 a	367.02 a	12.234 a	1.593 a	0.303 bc	3.024 abc	61.923 a
S1G1	24.267 a	18.943 ab	231.34 a	10.430 a	8.030 a	13.430 a	323.35 a	10.778 a	8.800 a	0.316 abc	3.013 abc	61.940 a
S1G2	25.400 a	18.347 ab	136.64 a	10.393 a	7.693 a	11.707 a	273.68 a	9.122 a	1.570 a	0.316 abc	2.761 bc	62.320 a
S2G0	23.967 a	16.940 b	169.34 a	9.790 a	8.023 a	11.787 a	281.40 a	9.380 a	2.130 a	0.386 ab	3.781 a	63.080 a
S2G1	22.400 a	17.717 ab	160.67 a	10.887 a	7.783 a	11.710 a	254.62 a	8.487 a	2.067 a	0.393 ab	3.628 ab	63.146 a
S2G2	26.067 a	21.393 ab	172.00 a	11.707 a	8.377 a	14.370 a	422.05 a	14.068 a	2.083 a	0.406 a	3.678 ab	62.903 a

a, b, c: means in the same Rows with different superscripts differ significantly according to Duncan's multiple test

As it contains of many macro and micro nutrients which taken by the plant directly through the leaves, or indirectly through the roots, which led to its accumulation inside its tissues. These results are in agreement with what was found by Hussein (2016), who explained that foliar

application of seaweed extract on cauliflower plants led to a significant increase in the leaves content of elements. Also, it is believed that spraying with both solutions encouraged root growth and thus increased the absorption of some soil elements (Daoud et al. 2013).

Additionally, the reason why the plant was mostly not affected significantly by the applied treatments could be due to the fact that soil may be poor in elements and exhausted most of the nutrients. Likewise, it is believed that seaweed extract affected the microorganisms of soil. It is providing them the needed energy to do their work and stimulating their growth and reproduction. Hence, this process caused an increase in decomposing organic matter, which leads to the excretion of organic acids that increase the pH of soil and thus increase the percentage of available nutrients for plants (Ordog, 1999). Ramya et al. (2010) showed in their study that the extracts of seaweed (*Ulva lactuca* and *Sargassum wightii*) have the ability to change working system of microorganisms in the growth medium, so it directly or indirectly affects the movement of roots into the soil. Moreover, its liquid extracts encourage the growth of beneficial bacteria such as *Pseudomonas putida* (Dickson et al, 2005) and stimulate the growth of beneficial fungi, such as mycorrhizal, so they extend more stimulating their activity in the depths of the soil (Khan et al., 2012).

On the other hand, the interaction between spraying seaweed and cytokinin showed that there was no significant difference in most of the vegetative and flowering growth characteristics. It turns out that spraying with both solutions did not show any significant difference except in the concentrations of elements (nitrogen, potassium, phosphorous, and boron) in the leaves, as well as in the leaf weight. This clearly indicates the effect of the absorption of elements in seaweed extract on building of leaves tissues which led to an increase in their weight (Abetz and Young, 1983).

CONCLUSION

It has been concluding from this experience that fertilizing cauliflower by spraying on the leaves (foliar application) does not have a significant effect on improving the growth and productivity of the crop. The addition of the cytokinin does not play a significant role in increasing the required qualities of the plant, at least quantitatively but may be able to have a positive effect on quality and chemical contents of curd. Also, spraying seaweed extract has a unique role in some plant characteristics that may benefit in increasing production.

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تأثير الرش الورقي بمستخلص الاعشاب البحرية والسايتوكاينين على نمو وحاصل نبات القرنابيط (*Brassica oleracea var. botrytis*)

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قسم البستنة، كلية الزراعة، جامعة تكريت، تكريت، العراق

الخلاصة

أجريت التجربة في محطة الابحاث التابعة لقسم البستنة وهندسة الحدائق في كلية الزراعة - جامعة تكريت للموسم الزراعي 2019-2020 لمعرفة تأثير الرش بالسماد العضوي (مستخلص الأعشاب البحرية) ومنظم النمو السايتوكاينين في نمو وحاصل نبات القرنابيط. تضمنت التجربة عاملين: الرش بمستخلص الأعشاب البحرية بمستويين بالاضافة لمعاملة المقارنة، (S0) بدون إضافة، (S1) الرش بتركيز3.3مل. لتر$^{-1}$, (S2) الرش بتركيز 6.6مل .لتر$^{-1}$. أما العامل الثاني فكان الرش بالسايتوكاينين بمستويين بالاضافة لمعاملة المقارنة، (G0) بدون إضافة، (G1) الرش بتركيز10مل غم.لتر$^{-1}$, (G2) الرش بتركيز40 ملغم. لتر$^{-1}$. نفذت التجربة وفق تصميم القطاعات العشوائية الكاملة R.C.B.D وبثلاثة مكررات وقورنت المتوسطات على وفق اختبار دنكن متعدد الحدود عند مستوى احتمال 5%.

أظهرت النتائج أن رش مستخلص الطحالب البحرية (S2) أدى إلى زيادة نسبة الفوسفور والبوتاسيوم والبورون معنوياً مقارنة بجميع المعاملات الأخرى. وفي الوقت نفسه، لم يؤثر اضافة السايتوكينين بشكل كبير على جميع الصفات المدروسة. سبب التداخل تأثيراً معنويا في الوزن الطري للورقة ، نسبة الفوسفور، ونسبة البوتاسيوم والبورون S0G0، S2G2، S2G0 و S2G1 على التوالي مقارنة مع معاملات S2G2 , S0G0 , S0G2 وS0G1 التي كانت لها أدنى قيم للصفات السابقة الذكر على التوالي.

الكلمات المفتاحية:
اعشاب بحرية, قرنابيط, منظمات نمو, سايتوكاينين