



Effect of Organic Nutrients on Growth and Yield of Broccoli *Brassica oleracea* L. var. *italica* Plenck

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Abstract: The experiment was conducted during the winter season 2016-2017 under desert condition in south of Iraq, it included nine factorial layout with three genotypes of Broccoli Cavolo, Paraiso and Monaco as main treatments and three concentrations of liquid seaweed extract Algaton (0, 1.5 and 3 ml.L⁻¹). Three sprays of Algaton was done at two weeks. Paraiso hybrid plants showed a significant increase in vegetative growth indicators including plant height, stem diameter, leaf area and both fresh and dry weights, in addition to yield indicators that include curd circumference, flower stalks, fresh weight and total yield and also in the qualitative characteristics of curd total including chlorophyll, vitamin C, total soluble carbohydrates, percentage of nitrogen, potassium, phosphorus, sulfur and protein. Spraying with Algaton spray at 3 ml.L⁻¹ caused a significant increase in vegetative growth and yield indicators. The interaction between the two factors was significant in some of the characteristics under study. Paraiso hybrid s sprayed with Algaton at 3 ml.L⁻¹ significantly exceeded in leaf area, fresh and dry weight of leaves, curd fresh weight, productivity and percentage of potassium.

Keywords: Broccoli, Genotypes and spraying with Algaton

Broccoli (*Brassica oleracea* var. *italica*) is one of the winter vegetables crops that belongs to the Brassicaceae family. The planted area of broccoli with cauliflower in Iraq reached 989 hectares with a production of 7187 tons and productivity of 7.2669 ton. ha⁻¹ (FAO 2019). Foliar feeding is one of the preferred methods of fertilization because the plants take high benefit of it, as nutrients are added in low concentrations by spraying them on the plant, whether in traditional, organic or biological agriculture in order to nourish, accelerate the growth and improve production of the plant (Al-Gebory and Al-Khafagy 2011). Foliar fertilization provide necessary nutrients by spraying the total vegetative and absorption through the stomatal openings spread on the top and bottom surfaces of the leaf, but is not a substitute for ground fertilization, but rather due to quick response because the nutrient solutions contain amino acids and organic compounds (Sadiq et al 2002). The spraying with seaweed extracts, including Algaton, which is considered as organic primary products, is useful Al-Samarrae and Hassan (2012) concluded that spraying *Tagetes erecta* L. plant with seaweed extract Algaton at a 4 ml.L⁻¹ in two and three sprays significantly improved plant height, number of main branches, number and diameter of flowers. The three times spraying gave the highest values in the vegetative and floral growth characteristics. Kareem and Al-Ajil (2012) indicated that spraying cauliflower *Brassica oleracea* var. *botrytis* with seaweed extract Algaton in three concentrations: 0, 1.5 and 3

ml.L⁻¹ 15 days after transplanting and re-spraying every 15 days led to the significant superiority of the plants sprayed with the extract in the vegetative growth characteristics. Spray at of 1.5 ml.L⁻¹ exceeded in curd speed of ripening, while at 2 ml.L⁻¹ exceeded in weight characteristics and curd tenacity. Ali et al (2017) found that local garlic plants that were sprayed with foliar fertilizer Microm at the concentrations 0.5, 1 and 1.5 g.L⁻¹ were superior to control. Al-Zubaidi (2018) indicated that spraying eggplant plants with nutrient solutions Basfoliar Kelp and Fylloton at concentrations had a significant effect on growth. Fylloton at 3 g.L⁻¹ were distinguished by recording the highest average of plant height, leaf area, fruits number and weight, yield of the plant and the dry weight, also Abboud et al. (2020) indicated that spraying watermelon plants with Huzone nutrient had a significant effect on all growth and yield characteristics. Due to the importance of the broccoli crop the experiment was conducted on spraying with Algaton, which is a liquid seaweed extract on the growth and yield of broccoli in the desert region of southern Iraq.

MATERIAL AND METHODS

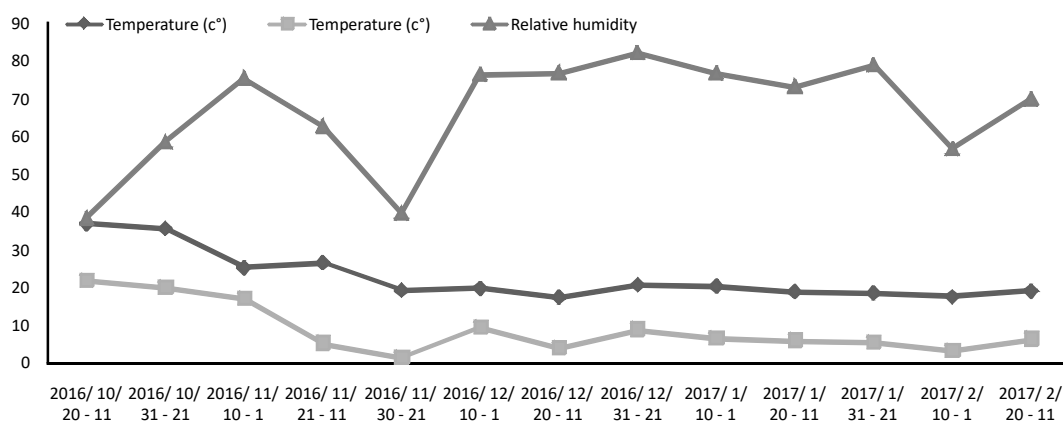
The field experiment was conducted in winter season 2016-2017 at Basra Agriculture Directorate, Khor Al-Zubair on a mixed sandy soil with a pH of 7.73, an electrical conductivity of 6.78 Des m⁻¹ and organic matter of 0.74%. The maximum, minimum temperatures and relative humidity of

the experiment area during the planting season were recorded using the data of the Al-Barjisia Agricultural Research Station (Fig. 1). The experiment included two factors in split plot design with the three varieties as main treatment (Cavolo, Monaco, and Paraiso) and spraying with Algaton (1.5 and 3 ml.L⁻¹) as sub treatment. Three sprays were done at two weeks after a month of planting seedlings and the untreated control was also kept. The data was analyzed using Genstat, V.10.3 (2011). Cavolo variety, seeds produced by the Italian company Hortus, hybrid variety Monaco with a germination rate of 96% and a purity of 99.9%, and hybrid variety Paraiso with a germination rate of 85% and a purity of 99% produced by the Australian company Syngenta and imported by Debana Modern Agriculture Company Ltd. was used in the experiment. The experiment included 27 experimental units with an area of 10 x 2 m for each unit, with a distance of 50 cm between row and 50 cm between plants. The seeds were planted on September 1, 2016 and the seedlings were transferred to the field at the age of 45 days. All recommended agronomic practices were followed (Al-Khalidy 2018). Seaweed extract Algaton, produced by the Spanish company Valencia, and contains total nitrogen (N) 6% w/w, phosphoric anhydride (P₂O₅) soluble in water 3% w/w, potassium oxides (K₂O) soluble in water 10% w/w, molybdenum (Mo) soluble in water 0.3% w/w. In addition, Algaton contains auxin, cytokinin, gibberellin, amino acids, sugars and carbohydrates. Data was collected from plants selected randomly at the end of the season and included plant height (cm), stem diameter (cm), number of leaves, leaf area (m²), fresh and dry weight of leaves (g), curd fresh weight (kg), dry weight (g), curd circumference (cm), number of curd flower stalks and the total productivity (ton ha⁻¹), also total chlorophyll, vitamin C (mg 100g⁻¹ fresh weight), total soluble carbohydrates (mg

g⁻¹ dry weight), percentage of nitrogen and potassium, phosphorous, sulfur and protein in the curds.

RESULTS AND DISCUSSION

The Paraiso variety was significantly superior in plant height, stem diameter, leaf area, and both fresh and dry weight of leaves, followed by Monaco hybrid then Cavolo. There was no significant difference between the genotypes in number of leaves (Table 1). Plants sprayed with Algaton extract at 3 ml.L⁻¹ were superior with a significant difference to those sprayed at 1.5 ml.L⁻¹ in all characteristics with the exception of the number of leaves. Paraiso hybrid variety plants sprayed with Algaton extract at 3 ml.L⁻¹ were significantly superior in leaf area and both fresh and dry leaf weights (2.625 m², 549.67 g, and 41.59 g) compared to Cavolo. There was a significant difference between the genotypes in yield represented by the curd circumference, number of flower stalks of the curd, curd fresh weight and total productivity. Paraiso hybrid exceeded in the aforementioned characteristics, followed by the Monaco hybrid and Cavolo (Table 2). Plants sprayed with Algaton extract at 3 ml.L⁻¹ was significantly superior in all yield contributing parameters to those sprayed at 1.5 ml.L⁻¹ with the exception of the dry weight of the curd as there was no significant difference between the genotypes, as well as the spraying with Algaton concentration. The interaction between the treatments had a significant effect on the fresh weight of the curd and total productivity as Paraiso hybrid variety sprayed with Algaton at 3 ml.L⁻¹ gave the higher yield. Paraiso hybrid variety was significantly superior in total chlorophyll of curd, vitamin C, total soluble carbohydrates and the percentage of protein, followed by Monaco plants and then Cavolo (Table 3). The significant increase in the aforementioned characteristics was observed as spraying with Algaton concentration increased.



Source: Meteorology and meteorology authority at Al-Barjisia station for agricultural sciences

Fig. 1. Maximum, minimum temperatures and relative humidity during the experiment 2016-2017

Table 1. Effect of spraying with seaweed extract Algaton on growth indicators of broccoli genotypes

Genotypes	Spraying with Algaton concentration (ml.L ⁻¹)	Plant Height (cm)	Stem diameter (cm)	Number of leaves	Leaf area (m ²)	Fresh weight of the leaves (g)	Dry weight of the leaves (g)
Cavolo	0	53.33 b	2.15 b	19.00	1.215 b	345.00 b	20.14 b
	1.5	59.00	2.42	21.33	1.513	352.67	23.87
	3	62.00	2.76	22.33	2.052	355.33	28.14
Paraiso	0	59.67	2.35	21.33	1.626	446.33	30.34
	1.5	71.33	2.72	23.33	2.564	539.33	37.71
	3	75.00	2.86	24.00	2.625 a	549.67 a	41.59 a
Monaco	0	60.00	2.31	21.00	1.571	357.67	23.73
	1.5	64.67	2.52	22.00	2.135	423.33	26.37
	3	67.33	2.82	21.67	2.474	440.33	31.44
LSD (p= 0.05)		NS	NS	1.51	0.003	5.03	0.05
Average genotypes	Cavolo	58.11 c	2.44 c	20.89	1.593 c	351.00 c	24.05 c
	Paraiso	68.67 a	2.64 a	22.89	2.272 a	511.78 a	36.55 a
	Monaco	64.00 b	2.55 b	21.56	2.060 b	407.11 b	27.18 b
LSD (p= 0.05)		1.10	0.04	NS	0.002	4.20	0.01
Average concentration	0	57.67 c	2.27 c	20.44 b	1.471 c	383.00 c	24.74 c
	1.5	65.00 b	2.55 b	22.22 a	2.070 b	438.44 b	29.32 b
	3	68.11 a	2.81 a	22.67 a	2.383 a	448.44 a	33.72 a
LSD (p= 0.05)		2.04	0.04	0.94	0.002	2.75	0.03

Table 2. Effect of the spray with seaweed extract Algaton on the yield indicators of broccoli

Genotypes	Spraying with Algaton concentration (ml.L ⁻¹)	Crud circumference (cm)	Number of crud flower stalks	Crud fresh weight (kg)	Crud dry weight (g)	Total productivity (ton ha ⁻¹)
Cavolo	0	45.67	16.67	0.354 b	62.25	6.24 b
	1.5	53.33	20.00	0.428	64.25	7.53
	3	61.67	22.00	0.468	67.69	8.23
Paraiso	0	58.00	33.00	1.221	87.41	21.49
	1.5	76.67	35.33	1.321	90.27	23.26
	3	84.67	38.33	2.253 a	93.70	39.65 a
Monaco	0	59.00	20.67	0.744	76.21	13.09
	1.5	67.33	27.33	0.847	78.76	14.90
	3	73.00	35.33	0.997	81.51	17.55
LSD (p=0.05)		NS	3.27	0.006	6.46	0.11
Average genotypes	Cavolo	53.56 c	19.56 c	0.417 c	64.73	7.33 c
	Paraiso	73.11 a	35.56 a	1.598 a	90.46	28.13 a
	Monaco	66.44 b	27.78 b	0.863 b	78.83	15.18 b
LSD (p=0.05)		2.91	2.11	0.003	6.57	0.05
Average concentration	0	54.22 c	23.44 c	0.773 c	75.29 c	13.61 c
	1.5	65.78 b	27.56 b	0.865 b	77.76 b	15.23 b
	3	73.11 a	31.89 a	1.239 a	80.97 a	21.81 a
LSD (p=0.05)		2.75	2.07	0.004	1.06	0.07

Table 3. Effect of spraying with seaweed extract Algaton on the cruds quality broccoli

Genotypes	Spraying with Algaton concentration (ml.L ⁻¹)	Total chlorophyll (mg 100g ⁻¹ fresh weight)	Vitamin C (mg 100g ⁻¹ fresh weight)	Total carbohydrates (mg g ⁻¹ dry weight)	Protein (%)
Cavolo	0	38.09	40.73	24.01	15.08
	1.5	47.46	50.79	25.77	17.48
	3	54.36	64.14	30.20	22.84
Paraiso	0	43.88	49.18	26.98	18.18
	1.5	59.52	73.45	34.84	19.68
	3	61.67	79.65	36.11	24.96
Monaco	0	43.01	40.67	25.02	16.24
	1.5	47.63	55.08	29.15	18.25
	3	56.59	68.28	32.04	23.61
LSD (p=0.05)		NS	NS	NS	NS
Average genotypes	Cavolo	46.64 c	51.89 c	26.66 c	18.46 c
	Paraiso	55.02 a	67.43 a	32.64 a	20.94 a
	Monaco	49.08 b	54.68 b	28.74 b	19.37 b
LSD (p=0.05)		1.77	1.38	0.80	0.35
Average concentration	0	41.66 c	43.53 c	25.34 c	16.50 c
	1.5	51.54 b	59.77 b	29.92 b	18.47 b
	3	57.54 a	70.69 a	32.78 a	23.80 a
LSD (p=0.05)		1.89	3.32	0.96	0.37

Table 4. Effect of spraying with seaweed extract Algaton on the percentage of nutrients in the cruds of broccoli genotypes

Genotypes	Spraying with Algaton concentration (ml.L ⁻¹)	Nitrogen (%)	Phosphorous (%)	Potassium (%)	Sulfur (%)
Cavolo	0	2.412	0.132	2.525 b	0.225
	1.5	2.797	0.165	3.634	0.288
	3	3.654	0.214	4.185	0.434
Paraiso	0	2.909	0.160	3.056	0.268
	1.5	3.149	0.185	3.928	0.324
	3	3.984	0.237	4.356 a	0.468
Monaco	0	2.598	0.142	2.827	0.246
	1.5	2.921	0.173	3.745	0.300
	3	3.777	0.225	4.274	0.446
LSD (p=0.05)		0.092	0.005	0.005	0.006
Average genotypes	Cavolo	2.954 c	0.171 c	3.448 c	0.315 c
	Paraiso	3.348 a	0.194 a	3.780 a	0.353 a
	Monaco	3.098 b	0.180 b	3.615 b	0.331 b
LSD (p=0.05)		0.060	0.002	0.003	0.005
Average concentration	0	2.640 c	0.145 c	2.802 c	0.246 c
	1.5	2.956 b	0.174 b	3.769 b	0.304 b
	3	3.805 a	0.225 a	4.271 a	0.449 a
LSD (p=0.05)		0.058	0.004	0.003	0.004

The interaction between genotypes and spraying with Algaton had no significant effect on the qualitative characteristics of the curd. The study showed the superiority of the Paraiso hybrid variety plants followed by Monaco and Cavolo plants with significant difference in the percentage of nutrients in the curds represented by the percentage of nitrogen, phosphorus, potassium and sulfur. The significant increase in the percentage was observed as spraying with Algaton concentration increased. Paraiso plants sprayed with Algaton extract at 3 ml.L⁻¹ resulted in higher percentage of potassium.

The genotypes difference in growth and yield indicators may be attributed to the nature of the genotypes and their suitability to the environmental conditions of the region and hereditary factors in the genotypes (Fig. 1). The superiority spray with Algaton in the vegetative growth indicators might be due to the availability of the necessary nutrients in them and their effects on the process of photosynthesis and respiration, or that the foliar spray may lead to an increase in the biological processes responsible for cell division and elongation, which helps in obtaining good vegetative growth and the reflection of that on yield indicators and its qualitative and chemical characteristics (Saud 2013 on cucumber and Al-Mafraji, 2014 on tomato). In addition spraying seaweed extracts on the leaves may protect the plant from stress such as cold and drought, and this explains the superiority of plants sprayed with seaweed extract compared to control (O'Dell 2003 and Patil et al 2008 on onions). The increase in the total chlorophyll concentration might be attributed to the increase in the nitrogen component (Table 4) and the increase in the fresh and dry weights of the leaves might be due to the increase in the number of leaves and the leaf area (Table 1).

CONCLUSION

The variety Paraiso with three sprays of organic nutrient Algaton at a concentration of 3 ml.L⁻¹ in Southern Iraq can be recommended for high productivity and good quality.

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