Effect of bio-fertilizer (Fulzyme Plus) and seaweed extract (Algae Stim) on vegetative growth and yield of kale (*Brassica oleracea* var. sabellica)

Ali Ebadi Mana **Muhammad Radi Sahib** **Bassem Halim Kashash Jaafar**

Muhammad Sadiq **Marwa Baqer Jawad** **Zainab Sajjad Shamkhi**

aliebide12@yahoo.com

Al-Qasim Green University, College of Agriculture

Abstract:

This experiment was conducted in the fields of the Faculty of Agriculture, Al-Qasim Green University for the academic year 2022-2021 to find out the effect of the biofertilizer Fulzyme Plus (with two levels), 2 kg. ha^{-1}, 4 kg. ha^{-1}) compared with the control treatment and the addition of seaweed extract Algae Stim)) at two levels (8 $kg.ha^{-1}$, 16 $kg.ha^{-1}$) compared with the control treatment in the vegetative growth trait and yield of kale plant, the study was applied as a factorial experiment according to the split-plot system within the RCBD design with three replicates. Biofertilizer was placed in the main plot and the main plot and seaweed extract in the subplot. The results were analyzed and the averages were compared according to the least significant difference test (LSD) within the probability level of 0.05, and the following results were obtained: -Biofertilizer exceeds 4 kg. ha^{-1} significantly in leaf area, which reached 26,969 cm^2. $Plant^{-1}$, the percentage of chlorophyll is 52.10 SPAD, and the yield of the plant is 364.4 g. $Plant^{-1,}$ and the total yield is 12.15 tons. ha^{-1}, compared to the control treatment, which gave lower average for these traits. Fertilization exceeds 16 kg. ha^{-1} of seaweed extract in the number of leaves, which gave the highest number of leaves reached 21,00 leaves. $Plant^{-1}$, leaf area 28710 cm^2. $plant^{-1}$, The percentage of chlorophyll is 53.43 SPAD, and the yield of one plant is 364.4 g. $Plant^{-1}$, and the total yield is 12.20 tons. ha^{-1}. Compared to the control treatment, which gave a lower average for these traits. All the bi-interactions of the two additive study factors had a significant effect on the vegetative traits and the yield, where it was noted that the treatment of the binary interaction B2F2 excelled and achieved the highest yield of 14.23 tons. ha^{-1}.

Key word: kale, bio fertilizer, sea weed extract

Introduction

Kale (*Brassica oleracea* var. sabellica) is a plant of the cruciferous Brassicaceae family. It is a cold-season leafy crop with good nutritional value. It has several names, including curly cabbage or curly kale, and kale, it's mainly cultivated in Northern and central Europe and in North America as a plant whose freshly wrinkled green leaves are used in making salads. In recent years it has wide use in making pickles or packed as fresh foods ready to eat and cook (Hassan, 2004). Kale is a plant rich in minerals such as iron, calcium, fiber, proteins, and vitamins such as vitamin A, vitamin C, B3 (Trani *et al.,* 2015). 67 g of kale contains seven times the recommended daily amount of vitamin K, 3 g protein, 6 g carbohydrates, and 2 g fiber and 33 calories, and in 100 g of which it contains 10% or more of the daily value of 17 essential nutrients and is considered a vegetable that is closely associated with a lower risk of heart disease and other non-communicable diseases (Gunnars), 2018. (It also contains the anti-cancer substance sulforaphane (Gunnars), 2018. This plant is characterized by its distinctive bitter flavor, which is due to the presence of glucosinolates. Fertilization is one of the most important crop service operations and one of the important means of production for its great impact in regulating the physiological processes of plants, especially nutrients. Which led to the use of organic

fertilization, which is one of the important agricultural processes in increasing vegetative and flowering growth because it contains macro and micronutrients and its direct effect on improving the physical and chemical properties of soil by retaining moisture, aerating the soil and reducing soil pH, which plays an important role in the readiness of most elements for absorption from Before the plant and prevents it from sedimentation (Al-Nuaimi, 1999). Excessive chemical fertilizers have a harmful and negative effect on the environment and many diseases for humans due to their lack of representation in the body and their fixation in the base soils and their high prices, in addition to the positive impact of organic agriculture on the environment and reducing the risks of contamination of groundwater with chemicals resulting from chemical fertilizers. This led to those interested in the field of plant nutrition. To find alternatives, such as organic nutrition, that reduce these harmful effects. The use of seaweed extracts is one of the basic materials that can be added or sprayed to the plant and soil to provide the plant with the basic elements because it contains the necessary macro and micronutrients and some hormones and growth regulators such as auxins, gibberellins, and cytokinins (O'Dell) (2003). Ahmad (2018) concluded from studying the effect of organic fertilization (adding residues in the cultivation of compost mushrooms) and spraying with Jamex seaweed extract on watercress plants and its effect on some vegetative traits and yield. The treatment of spraying with seaweed extract (Gamex) was superior in most of the studied traits that were sprayed at the level of 6 $ml.L^{-1}$ Gamex in giving the highest values, plant height, number of leaves, fresh weight, dry weight, leaf area, and total yield, on the rest of the treatments and control treatment. Al-Azzawi and Saleh (2018)) found that the addition of humic acid and seaweed extracts to the cress plant showed a significant increase in all vegetative growth traits. The interaction treatment between spraying with humic acid and a mixture of seaweed extracts Seaforce1 and Seamino excelled by giving the highest values in plant height, number of leaves, number of branches and leaf area , dry weight and chlorophyll content. Bio-fertilizer is prepared containing one or different types of microorganisms, added to the seeds, plant surface or soil. It increases the availability of plant nutrients, regulates the appropriate development of growth and regulates plant physiology, which leads to soil fertilization and its compatibility with sustainable agriculture in a long term. Fertilizers are environmentally friendly and do not pose any danger to them (Gad and Kandil 2003, and can be replaced to reduce chemical fertilizers) (Bhat *et. al.,,* 2015).In addition to its importance in the analysis of organic waste and its role in the secretion of some enzymes, growth regulators and plant hormones, and its importance in bio control (Ali, 2012),These microorganisms have the ability to settle in the rhizosphere, where this region represents the thin layer of soil with a thickness of between 1-2 mm, which surrounds the roots of plants and contains many microorganisms, including bacteria and fungi (Taha, 2007). Its benefits also include converting phosphorous and nutrients in the soil into a form suitable for use by plants, producing growth regulators, plant hormones, organic and amino acids, producing antibiotics, improving the natural and chemical properties of soil, obtaining a clean, economical crop that is free of pollutants and allowed to be exported. It also reduces the infection of the roots with molds, since the organisms secrete antibiotics that reduce the infection of the molds and stimulate the growth of the roots; Because beneficial microorganisms secrete natural growth stimulants (auxins and cytokinins analogues), which stimulate root growth and reduce the accumulation of nitrates and nitrites in the roots. El-Saadawi (2014) during the study of the effect of the biostimulant Bio health on the growth and yield of two types of watercress, where the results showed the excelled of plants treated with the biostimulant in the number of leaves and leaf area, while there were no significant differences in plant height, percentage of dry matter, and leaf content of carbohydrates and chlorophyll. In the light of what was mentioned above and in view of the

fact that the kale plant is a leafy vegetable that is expected to spread in Iraq, this study came to:

1. Effect of adding Fulzyme Plus bio-fertilizer on the growth and yield of plant kale.

2. Effect of Algae Stim seaweed extract on the growth and yield of plant kale.

3. Study the interaction between the above factors on growth and yield plant kale.

Materials and methods

The experiment was conducted in the vegetable field of the Department of Horticulture and Gardening Engineering, College of Agriculture, Al-Qasim Green University, during the winter agricultural season 2021-2022. To study the effect of adding bio-fertilizer and seaweed extract on the growth of kale plant yield. Samples of field soil were taken randomly and from different areas before the start of the experiment, with a depth of 30 cm from the soil surface area, then it was pneumatically dried, milled and passed through a sieve with holes diameter of 2 mm and analyzed to know some chemical and physical properties of field soil.

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

values	units	Traits
7.03	**---**	**pH**
3.73	**dc.m^{-1}**	**EC . electrical conduction**
1.4	**g. kg^{-1}**	**Organic matter**
31.11	**mg. kg^{-1}**	**available Nitrogen**
7.6	**mg. kg^{-1}**	**available phosphorous**
98	**mg. kg^{-1}**	**available potassium**
335	**g. kg^{-1}**	**sand percentage**
334	**g. kg^{-1}**	**silt percentage**
331	**g. kg^{-1}**	**mud percentage**
Clay loam	**soil texture**	

The chemical and physical properties of soil were analyzed in the laboratory of the College of Agriculture - Al-Qasim Green University. The soil of the field designated for the experiment was prepared using manual agricultural machines, after removing the growing plants and bushes, then carrying out the process of tillage, smoothing and leveling well and homogeneously, then the land was divided into three replicates, to include each replicate 9 experimental units, One unit represented a terrace with dimensions of 2 x 1 m (length x width), and the distance between one terrace and another was 0.75 cm, leaving a distance of 1 m between the units as an insulator to prevent confusion between treatments, leaving a buffer distance at the beginning and end of each replicate, and the drip irrigation system was installed. Kale seeds were obtained from local markets. The seeds were sown on 1/9/2021 in cork dishes filled with peat moss in one of the nurseries affiliated to Al-Musayyab district in Babylon province, with good and appropriate

conditions for the growth of seedlings. After the seedlings reached the stage of four-five true leaves, they were transferred to the Field on 7/10/2021. The planting was carried out inside the terraces by 8 seedlings for each experimental unit $2m^2$ distributed on one line, the distance between one plant and another is 50 cm. The cultivated plants were taken care of from the first day until the maturity process was completed. Where hoeing and weeding were conducted constantly to get rid of the growing weeds, as well as some grafting operations for some seedlings that failed in growing. As for the irrigation process, it was twice during the week at the beginning of the seedling and after that according to the needs of the plant and by means of drip.

Experiment treatments:

The experiment included a study of two factors: -

The first factor: adding bio-fertilizer: Fulzyme Plus

• control treatment (without fertilization).

• The first treatment is 2 $kg.ha^{-1}$.

• The second treatment is 4 kg ha^{-1}.

Agent Two: Algae Stim Seaweed Extract:

• control treatment (without fertilization).

• The first treatment is 8 $kg.ha^{-1}$.

• The second treatment is 16 $kg.ha^{-1}$ (Manufacturer's recommendation).

Table 3: Biofertilizer Ingredients Fulzyme Plus Algae Stim seaweed extract

Algae Stim	**Fulzyme Plus.**	**unit**	Material available content
-	**10^{10} ×2**	**Gram**	Bacillus Subtilis & Pseudomonas Putida
0.3 %	-	**%**	Gibberellins and cytokinins growth regulators
10 %	**20-10**	**%**	Moisture
-	**400**	**Mg:100g**	cation exchange capacity
55-45	-	**%**	Organic materials
1.5 - 0.5	-	**%**	total nitrogen
22 – 17	-	**%**	potassium oxide
1.1 – 0.0	-	**%**	phosphorous pentoxide
Dutch	**American**		Origin

The experiment was designed according to the split-plot-design system within the RCBD (Randomized Complete Block Design) and with three replicates, where the biofertilizer (main plot) and seaweed extract were placed in the sub plot.

Experimental readings and measurements

• Six random plants were selected from each experimental unit at the end of the experiment for the purpose of conducting the required vegetative measurements, which included the following: number of leaves, leaf length, leaf width (cm), leaf area ($cm^2.plant^{-1}$), total yield (ton. ha^{-1}) and content Leaves of total chlorophyll (SPAD). The results of the experiment were statistically analyzed according to the method of analysis of variance and according to the split-plot-design system within the randomized complete block design (RCBD) with three replications. The significant differences between the means were compared at the probability level of 0.05 using the least significant difference test LSD (Genstat, 2012) in statistical analysis.

Results and discussion

the results in Table (4) that the addition of biofertilizer, there were no significant differences in the number of leaves, leaf length and leaf width, While the addition of bio-fertilizer, had a significant effect on the leaf area, where it was excelled on the

fertilization by 4 kg.ha^{-1} of bio-fertilizer, it gave the largest leaf area amounted to 26,969 cm^2. Plant^{-1} compared to the control treatment, which gave the lowest average leaf area of 25481 cm^2. Plant-^{1}The results of the same table indicate that the addition of seaweed extract was excelled fertilization by 16 kg.ha^{-1} of seaweed extract and gave the highest number of leaves reached 21.00 (leaf.plant^{-1}) compared to the control treatment, which gave the lowest average number of leaves amounted to 19.39 (leaf.plant^{-1}) , As for leaf length and leaf width, it is noted that there are no significant differences for seaweed extract with these two traits. It is also noted that there are significant differences in the leaf area . The fertilization was with 16 kg.ha-1 of seaweed extract excelled and the greatest leaf area was 28710 (cm^2.plant^{-1}) compared to the control treatment, which gave the lowest leaf area of 25286 cm^2. plant^{-1}. The results of the interaction in Table (4) indicate between biofertilizer extract and seaweed extract, where the highest number of leaves was recorded at 22.75B2F2 significant differences in the number of leaves, where the treatment of the interaction excelled leaf. Plant-1 compared to the control treatment, which gave the lowest average number of leaves, which was 20.58 leaves. plant^{-1}. As for the leaf length and the leaf width, we did not notice any significant differences in the interaction treatments between the two factors for these two traits. B2F2 results of the interaction showed that there were significant differences in the leaf area, as the treatment of the interaction excelled and gave the highest leaf area amounting to 32057 cm^2. plant^{-1}.

Table 4: Effect of bio-fertilizer and seaweed extract and the interaction between them on number of leaves, leaf length, leaf width and leaf area of kale

Surface leaf area (cm.plant-1)	leaf width(cm)	leaf length(cm)	number of leaves (leaf. plant-1)	bio fertilizer
25481	11.14	20.52	19.36	**control**
25979	10.93	20.74	19.58	**2 kg. ha-1**
26969	11.22	20.90	20.06	**4 kg. ha-1**
345	NS	NS	NS	**L.S.D.0.05**
				seaweed extract
25286	11.03	20.31	19.39	**0**
24433	11.04	20.52	18.61	**8 kg. ha-1**
28710	11.22	21.33	21.00	**16 kg. ha-1**
498	NS	NS	2.28	**L.S.D.0.05**
	Biofertilization X seaweed extract			
27106	11.07	20.43	20.58	**B0F0**
24095	11.30	20.40	18.50	**B0F1**
25242	11.07	20.73	19.00	**B0F2**
25148	11.30	20.30	19.50	**B1F0**
23958	10.20	20.63	18.00	**B1F1**
28832	11.30	21.30	21.25	**B1F2**
23604	10.73	20.20	18.08	**B2F0**
25245	11.63	20.53	19.33	**B2F1**
32057	11.30	21.97	22.75	**B2F2**
736	NS	NS	4.75	**L.S.D.0.05**

It is noted from the results in Table (5) that the addition of biofertilizer significantly affected the percentage of chlorophyll, the yield of one plant and the total yield, as the addition

treatment was recorded for 4 kg. ha^{-1} biofertilizer, the highest rate of chlorophyll is 52.10, The yield of one plant is 364.4 g. $Plant^{-1}$ and a total yield of 12.15 tons. ha^{-1} compared to the control treatment, which recorded the lowest average for the traits, the percentage of chlorophyll, the yield of one plant and the total yield and 298.3 g. $plant^{-1}$ and 9.52 tons. ha^{-1} in a row. SPAD and amounted to 50.30. The results of Table (5) show that the addition of seaweed extract had a significant effect on the percentage of chlorophyll, the yield of one plant and the total yield. As it excelled the treatment of adding 16 kg. ha^{-1} gave the highest chlorophyll content of 53.43 and the highest plant yield of 366.0 g. $Plant^{-1}$ and the highest total yield was 12.20 tons. ha^{-1} compared to the control treatment without fertilization, which recorded the lowest rate for the above traits, which amounted to 49.18 sap and 301.7 g. $plant^{-1}$ and 10.06 tons. ha^{-1}. The results of the bi-interaction in Table (5) between the biofertilizer and seaweed extract indicate that there are significant B2F2 differences in the percentage of chlorophyll, the yield of one plant and the total yield. 1 and the highest total yield was 14.23 tons. ha^{-1} Compared to the control treatment without biofertilization and without extract, which recorded the lowest measurements for the above-mentioned traits, 49.83 SPAD, 285.5 g. Nabat-1 and 9.52 tons. ha^{-1}, respectively.

Table 5: Effect of bio-fertilizer and seaweed extract and the interaction between them on the percentage of chlorophyll, plant yield and the total yield of kale plants

Total yield (tons. ha^{-1})	Plant yield (g. plant-1)	Chlorophyll (spad)	bio fertilizer
9.52	298.3	50.30	**control**
11.07	332.1	50.72	**2 kg. ha^{-1}**
12.15	364.4	52.10	**4 kg. ha^{-1}**
2.02	60.5	0.228	**L.S.D.0.05**
			seaweed extract
10.06	301.7	49.18	**0**
10.91	327.2	50.51	**8 kg. ha^{-1}**
12.20	366.0	53.43	**16 kg. ha^{-1}**
2.14	64.3	0.782	**L.S.D.0.05**
	Biofertilization X seaweed extract		
9.52	285.5	49.83	**B0F0**
9.96	298.8	49.27	**B0F1**
10.36	310.8	51.80	**B0F2**
10.07	302.1	49.20	**B1F0**
11.13	334.0	50.49	**B1F1**
12.01	360.4	52.47	**B1F2**
10.58	317.4	48.50	**B2F0**
11.63	348.8	51.77	**B2F1**
14.23	426.9	56.03	**B2F2**
4.71	104.4	0.989	**L.S.D.0.05**

The reason for the role of biofertilizer in its effect on growth may be due to the fact that it contains different types of microorganisms that are added to the soil (Table 2)It increases the availability of nutrients for the plant, as well as regulates the appropriate development of plant growth, which leads to soil fertilization and its compatibility with

agriculture (Gad and Kandil, 2013) and (Bhat *et al.*, 2015),It analyzes organic waste and its role in the secretion of some enzymes, growth regulators, plant hormones and their importance in biological control (Ali, 2012). These microorganisms have the ability to settle in the rhizosphere, where this area represents the thin layer of soil with a thickness of between 1-2 mm, which surrounds the roots of plants contain many microorganisms, including bacteria and fungi (Taha, 2007). It also works to reduce the infection of roots by mold, because living organisms secrete antibiotics that reduce the infection of mold and stimulate the growth of roots because microorganisms secrete natural growth stimulants that activate the growth of roots and reduce the accumulation of nitrates and nitrites, and this is in line with Manea 2017 on Al-Hana and with Meena *et al.*, 2018 on cauliflower and Subedi et al., 2019 on cauliflower. Biofertilization contributed to improving vegetative growth indicators, which increased cell division and activity and increased vital activities. The different types of plants inside the plant such as photosynthesis, transpiration, enzyme activation, protein analysis, hormones, nucleic acids and others, which increased the number of manufactured materials inside the plant (carbohydrates, proteins, hormones, and amino acids), which positively reflected on the characteristics of the crop. The role of seaweed extract may be due to its content of microelements that contributed to the increase in vegetative growth and in turn reflected on the traits of the crop because iron and manganese have a role in the formation of protein by contributing to the process of nitrate reduction that results in ammonia to form the basic units in building proteins after their association with ketogenic acids Manganese plays an important role in its availability during the reactions of the Krebs cycle, while zinc is important in the formation of glucose, carbohydrates and safe acids, especially the manufacture of the amino acid tryptophan, which starts the vital pathway for building auxin, as well as its role in activating a number of enzymes (Husein, 2016) or due to raising the efficiency of photosynthesis and increasing vegetative growth, which is reflected positively in providing The food supply of inflorescences (Kowalczyk et al, 2008), and these results agree and these results agree with Manea (2017) on the plant of cabbage and agree with Al-Zamili and Al-Zamili (2012) on the cauliflower plant,We conclude from this research that the addition of bio-fertilizer (Fulzyme Plus) 4 kg. ha^{-1}, with 16 kg. ha^{-1} seaweed extract (Algae stim) achieved the highest yield (14.23) tons. ha^{-1}. Therefore, we recommend bio-fertilizer and seaweed extract in the above-mentioned quantities for kale. Conclude from this study that the highest total yield was achieved with the treatment of 4 $kg.ha^{-1}$ bio fertilizer with 16 $kg.ha^{-1}$ seaweed extract.

References

Ahmad, T. S. .2018. Effect of Organic Fertilizer Addition and Spraying Seaweed Extract on Some Growth Characters, Yield and Active Ingredient of Arugula Plant (Eruca sativa Mill). Journal Tikrit Univ. For Agri. Sci., 18 (1): 1813-1646.

Al-Azzawi, O. T. J. and S. M. Saleh. 2018. Effect of humic acid and marine algae extracts on the vegetative growth characteristics of cress and aloe vera plants. Tikrit Journal of Science. Tikrit Journal of Agricultural Sciences, 18(3): 1647-1813.

Ali, N. S. 2012. Fertilizer technologies and their uses. Baghdad University. Ministry of Higher Education and Scientific Research. The Republic of Iraq.

Al-Nuaimi, S. N. A.. 1999. Fertilizer and soil fertility. Dar Al-Kutub Foundation for Printing and Publishing. College of Agriculture and Forestry. University of Al Mosul. Ministry of Higher Education and Scientific Research. Iraq.

Al-Zamili, N. F. and Y. Al-Zamili. 2012. The role of organic and chemical nutrients in the growth and production of cauliflower. Master Thesis. faculty of Agriculture. Baghdad University.

Bhat ,T. A., L. Ahmad, M. A. Ganai, S.Ul-Haq and O.A. Khan .2015.Nitrogen fixing biofertilizers, mechanism and growth promotion: a Review. Journal of Pure and Applied Microbiology, 9 (2): 1675-1690.

El Saadawi, F. W. A. 2014. Response of two watercress cultivars, Eruca sativa Mill, to plant density and treatment with biostimulant Bio health on growth and yield of seeds and oil and its biochemical activities. Master's Thesis, Faculty of Agriculture. Albasrah university.

Gad ,N. and H. Kandil.2013. Evaluate the effect of molybdenum and different nitrogen levels on cowpea (Vigna unguicuata).Journal of applied sciences research,9(3): 1490-1497.

Gad N. and H. Kandil .2003. Evaluate the effect of molybdenum and different nitrogen levels on cowpea (Vigna unguiculata). Journal of Applied Sciences Research, 9(3): 1490-1497.

Genstat. 2012. Release 4.23DE, copyright Lawes Agricultural Trust. Rothamsted Experiment Station, Hertfordshire, UK.

Gunnars, K. 2018.10 health benefits of kale. Available https://www.healthline.com/nutrition/10-proven-benefits-of-Kale. Accessed November 3, 2019.

Hassan, A. H. A Production of non-traditional secondary vegetables. part One. Arab House for Publishing and Distribution. The Egyptian Arabic Republic. p. 236.

Husein, M. A. 2016. Response of Cauliflower plants to spray with nutrients solutions from different sources. The Iraqi Journal of Agricultural Scienc,47(5):1218-1224.

Kowalczyk, K., T. Zielony and M. Gajewski. 2008. Effect of Aminoplant and Asahi on yield and quality of lettuce grown on rockwool. Biostimulators in Modern Agriculture. Vegetable Crops,2(111): 35-43.

Manea, A. I. 2017. Fertilizer Type on Cabbage Growth and Yield. International of vegetable science, 23:6, 567-574.

Meena, M. k., k. Aravindakshan, M. Dhayal, J. Singh, and S.L. Meena. 2018. Effect of Bio fertilizers and Growth Regulators on Growth Attributes of cauliflower (*Brassica oleracea* var. botrytis L.) Interna tional journal current. Microbiology and. Applid. Scieuces., -7: 885-890.

O'Dell, C. 2003. Natural Plant Hormones are Bio stimulants Helping Plants Develop High Plant Antioxidant Activity for Multiple Benefits. Virginia Vegetable, Small Fruit and Specialty Crops. 2 (6): 1-3.

Subedi, R. A. khanal, A. Aryal, k. Aryal, L.B. chhetri , and B.P. kandel, .2019. Response of azotobacter in cauliflower (Brassica oleracea var. botrytis) productionat lamjung Nepal. Acta Scientifica Malaysia (ASM) 3(1):17-20.

Taha, A. M. R.. 2007. Bio-fertilizer and organic farming (healthy food and clean environment). Arab Thought House, Cairo. Egypt.

Trani, PE; Tivelli, SW; Blat, SF; Prelapantano, A; Teixeira, EP; Araujo, HS;Feltran, JC; Passos, FA; Figueiredo, JB; Novo, MCSS. 2015. Couve de folha: do plantio a pós- colheita. 42p. (Boletim Técnico IAC 214).