"Improvement of Growth and Yield of Cauliflower (Brassica oleracea Var. Romanesco) by Using Two Types of Biofertilizers

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Abstract:

Romanesco cauliflower belongs to Brassicaceae family, commonly known as a unique and visually striking vegetable that belongs to the species *Brassica oleracea*, Biofertilizers are microbial-based products that enhance nutrient availability to plants it is compatible with long-term sustainable agriculture, they often include beneficial bacteria, fungi, or algae that fix nitrogen, decompose organic matter, and promote plant growth two types of bacteria were used Azotobacter, Bacillus sp. combination from Azotobacter and Bacillus sp. (AB) and (control) without treatment with three replicates using two factors-factorial experiment designs (RCBD)using least significant range (L.S.D) test at probability level of 0.05. These variables comprised analysis of the plant's hight, leaf area, dry matter proportion, relative chlorophyll content, nitrogen, phosphorus, and potassium contents, weight of the flower crown, and overall yield. exhibited a substantial enhancement in the majority of the assessed parameters which significantly excelled in some studied traits (dry matter leaves proportion, relative chlorophyll leaves content, Leafe area 18.79%,58.35 spad,3247cm^2 respectively in addition to the percentage, Whight of the flower bud 9 .907gm.plant^{-1} and Total yield 36. 32kg.ha^{-1}.the results of bi- interaction between the studied factors showed no significant differences in some of the studied characters such plant height, number of leaves and the dry matter for leaves but it recorded significant differences in percentage of (nitrogen, phosphorus and potassium which was estimated (2.545%,0.3147%,3.377%).

Keywords. Cauliflower, Romanesco Azotobacter, Bacillus sp., Biofertilization

1.Introduction*:*

Romanesco cauliflower, *Brassica oleracea var. botrytis*, is part of a large group of plants known as Cole crops which is a unique and visually striking vegetable which also includes other well-known crops such as cabbage, broccoli, and kale. Romanesco cauliflower thrives in cool-season climates, preferring temperatures between 10°C to 20°C (50°F to 68°F) and affecting temperature on the crop 18° to 25° at day time ,night time slightly cooler but not below 10° (1). It can be sensitive to heat and does not perform well in high temperatures, making it ideal for spring or fall planting in temperate regions(2), Romanesco cauliflower is highly nutritious, offering a range of health benefits(3). Like other cruciferous vegetables, it is rich in High levels of vitamin C and vitamin K, which are important for immune function, wound healing, and bone health, A Good source of calcium, potassium, and magnesium, which support bone health, muscle function, and cardiovascular health it is a good source of dietary fiber, contains compounds such as glucosinolates and carotenoids, which have been linked to anti-inflammatory and anticancer properties.(4). Fertilization is one of the most important crop service processes and one of the important means of production due to its significant impact on regulating the physiological processes of the plant, especially nutrients(5). In addition, providing the plant with the nutritional elements it needs is a necessary condition whose importance is evident in obtaining optimal production and better quality (6). Biofertilizers play a major role in increasing crop production, due to the increase in soil fertility in the long term, as they are necessary to meet the global demand for food(8). These microbes can coexist with plants and enhance them with the essential nutrients that the plant needs for growth(9). Biofertilizers are produced by isolating, purifying and characterizing selected strains of microorganisms that are beneficial to the soil and are propagated in suitable farms until they are used(10). They are environmentally friendly and available compared to chemical fertilizers that are harmful to the environment and expensive(11). Azotobacter chroococcum was recorded as the first genus in Azotobacter bacteria by the Dutch botanist and microbiologist Beijerinck for the first time in 1901. In 1932, Winogradsky showed that it is a source of ammonia in the soil(12). It lives freely and is known as an obligate aerobe, Gram-negative, and relies on the analysis of organic matter as a source of energy and carbon(Briski & Vuković Domanovac, 2017). One of its distinguishing characteristics is its reliance on several carbohydrate sources to obtain energy(14). Azotobacter and Phosphorus solubilizing bacteria (PSB) are biofertilizers that nourish crops and soil by releasing growth-promoting substances and vitamins(15). Azotobacter fixes atmospheric nitrogen in the root zone of plants while PSB dissolves fixed, insoluble phosphates already present in the soil. (Ketut Widnyana et al., 2018) showed that Bacillus sp. can produce plant hormones that have the potential to develop sustainable agricultural systems. The plant hormones produced by these bacteria in the soil can affect plant growth, either directly or indirectly(16). The indirect effect of the plant hormone is to inhibit pathogenic activity in plants, while the direct effect of the plant hormone is to increase plant growth and can act as a facilitator for the absorption of some nutrients from the environment. For optimal growth, plants require phosphorus, another key nutrient, due to its vital role in metabolic processes, signal transduction, macromolecule production, and photosynthesis(17). Plants have difficulty absorbing the vast majority of readily accessible phosphorus because it is insoluble or deposited in the soil. In addition to producing low molecular weight organic acids such as gluconic acid and citric acid and phosphatase enzymes that dissolve inorganic phosphorus into monobasic or dibasic ions, these bacteria are capable of dissolving and mining phosphate(18).

2.Materials and methods: A soil sample was taken from a depth of 30 cm after scraping the surface layer of one of the privately owned field in the Al-Azzawiya region, Babylon province, during the 2024-2025 agricultural season, to investigate the impact of two types of organic extracts on the growth and yield of *Brassica oleracea* var. Romanesco. The outcomes of the analysis, which were conducted in the laboratory of the College of Agriculture/Al-Qasim Green University, are detailed in Table 1.

Table 1. Some chemical and physical characteristics of field soil before planting.

Traits	Units	Value
pH	.....	7.9
Electrical conductivity	Ds/m^{-1}	3.9
Organic matter	g. kg	11.3
Ready nitrogen	g. kg	13.4
Ready phosphorus	g. kg	5.6
Ready potassium	g. kg	192.0
Bulk density	$g.\ cm^3$	1.13
the sand	g. kg	600
Alluvial	g. kg	245
Clay	g. kg	155
	Texture	Silty loam

Using a randomized complete block design (RCBD) with three replicates. The experiment included two types of biofertilizer azotobacter was the first factor, Bacillus sp, combination of (Azotobacter and Bacillus sp.) and control without addition, added ($300gm.3l^{-1}$, $20ml.plant^{-1}$) in two periods between each time 45 days, The number of experimental units was 4 units in three replicates. The experimental unit was a terrace with a length of 3m and a width of 1 m. The number of plants was 12 plants in the experimental unit on both sides of the terrace, with 50 cm between one plant and another, leaving an area of 1 m between one experimental unit and another and 1.5 m between the sectors, The drip irrigation method was adopted as the basis for the irrigation process, The coefficients were compared using the least significant range (L.S.D.) at a probability level of 0.05%. A special isolate of Azotobacter was obtained from the laboratory of the Department of Plant Protection, College of Agriculture / University of Karbala, and a number of isolates were grown in the laboratory of the Department of Horticulture and Landscape Engineering / College of Agriculture / Al-Qasim Green University, the bacteria were cultivated by adding 1 g of soil to 1 ml of distilled water and making several dilutions of (10, 100 and 1000), 100 microliters were withdrawn and added to petri dishes containing a Nutrient Broth culture medium to grow on, The colonies in the dish were counted, The number was 10^7. The same method was followed with bacillus sp. Which is obtained from Al-Furat Al-Awsat University / Al-Musayyab Agricultural Technical College / Biocontrol Laboratories. The bacterial vaccine was prepared in the Pathology Laboratory in the Department of Horticulture and Landscape Engineering, Al-Qasim Green University and the number was 3×10^6. (Pikovskaya, 1948).

3.Results

The results in table2 indicate that there is no significant effect of biofertilizers on the average plant height. The addition of azotobacter, Bacillus sp., and their combination did not affect the average number of leaves, as the results were similar to each other and to the control groups, respectively, the addition of AB biofertilizer recorded the highest average dry matter percentage, at 18.79% compared to control 17.98%,, while the results were similar between azotobacter, Bacillus sp., recording 17.96%, 17.03%, and respectively, The results of the same table also indicate a control use effect of biofertilizers on the relative chlorophyll content in leaves, as the biofertilizer (Bacillus sp.) treatment achieved the highest average relative chlorophyll content of 58.35 spad, compared to the comparison treatment, which recorded

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the lowest average relative chlorophyll content of 53.72 spad. The results of the same table also indicate a significant effect of biofertilizers on the average leaf area, as the Bacillus sp. treatment outperformed the other treatments and achieved the highest average leaf area of 3247 cm^2. $plant^{-1}$ as compared to the control treatment, which recorded the lowest average leaf area of 2794 cm^2. $Plant^{-1}$. The results of the interaction between biofertilizers and the comparison group indicate that there are no significant differences in the average plant height, number of leaves, and percentage of dry matter, respectively. However, significant differences were recorded in the relative content of chlorophyll in the leaves (CA) 59.10 spad and the average leaf area2595 cm^2.$plant^{-1}$. at L.S.D (0.05)

Table 2: The effect of two types of biofertilizers and their interaction on vegetative traits

biofertilizer	Plant hight cm	Number of leaves	DM%	Chlorophyll 100g/mg	Leaves rea Cm^2
Control (C)	71.16 a	25.87 a	17.98 ab	53.72 b	2794 b
Azotobacter (A)	70.55 a	26.07 a	17.96 ab	56.22 ab	2847 b
Bacillus sp.(B)	72.92 a	26.69 a	17.03 b	58.35 a	3247 a
AB	70.08 a	25.64 a	18.79 a	54.23 b	2835 b
Interaction					
C	69.58 a	25.11 a	18.93 a	50.90 c	2082 d
CA	68.12 a	27.33 a	17.12 a	59.10 a	2565 b
CB	69.85 a	27.33 a	17.60 a	56.20 b	2595 a
CAB	69.81 a	25.56 a	18.50 a	54.87 d	2351 c

Table 3. The results in Table 3 indicate the effect of biofertilization A, B, AB on the percentage of nitrogen in the leaves, as all results were significant compared to the comparison treatment, while the content of phosphorus and potassium was not significantly affected by biofertilization. The combination between A, B (AB) recorded the highest average in the weight of the flower bud weight (907.9 gm. $plant^{-1}$) and total yield (36.32 ton. ha^{-1}). The interaction CB indicated significant value in the percentage of nitrogen (2.545%) and phosphorus (0.3147%), CA indicated significant value in the percentage of potassium (3.377%), CAB notably the higher values for the average of Whight of the flower

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bud (686. 7gm.plant^{-1}) and total yield (27. 47ton.ha^{-1}) at L.S.D (0.05)

Table 3. The effect of two types of biofertilizers and their interaction on the percentage of nitrogen, phosphorus, potassium, flowerhead weight (g/plant^{-1}) and total yield (kg/ha^{-1})

biofertilizer	N%	P%	K%	Whight 0f the flower bud (g. plant^{-1})	Total yield kg/ha^{-1}
Control (C)	2.151 b	0.3056 a	2.878 a	759.3 c	30.37 c
Azotobacter (A)	2.449 a	0.3161 a	2.768 a	796.6 b	31.86 b
Bacillus sp.(B)	2.439 a	0.3187 a	2.751 a	796.5 b	31.86 b
AB	2.456 a	0.3113 a	2.895 a	907.9 a	36.32 a
Interaction					
C	1.549 c	0.2450 c	1.550 d	564.7 c	22.59 c
CA	2.465 b	0.3017 b	3.377 a	673.0 b	26.92 b
CB	2.545 a	0.3147 a	3.062 c	673.4 b	26.93 b
CAB	2.454 b	0.3057 b	3.282 b	686.7 a	27.47 a

Discussion.

According to findings the results in Tables 2 and 3 validated that the application of biofertilizer had a positive effect on plant yield, total yield, leaf chlorophyll content, and dry matter (19)growth. This result is consistent with the results reached by(20), The increase in the plant's content of essential major elements such as nitrogen, potassium and phosphorus is due to the role of the biofertilizers used in this study in facilitating these elements in the soil and for the plant in a form that can be absorbed by the plant's roots.(21), in this study the plant hight ,number of leaves and leafe area didn’t show significant traits and that might referred to ineffectual function of biofertilizers if they used alone and that’s consists with results reached by (22). The biofertilizer Bacillus sp. achieved the highest average leaf area of the plant and the highest average relative chlorophyll content, Moreover the facilitating phosphorus in the soil and increasing the plant’s ability to absorb it(19).

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Conclusion.

Utilizing biofertilizers alone did not show comprehensive effects on all traits but rather, it significantly influenced certain vegetative growth characteristics, such as dry matter percentage in leaves, content of major nutrients, weight of flower bud, and total plant yield. Conversely, biofertilizers treatment didn’t influence the plant's Hight, number of leaves, relative chlorophyll content and leafe area. Hence, it is recommended using biofertilizers combined with other varieties of fertilizers to expand the effect of them on the plant and soil.

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