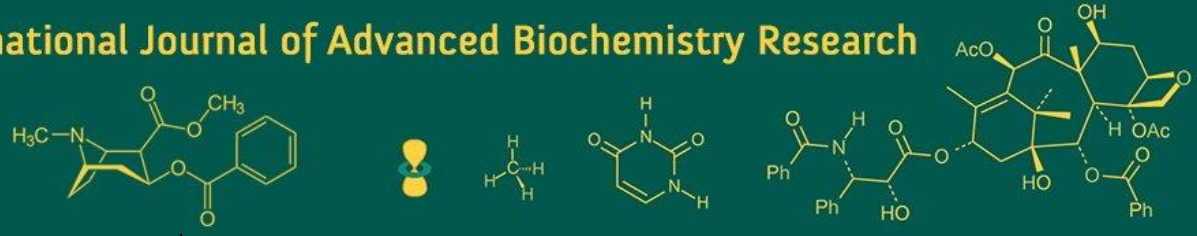
International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2025; 9(1): 360-364
www.biochemjournal.com
Received: 17-10-2024
Accepted: 20-11-2024

Wahhab Salih Mahdi Alfanous
Department of Horticulture and Landscape Architecture, College of Agriculture, Al-Qasim Green University, Babylon, Iraq

Baydaa Rasheed Hilo
Department of Horticulture and Landscape Architecture, College of Agriculture, Al-Qasim Green University, Babylon, Iraq

Zahraa Kadhum Al Mussawi
Department of Horticulture and Landscape Architecture, College of Agriculture, Al-Qasim Green University, Babylon, Iraq

Corresponding Author:
Wahhab Salih Mahdi Alfanous
Department of Horticulture and Landscape Architecture, College of Agriculture, Al-Qasim Green University, Babylon, Iraq

Effect of cysteine, ascorbic acid and organic fertilizers on the growth and yield of broccoli

Wahhab Salih Mahdi Alfanous, Baydaa Rasheed Hilo and Zahraa Kadhum Al Mussawi

DOI: https://doi.org/10.33545/26174693.2025.v9.i1e.3504

Abstract
The experiment was conducted. Field work in one of the fields of Al-Azzawiyah area / Al-Musayyab district, 40 km north of Babylon Governorate During the fall season 2024-2025 to study the effect of foliar spraying. blend from Cysteine and ascorbic acid and their interaction at a concentration of (0, 50, 50, mg. L^1) which is symbolized by T_0, T_1, T_2, and T_2, and the soil addition of organic fertilizer at a concentration of (0, 5, 10 ml. L^1) which is symbolized by (L0, L1, L2 ml. L1) on the growth and yield of broccoli. A factorial experiment was conducted within the RCBD design. In total 36 treatments. The land was divided into three replicates, each replicate containing 12 experimental units. The replicate contained two terraces, width Every bench1 m, leaving a distance of 1 m between one platform and another, and 50 cm between the experimental units as an insulator to prevent mixing between treatments, and 50 cm between one plant and another. And it was Drip irrigation. The results showed that the individual and interaction treatments recorded significant values between Attributes studied. And individual treatmentT_3 achieved the highest significant increase in the number of leaves, which amounted to 65.38 leaves/plant^{-1}, and the leaf area was 2965 dm/plant^{-1}. The results also showed a significant superiority in the soil addition treatments, as treatment L2 outperformed by giving the highest value in the number of leaves, which amounted to 62.90 leaves/plant^{-1}, and the leaf area amounted to 3039 dm/plant^{-1}. As for the interaction treatments between the study factors, the results showed a significant superiority, as treatment T_3 L2 achieved the highest significant increase by giving the highest value in the number of leaves, which amounted to 71 leaves/plant^{-1}, and the leaf area amounted to 3842 dm/plant^{-1}, and the chlorophyll content of the floral disc amounted to 16.38 (mg 1 gm^{-1} fresh weight), and the weight of the floral disc amounted to 576 gm/plant^{-1}.

Keywords: Foliar spraying, cysteine, ascorbic acid, organic fertilizer, broccoli growth, broccoli yield

Introduction
The Cruciferae family includes: Brassicaceae has many important vegetable crops, among which is broccoli. The scientific name of broccoli is (*Brassica oleracea* var. Italica), and it is an annual herbaceous plant, native to the Mediterranean region (Al-Sayed, 2009) [24]. It was first cultivated in England in 1720 AD, then moved to the United States of America in 1806 AD. This plant is cultivated for its flowers, which are eaten at the stage of green flower buds with thick, soft buds. Broccoli is considered one of the most profitable crops in this family in terms of nutritional value, and it is the most used in medicine, as it contains many vitamins and minerals (Thapa, 2012) [28]. It is also rich in profen and beta-carotene, and its leaves are considered a source of polyphenols, fats and fibers.

Broccoli is an important vegetable crop known for its economic value, and is part of the Brassicaceae (Broccoli is rich in nutrients, containing abundant amounts of vitamins A, E, B1, B2, B5, and B6, as well as essential minerals such as magnesium (Mg), calcium (Ca), iron (Fe), and zinc (Zn Weber, 2017) [29]. In addition, it is known for its high content of carotenoids and antioxidants, which enhance its nutritional value. Therefore, it is considered a good healthy food (Rodriguez-Casado, 2016) [23]. In Iraq, 989 hectares of broccoli and cauliflower were cultivated, producing 7,187 tons and 7.2669 tons per hectare of productivity (FAO, 2019) [12].

Vegetative growth is improved in various ways, one of the most important is the use of organic fertilizer systems that are based on natural ingredients, as these systems are considered an effective means of improving the physical, chemical and biological quality of the soil. One of the available alternatives to organic fertilizers that can contribute to reducing the use of inorganic fertilizers is liquid organic fertilizers. These fertilizers contain nutrients and biological microbes that are beneficial to plant growth (Martínez-Alcántara *et al*., 2016) [16]. Studies have shown that vegetative growth, productivity and nutrient content in broccoli plants are positively affected by liquid organic fertilizers. Specialists have become increasingly interested in producing and improving vegetable crops through the use of the best breeding methods. Many researchers have also moved towards encouraging and supporting organic production, which is characterized by low nitrate and oxalate content so that it does not exceed healthy limits, in addition to achieving high economic production, especially in developed countries (Abu Rayan, 2010 and AL-Bayati *et al*., 2019) [4, 5]. Recent studies have focused on reducing the amounts of mineral fertilizers added by using methods that enhance their availability in the soil and their ability to regenerate.

Humic acid increases the availability of nutrients to the plant, and enhances the absorption of potassium, calcium, magnesium and phosphorus. Humic acid also partially contributes to reducing the negative impact resulting from the addition of mineral fertilizers to the soil (Singer *et al*., 1998) [27]. Humic acid is a complex, hydrophilic, dark-colored organic chemical compound that comes in either liquid or powder form. Its chemical formula is (2)(3)C7H33017N3 (COOH), and it contains carbon, nitrogen, hydrogen, and oxygen in varying proportions, resulting in compounds with various molecular weights (Sensei, 1992) [25].

Confirmed Issawi-Al *et al*. (2021) [7] in an experiment conducted on broccoli plants showed that adding 0.25 mg of humic acid to the soil achieved significant differences in vegetative, chemical and yield characteristics. It recorded the highest significant value in plant height, reaching 32.639 cm, compared to the comparison treatment, which was 29.097 cm, and the highest head weight, reaching 246.5 g, compared to the comparison treatment, which was 116.0 g. It also achieved the highest total yield, reaching 8.215 tons per hectare, compared to the comparison treatment, which was 3.865 tons per hectare. It also recorded the highest percentage of sprouting in discs, reaching 5541%, compared to the comparison treatment, which was 3.201%. It also gave the highest annual percentage of falcons in discs, reaching 0.3816%, while the comparison treatment was 0.1459%. The highest percentage of potassium was recorded in the tablets, which amounted to 3.611%, compared to the control treatment, which was 1.973%.

Cysteine serves as a precursor to many essential biomolecules, such as vitamins and cofactors (Mohamed, 2012) [19] and antioxidants such as glutathione, which plays a crucial role in cellular redox balance and the synthesis of many defense compounds [Hell, 2008] [14]. All of these biomolecules contain sulfur groups that act as functional groups and are derived from cysteine in plants.

Cysteine synthesis plays a key role in the fixation of inorganic sulfur from the environment, and is the sole source of sulfide required for the formation of methionine, glutathione, phytochelatin, iron sulfide clusters, vitamin cofactors, and multiple secondary metabolites.

In a study conducted by Shekari and Javanmardi (2017) [26] reported on the effect of foliar fertilization with cysteine, methionine and amino acid (AA) on broccoli (Brassica oleracea var. italica) seedlings. Cysteine, methionine and amino acid (AA) were applied at three concentrations: 0, 100 and 200 mg/L, starting from 20 days after planting. The physicochemical characteristics of the seedlings were measured according to the methods described by Tabatabaei. The results showed that cysteine at concentrations of 100 and 200 mg/L increased leaf area by 53% and 48%, respectively, and increased fresh weight of shoots by 50% and 55%, respectively. L-cysteine at concentrations of 100 and 200 mg/L increased dry weight of roots by 26% and 60%.

Ascorbic acid is a growth promoter that affects physiological and metabolic processes such as the synthesis of proteins, nucleic acids and enzymes. It has antioxidant properties, is water soluble, and plays an important protective role against reactive oxygen species that are formed during metabolism. My light and breathing Abdul Rahman *et al*. 2012 and El-Khattab, 2019) [2, 11].

Metwally pointed out (Metwaly and El-Shatoury (2017) [17] found that foliar spraying with ascorbic acid on cabbage plants resulted in a significant increase in plant height, leaf area, chlorophyll content, yield, and vitamin C concentration. Osman and Rady (2018) [21] also found that foliar spraying with ascorbic acid on broccoli plants in both seasons resulted in a significant increase in leaf area, yield, and vitamin C concentration. Indicated that immersing flower heads in ascorbic acid resulted in a significant increase in shelf life, vitamin C concentration, chlorophyll content, and total dissolved solids, and recorded the least weight loss, and these results are consistent with Bilgin (2021) [8].

Materials and Methods

The field experiment was conducted during the planting season. A 2024-2025 in Al-Ezz area Oh It is affiliated with Al-Mahawil District, which is located 40 km north of the city center of Hillah. (governorate Babylon). This is because Head The effect of cysteine, ascorbic acid and organic fertilizer on the growth and yield of broccoli. The variety (max) The field soil designated for implementing the experiment was prepared by cleaning it from the remains of the previous crop. After that, it was ploughed, smoothed and leveled in a homogeneous manner. Then, the land was divided into three replicates, so that each replicate included 12 experimental units. The replicate contained two terraces. Show all1m platform with a distance of 1m between each platform and 50 cm between the experimental units as an insulator to prevent mixing between the parameters no T, and between one plant and another 50 cm, and then the drip irrigation system was installed.

The soil texture was a mixture of silty and clayey. Acids And pH (8) and its electrical conductivity EC (4.5) Decisiemens m-1, and the percentage of organic matter in it 11.3%.

The seeds were planted on 10/8/2024 For the purpose of seedling production, the experiment was carried out using a randomized complete block design. RCBD (Randomized Complete Block Design), the experiment involved the use of two factors.

The first factor: the amino acid cysteine, ascorbic acid and the interaction between them Four levels It is done by spraying the plants until they are completely wet, with three sprays depending on the growth stages.

Levels	cysteine	Ascorbic acid
T_0	0 mg/L	0 mg/l
T_1	50 mg/L	0 mg/L
T_2	0 mg/L	50 mg/L
T_3	50 mg/L	50 mg/L

The second factor: adding fertilizer. Organic For soil and three Levels
T_0 = 0 Ml / liter
L1= Ml / liter 5
L2 = Ml / liter 10

The indicator RaT and experimental measurements:
I was elected six Plants from each experimental unit for measurement purposes required
1. Plant height (cm).Plant$^{-1)}$
The height of the plant was measured from the point of contact with the soil to the highest leaf of the plant selected for the experimental unit using a measuring tape, and the average was extracted.

2. Number of leaves (leaf)
The total number of leaves for each of the selected plants in the experimental unit was counted during the flower disc maturity stage, and the average was extracted.

3. Paper space (Dcm^2 per plant)
Leaf area was assessed by taking six full-width leaves from each experimental unit containing five plants, using a scanner and software. Images, according to the method used and the average was calculated.

4. Chlorophyll content in leaves. (amalgam 100 GM - 1 fresh weight)
Total chlorophyll content in leaves was estimated by randomly sampling five plants per experimental unit. The samples were washed with water, air dried, and then weighed. It is fresh. 10 ml of 80% acetone was added to the fresh weight, and the paper tissue was crushed using a ceramic mortar. Then, the solution was filtered using filter paper (Wathrmann No. 1), and the crushing process was repeated again to extract the remaining dyes until the color of the fabric became white. The total volume of the filtrate was then supplemented with acetone to 20 ml and a spectrophotometer was used to measure the optical absorbance of the dyes at wavelengths of 645 and 663 nm.
The total chlorophyll amount was then calculated using the following equation:
Total chlorophyll = [20.2×D(645)] + [8.02×D(663)] × (size/width × 1000) / 100
Whereas:
D(663) - Light absorbance reading at a wavelength of 663 nm.
D(645) - Light absorbance reading at a wavelength of 645 nm.
The final extracted volume is 20 ml, and the weight of the paper tissue is 1 g.

5. Chlorophyll percentage in the flower disc
Total chlorophyll pigment estimation in Flower discs Random samples of five plants were taken from each experimental unit, then washed with water and air dried, then1Soft weight.

6. Disc diameter (cm)
The diameter of mature flower discs was calculated by measuring the widest area of the disc surface of the selected plants and calculating the average.

7. Disc weight (g)
The weight of mature flower discs from each experimental unit was calculated, and the average was calculated.

Results and Discussion
1. Plant height (cm)
The results shown in Table No. (1) indicated that there were no significant differences between the foliar spray treatments with nutrients.
The table also showed that there were no significant differences between the land addition coefficients.
As for the interaction between the study factors, treatment 2 achieved T_3 L gave the highest value of 69.67 cm while the comparison treatment T_0 L0 recorded a height of 65.08 cm.

Table 1: The effect of cysteine, ascorbic acid, organic fertilizer and their interaction on plant height (cm)

T / L	L0	L1	L2	Average T
T_0	65.08	67.67	68.94	67.23
T_1	66.22	68	68.42	68.21
T_2	64.58	65.64	68.03	66.08
T_3	67.80	69.37	69.67	68.95
Average L	66.42	67.67	68.76	
L.S.D L=2.794		L.S.D T= 3.226	L.S.D TL= 5.587	

2. Number of leaves (1 leaf)
The results shown in Figure (2) showed significant differences between the foliar spray treatments in terms of the average number of leaves, as the treatment was T_3 achieved higher The value is 65.38 leaf-1, while the control treatment gave the lowest value.T_0 which recorded 52.60 leaf-1,
The same table also shows that there are significant differences between the land addition treatments, as the treatment outperformedL2 had the highest value of 62.90 leaves per plant^{-1}, followed by treatment L1 which recorded the lowest number of 59.73 leaves per plant^{-1}, while the comparison treatment recorded the lowest value of 57.62 leaves per plant^{-1}.
As shown in the table Significant differences between transactions Interference Among the study factors in the total number of leaves of the plant, the treatment was superior.T_3 L2 outperformed all other treatments by giving

the best value of 71 leaves/plant^{-1}, while the comparison treatment To L0 had the lowest value of 52.60 leaves/plant^{-1}.

Table 2: The effect of cysteine, ascorbic acid, organic fertilizer and their interaction on the number of plant leave.

T L L	L0	L1	L2	Average T
T_0	52.60	53.97	55.10	53.89
T_1	58.77	59.27	63	60.34
T_2	59.33	60.33	62.50	60.72
T_3	59.80	65.33	71	65.38
Average L	57.62	59.73	62.90	
L.S.D L=1.632			L.S.D T= 1.884	L.S.D TL= 3.264

3. Paper area (ds^2)

The results shown in Table (3) indicated that there were significant differences between the spraying treatments, as the treatment outperformedT_3 gave the highest value for leaf area per plant, reaching 2965 dm.plant^{-1}, while the comparison treatment recorded the lowest value, reaching 2002 dm2.

The same table also showed significant differences between the land addition treatments, as the results showed that the treatment was superior.L2 gave the highest value of 3039 dm2, while the comparison treatment recorded the lowest leaf area of 2111 dm2.

As for the interaction between the study factors, the treatment was superior. T_3 L2 significantly increased the value of 3842 dm2, while the comparison treatment To L0 recorded the lowest value of 2002 dm2.

Table 3: Effect of cysteine, ascorbic acid, organic fertilizer and their interaction on leaf area (decimeter)

T L L	L0	L1	L2	Average T
T_0	2002	2226	**2338**	**2200**
T_1	1965	3037	3309	2782
T_2	2234	2788	2668	2563
T_3	2245	2708	2842	2965
Average L	2111	2732	3039	
L.S.D L=271.3			L.S.D T= 313.3	L.S.D TL=542.6

4. Total chlorophyll content of leaves (mg) 1001 gm (fresh weight)

The results shown in Table No. (4) showed: non There were significant differences between spraying and soil addition treatments in the chlorophyll ratio of broccoli.

As for the interaction of the study factors, the treatment achieved T_3 L2 percentage reached 15.69 mg per 1 g-1 fresh weight in the total chlorophyll content of the leaves, while the chlorophyll percentage in the comparison treatment T_0 L0 reached 15.85 mg per 100 g-1 fresh weight.

Table 4: The effect of cysteine, ascorbic acid, organic fertilizer and their interaction on the percentage of chlorophyll in leaves.

T L	L0	L1	L2	Average T
T_0	15.85	16.14	15.56	15.85
T_1	15.70	15.18	15.29	15.39
T_2	15.37	15.67	15.50	15.52
T_3	15.72	15.47	15.69	15.62
Average L	15.66	15.62	15.51	
L.S.D T= 0.763			L.S.D L=0.661	L.S.D TL= 1.321

5. Total chlorophyll content of the flower disc (mg) 1001 gm (fresh weight)

The results shown in Table (5) showed no significant differences between the spraying and soil addition treatments in the average percentage of chlorophyll in the flower disc of broccoli plants.

As for the interaction between the study factors, the treatment was superior.T_3 L2 was significantly higher, giving the highest value of 16.38 (mg/gm fresh weight), while the comparison treatment To L0 recorded the lowest value of 13.15 (mg/gm fresh weight).

Table 5: The effect of cysteine, ascorbic acid, and the organic fertilizer Libro and their interaction on the chlorophyll of the floral disc

T L	L0	L1	L2	Average T
T_0	13.15	13.87	16.19	14.41
T_1	15.92	11.94	13.24	13.70
T_2	14.97	15.63	12.78	14.46
T_3	13.43	15.09	16.38	14.97
Average L	14.37	14.13	14.65	

6. Flower diameter measurement (disc cm $^{-1}$)

The results in Table No. (6) indicate that there are no significant differences between the spraying and soil addition treatments in the average flower diameter of broccoli plants. As for the interaction factors between the two study factors. The transaction has been completed. T_3 L2 measured 20.67 cm disc-1, while the control treatment T_0 L0 measured 19 cm disc-1.

Table 6: The effect of cysteine, ascorbic acid, organic fertilizer and their interaction on the diameter of the flower disc

T L	L0	L1	L2	Average T
T_0	19	18.88	19.57	19.15
T_1	19.10	20.50	19.67	19.76
T_2	19.50	19.70	20.33	19.84
T_3	19.27	20.47	20.67	20.13
Average L	19.22	19.89	20.06	
L.S.D L= 1.223			L.S.D T= 1.412	L.S.D TL= 2.446

7. Flower disc weight (g plant^{-1})

The results in Table No. (7) indicate that there are no significant differences between the spraying and ground addition treatments in the rate of weight The village S Broccoli flower.

As for the interaction between the study factors, the treatment was superior. T_3 L2 was significantly higher, giving the highest value of 576 g plant^{-1}, while the comparison treatment ToL0 recorded the lowest value of 450 g plant.

Table 7: The effect of cysteine, ascorbic acid, organic fertilizer and their interaction on the weight of the flower disc (g plant^{-1}).

T L	L0	L1	L2	Average T
T_0	450	467	488	468
T_1	537	530	539	535
T_2	505	533	576	538
T_3	558	545	576	560
Average L	512	519	545	
L.S.D L= 53.4			L.S.D T= 61.7	L.S.D TL= 106.9

Conclusions

The increase in the vegetative growth indicators of broccoli, represented by the number of leaves, the total leaf area of the plant, and the diameter of the stem, may be attributed to:, Total chlorophyll content of leaves, Chlorophyll content of the floral disc In the forms(2, 3, 4, 5, 6) when dealing With cysteine, this is consistent with (Shekari and Javanmardi, (2017) [26] Ascorbic acid is a lion, and this is what he indicated.Ali,2023).Ascorbic acid is a growth promoter that affects physiological and metabolic processes such as the synthesis of proteins, nucleic acids and enzymes. It has antioxidant functions and is water soluble. It plays an important protective role against reactive oxygen species that are formed during photosynthesis and respiration (Abdul Rahman *et al*., 2012. The Khattab *et al*., 2019) [2, 11]. And the sky Organic D and this is what he pointed out (Hilo *et al*., 2023) [15]

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