Response of Cauliflower Plants to Different Types of Organic Fertilization and Soil Mulching

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Abstract

This study was conducted at the Research Station of the Department of Horticulture and Landscape Engineering / College of Agriculture / University of Tikrit for the agricultural season 2025-2026 autumn to investigate the effect of different types of fertilization and soil mulching using plastic of different colors on the growth and yield of cauliflower (*Brassica oleracea* var. botrytis). The experiment included two factors. The first factor was fertilization, which comprised five treatments: sheep manure, poultry manure, cattle manure, chemical fertilizer, and bio-fertilizer. The second factor was soil mulching with plastic, which included three treatments: yellow mulch, black mulch, and no mulch. The experiment was conducted according to a Randomized Complete Block Design (RCBD) with three replications. Means were compared using the Least Significant Difference (L.S.D.) at a 5% probability level. The results showed the following: Plants treated with poultry manure excelled in vegetative growth traits such as relative chlorophyll content, while in yield traits, they excelled in curd weight and total yield. Meanwhile, the cattle manure treatment excelled in leaf area. The biofertilizer treatment gave superior results in the number of leaves and root dry matter. At the same time, among the soil mulching treatments, the yellow mulch gave superior results in many vegetative traits, including number of leaves, leaf area, and width of the largest leaf, as well as yield traits such as curd stalk length, curd stalk diameter, curd circumference, curd weight, curd length, and total yield. The yellow mulch gave a significant increase in total yield, reaching 27.72% and 119.86% compared to black mulch and no mulch, respectively. The interaction treatment of poultry manure with yellow mulch excelled in total yield traits, including curd circumference, curd weight, total yield, and curd diameter, while the interaction of cattle manure with yellow mulch gave a significant superiority in leaf area. The interaction of sheep manure with black mulch excelled in curd stalk diameter. The interaction between biofertilizer and no mulch excelled in many chemical traits, including the percentage of nitrogen, phosphorus, and potassium in the leaves.

Key Words: *Brassica oleracea* var. botrytis **,** Organic Fertilization, Soil Mulching

Introduction

The family Brassicaceae, also known as the Mustard Family, includes many important winter vegetable crops such as cabbage, broccoli, kale, turnip, radish, mustard, Brussels sprouts, Chinese cabbage, and watercress. This family includes more than 350 genera and 4000 species (1). Cauliflower is one of the plants of this family, known in English as Cauliflower and scientifically as Brassica oleracea var. botrytis L. It is a winter crop and the second most important flower vegetable after broccoli and before artichoke in some countries of the world. The cauliflower plant is grown in most governorates of Iraq, especially in the central regions. The native home of cauliflower is southern Italy, the Mediterranean Basin, and Southern Europe. Cauliflower is grown for its fused curd, which is the edible part of the plant. It consists of flower buds before they open, along with flower stalks, which are fleshy

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and enlarged (2). Overuse of chemical fertilizers and pesticides without considering the actual needs of crops leads to numerous negative impacts on the environment and agricultural production. It contributes to the accumulation of nitrates and their leaching into groundwater and surface water, as well as disrupting the biological balance of microorganisms in the soil and reducing nutrient use efficiency. This negatively affects soil fertility and the sustainability of agricultural productivity (3). As a result of these negative effects, many countries worldwide have moved towards encouraging the use of organic fertilizers, whether animal or plant-based, due to their beneficial effects, as organic matter plays a role in improving soil chemical properties (4). Therefore, interest in organic fertilizers has increased globally to reduce problems resulting from field practices, such as soil structure deterioration, decreased fertility, pest resistance to pesticides, as well as soil and water pollution from pesticides and nitrates, which have serious effects on human, animal, and plant health m. These fertilizers have many advantages at functional (physiological), physical, chemical, and biological levels. Among their most prominent features is their balanced composition and lack of harmful heavy metals. Furthermore, they contribute to modifying soil texture, which limits waterlogging in the root zone and thus reduces the spread of undesirable microorganisms such as fungi, bacteria, and nematodes , An important agricultural practice is soil mulching, which farmers adopt to conserve soil moisture. It reduces water loss through evaporation from the soil surface, increasing water storage and improving water use efficiency, especially in arid and semi-arid environments (5). Soil mulching also helps reduce salt concentration, whether horizontally or vertically, minimizes nutrient wastage, and prevents weed growth depending on the type of mulching material used. The end result is achieving better production and preserving the physical and chemical properties of the soil (6).

Therefore, this study aimed to:

- Evaluate the effect of different types of organic residues (sheep, cattle, and poultry) on the vegetative growth traits of cauliflower plants.
- Study the effect of soil mulching with black and yellow plastic compared to no mulching on plant growth and yield.
- Determine the effect of the interaction between organic fertilizers, biofertilizer, chemical fertilizer, and soil mulches on the vegetative growth, yield, and quality traits of cauliflower plants.
- Provide scientific recommendations regarding the best fertilization and soil mulching programs suitable for cauliflower production under the conditions of Tikrit city.

Materials and Methods

1- Location of the Experiment

The experiment was conducted at the Research Station of the Department of Horticulture and Landscape Engineering - College of Agriculture - University of Tikrit for the agricultural season 2025-2026, during the period from 9/10/2025 to 7/2/2026. The field soil was analyzed to determine its physical and chemical properties. Random soil samples were taken from several areas within the experimental field at a depth of (0-30) cm. The collected samples were mixed thoroughly, air-dried, and then sieved through a 2 mm sieve. Physical and chemical analyses were

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performed in the laboratories of the Department of Soil Science and Water Resources / College of Agriculture - University of Tikrit. Similarly, irrigation water was tested. The results are shown in Tables 1 and

Table (1) Physical and chemical properties of the field soil before planting

Unit	Value	Element
Ppm	13	Nitrogen
Ppm	6.2	Phosphorus
Ppm	106	Potassium
dS/m	3.41	EC
	7.42	pH
%	0.17	Organic Matter
%	80.9	Sandy Loam
%	14.9	Silty Clay
%	4.7	Clay Loam
_____	Loamy Sand	Loamy Sand

Table (1) Physical and chemical properties of the field soil before planting

Unit	Value	Property
dS/m	3.2	EC
	7.63	pH
Ppm	2124.8	TDS
Ppm	492	Na
Ppm	792	SO4
Ppm	25	NO3

2-2Experimental Design:

The experiment was conducted according to a Randomized Complete Block Design (R.C.B.D.) as a factorial experiment with two factors and three replications. The treatments were distributed randomly within each replicate (15 treatments).

3-3Studied Treatments:

The experiment included two factors:

The first factor: Included the treatments: chemical fertilizer, sheep manure, cattle manure, poultry manure, and biofertilizer.

The full recommended dose of organic fertilizer was 11.200 kg, equivalent to 40 tons ha^{-1}, for each experimental unit treated with organic fertilizer only. The full recommended dose for chemical fertilizer was 126 g P (450 kg ha^{-1}) and 28 g K (100 kg ha^{-1}). For N, the full recommended dose was 72.8 g (260 kg ha^{-1}), which was added in a single application before planting. The full recommended dose of biofertilizer was 150 CC.

The second factor: Was the mulches, which included:

Yellow mulch, black mulch, and no mulch.

Table (3) Shows the results of the analysis of the organic fertilizer components.

Unit	Poultry	Cattle	Sheep	Element
%	2.89	0.84	1.4	Nitrogen
%	1.7	0.45	0.75	Phosphorus
%	1.8	0.7	1.2	Potassium
%	38.79	48.25	54.17	Organic Matter

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dS/m	11.68	3.53	7.28	EC
	7.13	7.27	7.81	pH

The biofertilizer (Tricholand) consists of the beneficial fungus Trichoderma harzianum as the active ingredient. It contains living fungal spores (Conidia) and mycelium carried on a sterile carrier material, in addition to supporting substances and stabilizers to maintain the fungus's viability and efficiency during storage and handling.

4-3Date and Method of Seedling Planting:

The field soil was prepared by plowing it twice with a disc plow, after which large soil clods were broken up. Raised beds were established, with three beds per replicate. Each bed was divided into 15 experimental units. The length of each experimental unit was 2 m, the distance between replications was 1 m, and the bed width was 40 cm. The area of each experimental unit was 2.8 m². A distance of 0.5 m was left between experimental units within the same replicate, and the spacing between plants was 40 cm. A drip irrigation system was installed with two drip lines per bed, spaced 20 cm apart, and the distance between emitters on a single line was 10 cm. The treatments were then added to the experimental units and thoroughly mixed with the soil. Subsequently, mulching was carried out using black plastic, yellow plastic, and no mulch. Seedlings were then planted on 14/10/2025 in an alternating pattern on both sides of the bed, with 9 plants per experimental unit.

5-3Service Operations:

All necessary cultural practices were carried out, including irrigation, hoeing, weeding, and pest control whenever required, from the start of transplanting until the curd harvest stage.

6-3Studied Traits:

1-6-3Vegetative Growth Traits:

Measurements were taken during the curd harvest stage. Measurements were taken from five randomly selected plants (samples) per experimental unit, and included the following traits:

1-1-6-3Plant Height (cm):

Plant height was measured from the point of contact with the soil to the longest leaf using a measuring tape.

2-1-6-3Number of Leaves (leaf plant^{-1}):

All leaves were counted for the five randomly selected plants, and then the average was calculated.

3-1-6-3Leaf Area per Leaf (cm² leaf^{-1}):

The area of 15 leaves was measured in different directions, and the sum of their areas was divided by 15 to obtain the average leaf area. Leaf area was determined based on fresh weight by taking a disc of known area from each leaf. The discs were weighed, and leaf area was calculated according to the equation :

$S = G \times s / g$

Where:

S = Leaf area (cm²)

G = Leaf weight (g)

s = Area of the cut disc (cm²)

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g = Average weight of the cut disc (g)

.6-1-6-3Relative Content of Total Chlorophyll in Leaves (SPAD):

Measurements were taken from 5 leaves per experimental unit using an electronic device (Chlorophyll meter, SPAD 502) manufactured by Minolta Co., Ltd., Japan, 93 days after transplanting.

7-1-6-3Percentage of Dry Matter in Leaves:(%)

A random sample was taken from the leaves of 5 plants and weighed immediately (fresh weight). They were then placed in perforated paper bags and dried in an electric oven at 70 °C for 72 hours until a constant weight was achieved. They were then weighed (dry weight), and the following equation was used to calculate the dry matter percentage:

Dry Matter Percentage (%) = (Dry Weight / Fresh Weight) × 100

8-1-6-3Percentage of Dry Matter in Roots:(%)

A random sample was taken from the roots of 5 plants and weighed immediately (fresh weight). They were then placed in perforated paper bags and dried in an electric oven at 70 °C for 72 hours until a constant weight was achieved. They were then weighed (dry weight), and the following equation was used to calculate the dry matter percentage:

Dry Matter Percentage (%) = (Dry Weight / Fresh Weight) × 100

2-6-3Yield Traits:

1-2-6-3Quantitative Yield Traits:

1-1-2-6-3Curd Stalk Length (cm):

Measurement was taken from the point of contact with the soil using a measuring tape for five plants per experimental unit, and the average was calculated.

2-1-2-6-3Curd Stalk Diameter (cm):

Measurement was taken using a Vernier caliper for five plants per experimental unit, and the average was calculated.

3-1-2-6-3Curd Circumference (cm):

The circumference of mature curds was measured using a measuring tape for five plants per experimental unit, and the average was calculated.

4-1-2-6-3**Curd Length (cm):**

The length of the curd was measured using a measuring tape for five plants per experimental unit, and the average was calculated.

5-1-2-6-3Curd Diameter (cm):

The diameter of the curd was measured using a measuring tape for five plants per experimental unit, and the average was calculated.

6-1-2-6-3Curd Weight (g):

The weight of the main curds from the plants in the experimental unit was calculated using a scale.

7-1-2-6-3**Total Yield (ton ha□¹):**

Total yield was calculated according to the following equation:

Total Yield (ton ha□¹) = (Yield of Experimental Unit / Area of Experimental Unit) × 10000

8-1-2-6-3Percentage of Dry Matter in Curds:(%)

A random sample was taken from the curds of 5 plants and weighed immediately (fresh weight). They were then placed in perforated paper bags and dried in an

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electric oven at 70 °C for 72 hours until a constant weight was achieved. They were then weighed (dry weight), and the following equation was used to calculate the dry matter percentage:

Dry Matter Percentage (%) = (Dry Weight / Fresh Weight) × 100

7-3Statistical Analysis:

The experimental data were analyzed using (25), and arithmetic means were compared according to the Least Significant Difference (L.S.D.) test at a 0.05 probability level.

4-Results and Discussion

1-4Vegetative Growth Traits

4-1-1-4Plant Height (cm)

The results in Table 4 show that the two study factors did not affect the plant height trait, whether individually or in their interaction.

Table (4) Effect of different organic fertilizers and soil mulch color on plant height (cm)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
56.77	57.40	56.66	60.20	53.13	56.46	Without
58.22	53.73	56.80	60.20	60.53	59.83	Yellow
57.40	52.66	58.20	58.60	57.06	60.46	Black
	54.60	57.22	59.66	56.91	58.92	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
11.52		6.65		5.15		LSD
				11.98		CV

4Number of Leaves (leaf plant^{-1})

It is observed from Table 5 that there were significant differences in the number of leaves trait as a result of the effect of different organic fertilizers. The biofertilizer treatment gave the highest mean, reaching 19.77 leaves plant^{-1}, while the sheep manure treatment gave the lowest value, reaching 15.11 leaves plant^{-1}, and did not differ significantly from the chemical fertilizer and cattle manure treatments. It is also evident from the results in the table that there were significant differences due to the effect of soil mulches. Both the yellow mulch and black mulch recorded the highest means for number of leaves, reaching 17.73 and 17.66 leaves plant^{-1}, respectively, and did not differ significantly from each other, compared to the no-mulch treatment, which gave the lowest mean of 15.93 leaves plant^{-1}. Regarding the effect of the interaction between organic fertilizers and soil mulches, the biofertilizer treatment with both yellow mulch and black mulch recorded the highest mean for number of leaves, reaching 20.33 leaves plant^{-1} for each. Meanwhile, the sheep manure treatment without mulch recorded the lowest mean of 12.00 leaves plant^{-1}, which did not differ from the cattle manure treatment without mulch.

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Table (5) Effect of different organic fertilizers and soil mulch color on the number of leaves trait (leaf plant□¹)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
15.93	18.00	14.00	12.00	18.66	17.00	Without
17.73	16.66	17.33	16.66	20.33	17.66	Yellow
17.66	18.33	17.66	16.66	20.33	15.33	Black
	17.66	16.33	15.11	19.77	16.66	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
2.90		1.67		1.29		LSD
				10.15		CV

3-1-1-4Leaf Area per Plant (cm² leaf□¹)

The results in Table 6 indicate that organic fertilizers had a significant effect on the leaf area trait, as the cattle manure treatment achieved the highest value of 15802.0 cm², which did not differ significantly from sheep manure, poultry manure, and biofertilizer. Meanwhile, the chemical fertilizer treatment achieved the lowest value of 11610.0 cm². The effect of soil mulch color and the interaction between organic fertilizer and soil mulch color also had a significant effect on this trait. It is observed that both black and yellow mulch colors gave the two highest values for this trait, thus significantly outperforming the no-mulch treatment. At the same time, the interaction treatment between cattle manure and yellow mulch gave the highest value for this trait, reaching 21660.0 cm², and did not differ significantly from poultry manure with the same mulch, nor from the sheep manure and cattle manure treatments with black mulch. Meanwhile, the interaction treatment between biofertilizer and no mulch gave the lowest value, reaching 6534.0 cm², which in turn did not differ significantly from the sheep manure, cattle manure, and chemical fertilizer treatments under the same no-mulch condition.

Table (6) Effect of different organic fertilizers and soil mulch color on leaf area trait (cm² leaf□¹)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
8607.7	12569.0	7247.0	8620.0	6534.0	8068.0	Without
16631.8	20729.0	21660.0	14937.0	13597.0	12236.0	Yellow
15807.1	12019.0	18497.0	18711.0	15309.0	14499.0	Black
	15106.0	15802.0	14090.0	11813.0	11601.0	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
3889.8		2245.8		1739.6		LSD
				2.0		CV

6-1-1-4Relative Chlorophyll Content in Leaves (SPAD)

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Table 9 shows that organic fertilizers significantly affected this trait, as the poultry manure treatment gave the highest value of 51.86 SPAD, and did not differ significantly from cattle manure. Meanwhile, the chemical fertilizer treatment gave the lowest value of 45.66 SPAD, and did not differ significantly from all fertilizer treatments except for the superior treatment. Regarding soil mulch color, it was found that it had no significant effect on this trait. The results also indicate the presence of significant differences for this trait as a result of the interaction effect between organic fertilizers and soil mulches. The interaction treatment of poultry manure with yellow mulch recorded the highest value of 54.21 SPAD, and did not differ significantly from all fertilizer treatments without mulch, nor from biofertilizer, cattle manure, and poultry manure with black mulch. In contrast, the interaction treatment between chemical fertilizer and black mulch gave the lowest value of 43.02 SPAD, which did not differ significantly from most other interaction treatments.

Table (9) Effect of different organic fertilizers and soil mulch color on relative chlorophyll content in leaves (SPAD)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
48.35	48.24	50.38	47.30	48.42	47.39	Without
47.39	54.21	46.68	45.38	44.11	46.56	Yellow
47.69	53.12	47.3	47.14	47.36	43.02	Black
	51.86	48.1	46.60	46.78	45.66	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
7.05		4.07		3.15		LSD
				8.81		CV

7-1-1-4Percentage of Dry Matter in Leaves(%)

The results shown in Table 10 indicate that the two study factors did not significantly affect the percentage of dry matter in leaves, whether individually or in their interaction.

Table (10) Effect of different organic fertilizers and soil mulch color on the percentage of dry matter in leaves(%)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
14.90	15.73	13.41	13.39	17.11	14.87	Without
14.88	14.94	15.38	14.21	13.70	16.18	Yellow
14.23	13.55	14.50	15.18	13.92	14.48	Black
	14.74	14.43	14.26	14.91	15.17	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
3.88		2.24		1.73		LSD
				15.78		CV

8-1-1-4Percentage of Dry Matter in Roots(%)

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Table 11 shows the presence of significant differences among organic fertilizers in the percentage of dry matter in roots. The biofertilizer treatment achieved the highest percentage, reaching 18.37%, which did not differ significantly from the sheep manure, cattle manure, and poultry manure treatments. In contrast, the chemical fertilizer treatment gave the lowest value for this trait, reaching 15.73%, which also did not differ significantly from the remaining fertilizer treatments except for the biofertilizer treatment. Regarding soil mulch, it had no significant effect on this trait.

The results of the interaction treatments in the same table showed that the interaction treatment between biofertilizer and black mulch gave the highest percentage, reaching 20.01%, and did not differ significantly from sheep manure with the same mulch, nor from all fertilizers with yellow mulch, nor from chemical fertilizer, biofertilizer, sheep manure, and cattle manure without mulch. Meanwhile, the interaction treatment of chemical fertilizer with black mulch gave the lowest percentage, reaching 14.27%, and did not differ significantly from all other interaction treatments except for the superior interaction treatment.

Table (11) Effect of different organic fertilizers and soil mulch color on the percentage of dry matter in roots(%)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
16.88	15.60	18.28	15.95	17.72	16.83	Without
17.18	17.82	17.42	17.22	17.38	16.09	Yellow
16.39	15.49	15.89	16.29	20.01	14.27	Black
	16.30	17.19	16.49	18.37	15.73	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
4.09		2.36		1.83		LSD
				14.56		CV

The superiority of poultry manure in increasing the relative chlorophyll content (Table 9) is attributed to its high concentrations of nutrients, especially nitrogen, as well as its rapid decomposition rate and low carbon-to-nitrogen (C:N) ratio, which increases the rate of nutrient mineralization and their availability for uptake. Nitrogen is the main component of the chlorophyll molecule and is also involved in the formation of amino acids, proteins, and enzymes responsible for photosynthesis, which leads to increased chlorophyll synthesis and enhanced photosynthetic efficiency, thereby increasing the relative chlorophyll content in leaves. This result agrees with what (7,8) found, who indicated that the use of organic fertilizers led to increased chlorophyll content and improved nutrient uptake in cauliflower plants. The superiority of cattle manure in increasing leaf area (Table 6) is attributed to its role in improving the physical, chemical, and biological properties of the soil. It improves soil structure, increases porosity and water-holding capacity, and releases nutrients gradually in accordance with plant needs during different growth stages, which encourages cell division and elongation, leading to increased leaf growth and expansion, thus increasing leaf area and improving light interception efficiency and the production of carbohydrates necessary for growth. This

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result agrees with what 9) mentioned, who showed that the use of organic fertilizers led to increased leaf number, plant spread, and biomass in cauliflower compared to the control treatment. As for the superiority of biofertilizer in increasing leaf number (Table 5) and root dry matter percentage (Table 11), it is attributed to the ability of its constituent microorganisms to fix atmospheric nitrogen, dissolve phosphorus, and secrete plant growth regulators such as auxins, gibberellins, and cytokinins, which stimulate root growth and increase its efficiency in absorbing water and nutrients. This is reflected in increased leaf formation and accumulation of dry matter in roots as a result of increased photosynthetic products and their translocation to underground parts. This result agrees with what (7) found, who demonstrated that the use of Bio-NPK with organic fertilizers led to increased leaf number and improved vegetative growth and yield traits in cauliflower. The superiority of organic fertilizer treatments, especially cattle, poultry, and biofertilizers, in vegetative growth traits such as number of leaves, leaf area, chlorophyll content, and root dry matter can be explained by these fertilizers containing quantities of organic matter, which directly reflects on increased cell division and elongation and stimulates the formation of chlorophyll, proteins, and enzymes essential for photosynthesis and vegetative growth. Moreover, the addition of organic fertilizers improves soil aeration and increases its water-holding capacity, thus increasing plant growth and the development of its vegetative traits (10). The superiority of some treatments can also be attributed to the ability of organic fertilizer to improve the nutritional balance within the plant, as organic matter increases the availability of micronutrients such as iron, zinc, and manganese, which are involved in the formation of enzymes and chlorophyll. (11) indicated that organic fertilization improves the efficiency of nutrient uptake and increases leaf and stem growth. (12) also explained that the addition of organic matter leads to improved soil physical properties such as aeration and granulation, which encourages root growth and thus increases vegetative growth efficiency. The superiority of the biofertilizer treatment containing the fungus Trichoderma harzianum in improving growth and yield traits can be explained by this fungus's ability to colonize the root zone, leading to increased root growth and enhanced nutrient uptake efficiency, as well as its secretion of growth-promoting substances such as auxins and gibberellins, and improving nutrient availability through decomposing organic matter and dissolving some mineral compounds. Additionally, it plays a role in reducing the severity of pathogen infection through competition, parasitism, and the production of antifungal bioactive compounds, which positively reflects on plant growth and productivity (13; 14; 15). These results also agree with what (23) mentioned, as they explained that Trichoderma species increase the availability of nutrients in the root zone and improve their uptake efficiency, which positively reflects on vegetative growth and yield. This superiority may also be attributed to Trichoderma's ability to stimulate systemic resistance in plants and reduce the impact of pathogens through competition, parasitism, and the production of antifungal bioactive compounds, as confirmed by(16). The superiority of yellow plastic mulch in increasing leaf area, width of the largest leaf, and number of leaves (Tables 6, 7, and 5, respectively) is attributed to its role in improving the micro-environment around the root zone by conserving soil moisture, reducing water loss through evaporation, limiting weed growth and their competition

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with the plant for water and nutrients, as well as improving soil thermal conditions, which provided suitable conditions for increased root activity and nutrient uptake, which was reflected in increased cell division and elongation and improved leaf growth. Soil mulching with black and yellow plastic helped the soil retain irrigation water, reduce evaporation, and increase moisture storage, which led to a significant increase in some vegetative growth traits. This is consistent with (16) on cauliflower plants. Plastic mulches raise soil temperature by 2-10°C (24). They also reduce weed growth that competes with the plant , thus accelerating plant growth. The superiority of soil mulches, especially black and yellow, in vegetative growth traits can be explained by their role in conserving soil moisture and reducing water loss through evaporation, as well as their role in regulating soil temperature and improving the environmental conditions around the root system, which positively reflects on nutrient uptake and increases the efficiency of vital processes within the plant. Soil mulches also reduce weed growth and thus reduce competition for water and nutrients, providing the plant with suitable conditions for growth (17). (18) confirmed that the superiority of black mulch can be explained by its high ability to absorb solar radiation and raise soil temperature compared to other treatments, which increases root and microorganism activity and leads to increased nutrient availability. (19) also showed that colored soil mulches affect the reflection of incident light on the plant and thus affect photosynthetic activity and vegetative growth. The reason for the superiority of soil mulches can also be attributed to their role in improving water use efficiency and reducing environmental stress, which contributes to the continuation of the plant's physiological activity for a longer period during the growing season.. (20) found that the use of plastic soil mulches increases water and nutrient use efficiency and leads to increased vegetative growth and productivity. This result agrees with what ,found, who indicated that plastic mulching with organic fertilization improved vegetative growth and yield traits in cauliflower. The superiority of the interaction between cattle manure and yellow plastic mulch in increasing leaf area is attributed to the integrative effect between improving soil fertility resulting from cattle manure addition and improving the microbial environment of the root zone provided by the plastic mulch, which led to increased nutrient availability and uptake efficiency, which was reflected in increased leaf growth and expansion. The superiority of the interaction between biofertilizer and yellow mulch in increasing leaf number, without significantly differing from its interaction with black mulch, can be explained by the fact that soil mulches provided suitable conditions for the activity of the microorganisms constituting the biofertilizer, which enhanced nutrient fixation and production of growth regulators, thus increasing vegetative growth. This result agrees with what (8) mentioned.

2-4Yield Traits

1-1-2-4Curd Stalk Length (cm)

Table 12 shows that there were no significant differences in curd stalk length as a result of the effect of different fertilizers.

However, significant differences were observed as a result of the effect of soil mulches, as both the yellow mulch and no-mulch treatments gave the two highest values for curd stalk length, and did not differ significantly from each other, thus significantly outperforming the black mulch.

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Regarding the effect of the interaction between organic fertilizers and soil mulches, the sheep manure treatment without mulch excelled by giving the highest value of 11.93 cm, and did not differ significantly from cattle manure and chemical fertilizer treatments without mulch, nor from all fertilizer treatments with yellow mulch, nor from chemical fertilizer and biofertilizer treatments with black mulch. Meanwhile, the poultry manure treatment with black mulch gave the lowest value of 7.66 cm.

Table (12) Effect of different organic fertilizers and soil mulch color on curd stalk length of cauliflower plants (cm)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
10.14	9.13	10.66	11.93	8.66	10.33	Without
10.19	10.40	10.10	10.80	9.86	9.80	Yellow
8.88	7.66	8.71	7.76	10.80	9.46	Black
	9.06	9.82	10.16	9.77	9.86	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
2.62		1.51		1.17		LSD
				16.10		CV

2-1-2-4Curd Stalk Diameter (mm)

The results in Table 13 indicate that organic fertilizers did not significantly affect the curd stalk diameter trait. However, the results indicate the presence of significant differences due to the effect of soil mulches. The yellow mulch recorded the highest mean for curd stalk diameter, reaching 21.41 mm, and did not differ significantly from the black mulch, which recorded 20.44 mm. Meanwhile, the no-mulch treatment gave the lowest mean of 18.56 mm. Regarding the effect of the interaction between organic fertilizers and soil mulches, the sheep manure treatment with black mulch recorded the highest mean for curd stalk diameter, reaching 23.36 mm, and did not differ significantly from other treatments. Meanwhile, the cattle manure treatment without mulch recorded the lowest mean of 15.86 mm, and did not differ significantly from poultry manure, sheep manure, and biofertilizer treatments without mulch, nor from chemical fertilizer and poultry manure treatments with black mulch.

Table (13) Effect of different organic fertilizers and soil mulch color on stalk diameter trait mm)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
18.56	18.85	15.86	18.52	18.73	20.86	Without
21.41	21.35	22.94	21.54	19.91	21.32	Yellow
20.44	19.33	20.81	23.36	22.66	16.08	Black
	19.84	19.87	21.14	20.43	19.42	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
3.79		2.19		1.69		LSD

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11.26	CV

3-1-2-4Curd Circumference (cm)

The results in Table 14 show that there was no significant effect of organic fertilizers on the curd circumference trait. Regarding the effect of soil mulch treatments, the results show that there was a significant difference, as both the yellow mulch and black mulch treatments significantly outperformed the no-mulch treatment and gave the highest values, while the no-mulch treatment gave the lowest values. From the same table, it is observed that there were significant differences among the interaction treatments. The poultry manure treatment with yellow mulch excelled, achieving the highest value of 73.50 cm, and did not differ significantly from the remaining fertilizers with the same mulch and with black mulch, nor from the poultry manure and cattle manure treatments without mulch. Meanwhile, the sheep manure treatment without mulch achieved the lowest value of 49.60 cm, which in turn did not differ significantly from all fertilizer treatments without mulch, nor from sheep manure with yellow mulch, nor from biofertilizer with black mulch.

Table (14) Effect of different organic fertilizers and soil mulch color on curd circumference trait (cm)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
56.28	61.63	62.36	49.60	52.43	55.40	Without
70.85	73.50	72.30	66.26	70.80	71.40	Yellow
68.49	68.61	69.66	67.86	65.53	70.80	Black
	67.91	68.11	61.24	62.92	65.86	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
16.83		9.71		7.52		LSD
				15.43		CV

4-1-2-4Curd Length (cm)

The results in Table 15 indicate that the different fertilizers did not significantly affect the curd length trait. The results show the presence of significant differences due to the effect of soil mulches. The yellow mulch recorded the highest mean for curd length, reaching 12.67 cm, and did not differ significantly from the black mulch, which recorded 11.99 cm. Meanwhile, the no-mulch treatment gave the lowest mean of 10.86 cm, which in turn did not differ significantly from the black plastic mulch treatment. Regarding the interaction, there were significant differences. The poultry manure treatment with yellow mulch gave the highest value of 14.20 cm and did not differ significantly from all fertilizer treatments with the same mulch and with black mulch, nor from the poultry manure and chemical fertilizer treatments without mulch. Meanwhile, the biofertilizer treatment without mulch gave the lowest value of 9.93 cm, and did not differ significantly from all fertilizer treatments without mulch, nor from black mulch treatments, nor from chemical, biofertilizer, and cattle manure treatments with yellow mulch.

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Table (15) Effect of different organic fertilizers and soil mulch color on curd length trait (cm)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
10.86	11.76	10.60	10.80	9.63	11.53	Without
12.67	14.20	12.16	12.93	12.20	11.86	Yellow
11.99	12.41	11.43	12.20	11.93	12.00	Black
	12.79	11.40	11.97	11.25	11.80	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
3.27		1.88		1.46		LSD
				16.51		CV

5-1-2-4Curd Diameter (cm)

The results in Table 16 show that organic fertilizers had no significant effect on the curd diameter trait. The results also indicate the presence of significant differences due to the effect of soil mulches. Both the yellow mulch and black mulch excelled by giving the highest mean curd diameters of 23.67 and 22.69 cm, respectively, and did not differ significantly from each other, compared to the no-mulch treatment, which recorded the lowest mean of 20.02 cm. The table indicates that the interaction between organic fertilizers and soil mulches had an effect on this trait. The poultry manure treatment with yellow mulch gave the highest value of 25.3 cm, and did not differ significantly from the remaining treatments with the same mulch, nor from chemical fertilizer, biofertilizer, sheep manure, and poultry manure treatments with black mulch, nor from chemical fertilizer, cattle manure, and poultry manure treatments without mulch. Meanwhile, the interaction treatment of biofertilizer without mulch gave the lowest value of 18.30 cm, and did not differ significantly from all fertilizer treatments without mulch, nor from biofertilizer and sheep manure treatments with yellow mulch, nor from cattle manure and poultry manure treatments with black mulch.

Table (16) Effect of different organic fertilizers and soil mulch color on curd diameter trait (cm)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
20.02	21.00	20.83	18.53	18.30	21.46	Without
23.67	25.03	24.96	21.60	22.86	23.91	Yellow
22.69	22.06	20.05	23.60	23.20	24.53	Black
	22.70	21.95	21.24	21.45	23.30	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
4.70		2.71		2.10		LSD
				12.70		CV

6-1-2-4Curd Weight (g plant□¹)

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The results in Table 17, which show the effect of organic fertilizers, soil mulch color, and their interaction on curd weight, indicate that the poultry manure treatment excelled in giving the greatest curd weight, reaching 1376.00 g, thus significantly outperforming all fertilizer treatments, compared to the lowest curd weight in the sheep manure treatment, which reached 976.67 g, and did not differ significantly from the biofertilizer treatment. Regarding the soil mulch treatments, it is observed that the yellow mulch significantly excelled by achieving the greatest weight of 1555.60 g, compared to the lowest curd weight in the no-mulch treatment. From the same table, it is evident that there were significant differences among the interaction treatments. The interaction treatment of poultry manure with yellow mulch excelled, giving the greatest curd weight of 2275.00 g, thus significantly outperforming all interaction treatments, compared to the lowest curd weight of 536.67 g in the sheep manure treatment without mulch, which did not differ significantly from the poultry manure and chemical fertilizer treatments under the same no-mulch condition.

Table (17) Effect of different organic fertilizers and soil mulch color on curd weight trait (g plant□¹)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
707.60	620.00	916.67	536.67	816.67	646.67	Without
1555.20	2275.00	1591.00	1133.33	1200.00	1576.67	Yellow
1217.60	1233.00	1155.00	1260.00	1180.00	1260.00	Black
	1376.00	1220.89	976.67 d	1065.56	1161.11	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
173.37		100.09		77.53		LSD
				2.04		CV

7-1-2-4Total Yield (ton ha□¹)

The results in Table 18 show that the effect of the study treatments on total yield, whether individually or in interaction, followed a pattern similar to that of the curd weight trait. Poultry manure recorded the highest yield of 44.225 ton ha□¹, compared to the lowest mean yield in the sheep manure treatment, which reached 31.390 ton ha□¹. Regarding the effect of soil mulch treatments, the yellow mulch treatment excelled by giving the highest yield of 49.984 ton ha□¹, compared to the lowest yield of 22.734 ton ha□¹ in the no-mulch treatment. Concerning the interaction treatments, the results showed significant differences among the treatments. The highest total yield mean of 73.119 ton ha□¹ was recorded in the poultry manure with yellow mulch treatment, compared to the lowest total yield mean of 17.248 ton ha□¹ in the sheep manure without mulch treatment, which did not differ significantly from poultry manure and chemical fertilizer under the same no-mulch treatment.

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Table (18) Effect of different organic fertilizers and soil mulch color on total yield trait (ton ha□¹)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
22.734	19.927	29.462	17.248	26.248	20.784	Without
49.984	73.119	51.135	36.425	38.568	50.674	Yellow
39.134	39.629	37.122	40.496	37.925	40.496	Black
	44.225	39.239	31.390	34.247	37.318	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
5.572		3.217		2.491		LSD
				2.048		CV

8-1-2-4Percentage of Dry Matter in Curds(%)

The results in Table 19 indicate that organic fertilizers and soil mulch color, when considered individually, did not significantly affect the percentage of dry matter in curds. However, the interaction between organic fertilizer and soil mulch color had a significant effect on this trait.

It is observed that the interaction treatment between biofertilizer and no mulch gave the highest percentage of 9.75%, and did not differ significantly from the poultry manure treatment without mulch, nor from chemical fertilizer, sheep manure, and cattle manure treatments with yellow mulch, nor from chemical fertilizer, biofertilizer, sheep manure, and cattle manure treatments with black mulch. Meanwhile, the interaction treatment between chemical fertilizer and no mulch gave the lowest percentage of 7.98%, and did not differ significantly from sheep manure, cattle manure, and poultry manure treatments under the same no-mulch condition, nor from all organic fertilizer treatments with black mulch, nor from biofertilizer, sheep manure, cattle manure, and poultry manure treatments with yellow mulch.

Table (19) Effect of different organic fertilizers and soil mulch color on the percentage of dry matter in curds(%)

Average	Poultry	Cattle	Sheep	Biological	Chemical	Cover / Color
8.56	9.04	8.20	7.82	9.75	7.98	Without
8.81	8.23	8.81	9.17	8.31	9.54	Yellow
8.72	8.34	8.73	8.49	9.16	8.89	Black
	8.54	8.58	8.49	9.07	8.80	Average
Cover color × Fertilizer interaction		**Fertilizer**		**Cover color**		
1.38		0.79		0.61		LSD
				9.51		CV

The superiority of poultry manure in curd weight and total yield traits is attributed to its high content of nutrients, especially nitrogen, phosphorus, and potassium, and its rapid decomposition compared to other organic fertilizers, which led to increased nutrient availability and

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enhanced uptake efficiency by the plant. This positively reflected on vegetative growth traits, especially increasing the relative chlorophyll content, which enhanced photosynthetic efficiency and increased carbohydrate production and their translocation to the curds, thereby contributing to increased curd weight and total yield. This result agrees with what (21) found, who demonstrated that the use of poultry manure led to improved vegetative growth and increased curd weight and total yield in cauliflower. It was also supported by (9), who showed that organic fertilizers improved growth and productivity as a result of enhanced nutrient uptake and increased photosynthetic efficiency. The superiority of yellow plastic mulch in traits such as curd length, diameter, circumference, weight, and total yield is attributed to its role in improving the environment around the root zone by conserving soil moisture, reducing water loss through evaporation, and limiting weed competition, which provided suitable conditions for increased water and nutrient uptake efficiency. This was reflected in improved vegetative growth traits, especially increased leaf area and leaf number, which led to enhanced light interception efficiency and increased photosynthetic rate, and consequently increased translocation of photosynthetic products to the curds, contributing to improved curd growth, increased dimensions, weight, and total yield. This result is consistent with what (22) mentioned, who explained that plastic mulching improved nutrient use efficiency and increased the productivity of Brassicaceae crops by improving the environmental conditions of the root zone. The superiority of the interaction between poultry manure and yellow plastic mulch in traits such as curd circumference, curd weight, and total yield is attributed to the integrative effect between improving soil fertility and increasing nutrient availability resulting from poultry manure addition, and the provision by yellow plastic mulch of a favorable environment for root growth, soil moisture conservation, and reduced weed competition. This integration led to improved vegetative growth traits, especially increasing relative chlorophyll content, leaf area, and leaf number, which enhanced photosynthetic efficiency and increased the production and translocation of carbohydrates to the curds, reflected in increased curd circumference, weight, and total yield. This result agrees with what. (21) found, and was also supported by (9), who showed that combining improved soil fertility with good agricultural environment management leads to achieving the highest cauliflower productivity.

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