



Research article

Effect of biocar, earthworms and mycorrhizal fungi on some yield and quality characteristics of cauliflower plants

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ABSTRACT

A factorial experiment was applied in the greenhouse of nursery of the Directorate of Agriculture in Baqubah, Diyala Province, 2024. The aim was to study the effect of the *Funneliformis mosseae* fungus, biocar, *Eisenia fetida* earthworm, and their interaction on some qualitative and quantitative traits of cauliflower *Brassica oleracea* var. *Botrytis* L. that grown in plastic pots. The results indicated a significant increase in the characteristics of the inflorescence disc and the yield. The interaction between the mycorrhizal fungus and 1 g of biocar significantly outperformed the other treatments in fresh and dry weight of the inflorescence disc, diameter and height of the inflorescence disc, yield of the experimental unit, and total yield. The results were 325.00 g, 23.22 g, 12.66 cm, 9.5 cm, 975 g, and 1218.75 g. kg. dunum⁻¹, respectively, compared to the control treatment, which was 65.00 g, 3.62 g, 4.66 cm, 4.66 cm, 195 g, and 243.75 kg. dunum⁻¹, respectively. There was also an increase in the content of nutritionally important substances in the disc. The interaction treatment between mycorrhizal fungi, earthworms, and 2 g of biocar significantly outperformed the other treatments in the percentage of carbohydrates, proteins, fats, total sugars, fiber, and sulfur. These percentages were 11.36%, 4.27%, 1.29%, 7.19%, 4.24%, and 0.78%, respectively, compared to the control treatment, which was 6.71%, 1.81%, 0.28%, 4.83%, 1.83%, and 0.08%, respectively.

1. Introduction

Cauliflower (*Brassica oleracea* var. *Botrytis* L.), commonly known as cauliflower, is a winter vegetable crop widely grown worldwide due to its nutritional and medicinal value. The cultivated area of this crop in Iraq reached 5903 dunams. The yield was 14247 tons, or 2413.5 kg/dunam in 2022 (Central Statistical Organization, 2022). With the increase in global production of this crop, there is an urgent need to use sustainable, environmentally friendly methods to meet the plant's nutritional needs with minimal chemical fertilizer requirements, and to use bio- and organic fertilizers for this purpose (Kula and Ghosh, 2022).

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Arbuscular mycorrhiza fungi represent a sustainable solution for enhancing plant growth. They form symbiotic relationships with many plants, on the one hand, and contribute to plant growth through their role in increasing the availability of nutrients in the soil. It helps plant more tolerant to abiotic stresses such as drought, salinity, heavy metals in the soil, and temperature changes. They also increase the plant's ability to withstand biotic stresses, such as stimulating plant resistance to pathogens and competing with pathogens in the rhizosphere (Ortaş and Rafique, 2017; Makarov, 2019; Basiru et al., 2020; Anand et al., 2022; Abdul, 2024; Faleh, 2025). According to the International Biochar Initiative (2015), biochar is defined as the solid material obtained after the thermal decomposition of organic biomass in oxygen-free conditions. The term biochar is derived from the Greek words (bios) meaning life, and (char) meaning coal. It is called biochar or biocarbon because it plays an important role in biological processes in soil, water, and the digestive system of animals (Yaashikaa et al., 2020).

Earthworms are among the oldest invertebrate organisms inhabiting soil, dating back more than 600 million years (Sinha, 2009). Farmers consider their presence in the soil a sign of its fertility, and they are considered friendly to farmers. They are often referred to as the intestines of the earth, the tiller of the field and the soil engineer (Brown et al., 2003). Due to the a few numbers of studies on the cauliflower crop *B. oleracea* and the above-mentioned fertilization factors. Therefore, the aim of study was the effect of biofertilization with the *F. mosseae* and adding biocar and *E. fetida* and their interaction on some quantitative and qualitative yield traits of cauliflower plants grown in plastic pots under greenhouse conditions.

2. Materials and Methods

2.1 Experimental Site

To evaluate the effects of treatment with the mycorrhizal *F. mosseae* fungus, the addition of biocar, *E. fetida* earthworm, and their interaction on the growth and yield of cauliflower *B. oleracea*, an experiment was done in plastic pots during the fall of the 2023-2024 agricultural season in a greenhouse belonging to the government nursery of the Directorate of Agriculture in Baqubah, Diyala Province. The greenhouse area was 50 m² (10 m long and 5 m wide). The land was leveled and weeds removed to prepare it for the experiment.

2.2 Experimental conduction

Cauliflower seeds (Hybrid) variety was obtained from the local market in Baqubah, Diyala Province. To grow cauliflower seedlings, plastic trays filled with peat moss sterilized using an autoclave were used. The seeds were sown in these trays after being superficially sterilized with a 1% sodium hypochlorite solution, one seed per hole. Planting took place on September 10, 2024, and the seedlings were transferred to plastic pots on October 10, 2024, at a seedling age of 30 days. The inoculum of the *F. mosseae* fungus was obtained from the Soil and Plant Improvement Laboratory of the Agricultural Research Department in Zafaraniyah, affiliated with the Ministry of Science and Technology. The inoculum consisted of peat moss, root fragments of sorghum infected with mycorrhizal fungi, and external spores. The mycorrhizal fungus inoculum was added to the soil at a rate of 10 g/plant.

The biocar was obtained from the Mycology Laboratory at the College of Education for Pure Sciences, University of Diyala, and was prepared by a former graduate student from the woody branches of eucalyptus plants.

The earthworms (*E. fetida*) were obtained from the National Company's Khalis Station, northwest of Baqubah, Diyala Province. This was organic soil containing immature worms. Each 100 g of soil contained 100 small and medium-sized worms. Earthworms were added at a rate of 20 worms per plastic pot. The experiment was done in a greenhouse at the government nursery affiliated with the Diyala Agriculture Directorate in Baqubah, Diyala Province. The experiment included 12 treatments with three replicates, bringing the total number of treatments and replicates to 36 experimental units. The area of the experimental unit was 2 square meters (1 m x 2 m).

2.3 Traits studied

After the experiment was completed, the yield of the experimental unit and the total yield were calculated according to the equation:

$$\text{Total yield (kg. dunum}^{-1}\text{)} = (\text{Yield of the experimental unit} / \text{Area of the experimental unit m}^2) \times 2500 \text{ m}^2$$

Qualitative tests were conducted at the Scientific Research Authority's Environmental and Water Research Center laboratories affiliated with the Ministry of Science and Technology. Total carbohydrate content was estimated according to Hedge et al. (1962). The Keldahl method was used to estimate the protein content of the samples based on Van Dijk and Houba (2000).

Fat was estimated using the method described in AOAC (1995). Total sugars were estimated according to the method described in AOAC (2000) using the Eynon Lane method, using Fehling's solution. Crude fiber content was estimated according to the method described in McCleary et al. (2015).

2.4 Statistical Analysis

A factorial experiment was done using a Randomized Complete Block Design (RCBD). The results were statistically analyzed using SPSS (2014). The differences between means were compared using Duncan's multiple range tests at the 0.05.

3. Results and Discussion

3.1 Quantitative Yield Characteristics

Table (1) shows an increase in the yield of the experimental cauliflower plant when biological fertilizers were added, including mycorrhizal fungi, earthworms, organic fertilizer with biocar, and their interaction. The results shows that the treatment of mycorrhizal fungi with 1 g of biocar significantly outperformed the other treatments that recording 975 g, followed by the mycorrhizal fungi treatment, which recorded 664.98 g. The results also show that the earthworm treatment, the 2-

g biocar treatment, and the mycorrhizal fungi and 2-g biocar treatment produced total yields of 630.00, 609.99, and 609.99 g, respectively. There were no significant differences between them. This was followed by the earthworm treatment with 2 g of biocar, which recorded 561.99 g, and the mycorrhizal fungi treatment. The earthworms' treatment yielded was 429.99 g, while the 1 g biocar treatment yielded was 394.98 g. The mycorrhizal fungus, earthworms, and 2 g biocar treatments, and the mycorrhizal fungus, earthworms, and 1 g biocar treatments yielded were 336.99 and 324.99 g, respectively. The control treatment recorded the lowest yield per experimental unit at 195 g.

The results also indicate a significant increase in the total yield of cauliflower. The mycorrhizal fungus and 1 g of biocar treatment significantly outperformed the other treatments, reaching 1218.75 kg. dunum⁻¹, followed by the mycorrhizal fungus treatment, which yielded 831.225 kg. dunum⁻¹ (Table 2). The results also show that the earthworm treatment, the 2 g biocar treatment, and the mycorrhizal fungus and 2 g biocar treatment yielded a total experimental unit yield of 787.50, 762.48, and 762.48 kg. dunum⁻¹, respectively. There were no significant differences between them. The earthworm treatment with 2 g of biocar yielded was 702.49 kg dunum⁻¹, and the mycorrhizal fungus and earthworm treatment yielded was 537.49 kg dunum⁻¹, and 1g of biocarbon treatment was 493.725 kg. dunum⁻¹.

Meanwhile, the mycorrhizal fungus, earthworms, and 2g of biocar treatment, and the mycorrhizal fungus, earthworms, and 1 g of biocar treatment recorded 421.24 and 406.24 kg. dunum⁻¹, respectively. The control treatment recorded the lowest yield per experimental unit, at 243.75 kg. dunum⁻¹. It also shows the effect of the above fertilization factors on the size of the flower disc of cauliflower plants, which demonstrates the differences between plant yields (Figure 1).

Table (1) Effect of biofertilization with mycorrhizal fungi and earthworms and organic fertilization with biocar on the total yield (g)

Treatments	Experimental unit yield (g)			Average
	0 g. plants ⁻¹	biocarbon 1 g. plants ⁻¹	2 g. plants ⁻¹	
Control	195 f	394.98 de	609.99 bc	399.99
Mycorrhizal fungi	664.98 b	975 a	609.99 bc	749.99
Earthworms	630.00 bc	408.00 de	561.99 c	533.33
Mycorrhizal fungi+ earthworms	429.99 d	324.99 e	336.99 e	363.99
Average	479.99	525.74	529.74	
			529.74	

Similar letters indicate no significant differences between the means at a 5% ($p \leq 0.05$) according to Duncan's multiple range test

Table (2) Effect of biofertilization with mycorrhizal fungi and earthworms and organic fertilization with biocarbon on the total yield of cauliflower plants (kg/dunum⁻¹).

Treatments	Total yield (kg/dunum ⁻¹)			Average
		biocarbon		
	0 g. plants ⁻¹	1 g. plants ⁻¹	2 g. plants ⁻¹	
Control	243.75 f	493.725 de	762.48 bc	499.98
Mycorrhizal fungi	831.225 b	1218.75 a	762.48 bc	937.48
Earthworms	787.50 bc	510.00 de	702.49 c	666.66
Mycorrhizal fungi+ earthworms	537.49 d	406.24 e	421.24 e	454.99
Average	599.99	657.17	662.17	

Similar letters indicate no significant differences between the means at a 5% ($p \leq 0.05$) according to Duncan's multiple range test

The weights mentioned refer to the total yield in each experimental unit, which includes three replicates noting that the harvesting process was carried out early in the beginning of the formation of the flower disc due to the specific plant growth conditions within the plastic pots. However, it notes that the significant differences between the treatments and the noticeable increase in the yield as a result of the biological and organic factors that were added, which led to an increase in the tuber weight and size, as previously mentioned in Tables (1) and (2), which was reflected in the yield of the experimental unit and the total yield of the cauliflower plant. This is consistent was confirmed by a number of studies that indicated that both mycorrhizal fungi, earthworms, and biocarbon contribute to increasing the plant yield (Kashyap et al., 2005; Abdulhassan and Abdul-Ratha, 2022; Fonte et al., 2023; Jeni and Fikrinda, 2024).

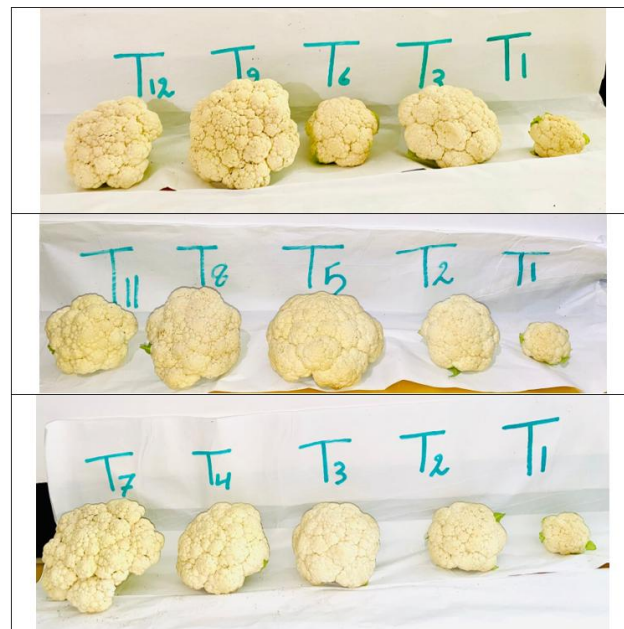


Figure (1) The effect of adding mycorrhizal fungi, earthworms, biocarbon, and their interaction on the size of the disc of cauliflower

Qualitative yield characteristics

The results of Table (3) show the effect of the treatment with mycorrhizal fungi, earthworms, biocar, and their interaction on the percentage of carbohydrates in the inflorescence disc of cauliflower. The results show that the treatment with mycorrhizal fungi and earthworms was superior, recording 6.57%, followed by the treatment with earthworms and 2g of biocar, and the treatment with mycorrhizal fungi and 1 g of biocar were 8.42%, 7.94%, 7.55%, and 1.7%, respectively.

The interaction treatments with mycorrhizal fungi, earthworms, and 2g of biocar was better than the other interaction treatments, as well as the single addition treatments, achieving 11.36% compared to the control treatment, which was 6.71%. This was followed by the treatment with mycorrhizal fungi, earthworms, and 1g of biocar, the treatment with earthworms and 2 g of biocar. The treatment with mycorrhizal fungi and 2 g of biocar, the treatment with earthworms and 1g of biocar, and the treatment with mycorrhizal and 1 g of biocar. These treatments significantly increased the carbohydrate content of the disc that reaching 11.13%, 10.21%, 9.64%, 9.26%, and 8.73%, respectively.

Table (3) Effect of biofertilization with mycorrhizal fungi and earthworms and organic fertilization with biocar on the carbohydrate content (%)

Treatments	carbohydrate content (%)			Average
	0 g. plants ⁻¹	1 g. plants ⁻¹	2 g. plants ⁻¹	
Control	6.71 l	7.1 k	7.94 i	7.25
Mycorrhizal fungi	7.55 j	8.73 g	9.64 e	8.64
Earthworms	8.42 h	9.26 f	10.21 d	9.29
Mycorrhizal fungi+ earthworms	10.57 c	11.13 b	11.36 a	11.02
Average	8.31	9.05	9.78	

Similar letters indicate no significant differences between the means at a 5% ($p \leq 0.05$) according to Duncan's multiple range test

Table (4) shows a significant increase in the percentage of protein in the cauliflower as a result of treatment with mycorrhizal fungi, earthworms, biocarbon, and the interaction between them. The results found that the treatment with mycorrhizal fungi and earthworms achieved a percentage of 3.99%, while the treatment with earthworms and 2 g of biocar, and the treatment with mycorrhizal and 1 g of biocarbon were 2.85%, 2.66%, 2.24%, and 2.05%, respectively.

The interaction treatments, the interaction treatment between mycorrhizal fungi, earthworms, and 2 g of biocar significantly better than the other interaction treatments, as well as the single addition treatments, which was 4.27%. This was followed by the treatment with mycorrhizal fungi, earthworms, and 2 g of biocar, the treatment with earthworms and 2 g of biocar, and the treatment with mycorrhizal and 2g of biocar. The treatment with earthworms and 1g of biocar, and the treatment with mycorrhizal fungi and 1g of biocar recorded increases of 4.17%, 3.80%, 3.58%, 3.36%, and 3.06%, respectively. Furthermore, the protein content in the control treatment was 1.81%.

Table (4) The effect of biofertilization with mycorrhizal fungi and earthworms and organic fertilization with biocarbon on the protein content (%).

Treatments	protein content (%)			Average
	biocarbon			
	0 g. plants ⁻¹	1 g. plants ⁻¹	2 g. plants ⁻¹	
Control	1.81 l	2.05 k	2.66 i	2.17
Mycorrhizal fungi	2.24 j	3.06 g	3.58 e	2.96
Earthworms	2.85 g	3.36 f	3.80 d	3.33
Mycorrhizal fungi+ earthworms	3.99 c	4.17 b	4.27 a	4.14
Average	2.72	3.16	3.57	

Similar letters indicate no significant differences between the means at a 5% ($p \leq 0.05$) according to Duncan's multiple range test

The results indicate a significant increase in the percentage of fat in the inflorescence of cauliflower as a result of the individual addition of mycorrhizal fungi, earthworms, and biocar, or the interaction between them (Table 5). The results indicated the treatment with mycorrhizal fungi and earthworms recorded 1.11%, followed by the treatment with earthworms and the treatment with 2g of biocar, and the treatment with mycorrhizal fungi and the treatment with 1g of biocar, which were 0.63%, 0.55%, 0.4%, and 0.38%, respectively.

The interaction treatments, the treatment with mycorrhizal fungi, earthworms, and 2g of biocar significantly was higher than the other interaction treatments, as well as the single addition treatments that recording a fat percentage of 1.29%. This was followed by the treatment with mycorrhizal, earthworms, and 1g of biocar. The treatment with earthworms and 2g of biocar, the treatment with mycorrhizal fungi and 2g of biocar, the treatment with earthworms and 2g of biocarbon, and the treatment with mycorrhizal and 1g of biocar, recorded 1.21%, 1.01%, 0.89%, 0.80%, and 0.72%, respectively. The lowest fat percentage was in the control treatment at 0.28%.

Table (5) Effect of biofertilization with mycorrhizal fungi and earthworms and organic fertilization with biocarbon on the fat content (%)

Treatments	fat content (%)			Average
	biocarbon			
	0 g. plants ⁻¹	1 g. plants ⁻¹	2 g. plants ⁻¹	
Control	0.28 l	0.38 k	0.55 i	0.40
Mycorrhizal fungi	0.46 j	0.72 g	0.89 e	0.69
Earthworms	0.63 h	0.80 f	1.01 d	0.81
Mycorrhizal fungi+ earthworms	1.11 c	1.21 b	1.29 a	1.20
Average	0.62	0.77	0.93	

Similar letters indicate no significant differences between the means at a 5% ($p \leq 0.05$) according to Duncan's multiple range test

The results indicate an increase in total sugars in the inflorescence of cauliflower as a result of treatment with biological fertilizers represented by mycorrhizal and earthworms and the organic

fertilizer factor represented by biocar and the interaction between them. The results of the single addition indicate that the treatment of mycorrhizal and earthworms recorded 6.85%, followed by the treatment with earthworms and the treatment of biocar 2g and the treatment with mycorrhizal and the treatment of biocar 1 g were 5.55%, 5.32%, 5.19% and 5.03%, respectively (Table 6). The interaction treatments, the treatment with mycorrhizal, earthworms and biocar 2 g significantly outperformed the rest of the interaction treatments, in addition to the single addition treatments, as it recorded 7.19% compared to the control treatment, which was 4.83%, followed by the treatment with mycorrhizal, earthworms and biocar 1 g. The percentages of 7.06%, 6.57%, 6.23%, 5.95%, and 5.72%, respectively, were determined by the treatment with earthworms and 2 g of biocar. The treatment with mycorrhizal and 2 g of biocar, the treatment with earthworms and 1g of biocar, and the treatment with mycorrhizal and 1 g of biocar.

Table (6) Effect of biofertilization with mycorrhizal fungi and earthworms and organic fertilization with biocarbon on the total sugar content (%)

Treatments	total sugar content (%)			Average
	biocarbon			
	0 g. plants ⁻¹	1 g. plants ⁻¹	2 g. plants ⁻¹	
Control	4.83 l	5.03 k	5.32 i	5.06
Mycorrhizal fungi	5.19 j	5.72 g	6.23 e	5.71
Earthworms	5.55 h	5.95 f	6.57 d	6.02
Mycorrhizal fungi+ earthworms	6.85 c	7.06 b	7.19 a	7.03
Average	5.60	5.94	6.32	

Similar letters indicate no significant differences between the means at a 5% ($p \leq 0.05$) according to Duncan's multiple range test

The results show a significant increase in the percentage of fibers in the inflorescence of cauliflower. The treatment with mycorrhizal and earthworms recorded a percentage of 3.90%, followed by the treatment with earthworms, the treatment with 2g of biocar, the treatment with mycorrhizal, and the treatment with 1g of biocar were 2.86%, 2.59%, 2.35%, and 2.1%, respectively (Table 7).

The interaction treatments, the mycorrhizal, earthworms, and 2g of biocarbon significantly higher than the other interaction treatments, which recorded 4.24%. The mycorrhizal, earthworms, and 1g of biocarbon followed recorded 4.17%. The earthworms and 2g of biocar, the mycorrhizal and 2g of biocar, the earthworms and 1g of biocar, and the mycorrhizal or 1g of biocar treatments recorded 3.70%, 3.48%, 3.29%, and 3.05%, respectively. The control treatment recorded 1.83%.

Table (7) Effect of biofertilization with mycorrhizal fungus and earthworms and organic fertilization with biocarbon on the fiber content (%)

Treatments	fiber content (%)			Average
	biocarbon			
	0 g. plants ⁻¹	1 g. plants ⁻¹	2 g. plants ⁻¹	
Control	1.83 l	2.1 k	2.59 i	2.17
Mycorrhizal fungi	2.35 j	3.05 g	3.48 e	2.96

Earthworms	2.86 h	3.29 f	3.70 d	3.28
Mycorrhizal fungi+ earthworms	3.90 c	4.17 b	4.24 a	4.10
Average	2.73	3.15	3.50	

Similar letters indicate no significant differences between the means at a 5% ($p \leq 0.05$) according to Duncan's multiple range test

The results indicate a significant increase in the concentration of sulfur in the inflorescence of cauliflower, whether with the single addition or interaction of fertilization factors. The treatment of mycorrhizal and earthworms recorded a percentage of 0.64%, followed by the treatment of earthworms and the 2g biocar treatment, and the treatment of mycorrhizal and the 1g biocar treatment were 0.32%, 0.24%, 0.19% and 0.14%, respectively (Table 8). The interaction treatments with mycorrhizal, earthworms, and 2g of biocar were better than other interaction treatments recorded 0.08%. The treatment with mycorrhizal, earthworms, and 1g of biocar, the treatment with earthworms and 2g of biocar, the treatment with mycorrhizal and 2g of biocar, the treatment with earthworms and 1g of biocar, and the treatment with mycorrhizal and 1g of biocar recorded 0.72%, 0.59%, 0.53%, and 0.50%, respectively.

Table (8) Effect of biofertilization with mycorrhizal fungi and earthworms and organic fertilization with biocarbon on the sulfur content (%)

Treatments	sulfur content (%)			Average
	biocarbon			
	0 g. plants ⁻¹	1 g. plants ⁻¹	2 g. plants ⁻¹	
Control	0.08 l	0.14 k	0.24 i	0.15
Mycorrhizal fungi	0.19 j	0.41 g	0.53 e	0.37
Earthworms	0.32 h	0.50 f	0.59 d	0.47
Mycorrhizal fungi+ earthworms	0.64 c	0.72 b	0.78 a	0.71
Average	0.30	0.44	0.53	

Similar letters indicate no significant differences between the means at a 5% ($p \leq 0.05$) according to Duncan's multiple range test

The weights mentioned refer to the total yield in each experimental unit, which included three replicates. Harvesting took place early in the flower disc formation period due to the specific plant growth conditions within the plastic pots. However, it notes significant differences between treatments and a noticeable increase in yield due to the added biotic and organic factors, which led to an increase in tuber weight and size, which was subsequently reflected in the yield of the experimental unit and the total yield of the cauliflower plant. This is agreed with what has been confirmed by several studies, which indicated that mycorrhizal, earthworms, and biochar contribute to increasing plant yield (Abdulhassan and Abdul-Ratha, 2022; Fonte et al., 2023; Jeni and Fikrinda, 2024). The results note from the results a significant increase in the carbohydrate content of the cauliflower flower disc when compared to the control treatment or previous studies, one of which showed that the percentage of carbohydrates in the cauliflower plant was higher. It constitutes approximately 4.97% of every 100 g (Farag and Motaal, 2010).

The increase in protein concentration is attributed to the increased availability of nitrogen, an important element in the biosynthesis process of protein synthesis in plants. Numerous studies have confirmed that mycorrhizal, earthworms, and biochar play an important role in enhancing the availability of nutrients in the soil, especially nitrogen and phosphorus. Mycorrhizal increase the efficiency of photosynthesis and increase the availability of nutrients. Consequently, they have been found to contribute to increased production of primary and secondary metabolites in plants (Khan et al., 2022; El Mazouni et al., 2025). Earthworms also contribute to the decomposition of organic matter in the soil, thereby releasing nutrients necessary for plant growth. This facilitates their uptake and utilization by the plant in the production of essential metabolic compounds such as proteins (Hong et al., 2011; Van Groenigen et al., 2014).

Several studies have confirmed the role of biocarbon in the adsorption of nutrients on the soil surface, thereby liberating them from their complex compounds and increasing their availability to the plant. Furthermore, the presence of biocar reduces nitrogen leaching in the soil, thereby increasing its availability for plant uptake (Yanai et al., 2007; Mia et al., 2014). It was noted that the fiber content of the inflorescence of cauliflower plants is approximately 2 grams per 100 grams of dry matter. The results indicate a positive role for the fertilizers used in the study in increasing the fiber content in the inflorescence (Manzoor et al., 2022). Cauliflower plants are characterized by their high need for sulfur for growth and production. Therefore, increasing the concentration of this element is evidence of the ability of the fertilizers used to increase the availability of this important element for cauliflower plants. A deficiency of this element leads to decreased cauliflower production (Westerman et al., 2000). Therefore, the increased yield demonstrated by this study can be attributed to increased availability and absorption of sulfur, as well as other nutrients.

Conclusions

The study concludes that an increase in the content of nutritionally important substances in the disc. The interaction treatment between mycorrhizal, earthworms, and 2 g of biocar significantly outperformed the other treatments in the percentage of carbohydrates, proteins, fats, total sugars, fiber, and sulfur.

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