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RESEARCH ARTICLE

Growth and quality of turnip (*Brassica campestris* L.) responding to different levels of foliar organic solution Taravert Evo

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Abstract

Plant growth regulators (PGR) at low concentrations may play an important role in increasing vegetable crop production, especially with the possibility of reducing fertilizer costs through foliar application. To produce turnips of good quality and economical yield, this study aimed to evaluate the use of foliar application with plant growth regulator Biozyme-TF at 0, 3 and 6 mL L^{-1} and the foliar organic Taravert Evo at 0, 2 and 4 mL L^{-1} on turnip vegetative growth and root quality characteristics. The experiment was a two-factor RCBD (randomized complete block design) with five replicates. Overall, the results indicate that the values of the measured parameters increased significantly with increasing Biozyme-TF concentration, remarkably at 6 mL L^{-1} compared to the lower concentration and the control. Foliar organic fertilizer Taravert Evo at 4 mL L^{-1} recorded significantly higher vegetative growth parameters than those recorded when using the lower concentration of 2 mL L^{-1}. However, the two concentrations did not differ much in their effect on the root qualitative traits, but they resulted in values significantly different from the untreated control. The highest values for all parameters, plant height, number of leaves, shoot fresh weight, shoot dry weight, leaf area, total leaf chlorophyll content, root length, root circumference, root diameter, root morphology index, root fresh weight and root dry weight were obtained in the interaction treatment of 6 mL L^{-1}. Biozyme-TF in the presence of 2 or 4 mL L^{-1} Taravert Evo foliar fertilizer, with significant differences ($p \leq 0.05$) compared to all individual treatments and the untreated control. The study confirms the possibility of producing high-quality turnips using economically low costs foliar nutrient-rich organic fertilizer, especially in combination with relatively low concentration of foliar PGR.

Keywords: botanicals; cruciferous; fertilization; PGR

Introduction

The turnip plant *Brassica campestris* L. belongs to the family Brassicaceae (Cruciferae) and is one of the important root vegetable crops. It is grown for its enlarged roots that are used in pickling, preparing soup or as a leaf crop (1). The roots of the turnip are rich in essential nutrients, vitamins, minerals and fibers, while the leaves are richer than the roots in their content of minerals, vitamins, proteins and carbohydrates and have many medical benefits (2). One of the methods used to regulate plant growth to a high degree is the use of a growth regulator solution that contains plant hormones (auxins, gibberellins and cytokinin) that play an important role in encouraging growth at different stages of the plant's life (3). Better plant growth can also be achieved by using mineral and organic nutrients that are produced on a large commercial scale and provide a standardized use and improve the type of crop and the plant's need (4). In an experiment on carrots indicated the effect of foliar spray of potassium and boron at a concentration of 2 g/L in a significant increase in plant height, number of leaves and shoot fresh and dry weight (5). Similarly, foliar spraying of potassium at 2 g/L on carrots showed significant results (6).

The effect of organic preparations, the same study found that spraying *Ceratophyllum* hornwort with plant extract and potassium at a concentration of 2 g/L had a significant effect on the vegetative and root growth indicators of carrot plants with a clear increase in plant height, number of leaves, leaf area, dry weight of the vegetative group, total chlorophyll content of leaves, root diameter and root length compared to single factor spray treatment or the untreated control. Amino acids in commercial preparations enhance plant growth by participating in protein biosynthesis, metabolic pathways and signaling mechanisms (7). It was also found that spraying broccoli plants with amino acids significantly increased growth indicators, plant height, leaf area, dry weight of the vegetative group and total chlorophyll content of leaves compared to the non-fertilization treatment (8). Foliar amino acids application at 2 or 4 mL/L was notably effective on cabbage plants and showed a significant superiority in vegetative growth traits such as number of leaves, leaf area and stem diameter compared to control treatment (9). Despite the importance of this crop and its many uses, limited research exists on turnip responses to combined application of growth regulators and organic fertilization. Therefore, this experiment was conducted to demonstrate the importance of studying the effect of growth regulator and spraying with organic solution on some vegetative and root growth characteristics of turnip plants.

Materials and Methods

General experiment procedure

The research was conducted in the nursery of the Horticulture and Forestry Division, Directorate of Agriculture of Najaf Governorate, Department of Plant Production during the 2023 season. The objective was to study the effect of the plant growth regulator Biozyme-TF and the commercial organic fertilizer Taravert Evo (Table 1) on certain vegetative and root growth characteristics of turnip.

A 3 × 3 m factorial experiment was conducted using three levels of the growth regulator (0, 3 and 6 mL/L) and three levels of liquid organic fertilizer (0, 2 and 4 mL/L) based on a RCBD with three replicates and nine treatments for each experiment. Seedlings were initially sown in seedling trays inside a plastic greenhouse. Before planting, 10 random soil samples were collected to represent the field soil and an analysis was conducted to determine the physical and chemical properties (Table 1). The ready seedlings, each with four true leaves, were transplanted into the field at a plant spacing of 75 cm, where all necessary agronomic practices were carried out as needed.

The growth regulator (Biozyme-TF by Arysta Life Science) was applied in two foliar sprays, 10 days apart. Fertilization with Taravert Evo was also conducted using three concentrations (0, 2 and 4 mL/L) in two sprays, the first at 45 days after sowing and the second 10 days after the first application.

Data collection and measurements

At the end of the experiment, measurements were taken from three randomly selected plants from each experimental unit for vegetative growth indicators. This included plant height (cm) measured from the crown to the farthest end of the apical meristem, number of leaves (leaves plant^{-1}), shoot dry weight (g plant^{-1}). The measurements also included:

Leaf area (cm^2 plant^{-1})

Leaf area was calculated for five randomly selected leaves per experimental unit using the 30-disc method of known area for each plant. The leaf samples were dried and their weight was measured (10).

$$\text{Leaf area cm}^2 = \frac{\text{5 leaves + Remaining (dry weight of all leaves)}}{\text{Leaf specific weight}}$$

Leaf content of total chlorophyll (mg 100 g^{-1} FW)

This was calculated using 5 g dry leaf sample from each experimental unit. The sample was crushed with 10 mL of acetone and 5 g of sodium carbonate and the mixture was then passed through filter paper. Chlorophyll content was measured using a spectrophotometer at a wavelength of 450 nm (11).

Root growth indicators include the main root length (cm), root circumference (cm) and root shape index (H/D), where H is the root height from the crown area to the base of the root and D is the root diameter measured at the widest area. Additional measurement included root diameter (cm) and root fresh and dry weights (g).

Experimental data analysis

Experimental data were subjected to analysis of variance (ANOVA) using GenStat (12th edition) to evaluate the effects of treatments, with statistical analysis performed using the GenStat 12th edition software (VSN International) (12). Differences among the treatment means were compared using the least significant difference (LSD) at a 0.05 probability level (13).

Results and Discussion

The findings showed that spraying the growth regulator had a significant effect on vegetative growth characteristics (Table 2). Spraying at the level of 6 mL/L recorded the highest values for plant height, number of leaves, fresh and dry weights of the vegetative mass, leaf area and total chlorophyll content in leaves, compared to both the lowest concentration treatment and the unfertilized control. Similarly, spraying organic fertilizer at 4 mL/L had the greatest effect in increasing the values of these vegetative growth indicators, with statistically significant differences-especially when compared to unfertilized plants.

Table 1. Field soil characteristics (A) and components of the growth regulator Biozyme-TF (B) and organic fertilizer Taravert Evo (C) used in this study.

A Field soil constituents and properties

pH	**EC**	**OM**	**N**	**P**	**K**	**Clay**	**Silt**	**Sand**	**Texture**
7.7	3.8 dS m^{-1}	0.1%	39.4 mg. Kg^{-1}	8.1 mg Kg^{-1}	233 mg Kg^{-1}	17 g Kg^{-1}	25.0 g Kg^{-1}	50 g Kg^{-1}	Silt loam

B Constituent of growth regulator Biozyme-TF

Mg	**S**	**B**	**Fe**	**Mn**	**Zn**	**GA**	**IAA**	**CK**	**Plant extracts**	**Total**
0.14 %	0.44 %	0.30 %	0.49 %	0.12 %	0.37 %	32.2 ppm	32.2 ppm	83.2 ppm	78.87 %	100

C Constituent of the organic fertilizer Taravert Evo

N	**K_2O**	**Seaweed extracts**	**Organic matter**	**Total amino acids**	**Free amino acids**
7 %	3 %	6 %	18 %	17 %	%

EC for electric conductivity, **OM** for organic matter, **NPK** for nitrogen, phosphorus and potassium, respectively, **Mg**, **S**, **B**, **Fe**, **Mn** and **Zn** for magnesium, sulphur, boron, Iron, manganese and zinc, respectively; **GA** for gibberellins, **IAA** for indole acetic acid and **CK** for cytokinin and **K_2O** for potassium oxide.

Table 2. Effect of growth regulator Biozyme-TF and organic fertilizer Taravert Evo on vegetative growth characteristics of turnip plant.

Treatments		Plant vegetative growth					
Biozyme- TF	Taravert Evo	Plant height (cm)	No. of leaves (leaves plant^{-1})	Shoot FW (g)	Shoot DW (g)	Leaf area (dcm^2 plant^{-1})	Leaf total chlorophyll (mg 100 g FW^{-1})
0	0	6.67	17.33	50.67	3.47	34.00	23.22
	2	8.33	22.00	64.67	5.03	55.50	31.96
	4	10.33	22.33	77.33	6.20	61.67	42.91
3	0	12.33	24.00	84.33	7.00	65.00	48.92
	2	13.00	24.67	92.00	7.50	70.00	57.79
	4	13.33	26.67	101.33	8.30	87.83	61.64
6	0	14.33	38.33	115.67	9.47	106.33	62.52
	2	15.33	45.67	127.33	11.40	134.17	65.08
	4	21.00	50.67	160.00	14.63	170.17	70.41
L.S.D. ($p \leq 0.05$)		1.89	2.79	12.10	0.99	14.67	4.65

Values are means of three replications, **FW** and **DW** are fresh weight and dry weight, respectively.

A comparable effect was observed on root growth indicators (Table 3), where a significant increase was recorded in root length, root circumference, root diameter, root shape index and fresh and dry weight of the root mass (Table 3). These improvements were most pronounced in the treatment involving the growth regulator at 6 mL/L and were nearly matched by the organic fertilizer treatment at 4 mL/L. In contrast, the unfertilized control treatment recorded significantly lower values for all studied indicators.

The effectiveness of growth regulator in enhancing growth characteristics in turnip plants is attributed to its content of growth-regulating plant hormones, which are organic substances that stimulate even at low concentrations, particularly by promoting cell expansion (3). Among these hormones, gibberellins are key contributors to plant growth, helping regulate cell membrane permeability, controlling enzymatic activity, increasing soluble carbohydrates levels by activating the alpha-amylase and promoting enzyme synthesis, nucleic acid formation and the reduction of nutrients to growth sites (4, 14).

Cytokinins, also present in the formulation, play essential role in cell division, delaying leaf senescence, preserving chlorophyll and increasing RNA synthesis, stimulating lateral bud formation and promoting rooting (3, 15). Additionally, the growth regulator solution contains trace elements that, although required in small amounts compared to macronutrients, significantly enhance enzymatic activity involved in vital physiological processes. These include:

- Zinc, essential for cell division and synthesis of endogenous growth regulators;
- Iron, necessary for chlorophyll formation and respiration;
- Boron, which enhance enzyme activity and root porosity, thereby improving carbohydrates transport and proteins/ nucleic acid metabolism;
- Manganese, important for redox processes and various metabolic functions;
- Magnesium, which helps phosphorus transport throughout the plant and supports enzyme function;
- Sulfur-containing compounds, which play key roles in redox reactions and nitrate assimilation (16).

The increased vegetative and root growth indices in turnips are also attributed to the Traver organic solution, which contains major nutrients such as nitrogen and potassium. Nitrogen plays a crucial role in the synthesis of many compounds essential for plant growth. Potassium acts as a cofactor in carbohydrates formation, their breakdown into sugars and amino acids synthesis. It is also vital for cell division (4). Additionally, potassium has been shown to significantly improve vegetative growth indicators in various crops, including table beet and turnips (17-19). It contributes to the development of a strong root system, which enhances the absorption of water and nutrients, thereby promoting vegetative growth and increasing biomass per unit area (16).

Phosphorus, also present in the fertilizers, stimulates enzyme activity and carbon metabolism, further supporting increased vegetative growth (20). Moreover, the amino acids in the fertilizer help reduce water stress and improve absorption, particularly potassium. They also serve as a source of nitrogen and support the synthesis of vitamin C (4). Thes findings are consistent with previous studies, which reported that amino acid foliar sprays on garlic plants significantly enhanced growth and yield indicators (21).

Table 3. Effect of growth regulator Biozyme-TF and organic fertilizer Taravert Evo on root growth characteristics of turnip plant.

Treatments		Plant root growth					
Biozyme- TF	Taravert Evo	Root length (cm)	Root circ. (cm)	Root dia. (cm)	Root shape index (H/D)	Root FW (g)	Root DW (g)
0	0	20.33	7.67	2.53	4.00	24.33	2.04
	2	22.33	12.67	3.97	4.80	51.67	3.83
	4	25.33	14.33	4.70	5.10	64.33	5.33
3	0	26.00	15.67	5.17	5.87	88.33	7.93
	2	27.67	16.33	5.40	6.10	102.67	9.43
	4	28.00	17.67	5.87	6.23	117.00	10.57
6	0	32.67	19.00	6.53	6.73	130.33	11.90
	2	37.00	20.67	7.00	7.63	151.33	12.80
	4	54.00	23.67	8.13	10.70	203.67	19.60
L.S.D. ($p \leq 0.05$)		9.27	1.57	0.43	1.21	11.93	1.14

Values are means of three replications, circ., dia., **FW** and **DW** are for circumference, diameter, fresh weight and dry weight, respectively.

Seaweed extracts, on the other hand, contain nutrients and growth regulators that are important for plant growth and development, as well as increasing both the quantity and quality of production, due to their richness in organic matter and nutrients (22). These extracts contain a variety of bioactive compounds, including plant hormones, polysaccharides, trace elements and amino acids, contribute to increasing both the fresh and dry plant weight. Amino acids play a key role in the essential metabolic processes within plant cells. They are involved in protein biosynthesis and other biosynthetic pathways and play a pivotal role in signalling processes (7).

The high performance of the growth regulators is largely the result of the interaction among auxin, gibberellin and cytokinin naturally present within the plant, which enhances the production of these hormones (23). Such interaction may lead to increased cell division facilitating the transport of nutrients from the roots and ultimately promoting overall vegetative growth (24). Fertilizer also contains essential nutrients, especially nitrogen, which plays a critical role in vital plant processes. Nitrogen is a key component of the deoxyribonucleic acid (DNA) and ribonucleic acid (RNA), chlorophyll, enzymes and cytochromes involved in respiration and photosynthetic activities (25). By enhancing chlorophyll synthesis and photosynthetic activity, nitrogen indirectly supports sugar accumulation, improves root development and stimulates phosphorus uptake from the soil (26).

Phosphorus stimulates growth, increases branching and strengthens the root system. Potassium positively influences the utilization of nitrogen and phosphorus, thus encouraging the growth of meristematic tissues and consequently, the formation of good vegetative and root growth, which increases the efficiency of water and nutrient absorption from the soil (4). Magnesium is a component of chlorophyll and is important for photosynthesis and root growth, thus increasing plant growth. Iron is also essential for chlorophyll formation and plays a role in energy transfer within root cells. Zinc is important for root development and elongation, root hormone regulation and cell division.

Manganese plays a role in root elongation and activation of enzymes necessary for root growth. Boron is an essential element for root cell division, increasing root length and assisting in the formation of root hairs (3). It has been shown that spraying gibberellic acid on onion plants had a significant effect on increasing root growth indices (27). It was also observed that spraying carrots with potassium at different concentrations and in three doses led to a significant increase in root growth indices (6).

Conclusion

The findings revealed that the growth and yield quality of turnip plants can be enhanced by applying commercial growth regulator as a foliar spray during the early growth stages. Overall, the interaction treatment of 6 mL/L growth regulator combined with either 2 mL/L or 4 mL/L of the liquid organic solution resulted in significantly improved plant growth and root yield quality compared to both individual and other interaction treatments.

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Compliance with ethical standards

Ethical issues: None

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