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Effects of the foliar application of humic biostimulant on alfalfa and cucumber – case studies

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Abstract. The aim of the research was to evaluate the effect of the new humic biostimulants preparation containing fulvic acids on the growth and quality of the yield of alfalfa (*Medicago* x *varia* T. Martyn) and cucumber (*Cucumis sativus* L.). In 2025, two experiments were conducted: 1. with alfalfa – a grow room experiment, and 2. with cucumber – a field experiment. Experimental factors: I – biostimulant, II – number of applications (2 and 4 sprays). The concentration of the preparation and the number and timing of treatments are recommended by the manufacturer. Morphometric characteristics (alfalfa), marketable yield (cucumber) and chemical composition (ICP-AES method) were determined in the plant material. Application of tested biostimulant increased the value of morphometric traits of alfalfa: the length of stalks, number of shoots per plant and leaves per shoot, diameter of root collar, weight of shoot and root system per plant, weight of leaves and inflorescence per shoot. It also resulted in an increase of up to 61% in the dry weight of plants compared to the control. Moreover, it increased the concentration of potassium, magnesium, and phosphorus in the dry matter of the plant. Foliar application of the tested biostimulant to cucumbers resulted in a statistically significant increase in fruit yield of gherkin cucumbers by 24% and in total marketable yield by 12.5% compared to the control. No significant changes were observed in the dry matter, protein, phosphorus, potassium, or magnesium content in cucumber fruit. The research conducted is a preliminary step towards expanding the assessment of the effects of fulvic acid use on the characteristics of tested plants under various growing conditions.

Keywords: growth stimulator, fulvic acids, *Medicago* x *varia* T. Martyn, *Cucumis sativus* L., quality of the yield, quantity of crop

INTRODUCTION

In modern agriculture, in the era of changing climate and, consequently, weather conditions that negatively affect plant yield and quality, in addition to fungicides, herbicides, and insecticides, many preparations classified as plant growth stimulators or biostimulants are used (du Jardin, 2015; Moradi et al., 2017). Researchers emphasize the beneficial effect of biostimulants on increasing plant yield, plant health, and increasing resistance to pests and diseases. Thanks to their use, crops are more resistant to abiotic (environmental) stress caused by factors such as drought, frost, or excessive humidity (Liu et al., 2022; Zhu et al., 2022; Pavadharini et al., 2025).

Plant growth stimulators are characterized as any substances, seaweeds, humic and fulvic acids, plant-growth-promoting bacteria, and extracts from algae applied to plants, seeds, or in the rhizosphere, with the aim to stimulate natural processes in plants and enhance nutrition efficiency (Gao et al., 2022; Liu et al., 2022) These compounds have effects on metabolic and enzymatic processes in plants, and the main aim is increasing the yield and quality of the final product (Yu et al,. 2023). When utilized as a foliar spray, they are absorbed by the leaves, leading to heightened metabolic activity by activating enzymes in various biological processes (Pizzeghello et al., 2002; Trevisan et al., 2010; Khalil et al., 2011, Hamail et al., 2014; Moradi et al., 2017).

Fulvic acid is an important component of soil organic matter. Fulvic acid are extracted from naturally humi-fied organic matter (e.g. from peat soils), composts, vermicomposts. Preparations based on fulvic acid extracts improve soil structure, stimulate the activity of soil microorganisms, enhance nutrient uptake by the root system, and improve soil parameters, increasing fertilization efficiency. They also improve the soils ability to retain water, Fulvic acid promotes plant growth mainly involves increasing cell membrane permeability and intracellular signal transduction functions, thereby stimulating root growth, enhancing chlorophyll content and photosynthetic efficiency, and activating carbon and nitrogen metabolism (Matysiak et al., 2011; Calvo et al., 2014; Canellasa et al., 2015; du Jardin 2015, Li et al., 2024 Pavadharini et al., 2025; Song et al., 2025).

In recent years, numerous studies have been undertaken on the possibility of using biostimulants in alfalfa (*Medicago* x *varia* T. Martyn) cultivation, the economic importance of which has been increasing following the patent application (WIPO ST 10/C PL 396362) concerning the production of a dietary supplement for humans. Studies have assessed the effects of applying synthetic plant hormones from the auxin and cytokinin groups on the physiology and morphology of this species (Sosnowski et al., 2019b; Marinova et al., 2023), and have indicated the positive impact of marine algae extracts (Sosnowski et al., 2019a; Gitau et al., 2021), preparations containing aminoacids, titanium (Godlewska and Ciepiela, 2018; Sosnowski and Truba, 2021), and iodine nanoparticles (Sosnowski et al. 2019c). Studies have also been conducted on the biostimulation of alfalfa growth and development with foliar application of ascorbic acid (Moukhtari et al., 2024) and microorganisms, amino acids, and pidolic acid in combination with silicon (Appiah et al., 2024). The effect of fulvic acids on high levels of transcriptional changes in alfalfa roots and the growth of developed root nodules has also been determined (Capstaff et al., 2020), but there is a lack of research on the effect of foliar application fulvic acids biostimulators on morphometry and chemical composition of alfalfa.

Also, studies on the effect of biostimulants on cucumber growth and yielding have focused mainly on biostimulants produced on the basis of seaweed extracts (Trejo Valencia et al., 2018; Cristofano et al., 2021; Hassan et al., 2021), protein hydrolysates (Cristofano et al., 2021; Harizanova et al., 2022; Najafi et al., 2022; Rodegher et al., 2024; Saadatian et al., 2025.), humic acids (Ekinci et al., 2015; Najafi et al., 2022; Amerian et al., 2024; Yaquby et al., 2024), or with the addition of silicon (Zhu et al., 2015; Bityutskii et al., 2018; Cristofano et al., 2021). However, there are few studies on the use of fulvic acid based preparations. The yield-enhancing effects of these preparations in cucumber crops were studied by Khalil et al. (2011), Hamail et al. (2014), Liu et al. (2022), and Yassin and Juma Al-Zubaidi (2025). The effect of fulvic acids on the nutritional value of cucumber was determined by El-Hadidi et al. (2010) and Khalil et al. (2011). This determines the need for comprehensive research on the effect of foliar applied fulvic acids on the growth, yield, chemical composition of cucumber fruit, and plant resistance to abiotic factors.

The aim of the research was to evaluate the effect of the new (introduced to the market in spring 2025) humic biostimulants preparation containing fulvic acids on the growth and quality of the yield of alfalfa (*Medicago* x *varia* T. Martyn) and cucumber (*Cucumis sativus* L.).

The undertaken research was to demonstrate to what extent a preparation based on fulvic acids would influence the morphometric characteristics of alfalfa (length of stalks, number of shoots per plant, number of leaves per shoot, diameter of root collar, total dry matter, mass of a shoot per plant, mass of leaves per shoot, mass of inflorescence per shoot, and mass of the root system), the marketable yield of cucumber (gherkins, pickles) and the chemical composition – the content of phosphorus, potassium, calcium, magnesium in the dry matter of alfalfa and cucumber fruit.

MATERIALS AND METHODS

The tested preparation Wokas Fulvi Universal growth stimulator was introduced and is intended for foliar application in agriculture crops. According to the manufacturer, the preparation contains fulvic acids, which positively influence plant growth and increase yield. They provide higher resistance of plants to stress and unfavourable external conditions. The Fulvi concentrate contains at least: 3% organic carbon (Corg), including at least 32 g dm^{-3} of humic substances carbon and 5 g dm^{-3} of fulvic acids carbon, pH value of the preparat: 10.0–13.0.

In 2025, two experiments were conducted: 1. with alfalfa – a grow room experiment, and 2. with cucumber – a field experiment. In both experiments, humus biostimulant was applied foliarly at the concentration recommended by the manufacturer and stated on the label, i.e., 10 ml per 5 liters of water, recommended for an area of 100 m^2. The product was applied four times (as recommended) and twice, which allowed for testing the effect of a total dose reduced by 50%.

Experiment 1

The first experiment was conducted in the cultivation room of the Institute of Agriculture and Horticulture, University of Siedlce, as a pot experiment with alfalfa (*Medicago* x *varia* T. Martyn 'cv. Kometa'). Experimental conditions: air temperature 24 ± 2/16 ± 2 °C; photoperiod 16/8 h; light intensity 200 µmol m^{-2} s^{-1} obtained using high-pressure sodium lamps; air humidity 45–55%. The entire experiment was conducted in 16 pots, four pots for each variant and one plant per pot. Each pot was filled with 5 kg of loamy sandy soil, collected from the humus horizon of arable land. Soil moisture was maintained at 60–70% of field water capacity. Alfalfa seeds (10 per pot) were sown at a depth of 2–3 cm. After germination, selection was performed, leaving one plant per plant.

The experimental factors were:

A. growth stimulator: – control (tap water), – humic biostimulant;
B. number of applications:
– two: 1. – fourth true leaf stage (BBCH 14), 2. – the first flower buds visible outside leaves (BBCH 51);
– four: 1. – fourth true leaf stage (BBCH 14), 2. – second internode stage (BBCH 32), 3. the first flower buds visible outside leaves (BBCH 51), 4. – beginning of flowering: 10% open flowers (BBCH 61).

A single spray application of 20 ml of spray solution was used about concentration 10 ml of humic biostimulant per 5 liters of water. Harvesting was carried out at the time of flowering. The obtained biomass was divided into roots, stems, leaves, and inflorescences. Morphometric analysis was then performed, determining: length of stalks (cm), number of shoots per plant (pieces), number of leaves per shoot (pieces), diameter of root collar (mm), total dry matter (g DM), shoot weight per plant (g DM), leaves weight per shoot (g DM), inflorescence weight per shoot (g DM), and weight of the root system per plant (g DM). The content of phosphorus, potassium, calcium and magnesium. was determined by ICP-AES method, using the PerkinElmer Optima 8300 emission spectrometer (PerkinElmer, Inc., Waltham, MA, USA).

Experiment 2

The field experiment was designed to determine the effect of foliar application of humic stimulator and the number of sprays on the yield and content of selected nutrients in cucumber (*Cucumis sativus* L.) fruit. It was conducted at a horticultural farm located in Kisielany Kuce (52º15'6"N, 22º11'53"E) in Siedlce County. It was established on a rye complex, class IVa, Luvisols, using a completely randomized design. The area of one experimental plot was 16.8 m^2 (7 m × 2.4 m). The experiment was performed in 3 repetitions.

Table. 1. Meteorological conditions in the cucumber growing period (IMGW-PIB, Hydrological and Meteorological Station in Siedlce).

Years	Month				Average during the cucumber vegetation period
	MAY	JUN	JUL	AUG	
Mean daily air temperature [ºC]					
2025	10.8	17.7	19.4	18.2	16.5
Many year (1991–2010)	13.5	17.0	19.7	19.5	17.2
Total precipitation [mm]					
2025	84.7	61.5	97.0	24.1	267.3
Many year (1991–2010)	58.3	59.6	57.5	59.9	235.3

The average contents of available nitrogen and mineral nutrients in the soil before the experiment were (mg kg^{-1}): 9.6 N-NO_3; 7.5 N-NH_4; 90.3 P; 263.0 K; 635.5 Ca; 70.0 Mg. The organic matter content was 1.9% and the soil pH_{KCl} = 5.7.

Phosphorus-potassium fertilization of the soil (150 kg ha^{-1} of potassium salt and 100 kg ha^{-1} of triple superphosphate) was carried out in the third decade of October 2024, and nitrogen fertilization (120 kg ha^{-1} of urea) in the first decade of May 2025. Before sowing the cucumber seeds (third decade of May), the beds were formed, T-tape irrigation tape was laid, and black foil for mulching rows to prevent weed pressure during cucumber growth and yield.

Cucumber seeds of the 'Śremski' variety were sown on May 26th in rows spaced 120 cm apart. Plant spacing within the row was 30 cm, and the seed sowing rate was 3 kg ha^{-1}. Sowing was performed manually, point-wise (two seeds per point), at a depth of 1–1.5 cm. Protective treatments in cucumber cultivation consisted of preventive spraying of plants against fungal and bacterial diseases and pests.

The average air temperature during the study period was 0.7 °C lower, and precipitation totaled 32.0 mm higher than the multi-year average (Table 1). May was the coldest month during the cucumber growing season, with average air temperature 2.7 °C lower than the multi-year average. July and August also recorded lower temperatures than the multi-year average. Precipitation in May and July was higher by 26.4 mm and 39.5 mm, respectively, while in August it was lower by 35.8 mm compared to the multi-year average. In June, both the average temperature and precipitation were close to the multi-year average.

The spray solution was prepared immediately before application by diluting the recommended amount of Fulvi concentrate in settled tap water (10 ml of humic biostimulant per 5 liters of water). Foliar applications of the product were made four times (the number and timing of treatments were as recommended by the manufacturer and indicated on the label) and twice (reducing the total applied dose by 50%). The control treatments consisted of treatments sprayed with tap water alone at the same rates and timings as the treatments with tested biostimulant. The experimental factors and spraying timing were as follows:

A. growth stimulator: – control (tap water), – humic biostimulant;
B. number of applications:
– two: 1. – 3–5 true leaves visible on the main shoot (BBCH 13–15), June 16; 2. – 3–5 open flowers visible on the main shoot (BBCH 63–65), July 14,

– four: 1. – 3–5 true leaves visible on the main shoot (BBCH 13–15), June 16; 2. – 3–5 flower buds visible on the main shoot (BBCH 53–55), July 8; 3. – 3–5 open flowers visible on the main shoot (BBCH 63–65), July 12; 4. – 3–5 typically shaped fruits visible on the main shoot (BBCH 73–75), July 22.

Cucumber harvesting was conducted manually from July 24 to August 19, 2025. A total of nine harvests were performed, every 2–3 days. During these harvests, the following were determined: marketable gherkin yield (t ha^{-1}), summing the gherkin yield from all harvests; marketable pickle yield (t ha^{-1}), summing the pickle yield from all harvests; total marketable yield (t ha^{-1}), summing the gherkin and pickle yield from all harvests. The principles set forth in Commission Regulation (EEC) No. 1677/88 were adopted to define the minimum requirements for field-grown cucumbers. Fruit that was straight, firm, mechanically undamaged, and free from disease and pest infestation was considered marketable. Marketable fruit was divided into two categories: gherkins – up to 6 cm in length, and pickled cucumbers – 6–12 cm in length.

Representative samples (20 marketable fruit of various sizes) were taken from the fourth harvest to perform chemical analyses for the following: dry matter (%), by drying to the constant weight at 105 °C (PN-EN 12145, 2001); protein (g 100 g^{-1} of fresh matter), by the classical Kjeldahl method using a conversion factor of 6.25, according to the AOAC procedure (AOAC, 2005); phosphorus, potassium, calcium and magnesium content (mg·100 g^{-1} of dry matter). by ICP-AES method, using the PerkinElmer Optima 8300 emission spectrometer (PerkinElmer, Inc., Waltham, MA, USA). The content of macroelements determined in dry matter was converted into the content in the fresh matter.

The study results (experiments 1 and 2) were analysed statistically using a two-way ANOVA for the completely randomized design. The significance of sources of variability was tested using the F Fisher–Snedecor test ($F \leq 0.05$) and the differences between the compared averages were verified using Tukey's HSD test ($p \leq 0.05$). Statistical calculations were performed using a program created in the Microsoft Excel.

RESULTS

Experiment 1

The study showed that the use of humic biostimulant increased the stalks length of alfalfa (*Medicago* x *varia* T. Martyn), on average by 19.2%, regardless of the number of applications (Table 2). Regardless of the number of treatments, the increase in the number of developed shoots and leaves compared to the control was 25.9%., and 30.6% respectively. Root collar diameter increases were also observed after twice (41.2%) and four (38.8%) times applications of the tested preparation.

Table 2. The selected morphometric traits of *Medicago x varia* T. Martyn in relation to the growth stimulator and number of application.

Biostimulant	Number of application		Mean
	Twice	Four times	
Length of stalks [cm]			
Control	45.9 Ba	41.3 Ba	43.6 B
Humic biostimulant	49.9 Ab	54.1 Aa	52.0 A
Number of shoots per plant [pieces]			
Control	14.0 Aa	13.0 Ba	13.5 B
Humic biostimulant	16.0 Ab	18.0 Aa	17.0 A
Number of leaves per shoot [pieces]			
Control	30.0 Ba	32.0 Ba	31.0 B
Humic biostimulant	38.0 Ab	43.0 Aa	40.5 A
Diameter of root collar [mm]			
Control	5.10 Ba	4.90 Ba	5.00 B
Humic biostimulant	7.20 Aa	6.80 Aa	7.00 A

Means in lines marked with the same small letters do not differ significantly

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Table 3. Mass of different parts of *Medicago* x *varia* T. Martyn in relation to the growth stimulator and number of application.

Biostimulant	Number of application		Mean
	Twice	Four times	
Total dry matter [g DM] per plant			
Control	182 Ba	194 Ba	188 B
Humic biostimulant	269 Aa	337 Aa	303 A
Shoot weight per plant [g DM]			
Control	9.20 Ba	10.0 Ba	9.60 B
Humic biostimulant	10.5 Aa	11.5 Aa	11.0 A
Leaves weight per shoot [g DM]			
Control	11.3 Bb	12.9 Ba	12.1 B
Humic biostimulant	14.4 Ab	16.4 Aa	15.4 A
Inflorescence weight per shoot [g DM]			
Control	0.80 Ba	0.90 Ba	0.85 B
Humic biostimulant	1.50 Aa	1.40 Aa	1.45 A
Root system weight [g DM] per plant			
Control	4.00 Ba	4.20 Ba	4.10 B
Humic biostimulant	4.60 Ab	5.10 Aa	4.85 A

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Humic biostimulant also contributed to an increase in the biomass developed by *Medicago* x *varia* T. Martyn (Table 3). It increased the total dry weight of plants by 61% compared to the control treatments. This increase was a consequence of a 14.6% increase in shoot dry weight, 27.3% in leaf weight per shoot, 69% in inflorescence

Table 4. Content of potassium, magnesium, calcium and phosphorus in dry matter of *Medicago* x *varia* T. Martyn in relation to the growth stimulator and number of application.

Biostimulant	Number of application Twice	Four times	Mean
Phosphorus [g kg^{-1}]			
Control	3.15 Ba	3.23 Ba	3.19 B
Humic biostimulant	3.72 Aa	3.80 Aa	3.76 A
Potassium [g kg^{-1}]			
Control	17.9 Ba	16.8 Ba	17.4 B
Humic biostimulant	19.9 Aa	19.5 Aa	19.7 A
Calcium [g kg^{-1}]			
Control	23.1 Aa	22.9 Aa	23.0 A
Humic biostimulant	24.2 Aa	24.5 Aa	24.4 A
Magnesium [g kg^{-1}]			
Control	2.70 Ba	2.85 Ba	2.78 B
Humic biostimulant	3.51 Aa	3.44 Aa	3.48 A

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weight per shoot, and 18.3% in root system weight. It is also worth noting that four applications of biostimulant in alfalfa increased the root system weight as compared to twice application.

The study also demonstrated the effect of humic biostimulant on the concentration of certain macronutrients in the dry matter of the above-ground parts of *Medicago* x *varia* T. Martyn, with no statistically significant effect on the number of applications (Table 4). The preparation increased phosphorus content by 18%, potassium by 13%, and magnesium by 25%.

Experiment 2

The study demonstrated a beneficial effect of humic biostimulant on cucumber yield (Table 5). After its application, the average total marketable cucumber yield increased significantly (by 12.5% compared to the control). However, the number of applications did not affect the total marketable yield. Gherkin cucumber yield was also significantly higher after the application than in the control treatments, by 24.1% on average. After two applications of humic biostimulant, it increased by 21.6% and after four applications, by 26.7%. However, there was no significant effect of the tested product on pickle cucumber yield.

Cucumber fruits contained on average 5.17% dry matter and 1.51 g 100 g^{-1} protein in fresh matter (Table 6). Application of humic biostimulant did not cause significant changes in the content of these parameters.

Cucumber fruits contained: 37.9 mg P, 218.4 mg K, 21.0 mg Ca, and 18.1 mg Mg per 100 g of fresh weight, on average (Table 7). The tested preparation modified only the calcium content. Cucumber fruits harvested from plants

Table 5. Cucumber fruit yield depending on the growth stimulator and the number of applications.

Biostimulant	Number of application Twice	Four times	Mean
Total marketable yield [t ha^{-1}]			
Control	32.57 Aa	33.07 Aa	32.82 B
Humic biostimulant	36.07 Aa	37.80 Aa	36.93 A
Gherkin cucumber yield [t ha^{-1}]			
Control	5.55 Ba	5.65 Ba	5.60 B
Humic biostimulant	6.75 Ab	7.16 Aa	6.95 A
Pickle cucumber yield [t ha^{-1}]			
Control	27.02 Aa	27.41 Aa	27.22 A
Humic biostimulant	29.32 Aa	30.64 Aa	29.98 A

Means in lines marked with the same small letters do not differ significantly
Means in columns marked with the same capital letters do not differ significantly

Table 6. Dry matter and protein content in cucumber fruits in relation to the growth stimulator and number of application.

Biostimulant	Number of application Twice	Four times	Mean
Dry matter [%]			
Control	5.11 Aa	5.08 Aa	5.09 A
Humic biostimulant	5.25 Aa	5.24 Aa	5.24 A
Protein [g 100 g^{-1} F.M.]			
Control	1.50 Aa	1.54 Aa	1.52 A
Humic biostimulant	1.48 Aa	1.50 Aa	1.49 A

Means in lines marked with the same small letters do not differ significantly
Means in columns marked with the same capital letters do not differ significantly

Table 7. Content of phosphorus, potassium, magnesium and calcium in fresh matter of cucumber fruits in relation to the growth stimulator and number of application.

Biostimulant	Number of application Twice	Four times	Mean
Phosphorus [mg 100 g^{-1} F.M.]			
Control	37.4 Aa	37.9 Aa	37.6 A
Humic biostimulant	38.2 Aa	38.0 Aa	38.1 A
Potassium [mg 100 g^{-1} F.M.]			
Control	217.4 Aa	217.8 Aa	217.6 A
Humic biostimulant	218.5 Aa	220.0 Aa	219.2 A
Calcium [mg 100 g^{-1} F.M.]			
Control	20.8 Aa	20.2 Ba	20.5 A
Humic biostimulant	21.1 Aa	21.9 Aa	21.5 A
Magnesium [mg 100 g^{-1} F.M.]			
Control	18.1 Aa	18.0 Aa	18.0 A
Humic biostimulant	18.2 Aa	18.2 Aa	18.2 A

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sprayed four times with humic biostimulant contained significantly more of this element (by 8.4%) compared to fruits from control plants. The content of the remaining macronutrients determined in the fruits did not differ significantly between the experimental combinations.

DISCUSSION

Studies have shown a positive effect of foliar application of fulvic acid (FA) on the growth of tested plants. The biostimulant, containing FA, positively influenced the development of assimilative parts and the root system of alfalfa. The positive effect of humic compounds on plant growth is confirmed by studies by Ferrara et al. (2008) and Matysiak et al. (2011), among others. They report that maize growth stimulation is possible after the application of humic and fulvic acids. The beneficial effect of these compounds can be observed primarily in the stimulation of the plant root system, resulting in an increase in their mass by up to 60%. Arancon et al. (2006) achieved a similar increase in root mass after the application of humic compounds. According to Sarir et al. (2005), the use of humic and fulvic acids can increase the green mass of plants by up to 28%. Furthermore, in the study by Matysiak et al. (2011) demonstrated the effect of the number of humic and fulvic acid applications on the shoot mass of plants, including maize. After two foliar applications of the preparations, shoot mass increased by up to 40%.

Existing studies have shown that the mechanism by which FA promotes plant growth is mainly by increasing cell membrane permeability and intracellular signalling functions, thereby stimulating root growth, increasing chlorophyll content and photosynthetic efficiency, and activating carbon and nitrogen metabolism (Jannin et al., 2012; Haghighi et al., 2012). Humic substances are also known to have a beneficial effect on increasing nutrient uptake by plants (Verlinden et al., 2010; Cheema et al., 2012; Billard et al., 2014; Wang et al., 2015). In the study by Matysiak et al. (2010), the highest increases in the weight of shoots and roots of winter oilseed rape were obtained after two foliar applications of humic and fulvic acids to plants. Our own research also showed that multiplying the application of tested biostimulant resulted in better results in terms of quantitative features of alfalfa such as total dry matter, mass of a shoot per plant and mass of leaves per shoot.

In the conducted study, the marketable yield of cucumber fruit after the biostimulant application increased by an average of 12.5% compared to the control, while the number of treatments did not cause significant changes in yield. Similar results were obtained by, among others, Hamail et al. (2014), who, after applying a fulvic acid-based biostimulant, observed a significant increase in the number of female flowers, early fruit set, and total fruit yield (by 18.2%) compared to the control treatment. El-Gazzar et al. (2020) also observed that foliar application of a biostimulant containing fulvic acids in melon cultivation resulted in an increase in the number of male and female flowers, as well as the average weight and number of fruits and the total yield. Liu et al. (2022) demonstrated that FA application at concentrations ranging from 100 to 900 mg L^{-1} improved the yield and quality of cucumbers subjected to drought stress, with the best results obtained at an FA concentration of 700 mg L^{-1}. The authors also found that FA application increased chlorophyll content in leaves. Afifi et al. (2017) found that FA extracted from compost and manure and applied at concentrations of 50, 100, and 150 mg L^{-1} significantly improved cucumber plant growth parameters compared to the control. An increase in total cucumber fruit yield, the number of fruits per plant, and also an increase in chlorophyll content in the plant after the application of bistimulants at concentrations of 10 g L^{-1} containing humic and fulvic acids was noted by Yassin and Juma Al--Zubaidi (2025). The increase in cucumber yield compared to the control was 19%. Zhang et al. (2021) reported that the yield-enhancing and health-improving effects of fulvic acids vary depending on the source and dose of fulvic acids, as well as environmental and crop growth conditions. According to Hamail et al. (2014), the stimulating effect of fulvic acid on cucumber yield may result from the dependence of the initiation and development of female flower buds on the hormonal activity of fulvic acid, as well as from the direct or indirect participation of FAs in plant anabolism, which results in the production of more plant metabolites necessary for plant growth and flowering. This is also consistent with previous studies by Khalil et al. (2011) on cucumber and Song et al. (2025) on tomatoes. In addition, Suh et al. (2014) reported that tomato plants exposed to fulvic acid foliar spraying experienced a promotion of their growth and marketable value. According to Anjum et al. (2011), fulvic acids stimulate plant growth not only as a result of increased photosynthesis and transpiration, but also as a result of increased intracellular CO_2 concentration and proline accumulation in plants. Aljasim (2019) attributes the beneficial effects of humic acids in cucumber cultivation to improved chemical and physical properties of the soil after their application.

Khalil et al. (2011) reported that after applying a preparation containing fulvic acids to cucumber crops, the content of protein, sugars, nitrogen, phosphorus, and potassium increased in the fruit. El-Hadidi et al. (2010) also noted increased uptake of nitrogen, potassium, and phosphorus by cucumber fruit after applying FA at various concentrations. Our study did not confirm this relationship. FA application only increased calcium content in cucumber fruit after four applications of tested biostimulant. However, no significant changes were observed in the concentration of the remaining tested minerals, as well as dry matter and protein. There have also been few studies on changes in the chemical composition of fruits of other vegetable species following the use of fulvic acid-based biostimulants. Suh et al. (2014) found, among other things, that foliar application of FA generally contributed to an increase in mineral content in tomato fruits at concentration of 0.8 and 1.1 g L^{-1}, although there were exceptions. In particular, calcium content at the 0.8 g L^{-1} concentration was significantly higher than in the control. Zhang et al. (2021) found an increase in calcium and magnesium content in tomato juice pressed from the fruit of plants treated with FA. According to Mora et al. (2010), the increase in plant yield, including cucurbits, and the increase in the content of minerals, protein and sugars in plants after the application of humic and fulvic acids results from the increased uptake of nutrients by plants from the surrounding solution and the simultaneous intensification of physiological processes. The studies by Rauthan and Schnitzer (1981) showed increased concentrations of nutrients (phosphorus, potassium, calcium, magnesium, copper, iron and zinc) in cucumber shoots after the application of fulvic acids.

CONCLUSIONS

1. Application of humic stimulator increased the value of analyzed morphometric traits of alfalfa (*Medicago* x *varia* T. Martyn): the length of stalks, number of shoots per plant and leaves per shoot, diameter of root collar, weight of shoot and root system per plant, weight of leaves and inflorescence per shoot. It also resulted in an increase of up to 61% in the dry weight of plants compared to the control. The number of applications of the preparation had a significant effect on the on the length of stalks, number of shoots per plant and leaves per shoot, weight of leaves per shoot and weight of root system per plant.
2. Humic stimulator used in the *Medicago* x *varia* T. Martyn cultivation increased the concentration of potassium, magnesium, and phosphorus in the dry matter of the plant material. However, the number of applications had no effect on the content of macronutrients in the plant biomass.
3. Foliar application of humic stimulator in cucumber cultivation resulted in an increase in fruit yield compared to the untreated control. Its significant effect was evident in a 24% increase in gherkin yield and a 12.5% increase in total marketable yield compared to the control.
4. Four applications of humic stimulator significantly increased the calcium content of cucumber fruit compared to the control. However, no significant changes were observed in the dry matter, protein, phosphorus, potassium, or magnesium content.

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