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Morphological and productive response of melon to fertilizer treatments on land of low fertility

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Abstract

Limited soil fertility and unfavorable climatic conditions significantly affect vegetable production, which requires the application of innovative fertilization strategies. In this research, the influence of organic fertilizer based on plant extracts containing phenolic compounds and phytohormones on the productive and morphological characteristics of melon (*Cucumis melo*) grown on acidic and poorly supplied soil (pH 3.74, humus 2.4%) was investigated. The experiment was set up in 2024 on the experimental field of the Institute of Vegetables in Smederevska Palanka according to a random block system in three repetitions. The treatments included one (Tr1), two (Tr2) and three (Tr3) fertilizer applications, as well as a control without fertilization. The results showed no statistically significant differences in fruit weight between treatments (1.03–1.23 kg). However, the number of fruits per plant was significantly higher in Tr3 (24), while Tr1 had the highest number of lateral branches (23.80). The largest peel thickness was determined in Tr2 (0.51 cm), which may contribute to better post-harvest durability of the fruits. The highest chlorophyll content was measured in the control variety (65.43 SPAD units), while there were no significant differences in sugar content between treatments (11.31–11.97 ºBrix). Correlation analysis showed a positive highly significant relationship between fruit mass and sugar content ($r = 0.41^{**}$), while the number of fruits and the number of side branches were negatively related ($r = -0.31^{**}$). The results indicate that organic fertilizer based on plant extracts can improve certain productive properties of melon in nutrient-poor soil conditions. Further research is needed to optimize the application strategy in different agroecological conditions.

Keywords: *Cucumis melo, plant fertilizer, fruit yield, morphological characteristics, soil fertility, sustainable agriculture*

Introduction

One of the world's biggest risks in recent decades is the production of food while preserving soil fertility and the resources necessary for survival. Due to the lack of sufficient amounts of organic fertilizer, it is essential to find an alternative that will meet the principles of sustainable plant production (Cvijanović et al., 2024). With the increase in the number of people on the planet, the need to produce more food has also increased (Raza et al., 2019). New technologies began to be sought in order to increase productivity and improve product quality. Also, by reducing the impact on the environment by adopting many mechanisms that help people reduce the use of conventional fertilizers, the use of which endangers the environment (El-

Akabawy, 2000, Stojiljković et al., 2021). In the conditions of global climate change, there could be problems in plant production, so finding effective ways to manage plant stress and improve crop yields is of great importance when it comes to economically profitable and health-safe plant production (Kumar et al., 2019). Application of large quantities of mineral fertilizers and pesticides, which are considered environmental pollutants, as well as poor management of plant residues, and insufficient application of organic fertilizers, affects soil degradation and negatively affects soil fertility (Rajičić et al., 2020; Stojiljković et al., 2021). Applying biological fertilizers reduces the use of chemical fertilizers, and encourages the restoration of microbial diversity in the soil (Sofyan et al., 2019). The use of biological fertilizers represents an alternative to the traditional approach in plant production, bearing in mind that production technology that focuses on the use of natural components tends to be economically profitable and environmentally acceptable (Šević et al., 2024; Bajagić et al., 2024). Melon is a vegetable crop that leaves high residual nitrogen in the soil after harvest (Oyediran et al., 2016). Melon is one of the most famous vegetable crops and is an excellent source of phytonutrients (Yavuz et al., 2021). It is produced all over the world, and it is estimated that about 27.5 million tons are produced annually (Li et al., 2022). Fruits differ in size, shape, skin characteristics and flesh colour depending on the genotype, applied agricultural techniques and growing conditions (Oyediran et al., 2016). In order to obtain a high yield and good quality, it is necessary that the leaf biomass produces a large amount of assimilates, which will go mainly to the fruits during their growth and development (Bartolo and Schweissing, 1998; Stojiljković et al., 2024). With the progress of agricultural production and the selection of genotypes with high yield potential, the role of fertilization also increases (Wen et al., 2022).

The work aimed to determine the influence of the application of liquid organic fertilizer of vegetable origin on certain productive and morphological characteristics of melon.

Materials and Methods

The research was carried out in 2024 on the plot of the Institute of Vegetables in Smederevska Palanka. Planting of "Ananas" melon seedlings was carried out on June 3, 2024, on plot number 6512/2, (N: 4911621 E: 496533) at 125 meters above sea level. The trial was based on a randomized block system with three replications. In each repetition, 40 plants were planted (4 rows of 10 plants each). The influence of fertilizers with plant extracts containing phenolic compounds and compounds with phytohormonal effects (commercial name of fertilizer Traiko) was investigated. The role of this fertilizer is to feed plants in cases where plants have difficulties absorbing nutrients from the soil or when it is necessary to quickly increase the content of nutrients in plants (in case of stressful conditions). This organic fertilizer is in liquid form and is applied foliarly and by watering, in the amount of 375 ml per 10 l of water. The treatments included three applications 15 days after planting every 7 days (Tr1 - one fertilizer application, Tr2 - 2 fertilizer applications, Tr3 - three fertilizer applications and control, without fertilizer application). Standard agrotechnical measures were applied in melon production (fertilization, irrigation, protection of plants from weeds, diseases and pests). The influence of fertilizers on the productive and morphological characteristics of plants was monitored: fruit weight, number of fruits per plant, number of side branches per square meter, bark thickness, chlorophyll content in the leaf and sugar content in the fruit. The number of lateral branches per square meter and the number of fruits per plant by counting in the field, on 5 plants per repetition, and the content of chlorophyll in the leaf was measured on the 5th, 10th and 15th days after the applied treatment by Portable Chlorophyll MeterCM-B (BioBase Industri, Shandong, Co., Ltd). The measurements are expressed in SPAD units. The weight of five average fruits from five plants per treatment was measured in the laboratory of the Smederevska Palanka Vegetable Institute on a technical scale (Kern & Sohn GmbH, Germany), and the sugar content was measured with a digital refractometer (Hanna instruments).

The statistical analysis of the obtained data was done in the program IBM SPSS Statistics, version 26.0. One-factorial analysis of variance (ANOVA) was used to assess the influence of factors on the examined traits, with significance levels of $p<0.05$ and $p<0.01$. Visual comparison of the mean values of different groups and assessment of the statistical significance of the difference between groups (Tuckey test) was done in the program Minitab (Trial version) and presented with Interval Plot graphics. The same program was used for Pearson's correlation analysis, to determine the relationship between the melon traits studied. The results are presented tabularly and graphically.

Soil characteristics

In order to determine the availability of nutrients to the soil, an agrochemical analysis of the soil was performed in an accredited laboratory using accredited methods. Soil acidity was determined potentiometrically. The humus content was measured using the Kotzman method. The nitrogen content was determined by calculation through the humus content, and it is shown in percentage, and easily accessible phosphorus and potassium by the AL method by the Egner-Riehm method (Table 1).

Table 1. Basic agrochemical properties of the soil in the experimental field

Depth (cm)	pH KCl	Hummus (%)	N (%)	P_2O_5 (mg/100 g)	K_2O (mg/100 g)	$CaCO_3$
0-30	3.74	2.40	0.12	7.07	14.51	-

The soil on which the research was conducted belongs to the group of very acidic soils (Belić et al., 2014), moderately provided with humus (Scheffer-Schachtschabel classification) and moderately provided with nitrogen, with low phosphorus content and moderately provided with potassium. Soils with an acidic reaction are characterized by low microbiological activity and the rhizosphere is limited to a shallow surface zone, so as acidity increases, the biomass of microorganisms decreases (Popović et al., 2019; Terzić et al., 2019).

Meteorological conditions

During the research period and the thirty-year average, differences in total amounts and distribution of precipitation, as well as average monthly air temperatures by month, were noted.

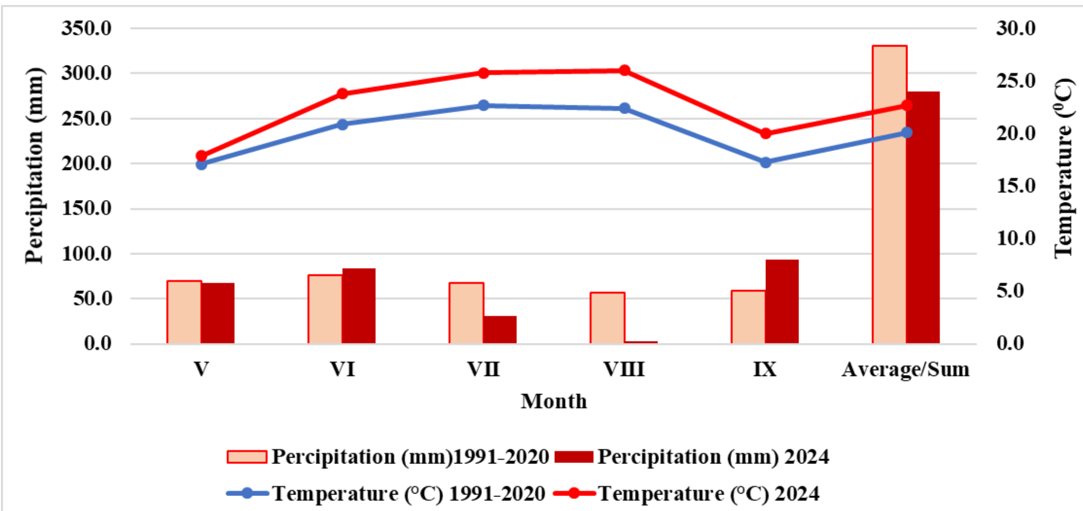


Figure 1. Mean monthly air temperatures and amount and distribution of precipitation during the melon vegetation period (2024) and multi-year period (1991-2020) in the studied area

Drought has become the main limiting factor for plant production in the world, which reduces yields in the developed world's agriculture as well (Đekić et al., 2019; Wang et al. 2024).

Results and discussion

In modern agricultural production, there is a growing need to determine a fertilization system that will be adapted to the cultivated plant species and climatic conditions in production areas with acidic soils (Popović et al., 2019; Rajičić et al., 2020; Stojiljković et al., 2021) Application of foliar fertilizers is gaining importance with the desire to increase yield and quality. Foliar fertilizers are rich in different nutrients and physiologically active substances. They contain easily accessible elements, and the effectiveness of foliar fertilizers depends on the amount of nutrients in the soil and the needs of plants for certain elements, as well as on the condition of the crop and the time of application (Miladinov et al., 2018). The obtained results of the average values of the properties examined in melon are shown in Table 2. The influence of the fertilizer factor, which was applied in three different treatments, on fruit weight did not show a statistically significant influence in relation to the control variant.

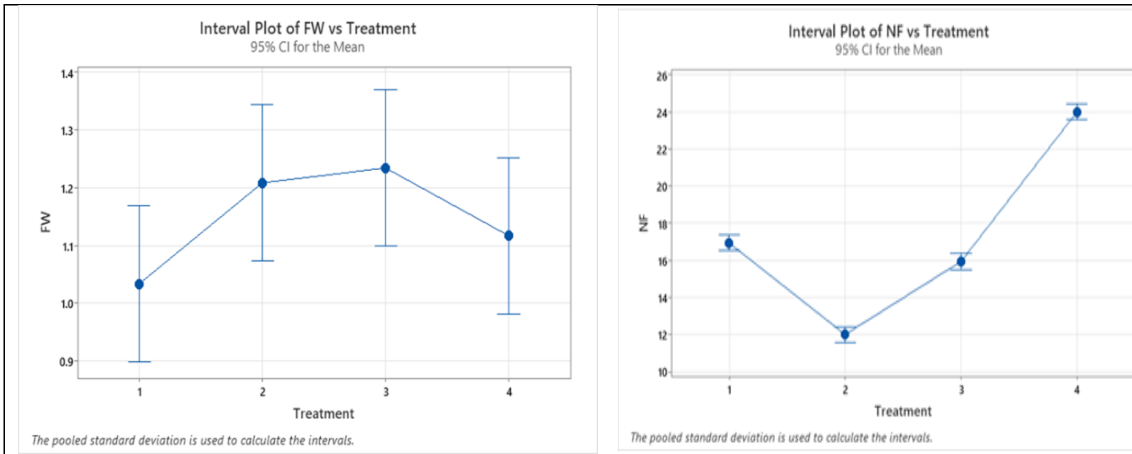
Table 2. Average values of studied traits in melon with the application of fertilizers

Treatment	**Fruit weight (kg)**	**Number of fruits**	**Number of side branches (m^2)**	**Thickness crust (cm)**	**Chlorophyll (SPAD units)**	**Total sugars (ºBrix)**
Tr1	1.21 ^{A}	12.00 ^{D}	23.80 ^{A}	0.41 ^{B}	57.31 ^{AB}	11.33 ^{A}
Tr2	1.23 ^{A}	15.93 ^{C}	18.80 ^{B}	0.51 ^{A}	56.71 ^{AB}	11.31 ^{A}
Tr3	1.12 ^{A}	24.00 ^{A}	19.80 ^{B}	0.45 ^{AB}	54.59 ^{B}	11.97 ^{A}
Control	1.03 ^{A}	16.93 ^{B}	14.80 ^{C}	0.49 ^{AB}	65.43 ^{A}	11.69 ^{A}
Average	**1.15**	**17.25**	**19.30**	**0.47**	**58.51**	**11.58**

Note: Different letters (A, B, C, D) indicate significant differences $p < 0.05$ (Tuckey test)

Comparing the treatments, no differences were found for fruit weight (Figure 2a). All three treatments in which fertilizer was applied had an approximate fruit weight. Based on the results from Table 2, it can be seen that the highest average fruit weight was measured in the Tr2 treatment (1.23 kg), while the lowest was found in the control (1.03 kg). In research (Miladinović et al., 2024; Ugrinović et al., 2024), the foliar application of different fertilizers did not show statistically significant effects on the examined traits due to the consequences of unfavorable climatic conditions (extremely high daily air temperatures). Analyzing the obtained values for the number of fruits (Table 2, Figure 2b), the best result was achieved in treatment Tr3 (24.00), where the effect of fertilizer was statistically very significant), in contrast to Tr1, where significantly fewer fruits were recorded (12.00).

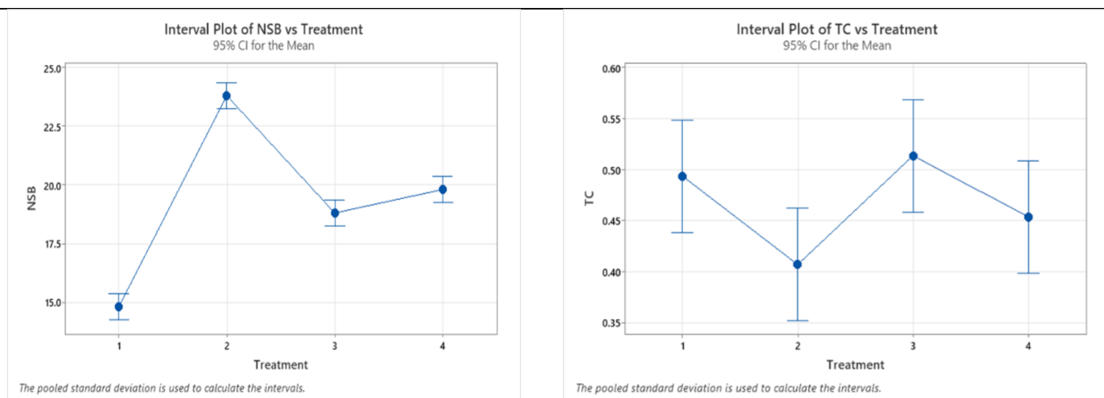
Statistically significant differences were found (table 3) in the average number of lateral branches in melon plants, where the values ranged from 14.80 to 23.80 (Table 2, Figure 3a). The highest average number of lateral branches was achieved in treatment Tr1. The highest average number of lateral branches was achieved in treatment Tr1. An important feature of the fruit, the thickness of the skin, was monitored, where a statistically significant influence of fertilizer on the obtained values was determined.



(a) (b)

Figure 2. Confidence interval of mean values for different groups and statistical significance of differences between groups in melon traits FW - fruit weight (**a**) and NF - number of fruits (**b**)
*Note: Treatment: 1-Tr1, 2- Tr2, 3-Tr3 and 4-Control.

In treatment Tr2, the highest average value of bark thickness of 0.51 cm was recorded (Table 2, Figure 3b). The use of foliar fertilizer affected the shape, skin color and quality of melon (Khomphet et al., 2023). Melons treated with foliar treatments showed better fruit quality values than untreated ones.



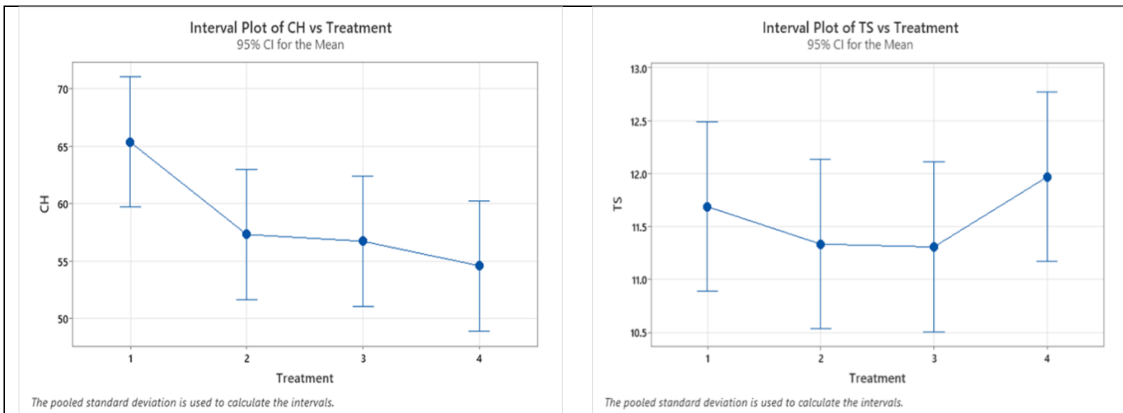
(a) (b)

Figure 3. Confidence interval of mean values for different groups and statistical significance of differences between groups in melon traits NSB–number of side branches (**a**) and TC – thicknesscrust (**b**).
*Note: Treatment: 1-Tr1, 2- Tr2, 3-Tr3, and 4-Control.

That fertilization is crucial for the quality of melon fruit has been stated in many studies. A lack or unbalanced diet of nutrients negatively affects the quality of melon fruits (Lopez-Zaplana et al., 2020; Roshaizak and Samad, 2024). Some of the melon fruit quality parameters, such as fruit firmness, pulp thickness, peel thickness, are affected by nitrogen associated with phosphorus (Bouzo and Munoz, 2018).

A good indicator of stressful conditions in vegetation in plants is the increased value of chlorophyll in the leaves. The influence of fertilizers is manifested in the reduced average values of this characteristic (Figure 4a). The highest chlorophyll content was measured in the control (65.43 SPAD units), shown in Table 2.

Sugars are the main source of sweetness in melon and its higher content contributes to better nutritional value, especially the energy value of the fruit. The sugar content has a highly significant effect on certain technological properties, such as the texture of the aroma and the conditions of canning of the fruits. Regarding the content of total sugar, the influence of applied fertilizer in this research was not statistically significant (Figure 4b). The measured values according to the treatments were approximate, and the highest content was in the fruits in the Tr3 treatment (11.97 ºBrix), Table 2. Foliar feeding had a positive effect on certain characteristics of the plant (plant length, leaf area, shoot weight per plant) and fruit quality, i.e. fruit diameter, fruit weight, total sugar (Morsy and Shams, 2018), while in our research there was no statistical significance for sugar content (Table 3), but the highest found in the Tr3 treatment (Table 2).



(a) (b)

Figure 4. Confidence interval of mean values for different groups and statistical significance of differences between groups in melon traits CH– chlorophyll (**a**) and TS – total sugars (**b**).
*Note: Treatment: 1-Tr1, 2- Tr2, 3-Tr3, and 4-Control.

Based on the obtained results, it can be said that the positive impact of applying organic fertilizer with plant extracts containing phenolic compounds and compounds with phytohormone effect was established even on soils of lower fertility for vegetable production. This is especially important for areas whose values of agrochemical parameters are below optimal for vegetable production, as well as in unfavorable climatic conditions.

The correlation coefficient represents the degree of connection between traits. The correlation coefficient between the studied melon traits showed different strengths of the relationship (Figure 5). A positive and very weak correlation was established between the traits FW and TC (r=0.02) and weak relationship between FW and CH (r= 0.00). A positive, medium strong and highly significant relationship was confirmed between FW and TS (r=0.41**), while it is negative and weak with FW and NF (r=-0.13). A positive and very weak correlation was recorded between the characteristics of NF and TC (r=0.06), while there was a negative and very weak correlation between NF and CH (r= - 0.08). That trend continues with the NF and NSB traits, where the correlation coefficient is negative and shows a very weak relationship between these traits (r= - 0.31**).

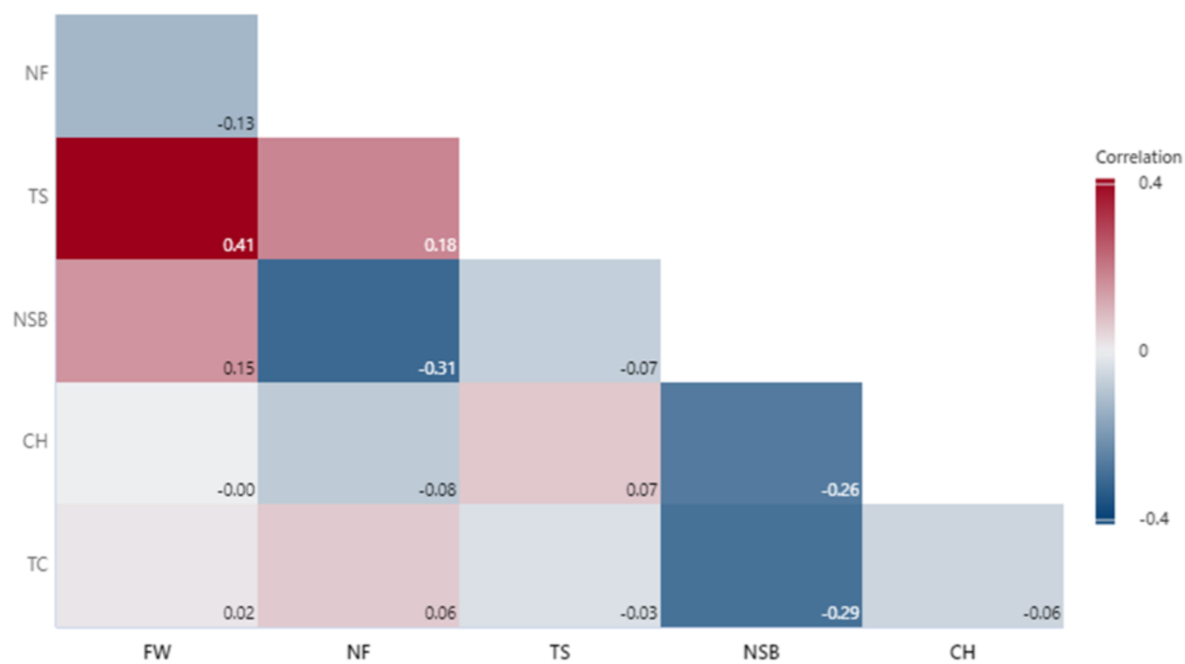


Figure 5. Correlation coefficients between the studied traits in melon (FW-fruit weight, NF-number of fruits, NSB-number of side branches, TC-thickness crust, CH-chlorophyll and TS- total sugars). Correlation is significant at the 0.01 level**; 0.05 level *.

Conclusion

The results show that the application of organic fertilizer with plant extracts had a positive effect on certain morphological and productive characteristics of melon grown on land with weaker production characteristics. Although no statistically significant differences in fruit mass were found between treatments, the number of fruits per plant was significantly higher in the treatment with three applications of fertilizer (Tr3), while the number of lateral branches was the highest in the treatment with one application (Tr1). Peel thickness was highest in the Tr2 treatment, this trait is important for better fruit persistence after harvest.

Chlorophyll content in the leaf was the highest in the control variant, which may indicate the adaptive responses of plants to stressful conditions without additional nutrition. The content of total sugars did not show statistically significant differences between treatments, although the highest values were recorded in treatment Tr3. Correlation analysis indicated different degrees of connection between the tested traits, where significant positive correlations were found between fruit weight and sugar content, while negative correlations were observed between the number of fruits and the number of lateral branches.

These results indicate that the application of fertilizers with plant extracts can have certain effects in improving the production characteristics of melon. Special importance is reflected in the possibility of growing melons on land with weaker production characteristics and unfavorable climatic conditions. Further research is necessary in order to more precisely define the optimal strategy for applying this fertilizer in different agroecological conditions.

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Morfološki i produktivni odgovor dinje na tretmane đubrivom na zemljištu niske plodnosti

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IZVOD

Ograničena plodnost zemljišta i nepovoljne klimatske prilike značajno utiču na proizvodnju povrća, što zahteva primenu inovativnih strategija đubrenja. U ovom istraživanju ispitivan je uticaj organskog đubriva na bazi biljnih ekstrakata, koje sadrži fenolna jedinjenja i fitohormone, na produktivne i morfološke osobine dinje (*Cucumis melo* L.) gajene na kiselom i hranivima siromašnom zemljištu (pH 3.74, humus 2.4%). Ogled je izveden 2024. godine na oglednom polju Instituta za povrtarstvo u Smederevskoj Palanci po slučajnom blok sistemu u tri ponavljanja. Tretmani su obuhvatali jednu (Tr1), dve (Tr2) i tri (Tr3) primene đubriva, kao i kontrolu bez đubrenja. Rezultati nisu pokazali statistički značajne razlike u masi ploda između tretmana (1.03–1.23 kg). Međutim, broj plodova po biljci bio je značajno veći u Tr3 (24), dok je Tr1 imao najveći broj bočnih grana (23.80). Najveća debljina kore utvrđena je u Tr2 (0.51 cm), što može doprineti boljoj postberbnoj izdržljivosti plodova. Najviši sadržaj hlorofila izmeren je u kontrolnoj varijanti (65.43 SPAD jedinica), dok između tretmana nije bilo značajnih razlika u sadržaju šećera (11.31–11.97 ºBrix). Korelaciona analiza je pokazala pozitivnu visoko značajnu vezu između mase ploda i sadržaja šećera ($r = 0.41^{**}$), dok su broj plodova i broj bočnih grana bili negativno povezani ($r = -0.31^{**}$). Rezultati ukazuju da organsko đubrivo na bazi biljnih ekstrakata može poboljšati određene produktivne osobine dinje u uslovima zemljišta siromašnog hranljivim materijama. Dalja istraživanja su potrebna radi optimizacije strategije primene u različitim agroekološkim uslovima.

Ključne reči: *Cucumis melo*, biljno đubrivo, prinos ploda, morfološke osobine, plodnost zemljišta, održiva poljoprivreda

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