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RESEARCH ON THE INFLUENCE OF FERTILIZATION ON TOLERANCE TO ABIOTIC STRESS IN THE CASE OF SOME TOMATO CULTIVARS CULTIVATED IN THE SOUTHERN AREA OF ROMANIA

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Abstract

Tomatoes (Solanum lycopersicon) are some of the most cultivated and consumed vegetables worldwide, having significant economic and nutritional importance. Tomatoes are some of the most important horticultural crops in Romania, but production is often affected by abiotic stress factors, characteristics this region. This research aimed to analyse how fertilization influences tolerance to abiotic stress (such as drought, salinity or extreme temperatures) in the case of some tomato cultivars grown in southern Romania, namely Pontica (Dacia), Florina 44 and Buzau 1600. The study focused on the evaluation of different types of fertilizers and their impact on the response of plants to stressful conditions. The obtained results of this research refer to the identification of optimal fertilization practices that can improve stress tolerance, and the determination of some tomato cultivars that show a superior resistance to adverse environmental conditions, offering valuable perspectives for the development of sustainable agricultural practices in the southwest region of the countries.

Key words*: abiotic stress, tomato, tolerant, foliar fertilization, southern Romania.*

INTRODUCTION

Tomatoes represent some of the most valuable vegetables from a food point of view. They are a good source of phytochemicals and nutrients such as lycopene, potassium, iron, folate and vitamin C (Bădulescu et al., 2020); Demidchik, (2018). In addition to lycopene and vitamin C, tomatoes also provide other antioxidants such as beta-carotene and phenolic compounds such as flavonoids, hydroxycinnamic acid, chlorogenic acid, homovanillic acid and ferulic acid (Cuc et al., 2015). Abiotic stress factors, such as drought, salinity, and extreme temperatures, significantly affect the growth and yield of tomato plants. Fertilization, particularly foliar and soil treatments, plays a crucial role in enhancing the tolerance of tomatoes to these stresses. This article examines the impact of various fertilization strategies on tomato cultivars, with a focus on the mechanisms that improve resistance to abiotic stresses. The results indicate that optimized fertilization, including the use of bio stimulants and essential nutrients, can mitigate the detrimental effects of environmental stress, resulting in improved plant growth and yield (Khan, 2015). The qualities they possess have caused them to be consumed in the most varied regions of the globe, even where they are not cultivated. The increase in tomato consumption is due to the fact that these vegetables have a very pleasant taste and an incredibly varied range of uses (fresh, in the form of tomato salad or mixed with other vegetables, soups, broth, pots, sauces, stuffed tomatoes, etc.). In the context of climate change and the intensification of extreme phenomena, abiotic stress has become a major problem for agriculture. Plant stress tolerance can be influenced by fertilization techniques, which can help crops better cope with adverse conditions. Drought among various abiotic stresses, is one of the basic factors for restricting crops production (Vallivodan, B., & Nguyen, H.T. 2006; Demidchik, V. 2018). It is predicted that one third of the world population will be threatened by water shortage in the year 2025 (Mahlagha et al., 2012). Various photosynthesis mechanisms and metabolic activities require water (Oo et al., 2020). Additionally, to maintain their growing performance, maximum amount of water is required by the plants (Tátrai et al., 2016).

Drought stress negatively affects the physiological, genetic, biochemical, and morphological characteristics of plants (Torres-Ruiz et al., 2015) Drought stress restricts plant growth by decreasing photosynthetic rate. Regarding photosynthesis in leaves, chlorophyll fluorescence reflects the intrinsic characteristics of this. There are some studies have been carried out on the photosynthesis of tomato under drought stress but are not comprehensive (Guoting et al., 2020; Brix, 2010; Jangid K.K., & Dwivedi V., 2016). Chlorophyll fluorescence technique is useful as a non-invasive tool in eco-physiological studies and has extensively been used in assessing plant responses to environmental stress (Parry et al., 2006). Plants growing under natural conditions are exposed to a variety of abiotic stresses, which adversely affect their development and performance due to the inhibition of a number of physiological and metabolic processes (Easwar R.D. & Chaitanya K.V., 2016). The light source plays an important role in the growth and development of tomatoes, providing energy for tomatoes on the one hand, and regulating tomato plant morphology on the other hand (Li Y et al., 2021). In plants, solar energy is converted into chemical energy by the complex process of photosynthesis. Crop production is strongly dependent on the photosynthetic rates. Generally, plants try to maintain photosynthetic efficiency under changing light intensities by balancing conversion of radiation energy and protecting any damage to photosynthetic apparatus by photoinhibition and repairing damage (Wimalasekera R., 2019). This research focuses on; identification of tomato cultivars that show a higher tolerance to abiotic stress, evaluation of the types of fertilizers (organic, mineral, combined) and their application in different phases of plant growth, observing the effect on studied parameters.

MATERIALS AND METHODS

The study was done in the year, 2024, in the south-west of Oltenia, more exactly in Varvoru de Jos commune, Dolj County The biological material used in this study was represented by three cultivars of tomato: Pontica (Dacica), Buzău 1600 and Florina 44. Pontica (Dacia) is a Romanian tomato variety favored by many growers. This variety offers a summer-autumn crop with determinate growth. The plants develop a single row of fruit, but the productivity is very high, 90-100 tons per hectare. You can easily establish a crop either by direct seeding or transplanting, without the need for additional care like in the case of indeterminate tomatoes. Pontica is also characterized by its drought tolerance and adaptability to different soil types. It is a semi-late and highly productive crop, with yields reaching 90-100 t/ha. The vegetative period lasts 110-120 days. The stem is vigorous and reaches a height of 60-70 cm. The fruits are round and can weigh around 90-150 grams. Buzău 1600 tomatoes are intended for growers who want indeterminate tomatoes, to be cultivated on stakes, both in open fields and in protected environments such as greenhouses or tunnels. The tomatoes are large, meaty, and very flavourful. Their average weight is around 200-250 grams. The fruits are resistant to cracking.

One seed packet is enough for approximately 200 plants. Sowing: Buzău 1600 tomatoes should be sown in seedbeds, pots, or seedling trays between February and March. Sow in February if you plan to plant them in greenhouses, or in March if planting them in open fields (garden).

Germination conditions: The plants need access to daylight and a temperature of 20-22°C to germinate properly. Transplanting: Seedlings can be transplanted into the garden or greenhouse after about 40 days. Plant them 90 cm between rows and 25-50 cm between plants in a row.

Direct sowing in the field: Direct sowing involves planting the seeds directly into the garden when the germination conditions are met usually around May. [20:14, 21.04.2025] Chat Gpt: Florina 44 Tomato. The Florina 44 tomato variety was developed at the Vegetable Research and Development Station (SCDL) Buzău as a result of research in tomato breeding carried out between 1996 and 2016. The newly developed variety was patented and added to the official list of cultivated plants in Romania starting in 2017.

It is a determinate growth variety (Sp), intended for open field cultivation. It was obtained from line 44 through intensive breeding efforts. The plant grows as a bushy type, consisting of 4-6 main stems with an average height of 60-65 cm.

Plant vigor is medium, with 60-80 leaves featuring medium-sized leaflets. The immature fruit is green with a slight shoulder, and at physiological maturity, it turns bright red. Each inflorescence bears 4-6 large, round fruits, with an average fruit weight of 180-220 grams. The fruits are firm, resistant to cracking and sunburn, and have good post-harvest shelf life (over 10 days). A cross-sectional cut reveals a pericarp thickness of 7-8 mm and 4 seed cavities (locules) [20:14, 21.04.2025] Chat Gpt:

- Each fruit contains a small number of well-developed seeds, around 60-80, which are covered with fine golden hairs. The fruit has an attractive commercial appearance and a pleasant, balanced taste. Fruits can also be harvested with the peduncle attached, thanks to their short pedicel, which improves post-harvest longevity. Economic Efficiency: Production potential: 50-60 tons/ha High quality and commercial value.

Florina 44 can be cultivated in all regions of the country that are favourable for open-field tomato cultivation. Its exceptional flavour and aroma make it ideal for fresh consumption, while its dry matter content of over 6.2% also makes it suitable for processing and industrial use. The Florina 44 and Buzău 1600 tomato varieties were developed at the Vegetable Research and Development Station (SCDL) Buzău. Pontica (Dacia) is a Romanian semi-early tomato variety created by ICDLF Vidra in 1988 and re-approved in 2009.

The measurement of growth was carried out through linear measurements at different time intervals, every 7 days, expressed in centimetres to determine photosynthesis, what is actually measured is the Photosynthetic Efficiency (based on cyclic photophosphorylation), starting from the premise that the highest efficiency (the highest potential for photon acceptance) corresponds to dark conditions - when the electron transport chain should be free of electrons. This Photosynthetic Efficiency can be expressed as a percentage (the reasoning is presented in the attached material). Photosynthesis measuring devices, based on chlorophyll fluorescence, have developed since the beginning of the 1990´s. EARS, in Delft, the Netherlands, was the first company that developed a handheld instrument. This plant photosynthesis meter (PPM) has since then been improved and developed further. So far the portable instrument was still of substantial size. But in 2011 the miniPPM was launched. This instrument is based on a novel measuring % method, has excellent measuring properties, but is not much larger than a mobile phone. Moreover the instrument is very affordable. As a result it is expected to reach a larger target group, in particular farmers and greenhouse growers. But the miniPPM is also very suitable for schools and in applied research. For the experiments the plants were grown in field condition. The experimental variants: Factors that were studied during the experiment:

- for intensity of plant growth:

Factor A [phenophase] $p<0.001$:a1-18.05.2024, a2-25.05.2024, a3-01.06.2024, a4-08.06.2024, a5-16.06.2024, a6-20.06.2024, a7-07.07.2024. Factor B [genotype] $p>0.05$:Pontica (Dacica), Buzău 1600 and Florina 44. The null hypothesis H0 for factor A [phenophase] is rejected, and the null H0 hypothesis for factor B[genotype] is accepted.

- for intensity of photosynthesis:

Factor A [phenophase];

Factor B [genotyp]:

Factor C[varianta]: **V0** - Atonik 10 ml/10 l; **V1** - Atonik 10 ml/10 l + Albit 2 ml/10 l + Albit 2 ml/10 l;

V2 - Atonik 10 ml/10 l + Albit 2 ml/10 l + Albit 2 ml /10 l + Poliamin/50/10 l + Poliamin /100/10 l + Poliamin /100/10 l.

Albit is a substance with a protective and stimulating role, positively influencing all plant life functions, contributing to strong immunity and a balanced metabolism. It is used in over 60 types of crops. It is based on natural combat mechanisms and contains substances synthesized by beneficial soil bacteria. Its composition also includes a set of substances that enhance and amplify the effect of PHB: MgO, SO4, K2O, P2O5, and N. Albit is used together with chemical pesticides to reduce their stressful effect and to increase their efficiency

Apply 10 ml of the product in 10 liters of water. Albit was applied when the plants had 3-4 leaves Atonik is a biochemical stimulator for:

growth, fruiting, rooting, and the stimulation of seed germination in horticultural plants.

Atonik stimulates rooting, seed and pollen germination, pollen tube growth, shoot proliferation and development, flower fertility, and fruit formation. In tomato cultivation, in order to achieve increased yield, the product is applied at a dose of 0.5 L/ha. Haifa Poly-Amin is a natural bio-stimulant, specially designed for foliar application. It contains amino acids and low molecular weight peptides, which act synergistically to catalyse growth processes and support the plant's metabolism. It is applied two to three times, every two weeks. Apply 100 ml of the product in 10 litters of water.

The fertilization was applied in different phenophases of plant growth. Variant 0 - Fertilization at this stage was done with Atonik when the plants had 10 leaves, on May 20, 2024.

Variant 1 - The first fertilizer applied was Atonik, on May 20, 2024, at the 10-leaf stage. The second fertilizer was Albit, applied on the following dates: June 5, 2024, June 12, 2024, and July 12, 2024.

Variant 2 - The first fertilizer applied was Atonik, on May 20, 2024, at the 10-leaf stage. The second fertilizer was Albit, applied on June 5, 2024, June 12, 2024, and July 12, 2024. The third fertilizer was Polyamin, applied three times on the following dates: June 11, 2024, June 26, 2024, and July 7, 2024. The parameters determined applied research methods were: determining the intensity of plant height, determining the intensity of photosynthesis. Experimental data have been processed by statistical methods: using analysis of variance (ANOVA) for 95% confidence level and DUNCAN test to determine the significance of differences.

RESULTS AND DISCUSSIONS

Given the results in Table 1, we can observe that the phenophase have a significant influence upon or on growth intensity evaluated by the plant height evalution.

As there are no significant differences between cultivars in terms of plant height, we looked for an adequate equation between phenophase and plant height - the average of cultivars. The equation sought was an exponential equation, i.e. the trend of development of the plant size is exponential depending on the phenophase. The exponential equation best approximates the evolution of plant growth as a function of phenophase. We can present 3 equations: linear, parabolic, exponential.

Table 1. Variance analysis of growth intensity

Source of variation	SSP [SP]	Degrees of freedom	Weighted sum of squares [s^2]	F-test vs. s2error		
				the value	p	the meaning
phenophase	15333.90	6	2555.65	24.8389	0.000004	***
genotype	190.17	2	95.08	0.9241	0.423364	ns
Error	1234.67	12	102.89			
Total	16758.74					

ns $p>0.05$; *$p\leq0.05$; **$p\leq0.01$; ***$p\leq0.001$

By comparing them, we can choose the one that best approximates the phenomenon studied [it all boils down to the analysis of the variance analysis table for examining the respective correlation - test F].

From the Table 2 we can see the influence of phenophase upon plants height. From this point of wiew, the best influence was registered to a7 phenophase (90).

Table 2. The influence of phenophase upon plants height

Phenophase	(Mean(Cm)	Std.Err.	-95.00%	+95.00%
a1-18.05.2024	6.33	0.33333	4.89912	7.7676
a2-25.05.2024	8.67	0.16667	7.94956	9.3838
a3-01.06.2024	11.33	0.33333	9.89912	12.7676
a4-08.06.2024	25.00			
a5-16.06.2024	33.67	1.85592	25.68128	41.6521
a6-20.06.2024	40.67	0.66667	37.79823	43.5351
a7-07.07.2024	90.00	15.27525	24.27589	155.7241

The cultivars studied showed mean values of this character between 28.07 cm in Florina 44 and 35 cm in Buzau genotype.

Table 3.The influence of phenophase uponcultivars studied

Cultivars	Mean (cm)	Std. Err.	-95.00%	+95.00%
b1 - Buzau	35.00	14.95071	-1.58308	71.58308
b2 - Pontica	29.36	9.81539	5.33975	53.37453
b3 - Florina 44	28.07	8.63853	6.93371	49.20914

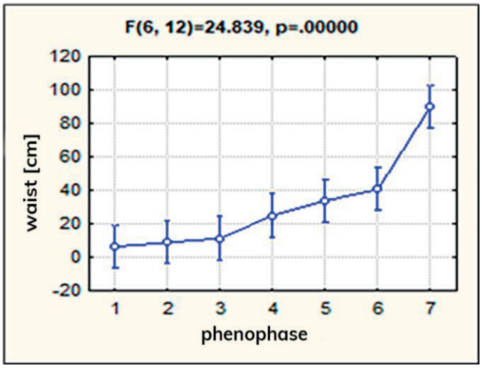

Figure 1. Influence of phenophaseupon plant height

The statistical results regarding the influence of genotype on plant height are presented in Figure 2.

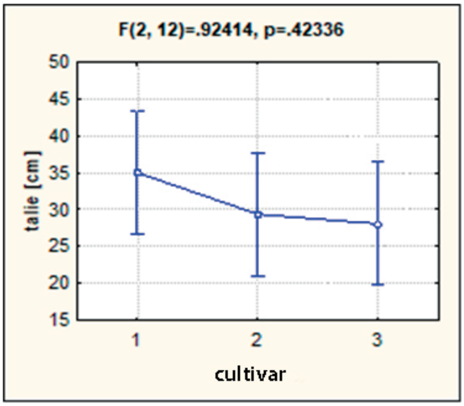

Figure 2. The influence of genotype upon plant height
ns p>0.05; *p≤0.05;**p≤0.01;***p≤0.001

Table 4.Variance analysis for intensity of photosynthesis

	SSP			Test F		
Source of variation	**[SP]**	**Degrees of freedom**	**[s²]**	**value**	**p**	**Signi ficance**
				5.21	0.005524	
[phenophase]	136.6	3	45.5	0.46	0.633607	**
[cultivars]	8.1	2	4.1	1.28	0.294133	ns
[variants]	22.4	2	11.2			ns
Error	244.9	28	8.7			
Total	411.9					

From the Table 4 we can observe that the phenophase had a statistically assured action.
The cultivars and fertilization treatments have an action without statistical assured.
The null hypothesis H0 for phenophase is rejected, and the null H0 hypothesis for factor genotype and fertilization variants were accepted.

Table 5a. The influence of phenophase upon intensity of photosynthesis

Phenophase	Mean %	Std. Err.	-95.00%	+95.00%	N
a1 – 20.06.2024	72.80	0.360555	71.96856	73.63144	9
a2 – 26.06.2024	71.24	0.955556	69.04093	73.44796	9
a3 – 01.07.2024	76.58	1.368878	73.42114	79.73442	9
a4 – 29.07.2024	73.96	0.952489	71.76652	76.15941	9
Mean	73.65				

The average intensity of photosynthesis was between 71.24%, in second period and 73.96%, in fourth period (Table 5a).
Low light intensity influences photosynthesis, which is central to plant productivity, and can therefore severely restrict plant growthand even death (Zhu et al., 2014; Wang et al., 2021).

Table 5b. The influence of cultivars upon intensity of photosynthesis

Cultivars	Mean %	Std. Err.	-95.00%	+95.0%	N
b1 - Buzau	73.56	0.687982	72.04410	75.07257	12
b2 - Pontica/Dacia	73.11	1.047383	70.80861	75.41916	12
b3 - Florina 44	74.27	1.220262	71.58089	76.95245	12

The best influence upon yield of photosynthesis had the Florina 44 (74.27%) (Table 5b). The results regarding the influence of fertilization treatmentson the intensity of photosynthesis during the 2024 year are presented in Table 6.

Table 6. The influence of fertilization treatments upon intensity of photosynthesis

Variant	Mean (%)	Std. Err.	-95.00%	+95.00%	N
c1 - V0	72.58	0.774774	70.87251	74.28304	12
c2 - V1	74.46	0.744851	72.81615	76.09496	12
c2 - V2	73.91	1.340265	70.95565	76.85546	12

The best fertilization treatment was V1. The application of this treatment option stimulated photosynthesis and intensification of plant metabolism, reducing oxidative stress. Foliar fertilization helps to quickly correct deficiencies and improves photosynthetic efficiency. The application of this mixture led to more vigorous plants with improved production and increased resistance to stressors.

CONCLUSIONS

The height of tomato plants is influenced not only by genotype, but also by the phenophase of growth. Cultivars control tomato size, plant architecture, and finally crop yield. The Buzau genotype recorded the largest plant hight.

Each phenophase has different requirements and influences plant growth. Proper management of water, nutrients, and temperature ensures healthy development and high production.

The best fertilization treatment was V1. Application stimulated photosynthesis and enhanced plant metabolism, reducing oxidative stress.

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