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NUTRIENT BALANCE EVOLUTION IN TOMATO CULTURE BASED ON LEAVES ANALYSIS AT DIFFERENT STAGES OF DEVELOPMENT

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Abstract
Worldwide, tomato culture occupies the first place as a percentage of the total area planted with vegetables. Knowing the requirements for growth factors is very important because cultivation technology must provide conditions as close as possible to the optimal levels. The research was carried out in Dâmbovița County during 2017. It aimed to establish the nutritional balance evolution on some tomatoes hybrids seedling (Colibri, Zadurella V370, ISI-36629F1) grown in a passive solar greenhouse, at different stages of development (3 leaves stage, 3-5 leaves stage, 5-7 leaves stage).
The nutritional balance is given by the percentage ratio of the elements N, P, K. The results indicated that there are some imbalances given by the inadequate ratios of the N,P,K in the culture substrate. Based on the development stage, at 3 leaves is recommended to be 1:1.3:1, for the stage of 3-5 leaves of 1:1.4:1.6 and for the stage 5-7 leaves of 1:1.4: 2,6. In conclusion, for tomato culture the culture substrate is well balanced if it correlates with the consumption of nutrients on the vegetation stages.

Keywords: hybrid, NPK, nutrient balance, tomato.

1. INTRODUCTION

Worldwide, tomato culture occupies the first place both as a percentage of the total area cultivated with vegetables and at the cultivation systems. Also, researches regarding the use of different fertilization systems, the use of different fertilizers as well as testing them are extremely numerous. Tomatoes are cultivated by seedling or sowing directly into the field and need special attention regarding the water and nutrition levels. The optimal progress of tomato metabolic processes is closely dependent on environmental factors. In Romania, tomatoes have been grown in recent years on approximately 45,000 ha with a total production of 650,000 tons. From this production, more than 550,000 tons are obtained from field crops (FAO, 2017). For tomato cultivation in greenhouses, hybrids that have to meet several requirements are used. They have to show genetic resistance to as many pathogens as possible, to have a good adaptability to natural light conditions, to have early production, fruit should have intense and uniform color and to be resistant to transport and handling (Ciofu et al., 2004).
Greenhouse tomatoes grow best in a well-aerated soil with a high water-holding capacity, rich in nutrients and free of pathogens. The most suitable soil types are loams, sandy loams, and silty

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loams, with high organic matter content. Other types can be used, with more difficulty and expense (Grubinger, 2011). Tomatoes prefer slightly acid soils with a pH of 6-6.5. They can also be cultivated with good results on neutral soils. If the pH is less than 5.5, the magnesium availability sharply decreases, while available aluminum and manganese start to increase significantly. These changes vary to a certain degree, according to soil type and organic matter content. For many soils, a low pH is associated with a reduced calcium content. When the soil pH is greater than 6.8, the availability of Zn, Mn and Fe will start to decrease (Benton, 1999). According to soil salinity, tomatoes are among the moderately tolerant plants. Soil salinity diminishes vegetative growth of tomatoes in favor of flowering (Ciofu et al., 2004). Tomatoes have high requirements in nitrogen (N) and potassium (K), medium in magnesium (Mg) and low in phosphorus (P) (Davidescu et al., 1992). During the vegetation period, the nutritional balance N:P:K:Mg changes accordingly with age and vegetation phases. Due to this, it is necessary to periodically (15-20 days) apply nitrogen and potassium fertilizers. The main determinant factors in vegetable crops fertilization in protected areas are the results of characteristics of soil (organic matter content, pH, texture, EC, N:P:K ratio of soil solution), irrigation water (total soluble salts content, hardness, watering temperature), plant biology (critical periods of nutrition in plant growing, intensity of nutrient absorption, N: P: K ratio during vegetation, low light nutrition adaptation and photoperiodism), climatic factors in protected areas, mineral nutrition which is differentiated by species and age (Davidescu et al., 1992).
As evidenced above, tomatoes are pretentious plants regarding growing factors. Knowing the requirements for vegetation factors is very important in order to offer growth conditions close to the optimal. In this way, higher yield and high quality production can be ensured. The fertilization technology and fertilization management require for an agrochemical control and monitoring of the soil-plat system (Crăciun, 2011).

2. MATERIALS AND METHODS

The experimental researches were carried out in the year 2017 and they aimed to establish the nutritional balance in protected crops of tomatoes hybrids at different stages of development. The experience took place in a passive solar greenhouse in Răcari, Dâmbovița County. Climate of Dambovita County belongs to the continental climate sector, with an average annual temperature of 10 °C (Primaria oraşului Răcari, 2017). Three tomato hybrids were cultivated: Colibri, Zadurella V370, ISI-36629F1 (Figure 1).

Figure 1. Three tomato hybrids: Colibri, Zadurella V370, ISI-36629F1

The main research objective was to establish nutritional balance based on tomato leaves analysis at different stages of development.

Cultivation technology of tomato seedlings

Sowing the tomato seeds was carried out in 200 cell plug flats and each seed was sown in it's own cell. The used substrate was composed from peat with a pH of 5,5-6,5 combined with manure and

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forest soil in approximately equal amounts. These plug flats have been used since they have many advantages over sowing on germination or furrows.
After sowing, the temperature of the space where they was kept constant over day and night (22-26 °C). To keep this temperature at optimal parameters, the cell plug flats were placed in a greenhouse where the temperature can be adjusted. Warm beds were made using straw and soil, and heating cable were introduced to maintain optimal temperature and to achieve a uniform growth. The cell plug flats were placed in these beds.
After the full rise of the leaves it is necessary to change the constant day/night temperature with the alternation of the day/night temperature, so during the day the temperatures are between 22-26°C and the night between 16-20°C. This alternation is necessary for the optimal development of seedlings.
The tomato prick out was made in plug flats as well, but the number of cells was much lower (80 cells) (Figure 2). After 2 to 3 weeks, when the thermal conditions were favorable, the seedlings were planted in greenhouse.

Figure 2. Tomato seedlings before and after prick out

Analytical methods
Substrate analysis was performed in 1: 5 aqueous extract, determining the following agrochemical indices: pH, total soluble salts content, nitrate, ammonium, phosphorus and potassium soluble content. In order to establish the absorption rate of nutritive ions in leaves, for each hybrids were achieved total forms of nitrogen, phosphorus and potassium. The pH values were carried out through potentiometric method, meanwhile EC (electrical conductivity) was determined using conductivity method. Soluble and total phosphorus contents were evaluated by spectrophotometric molybdenum blue method. The levels of nitrate and ammonium species were assessed by spectrophotometric means, also using phenoldisulfonic acid and Nessler reagent, respectively. Total nitrogen content was determined using Kjeldahl method, meanwhile potassium content was assessed using atomic emission spectrometry.

3. RESULTS AND DISCUSSIONS

Analyzing soil nutrient supply level, resulted a high supply level for nitrogen content (NO_3^- + NH_4^+), very high level for soluble phosphorus content and high/very high level for soluble

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potassium. The optimal pH range for tomato culture is 5.5 - 7 and the determined pH of 6.80 - 6.92 falls within the recommended range (Table 1)**.**

Table 1. Growing Substrates Analysis

Nr. crt.	Hybrid	pH	Total soluble salts %	Soluble forms (ppm)			
				$N_{mineral}$		P_{H2O}	K_{H2O}
				$N\text{-}NH_4^+$	$N\text{-}NO_3^-$		
1.	ISI-36629F1	6.80	0.126	15.40	52.74	43.66	281.00
2.	Colibri	6.82	0.141	11.25	51.99	48.00	113.44
3.	Zadurela	6.88	0.142	11.25	52.49	49.33	126.00

Nutritional balance at (En) different stages of development was determined calculating the global nutrition using the results of experimental analyzes performed during the vegetation period of tomato seedlings.

The nutritional balance is given by the percentage ratio of the total content forms in nitrogen (N), phosphorus (P) and potassium (K) in leaves at different stages of the vegetation period (Madjar et al., 2014):

$$En_N = \frac{\%N}{\sum N,P,K} \cdot 100$$

$$En_P = \frac{\%P}{\sum N,P,K} \cdot 100$$

$$En_K = \frac{\%K}{\sum N,P,K} \cdot 100$$

Interpretation was done by correlating the consumption of nutrients with the vegetation phase of seedlings (Table 2).

Table 2. Optimal nutritional balance in tomatoes,% (Davidescu D., 1981)

Stage	En_N, %	En_P, %	En_K, %	Balance report
Prick out→3 leaves stage	32-40	37-55	25-50	1 :1.3 :1
3 eaves stage→ 5 leaves stage	28-30	35-45	35-60	1 :1.4 :1.6
5 eaves stage→ 7 leaves stage	23-25	25-41	50-75	1 :1.4 :2.6

At the 3 leaf stage, the values for ISI-36629F1, Colibri and Zadurella hybrids are out of range, due to high levels of total nitrogen. In the analysis of the nutrient balance for phosphorus is observed that the calculated values are well below the optimal range of 37-55%. There is an imbalance

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regarding phosphorus accumulation in the N-P-K trilinear analysis for optimal balance, even the leaves phosphorus content corresponds to a normal supply. The nutritional balance for potassium ranges from 34.55-47.17%, within the optimal range of 25-50% (Table 3).

Table 3. Nutritional balance for hybrids at 3 leaf stage

Nr. crt.	Hybrid	SNPK, %	Nt, %	En_N, %	P_2O_5, %	En_P, %	K_2O, %	En_K, %
1.	ISI-36629F1	6.789	3.234	47.63	1.209	17.80	2.346	34.55
2.	Colibri	6.094	2.671	43.83	0.906	14.86	2.517	41.30
3.	Zadurella	7.298	3.049	41.77	1.044	14.30	3.205	43.91

At the 3-5 leaf stage, the determined nutritional balance shows an imbalance in nitrogen and phosphorus nutrition for all analyzed hybrids. The calculated values exceed the optimal range of 28-30% E_nN in the case of nitrogen (32.33-45.62% E_nN) and are below the values of 35-45% E_nP in the case of phosphorus. Potassium is within the specified range of 35-60% E_nK, ranging from 42.27 to 45.60% E_nK. (Table 4).

Table 4. Nutritional balance for analyzed hybrids at 3-5 leaf stage

Nr. crt.	Hybrid	SNPK, %	Nt, %	EnN, %	P2O5, %	EnP, %	K2O, %	EnK, %
1.	ISI-36629F1	6.776	2.713	40.03	0.973	14.36	3.090	45.60
2.	Colibri	8.800	4.015	45.62	1.065	12.10	3.720	42.27
3.	Zadurela	7.506	2.427	32.33	1.129	15.04	3.950	52.62

At the 5-7 leaf stage, the calculated nutritional balance shows imbalance in nutrition of nitrogen, phosphorus and potassium for all analyzed hybrids. The calculated values exceed the optimal range of 23-25% E_nN in the case of nitrogen (38.45-48.74% E_nN) and are below 25-41% E_nP in the case of phosphorus and 50-75% E_nK in the case of potassium.

Table 5. Nutritional balance for analyzed hybrids at 5-7 leaf stage

Nr.crt.	Hybrid	SNPK, %	Nt, %	EnN, %	P2O5, %	EnP, %	K2O, %	EnK, %
1.	ISI-36629F1	6.881	2.646	38.45	0.801	11.64	3.434	49.90
2.	Colibri	6.513	2.637	40.48	1.014	15.56	2.862	43.48
3.	Zadurella	5.806	2.830	48.74	0.744	12.81	2.232	38.44

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4. CONCLUSIONS

The results indicated that there are some imbalances given by the inadequate ratios of the N, P, K in the culture substrate. Based on the development stage, at 3 leaves is recommended to be 1:1.3:1, for the stage of 3-5 leaves of 1:1.4:1.6 and for the stage 5-7 leaves of 1:1.4: 2.6.

By the NPK triple analysis of the optimal balance for the ISI-36629F1, Colibri and Zadurela hybrids, it was found that the intense accumulation of nitrogen and potassium is detrimental to phosphorus at the 3-leaf stage and at the 3-5 leaf stage. For the 5-7 leaves stage, an intense accumulation of nitrogen is detrimental to phosphorus and potassium.

For tomato culture the culture substrate is well balanced if it correlates with the consumption of nutrients on the vegetation stages.

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