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CONTROL OF POTASSIUM CONCENTRATION IN FERTILIZING TOMATOES IN PROTECTED SOIL

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АНОТАЦІЯ

Томат – одна з головних і популярних овочевих культур не тільки в Україні, але і усьому світі. За даними ФАО (Food and Agricultural Organization), у світі томати займають перше місце за площами вирощування серед усіх овочів - понад 4 млн га. В Україні під цю культуру відводиться близько 93 тис. га - близько 24% загальної площі під овочами. З появою високоінтенсивних технологій із застосуванням систем крапельного поливу стали реальними врожаї томату у відкритому грунті 120-140 т/га, а в захищеному – більше 50 кг/м^2.

В роботі визначено кількісний вміст основного макроелемента калію у субстраті з мінеральної вати методом полум'яної фотометрії. Згідно з отриманими даними вміст калію виявився в межах норми, що узгоджується з відповідною фазою росту томата. Запропоновані рекомендації щодо коригування вмісту мінеральних калійних добрив у маточному розчині.

ABSTRACT

Tomato is one of the main and popular vegetable crops not only in Ukraine but all over the world. According to the FAO (Food and Agricultural Organization), tomatoes rank first in the world in terms of growing area among all vegetables - more than 4 million hectares. In Ukraine, about 93 thousand hectares are allocated for this crop - about 24% of the total area under vegetables. With the advent of high-intensity technologies with the use of drip irrigation systems, tomato yields in the open ground of 120-140 t/ha, and in the protected - more than 50 kg/m^2 became real.

The quantitative content of the main macronutrient potassium in the substrate of mineral wool was determined by flame photometry. According to the obtained data, the potassium content was within the norm, which is consistent with the corresponding phase of tomato growth. Recommendations for adjusting the content of potassium mineral fertilizers in the mother liquor are offered.

Ключові слова: гідропоніка, теплиця, томати, поживний розчин, мінеральна вата, калій, полум'яний фотометр.

Keywords: hydroponics, greenhouse, tomatoes, nutrient solution, mineral wool, potassium, flame photometer.

Tomato (Lycopersicum esculentum Mill.) Is one of the most common vegetable crops in the world. It is grown to produce fruits, the value of which is determined by high nutritional and taste qualities. Ripe fruits contain from 4.3 to 12% dry matter, 2-6% total sugar, 15-45 mg/100g of ascorbic acid, lycopene, β-carotene, minerals, vitamins (B1, B2, C, P, PP), malic and citric acid. The biochemical composition of the fruit varies depending on the variety, hybrid and growing conditions. About 75% of tomatoes grown in the world are used for fresh consumption, and 25% are processed (for the production of tomato paste, ketchup, sauces, canning, etc.) [1].

In the world ranking of gross fruit harvest, Ukraine is on the 14th place (1,492 thousand tons), but on the yield - on the 110th. One of the reasons for such low yields is that large areas of vegetable crops, including tomatoes are in small homesteads, where not enough attention is paid to the latest breeding and technological developments. At the same time, it is known that without the introduction of modern cultivation technologies, the realization of the genetic potential of new varieties and hybrids is impossible. A negative factor is that more than a quarter of the grown vegetable products are lost during transportation, sorting and storage.

Nowadays, the method of low-volume hydroponics using drip irrigation is becoming more widespread in greenhouses [2]. As a substrate using special materials - mineral wool, coconut, peat and more. The selected substrate serves as a medium for the roots, fertilization is carried out by applying a solution of fertilizer. When growing on a substrate it is necessary to dose fertilizers very precisely and to provide plants with a sufficient amount of nutrients.

The mineral substrate does not contain nutrients and has no sorption properties, so plants grown on mineral wool need to be fed with solutions of nutrient mixtures with a full composition of macronutrients and trace elements (Fig. 1).

Fig. 1. Growing tomatoes on mineral wool

For the proper cultivation of tomato crops using only liquid fertilizers requires an irrigation system that ensures accurate supply of the solution. This function is performed by the capillary irrigation system. Each dropper must have a capacity of at least 1 - 1.5 liters [3].

The average need for solution during the entire period of growing tomatoes is:

- in the spring cycle 200-250 liters per plant;
- in the autumn cycle 120-150 liters per plant;
- at long cultivation of 450-600 l on a plant.

Depending on the substrate used (mineral wool, expanded clay), the pH of the solution should be adjusted to the desired level in pH = 5.5 - 6.0, and the concentration of elements in the solution depends on the phases of plant growth and light conditions.

The required pH and EC ranges and the number of waterings when growing tomatoes on mineral wool are as follows:

Impregnation of mats:
- lowering the pH to 4.8 - 5.0;
- EC = 2.8;
- the need for a solution - about 5 liters per plant.

Installation of plants on mats:
- lowering the pH to 5.5;
- EC = 2.7;
- a single dose of 200 ml per plant.

Installation of plants in openings:
- lowering the pH to 5.5;
- Es = 2.6

Flowering period from 1 to 3 tassels:
- pH = 5.5;
- EC = 2.8 - 3.0;
- daily requirement of 0.8 - 1.2 liters per plant.

Flowering period from 3 to 5 tassels:
- pH = 5.5 - 5.8;
- EC = 2.6 - 2.8;
- daily requirement of 1.2 - 1.8 liters per plant.

Fruiting period:
- pH = 5.8;
- EC = 2.5 - 2.6;
- daily requirement of 1.8 - 2.5 liters per plant and more.

Autumn period:
- pH = 5.5;
- EC = 2.7 - 2.8.

The optimal values of EC in mineral wool mats when growing tomatoes are in the range of 3.5 - 4.5 mSm/cm.

If the plants become more vegetative, you need to increase the EC by 0.5 - 1 mSm in the substrate throughout the period.

If the plants become more generative, you need to reduce the EC by 0.5 - 1 mSm in the substrate throughout the period until the plant returns to balance.

The pH value of the substrate throughout the growing season may be in the range of 5.2 - 6.2, but the pH should not exceed 6.5 due to the subsequent unavailability of Fe and Mn. Usually the pH of the nutrient solution is 5.5. Regularly (1-2 times a week) checking the pH of the mat, you can adjust the balance of plant development.

When plants become vegetative, the pH of the mat begins to rise. In this case, return the required range by lowering the pH of the irrigation solution to 5.0.

If the pH in the mother decreases, the plants become generative. In this case, the pH of the nutrient solution is raised to 6.0.

During cultivation, you should systematically check the composition of the solution - extracts from the mats, especially the salt content and pH, which should be monitored every few days in several places in the greenhouse, and the content of trace elements - every 14 days. The solution from the mats for analysis is taken with a syringe or a special device for sampling.

The range of optimal values of the concentration of elements in the mat for cultivation is influenced by the variety and agronomic conditions. Currently, the optimal range of concentration of elements in the peak of plant vegetation is considered to be equal to 2.8 - 4.2. An increasing level of EC indicates drying of the substrate or indicates excessive accumulation of elements in the mat. Maintaining a high ES for a long time leads to root damage. Too low EC indicates overwetting of the substrate or insufficient amount of nutrients in relation to the requirements of plants. This phenomenon is often observed when overloading plants with fruit.

At higher EC, the absorption of Ca and Mg decreases and increases by K. The concentration of solutions increases gradually, while the one-time increase in ES should not exceed 0.5 mSm / cm. The level of the ES solution should lead to the corresponding ES solution in the mats. Depending on the growing period, the composition of the solution changes and the level of elements in the drainage from the mat depends on this [4].

Potassium is the most important nutrient, especially in the plant world. With a lack of potassium in the substrate, the plants develop very poorly, the yield decreases, so about 90% of the extracted potassium salts are used as fertilizers. The most important potassium fertilizers are natural potassium salts sylvinite (mKCl·nNaCl) and kainite ($KCl \cdot MgSO_4 \cdot H_2O$). Potassium sulfate K_2SO_4, which is not hygroscopic and does not agglomerate, is also used as fertilizer. Potassium nitrate KNO_3 is both a source of both potassium and nitrate nitrogen for the plant. Saussure first suggested the need for potassium for plants in 1804 on the basis of an analysis of plant ash, in which potassium was always present. Liebig then concluded that potassium fertilizers were needed. The first experimental data on the absolute need for potassium in plants were obtained by Salm-Gorstmar in 1846 [5,6].

Potassium is one of the three basic elements that are needed for plant growth along with nitrogen and phosphorus. Unlike nitrogen and phosphorus, potassium is the main cellular cation of K^+. In cells, these ions are found mainly in the protoplasm. Part of the ions is in the cell sap, the other part is absorbed by the structural elements of the cell. In its absence, plants primarily disrupt the structure of the membranes of chloroplasts - cellular organelles in which photosynthesis takes place. Externally, this is manifested in yellowing and subsequent death of leaves. When potassium fertilizers are applied to plants, the vegetative mass, yield and resistance to pests increase [7].

Potassium is found in fruits, stems, roots and leaves, and in the vegetative organs it is usually more than in fruits. Another characteristic feature: young plants have more potassium than old ones. As the individual organs of plants age, potassium ions move to the points of most intense growth. The role of potassium in the nutrition of tomatoes is significant, because potassium provides the formation of ovaries and new stems, as well as the active assimilation of various carbon dioxide. In fact, it is an elixir of youth for plant cells. Potassium increases immunity by accelerating the formation of carbohydrates. Contributing to the accumulation of carbohydrates in plant cells, potassium increases the osmotic pressure of cell sap and thus increases the cold resistance and frost resistance of plants. Potassium plays an important role in the synthesis and renewal of proteins in plants. In its absence, protein synthesis is sharply reduced and at the same time there is a breakdown of old protein molecules. The positive effect of potassium on protein synthesis is due, firstly, to its effect on the accumulation and transformation of carbohydrates (and the latter, as is known, in the process of respiration form ketoacids - a material for building aminoacids) and, secondly, to increase under the influence potassium activity of enzymes involved in protein synthesis. Accumulating in chloroplasts and mitochondria, potassium stabilizes their structure and promotes the formation of ATP. Potassium increases the hydrophilicity of protoplasm colloids; this reduces transpiration, which helps plants better tolerate short-term droughts. Similarly, this element stimulates the growth of the root plant and makes the stem stronger and firmer, thereby reducing the effect of "lodging the tops" [8].

The optimal potassium content for tomato culture should be 300-600 mg/l of substrate. Young plants need less potassium. During the period of intensive growth, the need for potassium increases, and then the content is maintained at the upper level, which takes into account the additional requirements of hybrid varieties.

Table 1.

Requirements for potassium content in the substrate of mineral wool in different periods of tomato growth

№	Indicator	Growth period						
		A	B	C	D	E	F	G
1.	EC	2,44	2,38	2,57	2,54	2,55	2,56	2,59
2.	pH	5,5	5,3	5,5	5,5	5,5	5,5	5,5
3.	K^+, mg/l	340	240	330	370	380	380	390

where A is the standard;
B - impregnation of mats;
C - from 1 to 3 tassels;
D - from 3 to 5 tassels;
E - from 5 to 10 tassels;
F - from 10 to 12 tassels;
G - mass fruiting.

Proper supply of plants with potassium has a beneficial effect on the color and ripening of fruits, especially in times of lack of light, and also has a positive effect on plant life and provides better fruit quality.

Signs of potassium deficiency are as follows: on the old leaf, starting from the edges of the leaf blade, changes color from green to lemon yellow, necrosis appears, the color of the fruit becomes uneven, there are light spots on the red fruit; there is a breakage of flower tassels with fruits at the base, which prevents their proper growth in the tassel. Increased signs of potassium deficiency always occur with an excess of nitrogen. Then a poorly visible green spot appears on poorly colored fruits, which persists on the fruit for a long time. In addition, the wrong color of the fruit can be caused by viruses and high temperatures.

Young plants need less potassium than nitrogen, during the period of intensive fruit growth there is a need for potassium, and then the ratio of N:K should be 1:1.5. At simultaneous need for nitrogen it is expedient to use potassium nitrate (KNO_3).

The low content of potassium in the substrate determines not only the quantity but also the quality of the harvest. Little used in practice, the method of preventing the fracture of improperly formed tassels under the weight of the fruit, is a very gentle damage to the layer of epidermis at the bottom, resulting in a layer that can withstand heavy loads. It is very convenient and effective to use brush holders at an early stage of growth after tying the fruit.

Without potassium, the fruit of the tomato will be less sugary and more acidic, compared to the tomato, in the diet of which potassium is present in the required amount, which means that the need for potassium is especially important during fruiting and pouring the fruit.

Excess potassium in the substrate is also harmful for tomatoes. Poor plant growth in the early stages, elongation of the internode, light green color of the leaves - all this is a sign of excess potassium. In the later stages, plant growth slows down; spots appear on the leaves, they wither and fall off, local damage, necrotic tissues [9,10].

To quantify potassium, the method of flame atomic emission photometry of a water body is used. Flame photometry is a type of spectral analysis based on the emission (absorption method) or absorption (absorption method) of light energy by atoms of elements in a flame. The radiation and absorption of light is related to the processes of transition of atoms from one energy state to another. During the transition of atoms from a lower to a higher energy level, the absorption of light is always forced as a result of the influence of external radiation with a certain frequency [11].

Analysis by flame photometry is performed using devices called flame photometers (Fig. 2).

Fig. 2. Flame photometer BWB-XP

In this device, the analyzed solution is converted into an aerosol by means of a spray, which is injected into the flame of a gas burner (light gas, acetylene, hydrogen, propane, etc.). In the flame there is evaporation of the solution, ionization of solutes. At a sufficient flame temperature, the atoms of the elements are easily excited and go into an excited state, which is characterized by the movement of external (valence) electrons to higher energy levels. The atom can be in the excited state for only a fraction of a second (10^{-7}-10^{-8}s), after which the electrons return to or close to their original levels. The latter process is accompanied by the release of portions of energy (quanta of light), the set of which forms a light flux (radiation) with a certain wavelength for each element. The radiation colors the flame, and the intensity of its color is proportional to the content of the chemical element in the solution used for quantitative analysis [12].

The aim of this study was to trace the fluctuations of the quantitative content of potassium in the substrate for two weeks and to investigate the effect of the quantitative content of potassium on the growth and development of tomato plants of the greenhouse variety "Campari".

Materials and methods

The object of the study were tomatoes of the variety "Campari" (cocktail) during the period of mass fruiting (after 12 tassels). Tomatoes were fed according to the recipe shown in table 2.

Table 2.

Uterine solution for tomato during flowering 12 tassels

Tank A (kg/1m^3)	Tank B (kg/1m^3)
$Ca(NO_3)_2$ – 95,0 KNO_3 – 30,0 HNO_3 – 1,0 l Chelate Fe (11%) – 0,76	HNO_3 (57%) – 31 l pH=5,5 KNO_3 – 12,9 KH_2PO_4 – 17,0 K_2SO_4 – 43,5 $MgSO_4$ – 46,7 Microelements: g/m^3 $MnSO_4$ (32%) – 174 $ZnSO_4$ (23%) – 61,5 Borax (15%) – 135 $CuSO_4$ (25%) – 14 Molybdate Na (40%) – 12

Sampling for nutrients was performed for two weeks with a frequency of three times a week.

Quantitative potassium content was determined in mineral wool extracts using a BWB-XP flame photometer using a propane-butane mixture. The BWB-XP flame photometer is a high-quality and high-performance device that uses modern technology to quantify 5 elements (Na, K, Li, Ca and Ba) with high accuracy. Calibration of the device was performed using solutions of potassium chloride of the following concentrations: 50, 100, 250, 500 and 1000 mg/l, the reference solution was deionized water.

Results and discussion

During a series of experiments, the potassium content in mineral wool extracts was determined.

Data on the change in potassium content in the substrate are shown in table 3.

Table 3.

Quantitative content of potassium, mg/l for tomato in the extract of mineral wool

№	Indicator	Allowable level		Date of sampling						Average value
		low	high	03.08	05.08	07.08	10.08	12.08	14.08	
1.	pH	5,0	6,5	5,7	5,6	5,8	6,1	5,9	5,8	5,82
2.	EC, mSm/cm	2,5	5,0	4,7	4,6	4,8	5,1	4,9	5,0	4,85
3.	K^+, mg/l	253,5	390	328	308	336	387	375	377	351,8

The well-won tributes, the value of acidity, the concentration of salts and the concentration of ions in calories in pre-juvenile knots appeared between the norms. For usunennya of the adjusted value of EC in mats up to 5.1 mSm/cm, the mats were promoted with a path, the frequency of irrigation was reduced and the rate of EC was reduced from 3.04 to 2.8 mSm/cm. For a whole bulo, it is recommended to change the amount instead of the good ones in the mother liquor, to reach the value of 390 mg/l potassium-ion, which is due to the growth of "G" tomato. In such a rank, regulating the level of the nutritive vivification of tomatoes, it is possible by a significant world to infuse on their productivity and quality of the acquired products.

Conclusions

1. The modified method of flame photometry for the analysis of extracts from mineral wool is rather sensitive, simple and is recommended for use in serial analyzes.

2. The determined content of potassium salts (351.8 mg/l) was optimal for growing tomatoes during the period of mass fruiting.

3. By conducting regular tests it is necessary to monitor changes in the content of batteries. If the results of the analysis reveal a deficiency or excess of an element, then adjust the composition of the nutrient solution.

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ПОЖАРОУСТОЙЧИВОСТЬЬ НАСАЖДЕНИЙ ЮЖНО-ТАЕЖНЫХ ЛЕСОВ ЗАПАДНО-СИБИРСКОЙ РАВНИНЫ И СРЕДНЕ-СИБИРСКОГО ПЛОСКОГОРЬЯ

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FIRE RESISTANCE OF SOUTHEN TAIGA FOREST STANDS WEST SIBERIAN PLAIN AND CENTRAL SIBERIAN PLATEAN

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АННОТАЦИЯ

В работе основное внимание уделено оценке первичной, или ожидаемой, пожароустойчивости насаждений, в случае возникновения первого природного пожара средней интенсивности в данных условиях местопроизрастания.

Из всего многообразия повреждаемости древостоев при лесном пожаре выделен отпад деревьев. Выделено две группы факторов влияющих на послепожарный отпад - относительно постоянных (лесоводственых) и меняющихся, в зависимости от температуры воздуха, скорости ветра, влажности горючих материалов и др. Для оценки влияния различных факторов применен метод многофакторного анализа.

ABSTRACT

The paper focuses on the assessment of the primary, or expected, fire resistance of plantings, in the event of the first natural fire of medium intensity in these conditions of local growth.

From all the variety of damage to stands in a forest fire, the fall of trees is highlighted. There are two groups of factors that affect the post - fire fall-relatively constant (forestry) and changing, depending on the air temperature, wind speed, humidity of combustible materials, etc. To assess the impact of various factors, the method of multivariate analysis was used.

Ключевые слова: первичная пожароустойчивость, многофакторный анализ, ртпад древостоя, статистическая обработка, лесоводственные факторы, пирологические факторы, климатические условия.

Keywords: primary fire resistance, multivariate analysis, stand fall, statistical processing, forestry factors, pyrologic factors, climatic conditions.

Одной из важных задач лесной пирологии остается исследование первичной пожароустойчивости насаждений и ее оценка. Она необходима для расчета ущерба от пожара и планирования лесоводственных мероприятий, позволяющих увеличить повышение пожароустойчивости насаждений, например, воздействуя на их структуру.

Под термином «пожароустойчивость» мы предлагаем подразумевать степень потенциальной повреждаемости огнем различных компонентов биогеоценоза и ее лесоводственную значимость. В порядке уменьшения лесоводственной значимости компоненты биогеоценоза можно расположить следующим образом: древостой, подрост, живой и мертвый напочвенный покров, биологически активная часть почвы. Наиболее полное представление о первичной пожароустойчивости того или иного насаждения можно получить располагая комплексной оценкой повреждаемости всех перечисленных компонентов. Очевидно, что получить такую оценку в большинстве случаев весьма затруднительно. На практике целесообразно оценивать степень повреждаемости наиболее ценных компонентов конкретного биогеоценоза, с хозяйственной и экономической точек зрения. В исследуемых нами лесных биогеоценозах таковым компонентом является древостой.

Повреждаемость древостоев при пожарах весьма многообразна. Она включает в себя образование нагара и подсушин, увеличение фаутности, снижение продуктивности и прироста древостоя. Однако наиболее существенным признаком повреждаемости древостоев, по мнению многих исследователей [1;2;3], является послепожарный отпад деревьев по запасу или количеству. Исследованиями установлено, что фактический послепожарный отпад деревьев обусловлен множеством факторов, о чем свидетельствует значительное количество литературы, посвященной этому вопросу [4;5;6]) и многих другие. Эти факторы в различных насаждениях изменяются в широких интервалах, а их влияние на пожароустойчивость насаждений имеет комплексный характер. Установлено, что величина отпада определяется интенсивностью пожара и

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