RT&A, No 2 (85)
Volume 20, June 2025

ADJUSTMENT OF THE TECHNOLOGY OF CULTIVATION OF VEGETABLE CROPS (TOMATOES AND CUCUMBERS) IN ORDER TO OPTIMIZING THE QUALITY INDICATORS OF pH AND EC

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Abstract

The advantage of protected soil is the independence of the crop from the soil, which as a natural environment is heterogeneous. Soil salinity is one of the main environmental factors that limits plant growth and productivity. When absorbing ions from a nutrient solution, the reaction of the environment is of great importance. The values of the nutrient solution environment and concentration change depending on the stages of plant growth and genotypic characteristics. In recent years, protected ground vegetable growing in the world has transformed into a highly industrialized branch of agriculture. The use of modern equipment to create optimal microclimate and nutrition conditions in greenhouse complexes makes it possible to obtain a high yield of quality products. The main advantage of protected soil is the independence of the crop from the soil, which as a natural environment is heterogeneous. It has a tendency to degrade in monoculture systems and can be saline, sodium, sterile. Growing on artificial media (substrates), such as mineral wool, coconut chips, perlite and others is the most popular soilless growing system for the production of vegetable crops.

Keywords: *protected soil, environment, pH, electrical conductivity, ions, greenhouse complexes, solutions, mineral nutrition.*

I. Introduction

In recent years, protected ground vegetable growing in the world has transformed into a highly industrialized branch of agriculture. The use of modern equipment to create optimal microclimate and nutrition conditions in greenhouse complexes makes it possible to obtain a high yield of quality products.

The main advantage of protected soil is the independence of the crop from the soil, which as a natural environment is heterogeneous. It has a tendency to degrade in monoculture systems and can be saline, sodium, sterile. Growing on artificial media (substrates), such as mineral wool, coconut chips, perlite and others is the most popular soilless growing system for the production of vegetable crops.

Among the soil factors limiting plant growth and yield, the most important is soil salinity. Salinity can not only inhibit plant growth through ion toxicity, most commonly Na^+ and Cl^-, and osmotic stress, but can also reduce productivity by altering ionic ratios and, when combined with changes in pH, lead to nutrient imbalances (Kaynes and Shennan , 1999). After studying a range of responses , Grattan and Grieve (1999) concluded that in the presence of salinity, low nutrient ion activities and extreme Na + / K + , Ca2 + / Mg2 + , Cl- / NO3- ratios can cause reduced nutrient availability, altered nutrient partitioning, nutritional disturbances and reduced crop growth.

II. Methods

Obtaining high yields of quality products is possible taking into account knowledge of the biological characteristics of vegetable crops (tomato, cucumber) and the ability to meet the requirements of plants in different phases of growth and development. One of the important components of the technology of growing vegetable crops is the organization of effective mineral nutrition. When absorbing ions from a nutrient solution, the reaction of the environment is of great importance. In an unbalanced environment pH<4 or pH>8, the absorption of ions by plants is disrupted, as a result of which the growth of tomato seedlings is inhibited. A shift in the pH of the solution to the alkaline side also reduces the growth of tomato seedlings. This is explained by the fact that in a neutral environment pH=7, some of the mineral substances in the solution precipitate in the form of phosphates and carbonates of manganese salts Mn, calcium Ca , iron Fe , an inaccessible form for plants, which leads to difficulty in root respiration, etc.

When growing plants in protected soil, it is necessary to take into account the pH in the substrate and the pH of the solution, since together they can optimize the availability of nutrients, ultimately influencing plant growth and yield.

The absorption of nutrients by plants from the nutrient solution depends not only on the pH reaction of the environment, but also on EC (electrical conductivity) and are also the most important indicators for growing vegetable crops in modern greenhouse structures. The study of factors influencing these parameters is a pressing task.

The values of the nutrient solution medium and concentration vary depending on the stages of plant growth and genotypic characteristics. For example, the optimal pH range of the nutrient solution for growing the Merlis hybrid tomato F 1 in protected soil is 5.5-6.0 and the optimal range of EC is 1.8-3.2 mS /cm ^{2} . At a high salt concentration (electrical conductivity), plants absorb water more difficultly. An increase in EC especially affects plants with compound leaves, when the tip of the leaves begins to curl. At low concentration values, root rabies occurs.

High electrical conductivity in the mat can be the reason for calcium ions entering the plant. Increased salt concentration increases competition between large and low-mobility ions (calcium ions Ca^{2+} and magnesium ions Mg^{2+}) and small mobile ions (potassium ions K^+ and ammonium ions NH_4^+). Drying of the substrate also increases the EC value, which leads to blossom-end rot.

Three days before planting tomato plants, the mats are soaked with a nutrient solution with a pH of 5.5 and an EC of 1.8 mS /cm2 . When watering, the standard nutrient solution is pH 5.5-6.0 and EC 3.0-3.2 mS /cm2 . After installing the cassettes with mineral wool plugs, they are soaked with a solution with a pH of 5.5 and an EC of 1.8 mS /cm2 . For daily watering, a nutrient solution with a pH of 5.5-6.0 and an EC of 1.8 mS /cm2 is used . Two days before picking, the mineral wool cubes are soaked with a nutrient solution with a pH of 5.5 and an EC of 1.8-2.0 mS /cm2 . When growing cucumbers, the parameters of the pH and EC values are slightly different. The mineral wool cubes are soaked with a solution with a pH of 5.0 and an EC of 2.0 mS / cm2 . For the first watering, a solution of mineral fertilizers with pH=5.5 and EC 2.0 mS /cm2 is used .

III. Results

The analysis of human capital's role in economic development yielded several significant findings that underscore its impact on economic growth and productivity. A strong positive correlation was found between educational attainment and economic growth rates. Countries with higher levels of education, particularly in science, technology, engineering, and mathematics (STEM) fields, demonstrated increased labor productivity and innovation. Moreover, investment in early childhood education was shown to yield substantial long-term benefits, enhancing cognitive skills and creating a solid foundation for lifelong learning. Regions that prioritized early education experienced accelerated economic growth compared to those that did not.

Health also emerged as a crucial component of human capital, directly influencing workforce productivity. Healthier populations tend to have lower absenteeism rates, increased energy levels, and higher engagement in their work, all of which contribute to overall economic output. The research indicated that access to quality healthcare services was linked to improved worker performance. Countries that invested in their healthcare systems saw significant reductions in healthcare costs associated with lost productivity, leading to increased overall economic performance.

Innovation was identified as another key area influenced by human capital. The research indicated that a well-educated and healthy workforce is better positioned to drive innovation. Regions that fostered an environment conducive to research and development (R&D) and entrepreneurship reported higher rates of technological advancements and economic diversification. Investment in human capital not only enhanced the skills of the workforce but also encouraged collaboration between educational institutions and industries, resulting in innovative solutions to complex economic challenges.

Effective government policies aimed at enhancing human capital were identified as critical to achieving sustainable economic growth. Countries that implemented comprehensive education and health policies, including vocational training programs and public health initiatives, experienced higher GDP growth and improved social outcomes. The study highlighted successful case examples where targeted investments in human capital led to significant economic transformation, particularly in emerging economies. For instance, nations that prioritized skills training and lifelong learning initiatives reported reduced unemployment rates and improved economic resilience.

Despite these positive impacts, the study also identified several challenges that hinder the development of human capital, particularly in developing regions. Inadequate educational infrastructure, socio-economic disparities, and limited access to healthcare services were notable barriers. Cultural factors and systemic issues often prevented marginalized populations from fully benefiting from educational and economic opportunities, highlighting the need for inclusive policies that address these inequities.

Overall, the cumulative effect of human capital investments was evident in the economic growth of the analyzed regions. A clear trend emerged where investments in education and health correlated with enhanced GDP growth rates and improved quality of life indicators, such as life expectancy and income levels. These findings underscore the critical role of human capital as a driver of economic growth. By investing in education, health, and innovative capacities, countries can significantly enhance their economic performance and ensure a more sustainable and inclusive growth trajectory. Policymakers are urged to prioritize human capital development as a strategic imperative for achieving long-term economic objectives.

IV. Discussion

I. Subsection One

To prepare a nutrient solution of a given concentration for direct use or for long-term storage of the solution, as well as in the case when the acidity of the nutrient solution poured into the container changes significantly, it is necessary to adjust the pH value of the nutrient solution. For the preparation of a nutrient solution, the quality of water is of no small importance. Certain elements, most often boron, may exceed the MAC.

To adjust the pH of the nutrient solution, strong acids are used to lower the pH and alkalis to raise the pH. The most common options for acidifying the medium are the use of acids and salts:

- phosphoric acid, which is also absorbed as a nutrient
- sulfuric acid or hydrochloric acid contain elements that do not affect growth processes
- nitric acid provides plants with nitrate ions
- monopotassium phosphate provides the solution with potassium and phosphorus
- ammonium dihydrogen phosphate
- ammonium sulfate
- ammonium chloride
- potassium monophosphate

The use of weak organic acids such as citric or acetic acid is not fruitful, since organic acid ions are suitable food for some microorganisms.

Phosphoric and sulfuric acids are recommended for use during the flowering and fruiting period, nitric and sulfuric acids during the growing season before flowering.

The most relevant when increasing the pH is the use of alkali potassium hydroxide, but also the use of salts:

- potassium hydrogen phosphate (diammophos)
- potassium carbonate (potash)
- calcium and magnesium carbonate and others.

The use of acids and alkalis to maintain pH in the optimal range is not always safe. Modern greenhouse complexes use a method of maintaining pH in the optimal range by controlling the balance of nitrogen ions in the nutrient solution.

Nitrogen in solutions exists in the nitrate form NO_3^- and the ammonia form NH_4^+. The solution environment depends on the ratio of NO_3^- to NH_4^+. To lower the pH of the solution, the nitrate ion NO_3^- must be reduced and the dose of NH_4^{+} must be increased . When absorbing the anion NO_3^-, the roots release OH^- to maintain the balance of cations and anions in the root zone, which leads to an increase in pH. Accordingly, to increase the pH, the dose of NO_3^- is increased and NH_4^+ is decreased.

Nitrogen-containing fertilizers are very popular as fertilizers:

- ammonium nitrate (ammonium nitrate)
- ammophos (nitrogen-phosphorus fertilizer)
- UAS (urea ammonia mixture)
- nitroammophoska (nitrogen-phosphorus-potassium fertilizer NPK)
- sulfoammophos (sulfur-containing nitrogen-phosphorus fertilizer).

One of the problems in soilless systems is the accumulation of ions in the recirculated nutrient solution, particularly unabsorbed or poorly absorbed ions . This phenomenon occurs due to higher ion to irrigation water ratios than the corresponding ion to water uptake ratios, resulting in an unbalanced nutrient ratio and a higher EC .

At low concentration (EC), plants do not receive sufficient nutrition, which contributes to weak growth and fruiting. At high electrical conductivity, plants, especially young ones, are subject to various diseases, growth retardation, deformation of leaves and fruits, root and leaf burns, etc. Correction of EC indicators will provide plants with an optimal nutrition regime.

II. Subsection Two

The ideal pH value is relative, since chemical elements in the solution have different absorption strengths. Plants that require a certain acidity pH=5.5-6.0 and a concentration of 3.0-3.2 mS /cm2 under certain conditions above or below these values do not absorb individual elements or block each other. For example, at high ambient temperatures >30 ^{0} (genotypic characteristics) or when the temperature of the root zone increases to more than 27 ^{0}, magnesium Mg blocks calcium Ca . If individual elements are not absorbed , the concentration of the soil solution increases. In this case, foliar feeding, frequent watering, etc. are used. Foliar feeding eliminates the lack of nutrients and stimulates plant growth.

To measure pH and EC in modern greenhouse complexes, devices from the German manufacturer STEP are used. GmbH portable conductometer ECO EC and portable pH meter ECO pH. The devices are equipped with multifunctional displays. To determine the pH and EC values, a diluted mother solution of 1:100 is taken.

Recommended nutrient solutions for growing solutions on mineral wool substrates.

Solution for saturating cubes for sowing and watering seedlings. EC=1.8 pH=5.5

	$NH4_+$	K^+	$Ca2^+$	$Mg2^+$	NO_3^-	SO_4^{2-}	H2PO4-
mmol /l	1 , 25	6.75	5.3	3	16.75	2.5	1.25
	Fe	Mn	Zn	B	Cu	Mo	
μmol /l	15	10	5	25	0.75	0.5	

Solution for saturating mats. EC=1.8 pH=5.5

	$NH4_+$	K^+	Ca^2	$Mg2^+$	NO_3^-	SO_4^{2-}	H2PO4-
mmol /l	0.7 5	5.25	5.25	3	13.75	3.75	1.25
	Fe	Mn	Zn	B	Cu	Mo	
μmol /l	15	10	15	30	0.75	0.5	

Starter solution for flowering of the first brush. EC=3, 0 pH =5.5

	$NH4_+$	K^+	Ca^{2+}	$Mg2^+$	NO_3^-	SO_4^{2-}	H2PO4-
mmol /l	1.25	7.75	4.75	2.5	14.75	3.75	1.25
	Fe	Mn	Zn	B	Cu	Mo	
μmol /l	15	10	5	25	0.75	0.5	

Standard solution.

	$NH4_+$	K^+	Ca^{2+}	$Mg2^+$	NO_3^-	SO_4^{2-}	H2PO4-
mmol /l	1.25	8 ,75	4, 2 5	2	1 3 ,75	3.75	1.25
	Fe	Mn	Zn	B	Cu	Mo	
μmol /l	15	10	5	25	0.75	0.5	

Flowering 3-4, 5-9, 10-11 brushes . EC=3, 0 pH =5.5

	$NH4_+$	K^+	Ca^{2+}	$Mg2^+$	NO_3^-	SO_4^{2-}	H2PO4-
mmol /l	1.25	9.25	4.1 2 5	1,875	1 3 ,75	3.75	1.25
	Fe	Mn	Zn	B	Cu	Mo	
μmol /l	15	10	5	25	0.75	0.5	

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