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Solanum lycopersicum: Novelties for Climate Factors and Its Agronomic Management for High Yields

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Abstract

The intensive production of vegetables such as tomatoes depends on various strategies to achieve high yields. Purpose of this manuscript is to provide scientific and technological strategies for the intensive production of tomato or other vegetables in mega-production factories. However, with the advancement of knowledge, new improvements in the strategies will be incorporated. We have carried out research related to growth and yield variables in S. *Lycopersicum*. From this research we have worked on the intensive production of this noble vegetable at an industrial level. The results obtained are improvements in the production system. The improvements include the selection of the appropriate variety, germination and development of seedlings in a certified nursery. Trans-plantation in soil or hydroponics. The conditions of nutrient applications from the irrigation head system. The ventilation system and monitoring of climatic factors both day and night (temperature and relative humidity). Monitoring of macro- and micronutrients in the plant system, including Ca, K, Fe, and Zn. Soil fertility analyzes should include: primary and secondary macronutrients (ppm), organic matter (OM), EC, pH, bulk density (BD), and cation exchange capacity (CEC). The nutritional diagnosis to confirm ranges of sufficiency. As a tool in plant nutrition programs, foliar application can include biostimulants and growth regulators. The foregoing can be considered strategies for the integral management of the tomato crop.

Keywords

Integrated Management, Climate Factors, Plant Nutrition, Growth Regulators

1. Introduction

Plants, being sessile organisms, cannot move or change position in favorable growing conditions. Therefore, it is necessary to know the production system well, like any crop. However, in this manuscript we will talk about climate factors that influence tomato physiology (CO_2, temperature, relative humidity, and transpiration) and comprehensive agronomic management to obtain high yields. Also, aspects of plant nutrition through fertigation will be addressed.

1.1. Temperature

The interaction of light and temperature affect the growth of the fruit in susceptible cultivars. Also, the inadequate development of the xylem in the fruit and the growing competition between the leaf and fruit for the available Ca^{2+} [1]. High or low temperatures of the optimum, the water content in the soil and the luminosity affect the transpiration of the plant. As a consequence, the absorption of Ca^{2+} is reduced and nutritional imbalances occur [2] [3] [4]. Suboptimal temperatures produce thicker leaves, this leads to a lower light interception and a lower relative growth rate [5]. With high temperatures (35˚C/23˚C, day/night) there is no fruit development in heat-sensitive tomato genotypes [6]. If the temperature exceeds the normal growth range of the plants (15˚C to 45˚C), a heat injury will occur that will damage the enzymes responsible for photosynthesis [7].

1.2. Relative Humidity

A study conducted by [8] observed that a low HR (40%) promotes an increase in Ca^{2+} levels. The intensity of light received directly affects the photoassimilates of the fruit, also influences the transpiration, uptake of water. And this, in turn, affects the EC of the root zone [9]. High salinity is related to the osmotic potential (OP) of the nutrient solution. The more negative the OP, the roots of the plants are difficult to uptake water and nutrients [10]. In addition, by the intermediate mobility of Ca^{2+} in soils with respect to other nutrients [11]. The high humidity during the day appears to promote Ca^{2+} movement into the young fruit. However, it seems that Ca^{2+} content accumulated by the leaves always decreased at high humidity, this response being greater at night than during the day [12].

For our understanding in this manuscript we will propose strategies to address and solve problems with the intensive production of *S. lycopersicum*, in general the following stand out:

1) Nutrient solution in fertigation;

2) Climate factors that influence tomato physiology;

3) Comprehensive management to obtain high yields.

2. Nutrient Solution in Fertigation

High yield and product quality of crops are only possible if nutrition is optimized, this includes nutrient solution composition, water supply, nutrient solution temperature, dissolved oxygen concentration, electrical conductivity and pH of the nutrient solution [13]. Oxygen content in nutrient solutions effects on the yield of sweet pepper and melon by about 20% and 15% [14]. pH and EC monitoring helps to eliminate the problem associated with fertilization, indicating the nutrient availability to the crops [15]. There must be a mutual relationship between the anions and cations of the nutrient solution [16]. The nutrient interactions are generally measured in growth response and change in the concentration of nutrients [17]. Root growth is essential for effective exploration of soil and for interception of nutrients [18]. When the roots absorb excessive cation compared to anions, the roots offset this by excreting protons (H^+), which generally leads to rhizosphere acidification. The roots excrete hydroxyl (OH^-) when they absorb more anions than cations. Hydroxyl reacts with carbon dioxide to form bicarbonate (HCO_3^-), which leads to rhizosphere alkalization [19].

3. Climate Factors that Influence Tomato Physiology

Plants absorb water and nutrients from the root system and they are transported by two conductive vessels: the xylem and phloem. However for these components to rise to the apex, flowers, lateral parts, or fruits, they will be influenced by CO_2, temperature, relative humidity, and transpiration (**Figure 1**). The medium where the roots develop, such as soil, substrates, or some other support medium. These are highly dependent on water or nutrients from the soil solution. As the temperature increases, the relative humidity decreases, which leads to great transpiration (**Figure 1**). Although, these factors can cause physiological problems in the fruits, flowers, and the entire plant system. All this is despite an irrigation or fertigation system in the root zone. These physiological problems can cause smaller stem diameter, small plants, and little foliage, translating into low-quality fruits, low pollination, and low fruit set [20].

These physiological problems must be very well understood and solved by experts at the commercial level [21]. Even these inconveniences can occur when the fruits are in an advanced stage of development. This phenomenon can considerably affect macronutrients such as N, Ca, and K and micronutrients such as Fe and Zinc. For example, although Ca is the "cement of the cell wall", its imbalance can cause poor quality fruit. Potassium imbalance can cause discoloration in the fruits ready to harvest, so the quality and low price in the market can be affected. Although Fe and Zinc can be applied as chelates from the irrigation head, with this physiological phenomenon, deficiencies may even occur due to these and other micronutrients, mainly in the apices. These can occur during fruit development or even during the first harvest.

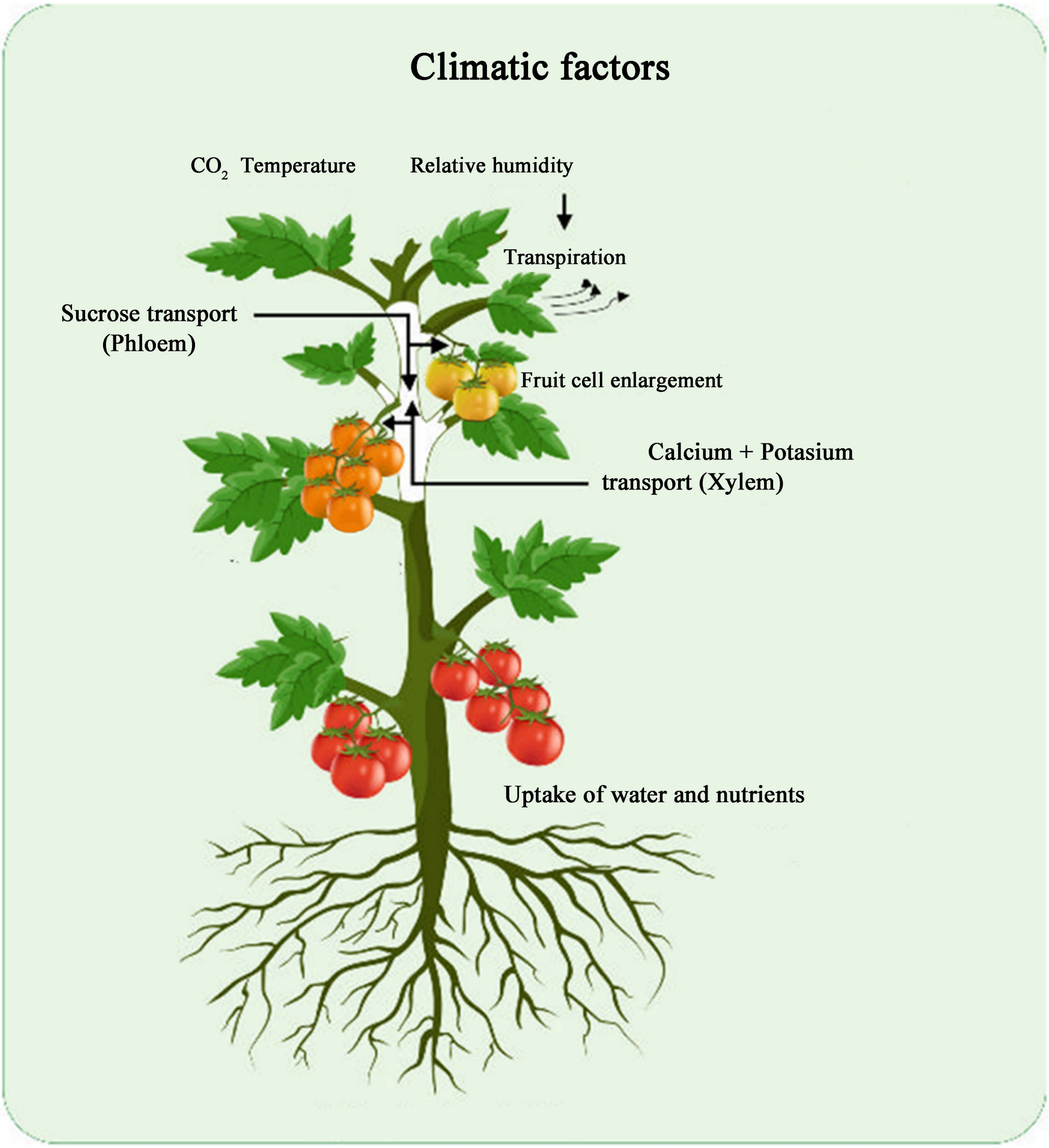

Figure 1. Tomato plants with fruits in different stages of development. Water and nutrients are transported from the root to distant parts such as leaves, flowers and fruits. The phloem vessels transport sugars and the xylem transports macronutrients such as Ca and K. These in turn are governed by climate factors such as temperature, relative humidity, and transpiration.

4. Comprehensive Management to Obtain High Yields

A tomato plant starts from its selection in the nursery, even before, because it is during the selection of seed (variety). However, tomato producers also have their favorite varieties, either because they are resistant to certain diseases, or because the fruits are firmer. However, all varieties are resistant to some diseases, or have some qualities that differ from others [22]. As previously mentioned, tomato production can be carried out in soil and hydroponics. Projections for tomato production on some soils differ significantly. Before transplanting the seedlings into intensive crops, a good physical-chemical analysis of the soil and water should be carried out. To help the availability of primary and secondary macronutrients (ppm), organic matter (OM), EC, pH, bulk density (BD), and cation exchange capacity (CEC). The water analysis will show the pH, EC, the presence of bicarbonates ($meq·L^{-1}$) and take actions for its displacement with acids (HNO_3, H_2SO_4, and H_3PO_4), to lower the pH, provide nitrogen, phosphorus, and remove salt from the irrigation system. With the soil analysis, amendments will be applied ($t·ha^{-1}$), application of OM (compost and vermicompost), agricultural plaster and agricultural lime. During the stages of plant growth, there will also always be different phases of fruit development. In the basal part, the ripe fruits will be found, in the middle part, intermediate color, and in the apices immature fruits with abundant flowers (**Figure 2**).

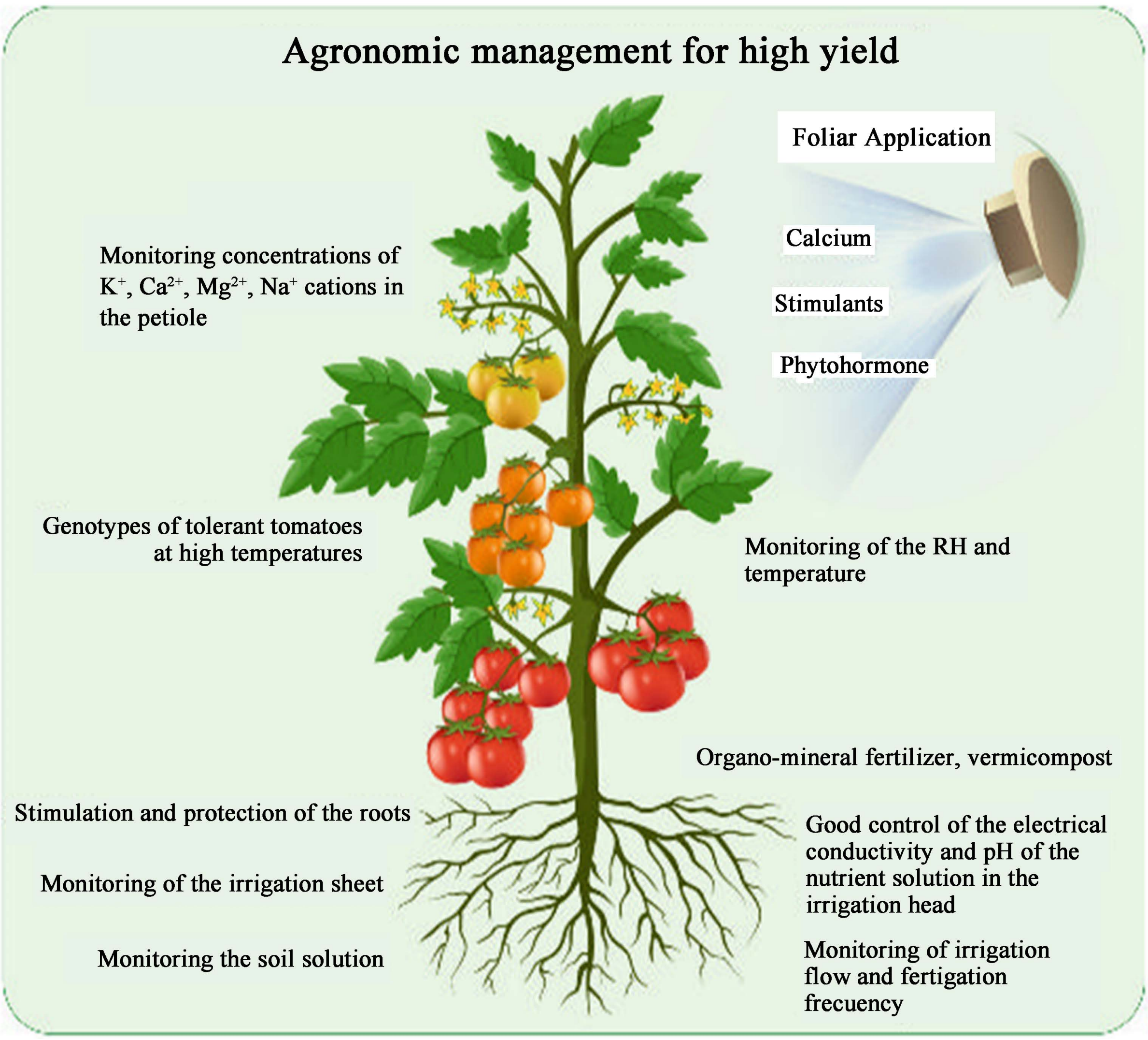

Figure 2. Agronomic and comprehensive management of tomato cultivation.

Just as the nutrient solution is monitored and programmed from the irrigation headit is also necessary to monitor the nutrients (cations) in the petioles of the plants. The most significant demand for nutrients in tomatoes must be considered develop organs such as leaves, flowers, and fruits. The leaves should be used for nutritional diagnosis to confirm deficiency symptoms or optimal nutritional ranges, which is of major importance for agronomists, growers, horticulturists, and physiologists [23]. Readings from a quick in-field sap NO_3-N meter were highly correlated with NO_3-N indications using a laboratory method for potatoes [23]. For many years, fresh plant sap nutrient concentration has been used to indicate plant nutrient status [24]. On field usually involves the analysis of NO_3-N and K content of petiole sap. The ion-specific electrode is the most commonly used approach [25].

Foliar application is another tool to support intensive tomato production. Physiological problems caused by Ca and K deficiency can be corrected immediately. The deficiencies of Fe and Zinc in the apices. Also, to fill the fruits present in the clusters, some practices in high population densities will be necessary to apply growth regulators. The use of biostimulants helps counteract biotic and abiotic stress factors in plants, helps translocation and use of nutrients. Among biostimulants can be found algae extracts, hydrolyzed proteins, humic acids, phosphites, and growth regulators [21]. Although, for the foliar application, it will be necessary to know the time of application, adjust the pH of the mixture, know the concentrations well, if it is a toxic or organic product. Know the possible synergistic or antagonistic effects between products to be prepared, among other details.

5. Conclusion

Climate factors directly influence the physiology of the plant; as the temperature increases, the relative humidity decreases, causing an increase in transpiration, which. Can cause physiological problems in the fruits or induce nutritional imbalances. Other variables to consider during tomato crop production are the availability of primary and secondary macronutrients (ppm), organic matter (OM), EC, pH, BD, and CEC. A tool that can be included in plant nutrition programs is the foliar application of biostimulants and/or growth regulators, which can be considered as strategies for the integral management of tomato crops.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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