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SURVEY OF THE INFLUENCE OF FERTILIZATION AND IRRIGATION IN THE TOMATOES, GREENHOUSE PRODUCTION

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Abstract

The optimization of the water and fertilization regime in vegetable crops solves a number of problems related to increasing the efficiency of usable irrigation water, the water deficit and a number of environmental problems. The purpose of this paper is to model the mathematical relationship between productivity and quality of yield in tomatoes, greenhouse production and the factors that have the strongest influence on its formation - irrigation and fertilization regimes. Investigated the interaction of different levels of the humidity created by the application of controlled constant water deficit (factor A - irrigation) at three levels of fertilization (factor B - fertilization) on the productivity and quality of tomatoes, greenhouse production. As a result of cluster analysis are distinguished and separated into groups according to similarities variants with optimum irrigation rate and 75% manure, and variants with 100% rate of fertilization and reduced irrigation regime. Based on the deduced Linear Regression models it was found that the overall yield is dependent on the output of the first quality. The coefficient of determination varies in a narrow range (R^2=0.925-0.989).

***Key words**: correlation, drip irrigation, fertilization, tomatoes, yield.*

INTRODUCTION

The ecological and intensive production of high-quality greenhouse crop products requires precision of fertilization regimes. The environmental risk factors fertilization is part of the problem with the intensification of greenhouse production of tomatoes. The application of large amounts of fertilizers leads from one side to the imbalance in the broth and the other to the contamination of soil and water. The main purpose of greenhouse production is to achieve better development of culture through the cultivation of plants in balance.

The optimization of the water and fertilization regime in vegetable crops solves a number of problems related to increasing the efficiency of usable irrigation water, the water deficit and a number of environmental problems. Water deficiency is an important problem in many countries. That's why in recent years it has been massively soaked with drip irrigation systems. This water-saving and high technology meets modern requirements for the development of ecological agriculture is available and requires little investment.

A team of scientists (Jensen et al., 2010) identifies how plants respond to optimum moisture supply and water deficit in different phases under different soil and climatic conditions (Denmark, Greece, Italy, China, Serbia). The researches have shown that gradual drying of the soil, resulting in a shortage of water for irrigation are observed hydraulic and chemical changes in the root system, increase in photosynthesis and efficiency of the use of water as well as a slight decrease in the vegetative growth of plants. Established degree of influence of water supply freezing (through controlled water deficit) on morphological parameters, the amount of biomass, the dynamics of evapotranspiration, quality and quantity of the yields (Weixia et al. 2009; Favati et al. 2009; Ozbahce et al. 2010; Patanè et al. 2011; Max et al. 2009).

The yield of tomatoes and productivity of the irrigation water is improved with the application of nitrogen fertilizer considered Li et al. (2017). Water is the main limiting factor productivity of crops in arid and semi-arid areas (Badr et al. 2016). Exploring methods of planting, fertilization rates and different irrigation regimes authors establish The results of this study suggest that dense twin planting can be viable and rational practice to increase crop yield and saving substantial amount of irrigation water as well as cost of drip laterals. According Çetin et al. (2008) the maximum irrigation water use efficiency (22.3 kg m3) was obtained from 2-m lateral spacing and the percentage of canopy cover for calculation of the amount of irrigation water applied. Thus, the canopy cover can be used successfully in any lateral design conditions. Jensen et al. ((2010) based on field studies develop water-saving strategies for irrigation in some vegetable crops. Regarding the magnitude of yields results of Zhang et al (2017) show that irrigation 80% ETC has been achieved the highest yield of tomatoes. The authors recommend that in the preparation of an optimal strategy for irrigation to apply irrigation at 80% ETc.

Linear regressions between the parameters of the quality and value of evapotranspiration derived from a number of researchers (Chen et al. 2013; Yang et al. 2017) define the scientific basis for saving irrigation water. Test results show the steps in which the fruits are sensitive to the shortage of water during the development of the flowering and development of the fruit (2nd stage) and ripening of fruit (3rd stage). The yields decrease with deficits in 2 or 3 stage, while the quality is affected by the deficit in Step 3.The rate of adoption of efficient irrigation practices, according to Adams et al. (2019), influences the return on investment from those practices and affects how much, and even whether, aquifer conservation occurs. The impact of the food and the irrigation system being studied and in terms of their impact on the qualitative composition of tomatoes. They have established relationships between irrigation regimes, nutrient and dry matter content, of soluble sugars, vitamin C and organic acids (DU et al. 2017; Lahoza et al. 2016).

The purpose of this paper is to model the mathematical relationship between productivity and quality of yield in tomatoes, greenhouse production and the factors that have the strongest influence on its formation - irrigation and fertilization regimes.

MATERIAL AND METHOD

Agrotechnics experience: Experience was conducted during the period 2016-2018, at the experimental field of Institute of Vegetable Crops „Maritza“, Plovdiv, Bulgaria. The region has the planar nature of elevation height of 160 m, and geographic coordinates 42 ° and 09' north latitude and 24 ° and 45' east longitude GMT (GPS). Inferred's experience with hybrid greenhouse tomatoes variety Vitellio F1. Plants are grown in unheated greenhouses.

The soil type is alluvial meadow soil, with less pronounced humus layer (average 0.25 m). Humus content in the surface layer is in the range of 1.5 to 2.0%. The soil is characterized by PWF of about 14-16% and good aeration. Total porosity varies in the range of 30-42%. Characterized by high water permeability, but its water-retaining capacity is small.

Characterized by the following content of nutrients in the test zone 0-0.30 m.

Table 1. Chemical composition of the soil

Depth of the soil layer	N-NH4	N-NO3	Total Mineral Nitrogen	P2O5	K2O	CaO	Fe	MgO
cm	mg/kg	mg/kg	mg/kg	mg/100g	mg/100g	mg/100g	mg/kg	mg/100g
0-30	16.74	100.45	117.19	6.67	20.09	48.5	1964.03	9.71

Scheme of the experiment: The test is set by the block method on a flat surface at planting scheme 110 + 50 + 35 cm, with the size of the plots 10 m^2 (Barov, 1982).

Studied the interaction of different levels of the humidity created by the application of controlled constant water deficit (factor A - irrigation) at three levels of fertilization (factor B - fertilization) on the productivity and quality of tomatoes, greenhouse production.

The experimental variants are: 1. Broken irrigation regime (50% of the irrigation norm) without fertilization; 2. Broken irrigation regime (75% of the irrigation norm) without fertilization; 3. Optimal irrigation regime (M-100%) without fertilization (control); 4. Broken irrigation regime (50% of irrigation rate) 50% fertilization; 5. Irrigated/Broken irrigation regime (75% of irrigation norm) 50% fertilization; 6. Optimal irrigation regime (M-100%) with 50% fertilization; 7. Irrigated irrigation regime (50% of the irrigation norm) and 75% fertilization; 8. Irrigated irrigation regime (75% of irrigation norm) and 75% fertilization; 9. Optimal irrigation regime M-100%) with 75% fertilization; 10. Irrigated irrigation regime (50% of irrigation norm rate) and 100% fertilization; 11. Irrigated irrigation regime (75% of irrigation norm) and 100% fertilization; and 12. Optimal irrigation regime (M-100%) and 100% fertilization.

Factor A - Irrigation: Irrigation of plants is carried out with a drip irrigation system. Drip irrigation pipes with built-in drippers are used to implement the irrigation. The floating wings have built in 0.1 m drippers, with a flow rate of 1.110 l/h. Maintained in front of irrigation humidity 75% to 80% FC as irrigation rate is calculated for active soil layer 0-30 cm.

Factor B - fertilization: experimental experience includes basic fertilization in three levels fertilizer rate (50, 75 and 100%) of the plants effected with P_{23} (as P_2O_5), K_{25} and $S_{9.2}$ (in the form of K_2SO_4) at 100% of fertilizer norm. The reduction of fertilizer rates in basic fertilization is as follows: 50% - $P_{11.5}$, $K_{12.5}$, $S_{4.6}$ and 75% - $P_{17.25}$, $K_{18.75}$, $S_{6.9}$. During the vegetation is carried out feeding at three levels of fertilization with nitrogen (in the form of NH_4NO_3), and potassium (as KNO_3) on the background of basic fertilization. When realizing a 100% rate fertilizer to nourish are embedded respectively N_{50} and K_{23}. As a result of the reduced rates of feeding of tomatoes are imported N_{25}, K_{11} and $N_{37.5}$, $K_{17.25}$ respectively at 50 and 75% fertilization rates.

Indicators: Phenological observations: flowering - and start mass; link - start and mass (fruit 5-7 mm large); redness of fruits - home and mass; harvest - first and last; duration of the growing season.

Biometric measurements - height, number of leaves, number of bunches, number of fruit, size of the fruit and the like.

Assessment of the tested irrigation regimes and levels of fertilization is made on the basis of the following biometric parameters: plant height (cm), number of leaves, number of inflorescences per plant, number of fruit set and grain yield.

The grouping of the 12 tested variants of irrigation scheduling is done through hierarchical cluster analysis. The method of intergroup binding was used (Ward, 1963; Dyuran et al. 1977). As a measure of similarity, Euclidean distance intergroup was used:

$$D(x, y) = \sqrt{\sum_{i=1}^{n}(x_i - y_i)^2}$$

A dendrogram was constructed to graphically represent the formed clusters. The dotted horizontal line of the dendrogram shows the distance at which the clusters are formed.

Data processing was performed with the SPSS statistical program.

RESULTS AND DISCUSSION

In the conditions of greenhouse production, tomato cultivation is impossible in irrigated conditions. Therefore, methodical plan was set for irrigation with optimal irrigation regime and irrigation with reduced watering rules that ensure availability of easily accessible water source for plants.

In the first experimental year were submitted 33 irrigations size of the irrigation rate 495 m^3/da at optimum irrigation. The amount of irrigation norm during the second year was 405 m^3/da, implemented by 27 irrigations. During the third year were held 29 irrigations size of the irrigation rate 435 m^3/da. Reduction of irrigation norms options is applied according methodical plan.

The analysis made by cluster analysis indicates that the appended levels of fertilization and different irrigation regimes results in study options of tomato, grouped into two main clusters. The results are shown by the steps of combining the cluster and inter-group distances dendrogram (Fig. 1).

The first cluster with very similar results includes options 9, 10, 11, which at a later stage together with 7 and 8. They are more uniform in overall yield, height, and number of fruit set. The similarity between the option with optimum irrigation rate and 75% fertilization, and options with 100% rate of fertilization and reduced irrigation regime shows how the

factors irrigation and fertilization interact and optimize the conditions for development of the plants.
Similar are options with reduced 75% rate of fertilization and 50% and 75% irrigation rate.

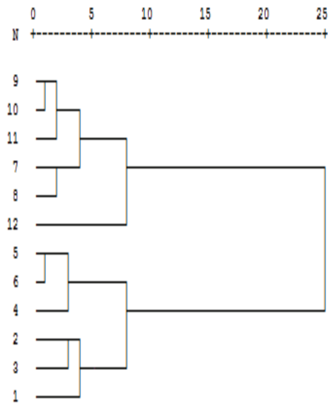


Fig. 1. Dendrogram based on the average intergroup Euclidean distances

There is the greatest similarity in all tested parameters and at least Euclidean distance between them. The results indicate that the reduced plant nutrition and controlled water deficit may provide for normal growth and development. The data confirm that reducing irrigation norms or fertilization regime can ensure optimum development and productivity of culture. The positive influence of the feed through the vegetation with potassium fertilizers has been found by Vasileva et al. (2016).
In the second cluster we observe two sub-clusters, the first one includes options 5, 6 and 4 and the second sub-cluster - 2, 3 and 1. They show similarity to the variants in which we have an irrigation regime and 50% fertilization. The options are similar in the surveyed indicators - yield, number of leaves and number of inflorescences. In this case, the grouping of similarity is determined by the reduced fertilizer rate.
The role of fertilization regime amid realized irrigation norm is decisive and this is due to the relative values of the Euclidean distance.
Built linear regression model for data mining of first quality and total yield.

The correlation coefficient squared - R^2 (R Square) is called the coefficient of determination. It shows what percentage of the variance of the resulting variables can be explained by the action of factors variable. For our case we get a high coefficient of determination for each viewed year, respectively R^2=0.989, i.e 98.9% of total yield is dependent on the output of the first quality (2016), R^2=0.925, (2017), and R^2=0.989 for 2018. (Figure 2).

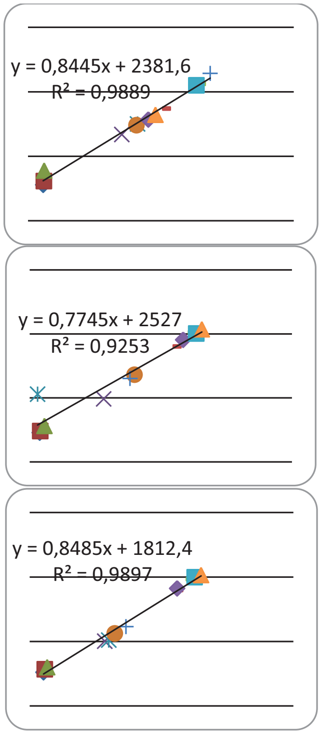
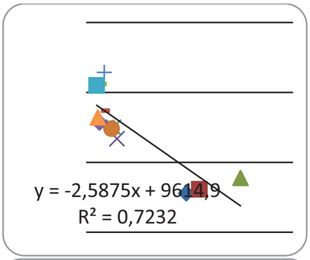
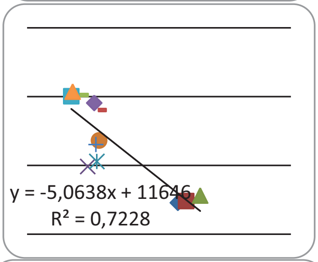


Fig.2. Linear regression model between the yield of first quality and total yield in 2016 - 2018

Linear regression models that express the influence of the indicator compared to the total yield per unit area, enabling theoretically to determine how and in what direction the change in these indicators contributes to improved yield.
According to an a linear regression model of the yield of the second quality and total yield, we get again adequate mathematical models (Fig. 3).





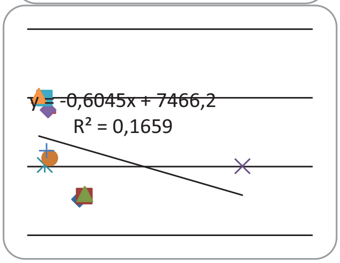


Fig. 3. Linear regression model between extraction of the second quality and total yield in 2016 - 2018

From the obtained linear equations, the coefficient of determination for each examined year is respectively R^2 = 0.72, i.e. 72.3% of the total yield depends on second quality output (2016), R^2=0.92, (2017) and R^2=0.166 for 2018.

CONCLUSIONS

As a result of cluster analysis are distinguished and separated into groups according to similarities variants with optimum irrigation rate and 75% manure, and variants with 100% rate of fertilization and reduced irrigation regime.

Designated promising options are 7 and 11, which are characterized by high values for key indicators.

Based on the deduced Linear Regression models it was found that the overall yield is dependent on the output of the first quality. The coefficient of determination varies in a narrow range (R^2=0.925-0.989).

The resulting mathematical model of the plant is characterized by high productive capacity.

REFERENCES

Adams, K., Kovacs, K. (2019). The adoption rate of efficient irrigation practices and the consequences for aquifer depletion and further adoption. *Journal of Hydrology* 571, 244-253. DOI: 10.1016/j.jhydrol.2019.01.040.

Badr, M.A., Abou-Hussein, S.D., El-Tohamy, W.A. (2016). Tomato yield, nitrogen uptake and water use efficiency as affected by planting geometry and level of nitrogen in an arid region. *Agricultural Water Management*. Volume 169, 90-97.

Barov, V. (1982). *Analiz i shemi na polskia opit.* NAPS, Sofia.

Chen, J., Kang, S., Du, T., Qiu, R., Guo, P., Chen, R. (2013). Quantitative response of greenhouse tomato yield and quality to water deficit at different growth stages. *Agricultural Water Management*. Volume 129, 152-162.

Çetin, Ö., & Uygan, D. (2008). The effect of drip line spacing, irrigation regimes and planting geometries of tomato on yield, irrigation water use efficiency and net return. *Agricultural Water Management*. Volume 95 (8), 949-958.

Dyuran, B., Odelly, P. (1977*). Klasterniy analiz.* M., Statistika.

Du, Y., Cao, H., Liu, S., Gu, X., Cao, Y. (2017). Response of yield, quality, water and nitrogen use efficiency of tomato to different levels of water and nitrogen under drip irrigation in Northwestern China. *Journal of Integrative Agriculture*. Volume 16 (5), 1153-1161.

Favati, F., Lovelli, S., Galgano, F., Miccolis, V., Tommaso, T.D., Candido, V. (2009). Processing tomato quality as affected by irrigation scheduling. *Scientia Horticulturae*. Volume 122 (4), 562-571.

Jensen, C. R., Battilani. A., Plauborg, F., Psarras, G., Chartzoulakis, K., Janowiak, F., Stikic, R., Jovanovic, Z.,.Li, G., Qi, X., Liu, F., Jacobsen, S.E., Andersen, M. N. (2010). Deficit irrigation based on drought tolerance and root signalling in potatoes and tomatoes. *Agricultural Water Management*. Volume 98 (3) 403-413.

Lahoza, I., Castro, A.P., Valcárcel, M., Macua, J.I., Beltrán, J., Roselló, S., Cornejo. J.C. (2016). Effect of water deficit on the agronomical performance and quality of processing tomato. *Scientia Horticulturae.* Volume 200, 55-65.

Li, Y., Sun, Y., Liao, S., Zou, G., Zhao, T., Chen, Y., Yang, J., Zhang, L. (2017). Effects of two slow-release nitrogen fertilizers and irrigation on yield, quality, and water-fertilizer productivity of greenhouse tomato. *Agricultural Water Management.* Volume 186, 139-146.

Max J.F.J., Horst, W. J. Mutwiwa, U. N, Tantau, H.J. (2009). Effects of greenhouse cooling method on growth, fruit yield and quality of tomato (Solanum lycopersicum L.) in a tropical climate. *Scientia Horticulturae* Volume 122 (2), 179–186.

Ozbahce, A., Tari, A. F. (2010). Effects of different emitter space and water stress on yield and quality of processing tomato under semi-arid climate conditions. *Agricultural Water Management*. Volume 97 (9), 1405-1410.

Patanè, C., Tringali, S., Sortino, O. (2011). Effects of deficit irrigation on biomass, yield, water productivity and fruit quality of processing tomato under semi-arid Mediterranean climate conditions. *Scientia Horticulturae*. Volume 129 (4), 590-596.

Vasileva, V., Dinev, N., Mitova, I. (2016). *Effect of different potassium fertilization treatments on some biochemical parameters, related to tomato fruit quality.* ttp://hst.bg/bulgarian/conference.htm

Ward, J. H. (1963). Hierarchical grouping to optimize an objective function. *Journal of the American Statistical Association*. 58, 236-244.

Weixia Z., Huanjie, C., Zhijie, S., Xinming, C., Jian, W. (2009). *High yield indicators of greenhouse tomato under non-pressure irrigation[J*]; Transactions of the Chinese Society of Agricultural Engineering, 03.

Yang, H., Du, T., Qiu, R., Chen, J., Wang, F., Li, Y., Wang, Gao, C.L., Kang, S. (2017). Improved water use efficiency and fruit quality of greenhouse crops under regulated deficit irrigation in northwest China. *Agricultural Water Management. Volume* 179, 193-204.

Zhang, H., Xiong, Y., Huang, G., Xu, X., Huang, Q. (2017). Effects of water stress on processing tomatoes yield, quality and water use efficiency with plastic mulched drip irrigation in sandy soil of the Hetao Irrigation District. *Agricultural Water Management.* Volume 179, 205-214.