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The Effect of the Depth of Soil Moisture on the Growth and Development of Cherry Seedlings

O.A. Nikolskaya[1], E.V. Seminchenko[1]

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ABSTRACT

Background: For the first time in the conditions of the Volgograd region, new knowledge was obtained, which made it possible, taking into account the changes in the morphology of the root system occurring during the formation of seedlings, the orientation of physiological processes and the biological needs of plants for their optimization, to justify a differentiated water-saving drip irrigation regime in combination with fertilizing vegetating plants, providing high-quality annual sweet cherry seedlings with high economic and water-saving efficiency, environmental tolerance.

Methods: The experimental part of the work was carried out in the laboratory of breeding, seed production and nursery breeding 2017-2021 years. The productivity of the variety-rootstock combination was calculated relative to biometric parameters: crown projection area (S), crown volume (V), stem cross-sectional area (S).

Result: In the course of the work, methods of watering stone crops, in particular cherries and their effect on survival, growth and development of seedlings in the nursery were studied. The scheme of experiments provides for an assessment of the influence of the water regime of the soil on the formation of the height of the central stem, the root system and the yield of seedlings of class 1 according to the variants of the experiment. Their values were greater than in the control, respectively, by 21 and 17 cm, 24-32%. At the same time, the yield of first-class seedlings in the third variant exceeds the second variant by 6%. According to the results of the conducted studies, the option of maintaining soil moisture at least 80% of the lowest moisture capacity during the adaptation period of the graft with a rootstock in a layer of 0.2 meters, followed by an increase in the soaking depth to 0.4 meters, proved to be the best. In the phase of the transition of seedlings to the dormant period, the pre-watering soil moisture should be maintained at least 70%.

Key words: Cherry, Fertilizers, Irrigation, Landscaping, Nursery, Seedlings.

INTRODUCTION

Gardening in our country for the production of fruits and berries does not yet saturate the market with a sufficient number of products (Alekseev *et al.*, 2020; Dubenok *et al.*, 2021). This is explained, first of all, by insufficient area, as well as low productivity of garden plantings. The shortage of fruit production, even taking into account the expansion of the area of gardens by the agrofirm “Gardens of the Don area”, is also characteristic of the Volgograd region. The market is especially poor with early ripening, vitamin-rich, attractive locally produced sweet cherry fruits (Solonkin *et al.*, 2022).

Sweet cherry is grown in more than 40 countries. The main suppliers of sweet cherry to the world market are Germany, Italy, France and the USA. In the Russian Federation, the industrial production of sweet cherry is concentrated in the most heat-supplied North Caucasus and Southern Federal Districts. Thanks to the work of breeders, the sweet cherry culture has advanced to Voronezh, Belgorod, Moscow and a number of other regions (Gudkovsky *et al.*, 2016). The expansion and renewal of sweet cherry plantations causes an increasing need for high-quality seedlings obtained in nurseries of their use zone. Such seedlings are characterized by high survival rate, growth, durability and yield of the planted gardens (Solonkin *et al.*, 2019).

The Volgograd region is characterized as one of the most arid regions in the Russian Federation. The lack of soil moisture during the growing season of seedlings negatively affects the formation of vegetative and root mass. Therefore, it is almost impossible to obtain high-quality, annual sweet cherry seedlings in such conditions without irrigation. At the same time, growing seedlings must be provided not only with a sufficient amount of moisture, but on weakly humus soils and elements of mineral nutrition (Dupleks *et al.*, 2020; Kuznetsova, 2020; Kruzhilin and Nikolskaya, 2021; Romanovskaya abd Shumakova, 2021).

[1]Federal State Budgetary Scientific Institution “Federal Scientific Center of Agroecology, Integrated Land Reclamation and Protective Afforestation of the Russian Academy of Sciences” (FRC of Agroecology of the RAS), University Avenue, 97, 400062, Volgograd, Russia.

Corresponding Author: E.V., Seminchenko, Federal State Budgetary Scientific Institution “Federal Scientific Center of Agroecology, Integrated Land Reclamation and Protective Afforestation of the Russian Academy of Sciences” (FRC of Agroecology of the RAS), University Avenue, 97, 400062, Volgograd, Russia. Email: eseminchenko@mail.ru

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Drip irrigation is one of the most water-saving irrigation methods, well compatible with the application of fertilizer with irrigation water. The combination of drip irrigation with feeding directly into the root zone with the introduction of fertilizers does not prevent mechanized processing of soil and planting material, carrying out other agrotechnological techniques aimed at reducing labor costs, increasing labor productivity and economic efficiency of nursery farming and, consequently, gardening (Zhuravleva, 2018; Egorov *et al.*, 2020).

Taking into account the above, our research was subordinated to the justification of the optimal introductory soil regime and the drip irrigation regulations that ensure it, which, in combination with mineral fertilizing of vegetative plants with growth-stimulating fertilizers, produce competitive annual sweet cherry seedlings with a high economic effect.

MATERIALS AND METHODS

The experimental part of the work was carried out in the laboratory of breeding, seed production and nursery breeding of the Federal State Budgetary Scientific Research Center of Agroecology of the Russian Academy of Sciences in the Volgograd region. The soil cover of the experimental site is represented by slightly alkaline light chestnut soil in combination with salt pans. years of research 2017-2021.

The object of the research were seedlings of sweet cherries of the Vasilisa variety, grafted on the rootstock of the Magalebskaya cherry (Antipka) (Eremin, 2017). The scheme of experiments in order to activate the influence of the studied techniques on the formation of seedlings was based on taking into account the characteristics of three plant life cycles (Table 1).

Taking into account what is happening during the life cycle of seedlings , the scheme of two- factor experience included the following options: Factor A - the water regime of the soil - is represented by options: A_1-maintenance by irrigation of soil moisture in a layer of 0.4 m during the growing season not lower than 80% LWC (lower water capacity) (control); A_2-maintenance by irrigation of soil moisture not lower than 80% LWC in the first period in a layer of 0.2 m, followed by deepening of the layer to 0.4 m; A_3 - maintenance of soil moisture until the end of the second period according to the scheme of the variant A_2 with followed by a decrease in pre-watering humidity to 70% LWC.

The irrigation norm with a pre-irrigation humidity of 80% LWC for a layer of 0.2 m was determined to be 50, 0.4 m - 100 and at 70% LWC in a layer of 0.4 m - 160 m^3/ha.

As a mineral nutrition, top dressing was used in the first period of vegetation N10P5 kg d.v./ha, in the second period with a chelated fertilizer form “Master”.

Observations, records and measurements were carried out according to the generally accepted methods of Sedov and Ogoltsova (1999), Dospekhov (2014). The dynamics of growth was characterized by a change in the fivefold repetition of the height of seedlings once every 14 days. The variety of seedlings was determined according to established standards.

RESULTS AND DISCUSSION

Analysis of the dynamics of the growth of seedlings showed that its highest rates were observed in all variants from the end of the first decade of June to the beginning of the second decade of August with a weekly increase in the range of 0.11-0.20 m, (Table 2).

Table 2 shows that at the end of the first growing season, the difference in height of the central shoot in the control and two other variants of the water regime when combined with top dressing $N_{10}P_5$ was 50-60 mm. This is explained by the same background of mineral nutrition and the orientation of the physiological process of plants in all variants on the compatibility of the functioning of the scion and rootstock.

The synergetic effect of water regimes of soil with top dressing in the second and third variants at the end of the period of active growth of seedlings compared with the control variant on average for 4 years in height of the central stem differed by 0.10 and 0.09 m.

Table 1: Analysis of the dynamics of the process and features of the formation of seedlings.

Periods of the vegetation cycle of seedlings	Dynamics of root system morphology and physiological processes	The focus of anthropogenic activity on the optimization of ontogenesis
Adaptation of graft and root stock	Poorly developed root system of the school, physiological processes are subordinated to the adaptation of the graft with the stock	Maintenance of favorable water and fertilizer nutrition regimes of the soil in the root-inhabited layer by irrigation
Active growth and formation of vegetative and root mass	Development of a deeper soil layer by the root system, activation of photosynthetic activity for the purpose of deficiency- free provision of organ - forming physiological processes	Increase of the soil layer regulated by irrigation and maintenance of deficiency -free humidity in combination with growth-stimulating fertilizing
Transition to a state of rest	Sequential reduction of photosynthetic and growth activity to a state of rest	Reduction of anthropogenic influence on growth-stimulating processes in order to activate the transition to a state of rest

Table 2: Dynamics of growth of the central shoot of sweet cherry seedlings according to the variants of the experiment, m (average data for 2017-2021).

Option	Awakening of the kidneys (18.04)	Education 3-4 sheets (10.05)	Active growth		Completion of vegetation (21.09)	% to control
			Beginning (10.06)	The end (12.08)		
A_1	0.01	0.05	0.32	1.64	1.86	100
A_2	0.01	0.05	0.38	1.78	1.99	107
A_3	0.01	0.05	0.38	1.83	1.96	106

HCP_{05} by factor A: A_1 - 0.009; A_2- 0.010; A_3- 0.010.

Table 3: Indicators of the influence of the water regime of the soil and mineral fertilizing on the formation of the root system of seedlings (average data for 2017-2021).

Variant code	Root weight, gr.	Number/length of skeletal roots, m
A1	253.3	5/0.59
$HCP_{0.5}$	1.27	-
A2	272.7	6.5/63
$HCP_{0.5}$	1.37	-
A3	270.0	6.3/0.65
$HCP_{0.5}$	1.35	-

According to the data given in the works carried out by researchers, seedlings grown in conditions of scarce access to soil moisture have several waves of active growth of the central shoot during one growing season and plants grown in conditions of uniform and sufficient soil moisture have no second and third waves of active growth. In our studies, the growth of the central shoot went evenly, in one wave in all variants of the water regime. This means that the plants received sufficient water and did not experience the stress of soil drought.

Studies show that maintaining an optimal level of soil moisture by means of irrigation contributes to a more powerful and uniform growth of plants, as well as the formation of a well-developed crown. Differentiation of the depth of the soil layer regulated by irrigation, consistent with the morphology of the development of the root system of seedlings, allows stimulating growth activity and crown formation. It is interesting to note that a change in the water regime in the depth of the soil layer soaked by irrigation can have a positive effect on the quality of seedlings. For example, reducing the pre-irrigation humidity from 80 to 70% HB at the end of the formation period of seedlings can help improve their quality, presentation and efficiency of irrigation water use.

The root system in appearance in all variants was formed approximately uniformly with a slight advantage in comparison with the control in terms of volume and weight of roots in the second and third variants of the water regime and mineral fertilizing (Table 3).

The greatest indicators of root mass, the number and length of skeletal roots, as can be seen from Table 3, were formed in variants of A_2 and A_3. This means that taking into account the growth of the stem and root system showed that changing the water regime of irrigation in depth can be a useful tool for optimizing the process of growing seedlings. This approach makes it possible to achieve more efficient use of water resources and increase yields. It is important to note that the optimal level of soil moisture may depend on the type of plant and growing conditions. Maintaining a higher level of soil moisture by watering is an important factor for the successful cultivation of seedlings. Differentiation of the water regime by the depth of the soaked soil layer, taking into account the growth of the root system and changes in pre-irrigation moisture, can contribute to improving the quality, presentation and efficiency of irrigation water use.

The main indicators of the economic efficiency of the experience options is the amount of income received from the sale of commodity sales. The largest yield of first-class seedlings in the experiment falls on the third variant of the water regime of the soul in combination with the use of biostimulants “Master”. The proportion of first-class seedlings in this variant varied from 85 to 96% in different years. The lowest yield of seedlings of the 1st grade with the maximum yield of the 2nd grade in all the years of research was formed in the control variant A1. On average, over the years of research on the water regime factor in the first variant, the yield of seedlings of the first grade varied from 65 to 83%, in the second - from 71 to 86 and the third - from 73 to 90.3%.

CONCLUSION

In the soil-climatic conditions of the Volgograd region within the Volga upland, characterized by aridity of the climate and low content of macro- and microelements in the soil, irrigation in combination with mineral macro fertilizers and top dressing of vegetative plants with growth-stimulating preparations contributes to the production of high-quality well-formed annual sweet cherry seedlings.

According to biometric indicators and qualitative characteristics, the third variant of the water regime of the soil is distinguished in combination with top dressing of vegetating sweet cherry seedlings according. The advantage of this variant of the water regime over others is explained by a more favorable combination of anthropogenic regulated vegetation conditions with the dynamics of the formation of

the root system and the changing activity of physiological processes in plants during the formation of organic mass.

The cultivation of sweet cherry seedlings with drip irrigation according to the scheme of the recommended differentiated water regime of the soil in combination with the use of macro fertilizers and growth-stimulating top dressing of vegetative plants provides an increase in the yield of commercial, mainly of the first variety, seedlings compared with the control by 7%.

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Conflict of interest

All authors declare that they have no conflict of interest.

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