The influence of drip irrigation on growth of plum seedlings in central non-black soil zone of European Russia

N N Dubenok, A V Gemonov and A V Lebedev
Russian State Agrarian University - Moscow Timiryazev Agricultural Academy, 49, Timiryazevskaya st., Moscow, 127550, Russia Federation

E-mail: agemonov@yandex.ru

Abstract. One of the methods of environmentally friendly irrigation is drip irrigation, which also improves the quality and yield of agricultural and fruit crops. The aim of the work was to study the effect of different moisture content of the soil on the growth and development of plum seedlings grown in a fruit nursery in the conditions of the Non-Black Soil Zone of European Russia. For the rational use of irrigation water and obtaining high-quality plum planting material in the nursery, it is recommended to use an irrigation regime with maintaining soil moisture in the range of 80-100% lowest moisture capacity with a soaking depth of 30 cm in the first year and 40 cm in the second year.

1. Introduction
The incoming heat and precipitation are indispensable environmental factors when growing crops. Drought in the Central Non-Black Soil zone of European Russia may be due to the uneven distribution of precipitation during the growing season. In horticulture, drought leads to a reduction in the active surface of the root system of fruit trees, which causes a decrease in the absorption of water and mineral salts from the soil [1].

The surface method of irrigation and sprinkling has become widespread when irrigating fruit crops. But these irrigation methods do not allow rational use of incoming irrigation water, energy, labor and other types of resources. Currently, methods of small-scale irrigation are gaining popularity, which allow regulating the water supply, water and nutrient regimes of the soil in accordance with the needs of plants [2]. One of the methods of environmentally friendly irrigation is drip irrigation, which also improves the quality and yield of agricultural and fruit crops [3].

Currently, theoretical and experimental studies on drip irrigation of orchards and nurseries are related to the forest-steppe, steppe and semi-desert zones of the Russian Federation [4, 5, 6]. However, for the zone of the Central Non-Black Soil Region, including the Moscow Region, such studies are fragmentary [3, 7] or have not been conducted. In this regard, the aim of the study was to establish the effect of different moisture content of the soil on the growth and development of plum seedlings grown in a fruit nursery in the conditions of the Non-Black Soil Zone of European Russia.

2. Methods and materials
The studies were conducted on the lands of the educational experimental farm of the Michurinsky Garden fruit growing laboratory of the Russian State Agrarian University - Moscow Timiryazev Agricultural Academy in 2018 and 2019. The territory belongs to the zone of sufficient moisture.
According to long-term observations, the average annual precipitation is 550-650 mm. The maximum rainfall (40% of the annual norm) falls in the summer months and reaches 225 mm. During the growing season, rains of medium intensity fall, which moisturize the soil well, in addition, rainfall is frequent and hail is possible. The soil of the experimental plot is sod-podzolic, cultivated, gley-clay, deep arable, medium loamy on moraine loam, and lined at the depth of 150-170 cm with submerged sands.

The field experiment was based on a two-factor scheme: factor A - the level of supported soil moisture in the range: 60-80, 70-90, 80-100% lowest moisture capacity and control without irrigation; factor B - plum variety: “Mashenka” and “Utro” (on a plum rootstock). A total of 8 options were studied. Planting of seedlings was carried out according to the scheme of 0.9 × 0.33 m, and the distance between adjacent rows of different options was 1 m. In each repetition of the experiment, 30 plants were planted. For irrigation, a long-term drip line was used. Soil moisture was monitored using tensiometers graduated on the basis of thermostat-weight method data. The study of the humidification contours that were obtained during the application of the drip irrigation line was carried out in a typical place of the experimental plot by sampling soil for moisture every 10 cm, both in depth (up to 70 cm) and in the horizontal plane. The studies were performed in triplicate with a systematic arrangement of options. Biometric measurements were carried out according to the generally accepted methodology in experimental practice.

3. Results and discussion

The highest values for the irrigation rate were obtained on the most moistened options. The irrigation norm was influenced by the uniform distribution of precipitation during the growing season and the depth of soil wetting during drip irrigation. The observation results (table 1) show a trend that increased soil moisture leads to greater water consumption, and, consequently, there is an increase in water consumption to maintain such a level of soil moisture. In such cases, the values of irrigation norms increase due to an increase in the number of irrigations.

| Table 1. Irrigation modes by year of study. |
|--------------------------------------------|
| Option experiments                        |
| Index                                      |
| Year of study                              |
|                                            |
| Irrigation rate, m³/ha                      |
| 2018 | 2019 | Mean | 2018 | 2019 | Mean | 2018 | 2019 | Mean |
| 705  | 593  | 649  | 893  | 816  | 855  | 952  | 960  | 956  |
| Average irrigation rate, m³/ha              |
| 37.1 | 45.6 | 41.4 | 38.8 | 45.3 | 42.1 | 38.1 | 45.7 | 41.9 |
| Number of irrigations                       |
| 19   | 13   | 16   | 23   | 19   | 21   | 25   | 21   | 23   |
| Irrigation period, days                     |
| 6    | 9    | 8    | 5    | 6    | 6    | 5    | 6    | 6    |

The average irrigation rate and the number of irrigation in 2018 according to the experimental options amounted to: 60-80% lowest moisture capacity - 37.1 m³/ha (19 irrigations), 70-90% of lowest moisture capacity - 38.8 m³/ha (23 irrigation), 80-100% lowest moisture capacity - 38.1 m³/ha (25 irrigations); and in 2019, the following values were obtained: 60-80% lowest moisture capacity - 45.6 m³/ha (13 irrigations), 70-90% of lowest moisture capacity - 45.3 m³/ha (19 irrigations), 80-100% lowest moisture capacity - 45.7 m³/ha (21 watering). Compared with existing recommendations for irrigation of fruit crops by sprinkling, the use of drip irrigation technology demonstrates significant savings in irrigation water.

The analysis of biometric indicators of the growth and development of plum seedlings during drip irrigation for the first and second years of cultivation is shown in figure 1-4. For such indicators as the diameter of the stem, plant height, annual growth of shoots, leaf surface area of seedlings, the best results were obtained in the experiment with maintaining soil moisture in the root layer in the range of 80-100% of lowest moisture capacity. The least biometric indicators of growth and development are characterized by seedlings in the control variant, where watering was not carried out. Periods with absent precipitation
in the control led to the appearance of several growth waves of seedlings. Varietal features were manifested as follows. The highest values of biometric indicators of growth and development are characterized by seedlings of the cultivar "Mashenka", which is associated with their biological characteristics.

**Figure 1.** The average diameter of the stem of two-year-old seedlings according to the options of experience.

**Figure 2.** The average height of two-year-old seedlings according to the options of experience.

**Figure 3.** The average annual increase in height of two-year-old seedlings according to experience options.
A study of the structure of the root system of seedlings showed that in the control version, where irrigation was not applied, the root system acquires a conical shape in the process of growth. The predominant direction of root growth is down, toward the wetter layers of the soil. In the test cases where drip irrigation was carried out, the root system of plum seedlings mainly spreads in the upper soil layer (20-30 cm) and stretches along the line with droppers. This, firstly, facilitates the excavation of seedlings in nurseries, and, secondly, leads to their less damage during transplantation.

The results of our studies show that drip irrigation contributes to the cultivation of more developed plum seedlings and more suitable for transplantation from the nursery compared to the control version where irrigation was not carried out. Similar results were obtained in the garden of the Institute of Horticulture and Floriculture in Skierniewice (Poland) [8]. Using the example of Valor plum trees grafted onto Myrobalan plum and Wangenheim prunes, it was shown that, as a rule, drip irrigation significantly increased tree growth, yield and fruit quality. Also, our results are consistent with the experimental data obtained in the study of irrigation for the growth and development of seedlings of stone fruit crops (sweet cherry and plum) in the Volgograd region [9, 10]. The authors state that the most favorable is the irrigation regime with maintaining soil moisture of at least 80% of lowest moisture capacity with a differentiated moisture layer from 0.2 to 0.4 m.

4. Conclusion
The results of the field experiment show on the example of one-year and two-year-old seedlings that for a more rational use of irrigation water and to obtain high-quality planting material for plums in the nursery, it is recommended to use an irrigation regime with maintaining soil moisture in the range of 80-100% lowest moisture capacity with a soaking depth of 30 cm in the first year and 40 cm in the second year. With this irrigation regime, the maximum values of the diameter of the stem, the height of the seedlings and the area of the leaf surface are observed. Also, with this option of irrigation, the maximum yield of standard seedlings is observed.

References
[1] Evans R and Proebsling E 1985 Response of Red Delicious apples to trickle irrigation Proc. 3rd Inter. Drip / Trickle Irrigation Congress 1 239-321
[2] Ovchinnikov A S, Borodichev V V, Kucher D E and Shuravilin A V 2016 Apple orchard drip irrigation of intense type on sod podzolic soils of Moscow region News Volga agrouniversity complex 42 211-20
[3] Dubenok N N, Gemonov A V, Lebedev A V and Glushenkova E V 2019 Formation of plum seedlings under drip irrigation in Central Non-Black Soil region of Russia RUDN Journal of Agronomy and Animal Industries 14 40-8
[4] Borodychev V V and Krivolutsky A A 2012 Water consumption of intensive apple orchard Melioration and Water Management 1 19-22
[5] Kuzin A I and Trunov Y V 2015 Distribution of available phosphorus in the soil root zone under the influence of drip irrigation and fertigation in the intensive apple orchard *Fruit growing and viticulture in the South of Russia* 34 72-85

[6] Popova V P and Fomenko T G 2012 Influence of a drop irrigation of fruit plantings on change of properties of chernozems of the North Caucasus *Reports of the Russian Academy of Agricultural Sciences* 3 37-40

[7] Dubenok N N, Gemonov A V, Lebedev A V and Gradusov V M 2019 Development of plum seedlings under drip irrigation in Central Non-Chernozem Zone *Izvestia Timiriazevskoy selskohozajstvennoy akademii* 6 23-35

[8] Treder W, Grzyb Z and Rozpara E 1999 The influence of irrigation on growth and yield of plum trees cv. Valor grafted on Myrobalan and Wangenheim Prune *Acta Agrobotanica* 52 95-101

[9] Kurapina N V, Nikolskaya O A and Kikteva E N 2019 Ensuring environmental safety under low-volume irrigation of fruit nurseries *Agricultural Technologies Of Central Russia* 14 55-8

[10] Nikolskaya O A, Kikteva E N and Kurapina N V 2019 The impact of irrigation on the growth and development of seedlings of stone fruit crops in the nursery *Irrigated Agriculture* 1 42-5