Management of the technological process of irrigation of garden plants

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Abstract. Irrigated agriculture has played a very important role in the history of mankind. In many respects, the irrigation technique was highly dependent on local natural conditions, and its development was the process of adapting local plant and water resources to the needs of farmers. The use of land reclamation in modern conditions must be environmentally and energetically justified. Comparing various irrigation technologies for the cultivation of garden plantings, we proposed the introduction of the agrotechnical technique “slitting” into the irrigation technology of garden plantings. Reclamation reception of soil crevice is carried out with a trailed modified unit of the “Slot cutter 2-140” brand, for cutting narrow slots of 3...4 mm, with a chisel located at the end of the cutting body of the slot, for cutting focal reservoirs, followed by accumulation of irrigation water. The research presents a method of cutting slits directed parallel and perpendicular to the aisles of garden plantings. After cutting the cracks, the soil is formed inside the soil - a natural water-intercepting and transporting network of focal reservoirs stretched along and across the entire perimeter of the garden irrigation module. The proposed cutting unit is mounted on a reinforced slot cutter frame on both sides. The distance between the two cutting tools is exactly 2 meters. Such a distance between the working bodies of the slot is dictated by the scheme for planting garden plantings. Irrigation of the garden is carried out by a surface method, i.e. flooding, an irrigation rate calculated for the complete saturation of the soil of the entire area of the garden plot with the lowest moisture capacity up to 100% of the lowest moisture capacity of the calculated meter layer. The proposed technology for irrigation of garden plantations with the obligatory cutting of over narrow slots with focal reservoirs will allow saving water and energy resources spent on the irrigation rate when growing garden plantings.

1. Introduction

To ensure maximum retention of various waters, special soil cultivation techniques are required. By their purpose, they are divided into several groups:
- techniques aimed at creating an anti-erosion microlief on the surface of arable land (ditching, creating microlimans, irrigation checks, embankment);
- techniques that increase the permeability of soils (crevice, rolling, soil deepening, chisel processing, deep strip loosening);
- techniques that ensure the retention and regulation of snow melting in the fields (sowing the wings, making snow rolls, strip compaction, blackened snow).
Techniques: features of tillage on slopes and the degree of soil washout, the nature and timing of liquid precipitation, the presence and thickness of stable snow cover, and the intensity of snow melting. These techniques are effective in erosion caused by meltwater, where, along with the specified soil cultivation measures. Snow measures are applied to till the soil. Snow melioration is used to slow down or accelerate the intensity of snow melting and, thereby, to reduce the erosion force of meltwater in the spring [1, 2, 3].

On slopes with a steepness of 3…50, soil cultivation is used with the creation of a water-retaining microrelief by the method of slotting, rolling, dumping, plowing without plowing, and other reclamation measures [4, 5, 6]. The method of slotting is a special method of soil cultivation that is carried out to regulate surface water flow on slope lands. The method of slotting is especially effective on heavy soils with insufficient water permeability. It is carried out during the period of finch tillage by cutting cracks by means of a “Slot cutter 2-140”, up to 0.4...0.5 meters deep and 0.05...0.08 m wide, with a distance between them of 1.4 m, and between spans of 5...10 meters or more, depending on the slope of the field array. The method of slotting is performed in late autumn, when the soil cover is somewhat compacted, protecting the cracks from shedding and retaining soil moisture, as a result of the melting of the snow cover that forms during the winter period. When water is taken for irrigation from wells where its temperature is significantly lower than the temperature of the soil and the surrounding air, the slitting operation contributes to the accumulation of water after irrigation, thereby reducing the temperature of the soil. This technology is especially effective in dry and hot years [7, 8].

2. Materials and methods
Water consumption is directly dependent on climatic, hydrogeological conditions, and biological characteristics of the cultivated crop. An important element is the method of hydro reclamation, which determines the role of the formation of the water balance of the field. When calculating the determination of the water balance, we used the method of direct field measurements, the water balance method, which includes methods based on the field water balance equation and the methods of evaporators and lysimeters. The agrotechnical of garden plantations grown to obtain a stable fruit yield was developed on the basis of the experience of scientists of the All-Russian Scientific Research Institute of Hydraulic Engineering and Melioration named after A. N. Kostyakov and zonal recommendations supplemented with their options for irrigation technology and the introduction into agricultural technology of the technological method of slotting, the unit “Slot cutter 2-140”, with experimental working parts.

3. Results and discussion
At present, in irrigated horticulture, various irrigation technologies are used, such as continuous flooding of the entire area of the garden, watering along the near-stem bowls, with simultaneous moistening of row spacings, sprinkling and irrigation by checks [9, 10].

When sprinkling irrigation without careful planning, pockets of non-absorbed water appear on the soil surface, which arise depending on the intensity of flow and water supply throughout the entire irrigation rate. With sprinkler irrigation with a given rainfall rate (q), all water entering the field is absorbed over time (t). Reasoning about water permeability, it can be shown that when irrigated with the same intensity, part of the water consumption will be absorbed by the soil, and the volume can cause irrigation runoff.

Based on mathematical transformations, the irrigation rate, at which an uncontrolled runoff is formed due to a number of reasons, on which the rate of water permeability depends, can be calculated by the formula:

$$m_{ep} = \sqrt{K_0 \cdot t^{2a-1}}$$

where $m_{ep}$ - irrigation rate erosion-permissible, m³/ha;
$K_0$ – absorption rate, m/h;
$a$ – parameter that characterizes the dynamics of changes in the absorption rate;
i – slope of the soil surface.

It should be emphasized that if the optimal irrigation rate is greater than the non-flow rate, then the erosion – permissible rate is calculated and compared with the optimal one. At a lower value \( (m_{ep}) \) in comparison with the nominal one, the layer of possible irrigation runoff is calculated (block diagram of the algorithm for calculating the erosion-permissible norm).

The resulting dependence for calculating the possible irrigation runoff is shown in Figure 1.

In order to avoid soil washout and accumulation of water on uneven surfaces of an irrigated area during sprinkling, we proposed an agrotechnical method of slotting with crafting narrow cracks with focal reservoirs cut in the lower part of the crevice, developed and patented by scientists of the All-Russian Research Institute of Hydraulic Engineering and Land Reclamation named after A.N. Kostyakov cutting working parts.

![Figure 1. Dependence of the calculation of the possible irrigation flow.](image1)

The technology of surface irrigation by flooding the entire area of the garden or irrigation by checks, have been used since ancient times, and have come down to our time without any changes. We decided to pay special attention to such ancient, but very effective methods of irrigation by flooding and flooding of perennial plantations, since the main root system of a garden tree is up to one meter in diameter, but the root mass of secondary roots is located in the subsoil layer of the entire garden massif [11, 12, 13].

![Figure 2. Working parts for the unit “Slot cutter 2-140”: 1 - silencer; 2 - small blade; 3 - large blade; 4 - chisel; 5 - persistent socket; 6, 7 - fastening rings.](image2)

In this regard, we, as well as with sprinkling, have proposed technology for irrigation of perennial garden plantings, by means of flooding the entire area of the garden, using an agrotechnical method of
slotting spacing of the garden massif. For the rational use and interception of irrigation water, it is obligatory to carry out the method of slotting in autumn and before carrying out the subsequent vegetative irrigation, the trailed the unit “Slot cutter 2-140” with experimental working parts, with removable blades and a chisel for cutting soil focal reservoirs (Figure 2).

The method of slotting is carried out in the autumn, when the soil is more compacted, in order to avoid shedding the cut cracks, which will serve for water retention, after the spring thaw of snow. The slits are cut in the aisles parallel to the garden plantings, then perpendicular to the cut slits, after the first flooding, the next slits with focal reservoirs are cut for the subsequent accumulation of irrigation water (Figure 3).

**Figure 3.** Conditional scheme of cutting garden cracks: 1 - slot cutter for cutting garden cracks; 2 - caterpillar tractor; 3 - near-stem garden bowl without soil roller.

The location of the working parts of the slot cutter is provided taking into account the distance between the garden plantings 3, that is, two working parts along the edges of the frame of the slot cutter 1.

![Diagram](image)

**Figure 4.** Conventional scheme of irrigated modules: 1 - water intake; 2 - pump; 3 - coarse filter; 4 - controllers of locking devices; 5 - hydrants; 6 - reinforced wells; 7 - irrigation pipelines with water outlets.

The distance between the working parts of the slot cutter is 2 meters. The plan for planting garden plantings depends on the biological characteristics of the garden culture [14, 15]. If the garden is grown on dwarf or semi-dwarf rootstocks, then the planting of garden plantings will correspond to the
scheme 4 × 4 meters. For ordinary, zoned fruit trees, the layout will be slightly different and will be 4.5 × 4.5 meters.

Irrigation technology assumes two options for flooding the garden with flooding. In the first and second versions, the principle of irrigation is carried out by means of irrigation water intake hydrants leading to each irrigation module (Figure 4).

In the first version, the irrigation water is transported through the supply pipeline from the water intake 1 to the distribution pipeline 8, through the locking devices of the controllers 4, the water is supplied to the hydrants 5 of the irrigation modules. The hydrants are connected to two irrigation pipelines 10 with water outlets 7, which are located along the lateral boundaries of the irrigated area. By means of water outlets, the irrigated module of perennial garden plantings is flooded.

The second option represents a similar system of water intake and transportation to the hydrants of the irrigation module. An exception is a different principle of supplying irrigation water to the irrigated module. Irrigation water from a hydrant (5) is supplied to two irrigation pipelines (9), the ends of which are fed into reinforced wells (6) from which irrigation water flows through water-intercepting slots with focal intrasoil reservoirs and along the soil surface, flooding the irrigated module garden plot.

4. Conclusion
The most economical methods of irrigation of perennial garden plantations are conventionally irrigation in near-stem bowls. When irrigating along the near-stem garden bowls, there is a saving of irrigation water due to the direct point moistening of the near-stem bowl, but the root system of the garden tree is far beyond the bounds of the bunned bowl. Insufficient moisture of the entire root system of garden trees leads to a significant loss of fruit yield. Such irrigation is constrained by the energy and economic costs required for the acquisition and operation of stationary irrigation systems. No less costly is the method of irrigation of perennial garden plantings by sprinkling, for similar reasons.

The method of irrigation by flooding of irrigation water over garden tracts or checks exceeds the water consumption in comparison with the above-mentioned irrigation methods but significantly exceeds them in terms of energy assessment and a significantly larger yield of fruit products. More rational and economical use of irrigation water with surface irrigation methods will make it possible to carry out an agrotechnical modernized method of cracking on irrigated areas of garden plots, with the interception of irrigation water by cracks cut in the soil with focal reservoirs, for accumulating water and shifting the timing of the next irrigation. The introduction of an agrotechnical method of slotting into the technology of irrigation of perennial garden plantations will reduce the irrigation rate by reducing vegetative irrigation. The agrotechnical method of slotting is especially effective in areas in the mountainous or hilly regions of the Russian Federation.

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