Relevance of long-jet sprinklers use when watering potatoes in the northwestern region conditions

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Abstract. The authors note the relevance of potato irrigation in the North-West region of the Russian Federation. The meteorological characteristics of the region are given, the need for irrigation in the first half of the growing season is noted. The objects of research were potato varieties of the mid-early and mid-season groups: Spring Belaya, Lomonosovsky, Charoit, Real, Gusar, Lilac fog, May flower, Peter's Riddle. The studies were carried out in 2018 - 2019. at the experimental field of the Velikie Luki State Agricultural Academy. The results of the study of the influence of the use of metered irrigation in the first half of the growing season on the increase in the productivity of the improved seed material of potatoes are given. The article presents the results of assessing the productivity of these varieties of potatoes.

1. Introduction
Potatoes are a demanding crop of nutrients. For the formation of high yields of potato tubers, it is important to have a sufficient amount of nutrients in the amount required for plants. [1] The variety is also important in the formation of the potato yield. In recent years, the state has especially supported domestic breeders, a number of programs have been developed aimed at strengthening selection and seed production [2].

2. Description of the problem
Despite the fact that the territory of the Pskov region is located in a zone of excessive moisture, long-term observations show that in the vast majority of years the beginning of the growing season of field crops, including potatoes, falls on the acutely arid period, when less than 30-50% of precipitation falls from the climatic norms and needs of plants. As a result, plant nutrition worsens, there is a significant lag in growth and development, which is not eliminated at subsequent stages of ontogenesis [3]. In this regard, it becomes relevant in our zone for irrigation of potatoes in the first half of the growing season. So, for example, in 2020, about 60 hectares out of 350 in the peasant farm Pavlova V.I. ended up in an area where there was no rain from the moment of disembarkation to harvesting. As a result, the potato turned out to be unsuitable for sale, due to the discrepancy between its market indicators. Figure 1 shows the state of the field with and without watering.

Potatoes endure short droughts, but during long dry periods (less than 50% of the normal field moisture capacity), the yield greatly decreases [4]. Under these conditions, the plants stop growing, the tuber phellogen dies off and the cork layer becomes hard. During subsequent precipitation, the growth
of tubers is not restored, which leads to regrowth of their tops and the formation of constrictions and children [5, 6]. After a period of optimal water supply, which promotes strong leaf growth, even minor disturbances in the water regime lead to a decrease in yield [7].

![Figure 1](image-url)  
*Figure 1.* Potato planting of the farm Pavlov V.I., August 2020, Porkhov, Pskov region (left with watering, right without watering).

Previously, there were about 8 thousand hectares of irrigated land in the Pskov region, but at the moment, due to the changed economic situation, only 800 hectares are irrigated. The experience of using irrigation systems is available in the farms of Novosokolniki, Pskov and Pechersk districts. The development of irrigation, as in most regions of Russia, can make tangible progress due to public-private partnership, which has received a high priority in federal programs of recent times [8].

Among other things, irrigation allows you to regulate the phytoclimate of plants, as well as combine it with the introduction of micro- and macroelements, reducing the anthropogenic load on the soil. In modern conditions of climate change, irrigation is becoming a necessity [9]. However, high prices for irrigation equipment require the use of technologically sound solutions that take into account the specific features of the region and production technology.

A risk factor for the development of irrigated areas is the lack of new Russian research and development projects for sprinkler equipment, while there is a significant share of foreign irrigation equipment. In this regard, the most important issue in the development of irrigated agriculture is the provision of agricultural commodity producers with Russian sprinkler equipment, which is not inferior in its characteristics to advanced samples of sprinkler equipment of foreign production.

As sprinkling equipment, both wide-grip machines and mobile drum-hose sprinklers, which have become very popular in the Pskov region, are used. The implementation of the Federal Target Program "Development of land reclamation of agricultural lands in Russia for 2014-2020" showed that for the period 2014-2018 the structure of irrigated areas put into operation and irrigated with hose-type drum
sprinklers increased to 7%. Most of the machines are modifications of foreign manufacturers and are successfully operated in many countries of the world.

Drum installations have become more widespread in the territory of the North-West of the Russian Federation due to their advantages: mobility, the ability to work in fields with significant slopes. Not unimportant is the possibility of using installations on leased land, which allows in the future to reduce investment in the organization of sprinkling in comparison with wide-coverage installations.

When using these installations on difficult terrain, it is necessary to ensure the regulation of the pressure, since it can vary within 30-40%, which leads to irrigation irregularity over 25% of the average rain intensity. In the case when the installation is not equipped with a pressure regulator, stabilizing and anti-slip devices, the achieved irrigation efficiency coefficient on difficult terrain reaches 0.42 with the required 0.7 and higher [10].

Automation technology has a certain prospect, which makes it possible to further reduce the consumption of water resources through the use of differentiated irrigation, as well as create the most optimal conditions for the growth and development of plants [11]. Along with the change in the intensity of rain, it is important to dosed application, together with irrigation water, of mineral and organic fertilizers, trace elements and chemical amelioration agents to improve the chemical and physical properties of soils.

3. Materials and methods

Research on irrigation machines is mainly aimed at studying the indicators of the quality of water distribution, the formation and disintegration of the jet, which determine the yield of agricultural crops. However, the existing mathematical models of the functioning of sprinkler machines, as a rule, are deterministic and do not take into account many factors associated with the operating conditions. In this regard, it becomes urgent to solve the problem of unproductive water losses.

On the basis of the academy, comprehensive research is being carried out aimed at developing optimal schemes for the production of seed potatoes, including by improving the quality of irrigation by improving the design and technological parameters of the long-range sprinkler. Tasks are being solved to optimize the sprinkling process, positioning devices and their parameters based on probabilistic modeling to increase the uniformity of irrigation and reduce the unproductive consumption of irrigation water, as well as determine the optimal irrigation doses in the conditions of the north-western region, since when designing the system in the future, the main condition is a reasonable range of the amount of water required by plants.

Studies of the effect of irrigation on biometric indicators of potatoes and the structure of the crop were carried out in 2018 - 2019 on the experimental field of the Velikie Luki State Agricultural Academy. The objects of research were potato varieties of mid-ripening and mid-early ripeness groups Spring White, Lomonosovsky, Charoit, Real, Hussar, Purple Haze, May flower, Peter's Riddle [12].

4. Results and discussion

Meteorological conditions in 2018 deviated from the long-term average values. During the growing season, the temperature slightly exceeded the average long-term values (the maximum deviation was noted in the first ten days of May + 8.9 °C). Precipitation during the growing season was uneven. The year was marked by a dry summer period. The amount of precipitation in the period June-August was less than the climatic norm. In general, the growing season was characterized as warm and dry: the average air temperature in April-September was 17.9 °C, GTC = 1.87 (with a norm of 1.56).

In 2019, the weather was characterized by sharp temperature changes, for example, at the end of May and throughout June it was very hot and dry (GTK = 006), July and August were characterized by cool and rainy weather.

Planting in the ground was carried out in the first ten days of May. The soil on the field plot is sod-podzolic medium loamy. The content of humus in the soil is 2.5%, pH - 6.5. The content of the main nutrients: N - 50 mg / kg; P2O5 - 180 mg / kg; K2O - 200 mg / kg. The arable layer is 25-30 cm, 15 t / ha of compost manure was applied for autumn plowing. The predecessor is pure steam. Background
dose of mineral fertilizers N90P180K180 kg / ha. Repetition in field experiments was 4-fold, accounting plot area - 1.54 m². Planting scheme 70x25 cm. Tubers were planted in the first decade of May. Soil cultivation was carried out: in autumn - autumn plowing, in spring - milling and cutting of ridges. The care consisted of one inter-row cultivation, hilling, spraying against late blight when closing the tops with Ridomil Gold MC 2.5 kg / ha and 10 days later - Ditan M-45 1.5 kg / ha, UNIFORM, SE.

The temperature regime, the amount of precipitation and other meteorological conditions have a significant effect on the state of potato plants, the development of diseases and the number of pests [13]. The instability of the weather, characteristic of the North-West region of Russia, manifested itself in the years of the study. Irrigation was carried out to maintain soil moisture at optimal values for potatoes. The number of irrigations varied depending on the weather conditions of the year and soil moisture from 2 to 8 per year with a calculation rate of 35-40 m³ / ha. All carried out observations - biometric indicators of plants, soil moisture, and data processing was carried out according to generally accepted methods.

Potatoes are extremely sensitive to a lack of moisture in the soil, especially for test-tube material planted in natural conditions, since the root system is not yet perfect enough [14]. The not too extensive, reaching a depth of 30 cm, the root system of this culture has a significant load. During a short growing season, the plant not only builds up a large amount of greenery, but should also provide what it is cultivated for - tubers [15].

Meristemic plants in the first month or two need special care. This is due to the fact that they grew up all their lives in sealed vessels with constant high humidity (reaching 100%). And a sharp transition to conditions of atmospheric humidity (often not exceeding 60%) can be disastrous for them. The initial care of plants is to maintain air humidity and timely watering [16].

When studying the biometric parameters of potato plants from Figure 2, it can be seen that during irrigation they were much higher. So, for example, the number of stems during irrigation was on average 2 more per bush. The largest number was formed in the variety Hussar 4.8 pcs / bush, Real-4.6 and Purple Haze - 4.5 pcs / bush, the minimum number of stems was noted in the mid-season variety Peter’s Riddle - 4.0 pcs / bush.

In terms of stem height, the maximum indicators were observed in the varieties Hussar - 76.2 cm, Lomonosovsky - 75.5 cm and Charoite - 72.4 cm, which is on average 20 cm more than without watering. A small height during irrigation of the ball was noted in the varieties May flower 58.7 cm, the Peter’s Riddle 60.3 cm. The best indicators for the assimilation surface of leaves were noted in varieties Hussar - 841 m² / bush, Lomonosovsky - 827 m² / bush and Real - 824 m² / bush, which in an average of 300 m² / bush more than without irrigation. The minimum formation of the assimilation surface was observed in Spring White - 650 m² / bush.

According to the accumulation of the greatest mass of tops during irrigation, the varieties Hussar were distinguished - 814 g / plant and Charoite 800 g / plant. The smallest tops mass was formed in the early Spring Belaya variety - 495 g / plant.

Analysis of the data obtained depending on irrigation for potato productivity shows that all options with irrigation contributed to an increase in its productivity (Figure 3).

The largest number of tubers was formed in the potato varieties Hussar - 19.2 pieces / plant and Lomonosovsky 15.4 pieces / plant, which is on average 3-6 pieces / plant more than in the variant without irrigation. The minimum number of tubers 12.2 pcs./plant was formed in the May flower variety during irrigation.
By the mass of tubers, the maximum results were also noted in the varieties Hussar - 1275 g / plant and Lomonosovsky - 1231 g / plant, the increase from watering was 404-528 g / plant, respectively. The smallest mass of tubers under irrigation was observed in the Peter's Riddle variety - 987 g / plant.

The use of irrigation had a beneficial effect on increasing the size of tubers. The weight of one tuber increased by cultivars from 10-30 g / plant in comparison with the variant without irrigation. The largest tubers were formed in the varieties Hussar -121 g, Lomonosovsky - 91 g and Charoite - 89 g. The smallest tubers were observed in the potato varieties May flower - 65 g, Peter's Riddle - 64 g.
5. Conclusion
The study of potato irrigation in the conditions of the Pskov region made it possible to propose a scheme for the production of high-quality seed potatoes that meet the requirements and provide an increase in yield up to 20%, and the data obtained allow us to draw the following conclusions:

1. The cultivation of a healthy test tube material of potatoes with the implementation of irrigation technology has significantly influenced the biometric parameters of plants. The number and height of stems, the assimilation surface of potato leaves increased 1.3-1.5 times compared with the option without irrigation.

2. The most productive in terms of yield with the use of an irrigation system was the potato variety Gusar, the increase was 528 g / plant. Therefore, in order to achieve a stable result in changing environmental conditions, it is important not only to choose the right variety, but also to apply cultivation techniques that can maximally mobilize the potential defenses of the plant organism.

3. The machines used at the moment cannot fully provide high-quality sprinkling, due to the formation of zones with excessive and insufficient moisture, the solution to this problem will allow high-quality irrigation, including in fields with difficult terrain.

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