

IRRIGATION OF VEGETABLE CROPS ON SOD-PODZOLIC SANDY LOAM SOILS OF BELARUS

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Abstract. *The results of studying the effect of irrigation on the yield of vegetable crops on sod-podzolic sandy loam soil are presented. Vegetable crops from different botanical families—Brassicaceae (white cabbage), Apiaceae (carrot), Chenopodiaceae (table beet), Allium family (onion), and Solanaceae (potato)—regardless of their biological characteristics, showed an increase in yield of 23.6–30.3% under irrigation conditions on sandy loam soils. The maximum yield increase from irrigation, 165 centners/ha, was obtained for the Belarusian 85 white cabbage variety, while the minimum increase was observed for potato—70 centners/ha. Higher profit (5733 rubles/ha) and profitability (201%) were achieved with the irrigation of white cabbage.*

Keywords. *vegetable crops, irrigation, yield increase, economic effect.*

INTRODUCTION

The territory of the Republic of Belarus belongs to a region with an unstable heat and moisture regime, with a high probability of soil droughts during the growing season. Especially in recent years, there has been an increase in soil water balance deficits. Since 1989, the longest period of warming has begun in Belarus for the entire period of instrumental observations of air temperature over the past almost 130 years. During the period from 1989 to 2015, the average annual air temperature in Belarus exceeded the climatic norm adopted by the World Meteorological Organization (WMO) by 1.3 °C. In 2015, the average annual air temperature was +8.5 °C, which is 2.7 °C above the climatic norm and was the highest for the entire period of instrumental observations since 1881. As a result of warming, the boundaries of agroclimatic zones (regions) have changed: the Northern agroclimatic region has shifted north, and a new, warmer agroclimatic region has formed in the south of Belarusian Polesie. Studies show that the trends of these changes will persist in the coming decades. Significant changes in the growing conditions of agricultural crops as a result of warming require adjustments in agricultural practices and consideration when developing the strategy for agricultural production development and its adaptation to climate change [1]. Since almost all vegetable crops have high requirements for soil water regime, a lack of moisture leads to a decrease in their water consumption and, accordingly, to yield losses.

Average water consumption coefficients for the conditions of Belarus have been established based on long-term experimental observations: late cabbage — 85 m³/t; carrot — 110 m³/t; table beet — 80 m³/t [2].

Mobile hose irrigation machines are intended for irrigating vegetable and forage crops, annual and perennial grasses, nurseries, and plantings of forest, fruit, and berry crops. These machines are considered the best for irrigating plots of any shape with a small to medium area (10–50 ha). Hose irrigation machines with climate designation “U” are intended for operation in areas with a temperate climate in the open air. They are allowed to be used on calm and slightly undulating terrain, on slopes regulated by technical specifications for irrigation equipment — no more than 0.2. The mobility of hose machines allows irrigating not just one but several plots. Irrigation is carried out during the irrigation season (for Belarus conditions, April–August) during both daylight and nighttime hours. Hose irrigation machines can operate both from hydrants of a closed irrigation network and by taking water from open water sources using an autonomous diesel pumping station or a pump unit driven through a power take-off (PTO) shaft of a tractor. The water supply distance to the hose irrigation machine from a reservoir or other water source via a detachable pipeline is up to 2–3 km. Irrigation contributes not only to yield increase but also significantly improves product quality. It should be noted that irrigation of agricultural crops by sprinkling is not new for Belarus and is currently the main method of irrigation in Belarus. Sufficient scientific and practical experience has been accumulated with this method of irrigation. However, in recent years, attention has increasingly turned to drip irrigation. Drip irrigation fundamentally differs from sprinkling. It is a tool for maintaining soil moisture at an optimal level for the crop throughout the growing season. In drip irrigation, water is supplied directly to the root zone of plants. This is the key difference between drip irrigation and sprinkling. One of the main positive characteristics of drip irrigation is the ability to use water more efficiently. The main disadvantages of drip irrigation are significant initial capital investments and the high cost of water-soluble fertilizers for drip equipment [3].

Most vegetable growers divide vegetable crops according to their water requirements into the following groups: 1) Very demanding (plants of the cabbage family, leafy vegetables, celery). The optimal soil moisture for them is 80–95% of field capacity (FC); 2) Demanding (cucumber, onion, pepper, eggplant, tomato). The optimal soil moisture for these crops is 70–80% FC; 3) Moderately demanding — legumes, root crops (except cabbage family), sweet corn, perennial crops. The optimal soil moisture for them is 65–75% FC; 4) Drought-tolerant (watermelon, melon, pumpkin). High yields of these crops are obtained at 60–70% FC, but with deep soil wetting.

According to the combination of water consumption and root absorption activity, vegetable plants are divided into four groups: 1) Cabbage (white, cauliflower, Chinese, kohlrabi), cucumber, eggplant, lettuce, radish, celery, spinach, and other salad crops. These crops absorb water poorly due to relatively weak root development and inefficiently use it for transpiration. These crops are very demanding for soil moisture. 2) Carrot, tomato, parsley, melon crops, beans, asparagus show good ability to absorb water and use it efficiently. They have a relatively strong root system and good transpiration regulation. 3) Onion, garlic, and some other allium plants absorb water poorly due to a weak root system but use it efficiently. In the first half of the growing season, they are demanding for soil moisture. 4) Beet, which has a well-developed root system, can easily absorb water but uses it intensively for transpiration. It responds well to irrigation [4].

Agricultural crops experience the most acute water deficit on soils with light granulometric composition — sandy and sandy loam soils. According to RUE “Institute of Soil Science and Agrochemistry,” as the granulometric composition of sandy soils becomes lighter, the yield of agricultural crops decreases significantly. For example, when growing perennial grasses, winter wheat, or barley on sandy soils, their yield on sandy soils is 50–60% lower than on loamy soils, and for winter rye or potatoes — 30–40% lower [5].

Approximate irrigation regimes for vegetable crops for the southern region of the Republic of Belarus are presented in Table 1. Irrigation and water norms are given without accounting for water losses during sprinkling (net). Water losses due to evaporation during sprinkling in Belarus average about 6% [4].

Table 1. *Approximate irrigation regimes for vegetable crops for the southern zone of Belarus [4]*

Crop	Irrigation period		Distribution of irrigations by month, pcs/m ³ /ha				Irrigation norm, m ³ /ha	Minimum interval between irrigations, days
	Before	End	may	june	july	august		
Cabbage	$\frac{V^*}{3}$	$\frac{VIII^*}{3}$	$\frac{1^{**}}{100}$	$\frac{2}{250}$	$\frac{2}{250}$	$\frac{2}{250}$	1600	4-8
Beet	$\frac{V}{2}$	$\frac{VIII}{1}$	$\frac{2}{150}$	$\frac{1}{250}$	$\frac{1}{250}$	$\frac{2}{250}$	1300	4-8
Carrot	$\frac{V}{3}$	$\frac{VIII}{1}$	$\frac{1}{150}$	$\frac{2}{250}$	$\frac{1}{250}$	$\frac{1}{250}$	1150	5-9

**Note.) numerator – month, denominator – decade; ** numerator – decade, denominator – irrigation norm.*

MATERIALS AND METHODS

At the KSUP “Vostok Combine” (Gomel District, Gomel Region) on sod-podzolic sandy loam soils with an average score of 34, irrigation of vegetable crops was conducted: Belarusian 85 white cabbage, Karlena carrot, Prygahunya table beet, Stuttgart Riesen onion, and Zdabitak potato. Groundwater, located at a depth of 0.5–3.6 m, was used as the water source. Water supply to the irrigation network was carried out using a mobile pumping station, which was installed near the storage reservoir for the duration of irrigation. For irrigating agricultural crops, one mobile sprinkler machine PDM-2500 (irrigation area 34 ha) and two circular-action sprinklers “Reinke” with irrigation areas of 58 ha and 38 ha were used.

RESULTS AND DISCUSSION

It was established that vegetable crops belonging to different botanical families—white cabbage (Brassicaceae), carrot (Apiaceae), table beet (Chenopodiaceae), onion (Allium), potato (Solanaceae)—responded very well to irrigation. The magnitude of yield increases obtained from irrigation depended little on the biological characteristics of the crop and ranged from 23.6–30.3% (Table 2). It should be noted that the maximum yield increase from irrigation (165 c/ha) was observed in white cabbage, which is associated with the fact that during its 6-month growing season, its leaf apparatus is capable of active growth. The minimum yield increase was observed for potato, since for this row crop, evaporation from the ridges was higher due to inter-row cultivation.

Table 2. Yield of vegetable crops under irrigation, c/ha

Crop	Yield, c/ha		± Increase from irrigation	
	Without irrigation (control)	With irrigation	c/ha	%
Belarusian 85 white cabbage	559	724	165	29,5
Karlana table carrot	390	508	118	30,3
Prygahunya table beet	476	610	134	28,2
Stuttgart Riesen onion	322	412	90	28,0
Zdabitak potato	297	367	70	23,6

Water consumption of vegetable crops changes throughout their growth period, and soil moisture was maintained within the optimal range until the formation of the yield and during its ripening period. For example, the daily water consumption by onion plants during the period of active leaf growth is 25–30 m³/ha per day; during bulb formation, it is 40–45 m³/ha; and during the ripening period, irrigation is not required, as the plant needs dry conditions.

To assess the economic efficiency of the studied agricultural practice, a calculation of economic efficiency was carried out. The cost structure for irrigation, in addition to the costs for harvesting additional produce, staff wages, and electricity costs, included annual costs for irrigation, fixed annual costs for maintenance of the irrigation system, which is on the balance of the agricultural organization, and the price of water supplied for irrigation [6]. As can be seen from the presented calculation, irrigation of vegetable crops under modern conditions is a profitable activity (Table 3). The maximum profit and profitability were obtained with the irrigation of white cabbage, which amounted to 5733 rubles/ha and 201%, respectively. Irrigation of potatoes was less profitable.

Table 3. Calculation of the economic efficiency of vegetable crop irrigation

Crop	Yield increase, c/ha	Purchase price, rub./c	Value of increase, rub./ha	Irrigation costs, rub./ha		Profit, rub./ha	Profitability, %, %
				Irrigation	Depreciation charges		
Cabbage	165	52	8580	689	2158	5733	201
Carrot	118	53	6254	611	2158	3485	126
Beet	134	46	6164	611	2158	3395	123
Onion	90	72	6480	585	2158	3737	136
Potato	70	43	3010	637	2158	215	8

CONCLUSIONS

Vegetable crops from different botanical families—Brassicaceae (white cabbage), Apiaceae (carrot), Chenopodiaceae (table beet), Allium (onion), Solanaceae (potato)—regardless of their biological characteristics, increased yield by 23.6–30.3% under irrigation on sandy loam soils.

The maximum yield increase from irrigation, 165 c/ha, was obtained for Belarusian 85 white cabbage, while the minimum increase was observed for potato—70 c/ha.

Higher profit (5733 rubles/ha) and profitability (201%) were achieved with the irrigation of white cabbage.

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