Improved technology elements of table carrot cultivation in the Volgograd region

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Abstract. During the period of field research to find ways to improve the elements of table carrot cultivation technology, we proposed a comprehensive resource-saving technology for the cultivation of carrot root crops on drip irrigation in the Lower Volga region. A hypothesis was put forward to increase the productivity and quality of table carrots through the use of new generation biological products and fertigation of crops using drip irrigation. The research program included a comparative assessment of the zoned table carrot variety Shantane (control) and promising Red Core and Santa Cruz hybrids, which belong to the same early maturity group. For this, mineral fertilizers were calculated in doses for the planned yields of 90, 110, and 130 t/ha, using drip irrigation. Biological preparations Agriful (concentration 3 and 4 l/ha) and Fertigrain Foliar (concentration 1.3 l/ha) were used, in addition, to their complex use together with mineral fertilizers.

1 Introduction

The soil and climatic resources of the Volgograd region make it possible to grow vegetable products in gross volumes not only for domestic needs but also for export to other regions of the country [1–3]. Nevertheless, the biological potential of the studied region is currently exploited very inefficiently, only by 25–38%. The state of the old arable land fund of the region can be characterized as satisfactory but the state of reclamation systems is declining catastrophically [4].

Based on the formulated hypothesis, the fastest application of the latest agrotechnological elements with constant drip irrigation [5–7], the introduction of seeds of hybrids and carrot varieties of domestic and foreign producers [8], will significantly accelerate the growth of average yields of more than 100 t/ha.

The most important condition for increasing the efficiency of irrigated agriculture at the present stage is the rational use and implementation of modern intensive agricultural technologies [9–10]. The main component of these elements will be actively implemented drip irrigation regimes. Such an application will allow to form stable and high yields and to switch to modern industrial technologies for growing table carrots.

The development of agricultural production at the present stage is becoming one of the most important strategic tasks of the government of the country in the field of agrarian policy, aimed at the formation and further development of agricultural production. These activities are primarily necessary to ensure the country's food security, as well as the development and promotion of products in the world food markets.

The conditions for worthy and successful competition of domestic products in the world food market are high quality, satisfying the diverse taste preferences of consumers, and an acceptable purchase price. Therefore, in the program of proposed activities that we are considering, a special place is given to ecological and biological farming systems. These activities will ensure the formation of stable and high yields with excellent and good quality values [11–13].

Consequently, the observance of all elements of agricultural technology for growing table carrots, the water, and nutrient regimes of the soil, will basically allow for growing consistently high yields of carrot root crops in the conditions of the Volgograd region. However, the following issues need to be studied: new types of biological products, varieties and hybrids that appear on the market, and modes, and methods for implementing drip irrigation for a given crop.

It should be borne in mind that the vegetable growing complex is a rather complex system of interconnected technological links of agro-industrial production, processing, and storage. Therefore, it is realistic to reduce losses only under the condition of systematic integrated development of all its component techniques [14, 15].

2 Materials and methods

Experimental studies were carried out on the collective farm "V. A. Zaitsev". Gorodishchensky district, Volgograd region since 2019–2021 For research, a zoned variety of table carrot Shantane (control) and new promising hybrids Santa Cruz and Red Core belonging

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to the same early maturity group were selected. The dosage of mineral fertilizers was calculated for the planned yield of 90, 110, and 130 t/ha. Drip irrigation kept the humidity threshold at 75–80% HB.

Biological preparations Agriful (with a concentration of 3 and 4 l/ha) and Fertigrain Foliar (with a concentration of 1.3 l/ha) were chosen for the study, in addition, their complex effect with mineral fertilizers on the formation of the yield of table carrots of the Champagne variety, a hybrid of Santa Cruz and Hybrid Ed. Cor. Dosages of biological products from the manufacturer.

Carrots are very sensitive to the fertility of the soil, as well as to the nutrients contained in it in a balanced ratio. With a yield of 1 ton of carrots per hectare, the removal of microelements is as follows:

– K2 is 5.0 – 6.5 kg, depending on the grown hybrid or variety;
– P2O5 is 1.0 – 1.7 kg depending on the cultivated hybrid or variety;
– N is 2.2 – 4.0 kg depending on the cultivated hybrid or variety.

Table 1. Scheme of applying mineral fertilizers for carrot crops.

Indicator	Planned yield, t/ha								
	90			110			130		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Required	240	120	440	300	150	550	360	180	660
For basic processing	120	90	220	150	90	280	180	90	330
1st top dressing (phase 3 sheets)	80	15	120	105	30	170	90	45	200
2nd dressing	40	15	100	45	30	10	90	45	130

Foliar top dressing was applied in three terms:

– phase 3 – 5 leaves with Agriful dilution (4 l/ha + Fertigrain Foliar (1.3 l/ha);
– after 10 days with Agriful dilution (3 l/ha + Fertigrain Foliar (1.3 l/ha);

We adopted the technology for growing carrot roots recommended for this zone. The repetition of the experiment is 4-fold. A 4-line sowing scheme was used: 0.05 + 0.30 + 0.30 + 0.05. The seeding rate was 1.2 million viable seeds per hectare. Sowing was carried out by a seeder – Maple. The area of the accounting plot was 36 m^2. The location of the plots was systematic.

3 Results and discussion

The experiments were carried out on typical medium loamy chestnut soils, which are most common in the Volga-Don interfluve. The presence of a bulk density of 24.7 t/m^3 and a total porosity of 22.08% indicates the presence of humus in the arable horizon was 1.8%. that these soils are very favorable for the growth of table carrots. The experimental soils were rich in exchangeable potassium (up to 310 mg/kg of soil). The absorption capacity of the plow horizon was within 22.8 mg-eq.

Achieving a stable and high yield of carrots is possible only with the introduction of drip irrigation. When conducting research, 10-12 days before the start of the harvest of root crops, the last watering was carried out. Harvesting began with the onset of the first autumn frosts, which contributes to the better preservation of root crops during storage. Not significant autumn frosts lead to deep chemical transformations in carrot roots. Under the influence of frost, complex molecular compounds are transformed into simple ones. These processes influenced the increase in the total sugar content in root crops (19 – 20%) and had a positive effect on the safety of root crops. The difference in the losses of carrot root crops put into storage, subjected to frost, and harvested before the onset of frost was 5–10% in favor of frozen root crops. These indicators also affect the overall quality characteristics of marketable root crops in storage.

Another feature of the late harvest is the fact that there is a fairly intensive increase in the mass of root crops, especially in autumn. Based on these provisions, early harvesting actually reduces the potential yield and is considered impractical. When harvesting, both the biological characteristics of the cultivated variety or hybrid and the weather conditions that existed during the growing season are considered. Table 2, Table 3, and Table 4 contain information on the obtained harvesting yield.

Table 2. Dependence of the yield of carrot roots on the application of mineral fertilizers, t / ha, (average value for 2019–2021).

N	Hybrid name, varieties	Experience option	Planned yield	Actual yield
1	Shantane	Control	–	88.37
		$N_{240}P_{120}K_{440}$	90	101.09

		$N_{300}P_{150}K_{550}$	110	100.34
		$N_{360}P_{180}K_{660}$	130	97.83
2	Santa Cruz	Control	–	98.71
		$N_{240}P_{120}K_{440}$	90	115.32
		$N_{300}P_{150}K_{550}$	110	139.25
		$N_{360}P_{180}K_{660}$	130	142.51
3	Red Cor	Control	–	103.73
		$N_{240}P_{120}K_{440}$	90	129.42
		$N_{300}P_{150}K_{550}$	110	148.89
		$N_{360}P_{180}K_{660}$	130	157.31

The analysis of the presented material allows us to state that in the aspect of applying the calculated amount of mineral fertilizers for the planned table carrot yields of 110 and 130 t/ha, it is possible when applying $N_{300}P_{150}K_{550}$ and $N_{360}P_{180}K_{660}$ on modern hybrids of Santa Cruz and Red Cor. While on the released variety Shantane, when applying similar doses of mineral fertilizers for the planned corresponding yields, it formed 100.34 and 97.83 t/ha. Against the background of natural fertility, the yield, depending on the variety or hybrid, varied from 88.37 t/ha (for the Shantane variety) to 103.73 t/ha (Red Core hybrid). That is, the introduction of the planned doses of mineral fertilizers allows you to form a given yield.

Table 3. The yield of carrot roots depending on the use of biological products, t / ha (average value for 2019–2021).

N	Hybrid name, varieties	Experience option	Planned yield	Actual yield
1	Shantane	Control	–	87.45
		1st top dressing	90	93.57
		2nd top dressing	110	102.81
2	Santa Cruz	Control	–	98.71
		1st top dressing	90	113.63
		2nd top dressing	110	130.92
3	Red Cor	Control	–	101.08
		1st top dressing	90	122.68
		2nd top dressing	110	141.39

A statement of the results of the experiments presented in Table 2 allows drawing the following conclusion: on the variants of natural soil fertility, neither the zoned variety nor modern hybrids (Santa Cruz and Red Core) are able to form the programmed yield according to the given program. The picture is completely different after the introduction of the new generation of biological products Agriful and Fertigrain Foliar. With the introduction of one top dressing, a research program was carried out to obtain 90 t/ha (for the Shatane variety – 93.57 t/ha, for the Santa Cruz hybrid – 113.63 t/ha and for the Red Core hybrid – 122.64 t/ha). Applying an additional second top dressing with biological products led to a further increase in the yield of table carrots. As a result, the Shantane variety had a yield of 102.81 t/ha, the Santa Cruz hybrid – 130.92 t/ha, and the Red Core hybrid – 141.39 t/ha. All this indicates that modern hybrids were more responsive to the use of new generation biological products.

Table 4. Dependence of the yield of carrot roots on the complex impact of biological products and mineral nutrition, t / ha (average for 2019–2021).

N	Hybrid name, varieties	Experience option	Planned yield	Actual yield
1	Shantane	Control	–	89.74
		$N_{240}P_{120}K_{440}$ + 1st top dressing	90	1121.67
		$N_{300}P_{150}K_{550}$ + 2nd top dressing	110	123.45

		$N_{360}P_{180}K_{660}$	130	98.11
2	Santa Cruz	Control	–	97.69
		$N_{240}P_{120}K_{440}$ + 1st top dressing	90	131.73
		$N_{300}P_{150}K_{550}$ + 2nd top dressing	110	158.61
		$N_{360}P_{180}K_{660}$	130	141.36
3	Red Cor	Control	–	104.37
		$N_{240}P_{120}K_{440}$ + 1st top dressing	90	141.56
		$N_{300}P_{150}K_{550}$ + 2nd top dressing	110	167.60
		$N_{360}P_{180}K_{660}$	130	172.08

The analysis of the experimental data showed that the maximum yield of carrot roots was obtained with the complex application of biological products, mineral fertilizers $N_{300}P_{150}K_{550}$ at the calculated dosage using the 2nd top dressing. The yield on the Red Core hybrid was 167.7 t/ha. Increasing the dosage of mineral fertilizers to $N_{360}P_{180}K_{660}$ increased the yield on this hybrid up to 172.08 t/ha. The combined use of new generation biological products in conjunction with the applied mineral fertilizers made it possible to raise the yield of table carrots to a higher level. The excess of the actual carrot yield of the Red Core hybrid over the planned yield level (130 t/ha) was 42.08 t/ha.

However, the cost of applied fertilizers was incomparable with the yield increase obtained. Against the background of natural fertility, the lowest root crop yield of 87.45 t/ha was obtained on the zoned variety Shantane. The Santa Cruz hybrid showed intermediate yield values between the released Shantane variety and the promising Red Core hybrid. The maximum yield on this hybrid, on average over three years, was obtained with the variant $N_{300}P_{150}K_{550}$ + 2nd top dressing and it was 158.61 t/ha, while in the control variant it was 97.69 t/ha. That is, the Red Core hybrid proved to be more responsive to the use of mineral fertilizers and the use of biological products.

4 Conclusion

The results of the research over a three-year period allow concluding that the recommendations for commodity producers of the Volgograd region on drip irrigation of chestnut soils for the cultivation of the Red Core hybrid against the background of the application of calculated doses of mineral fertilizers N300P150K550 + 2nd top dressing.

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