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Improving technology elements in multi-purpose carrot cultivation

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Abstract

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The given research conducted in 2015-2017 was carried out to improve technology elements in cultivation of carrots for different target use in natural conditions of the southern forest-steppe zone of the Republic of Bashkortostan. Studies on yield enhancement and technological qualities of carrot depending on its varieties and hybrid cultivars (experiment 1) indicated 51.6-57.1 t/ha of carrot yields depending on hybrids that amounted 105.3-116.5% compared to the control. The highest yield of carrots in the experiment being 57.1 t/ha was shown by Sentiabrina F_1 hybrid cultivar. When using Vermiculite (experiment 2) the diameter of roots increased and the category of the vegetable lowered at the first class. The experiment showed yield rise at the dose of Vermiculite 1.5 l/m^2 and drop at the dose up to 2 l/m^2. Experiment 3 revealed that using Bisol-2 preparation increased the yield of dry matter at the rate of seed treatment 1 and 6 l/ ha. At the rate of 3 l/ha there was a decrease. The sugar content ranges 10.50-11.40%, vitamins vary 11.5-13.8 mg/ kg, and carotene is 259.72-281.63 mg/kg. The best results were received when using Bisol-2 preparation at the seed treatment rate being 1 l/ha. Experiment 4 aimed to study the effect of Prometrin and Stomp herbicides on yield capacity didn't show any influence of herbicides on carrot root shape. Within two years of investigation the highest yield of carrot roots was 33.5 t/ha when using Prometrin herbicide.

Keywords: carrot; variety; hybrid cultivar; vermiculite; Bisol-2; Prometrin; Stomp

Introduction

Carrots (*Daucus carota*) as cultivated crops have been grown since ancient times. Even in 2000 BC it was known to the ancient Greeks and Romans. The fact carrots were grown long time ago is evidenced by fossil carrot roots found in pile buildings in Switzerland (in the Bern Canton) (Bunin et al., 2004). Carrots occupy a significant place among other vegetable crops (more than 10%) in the total structure of acreage. The currently grown orange rooted carotene carrots, we used to see on our tables, weren't as orange, sweet and juicy before (Koltunov & Chepurnyi, 1989). There are evidences of yellow and even black rooted carrots used as food in ancient times. By selecting and breeding different varieties of wild carrots around the world a cultivated carrot was developed. According to Singh et al. (2018) useful properties of black carrots are being studied in India. We have little idea about this variety of carrots compared to orange, red, yellow rooted ones. The greatest number of carotenoids is found in orange-red carrot roots (Singh et al., 2018). Studies of black carrots are conducted by Espinosa-Acosta et al. (2018) using its extracts for scientific purposes.

Carrot roots are rich in carbohydrates, they contain a significant amount of easily digestible mineral salts, different vitamins and other substances useful for the human body. Carrots are valuable for their high nutritional, taste, diet and other qualities. Currently, carrots are grown in all countries of the world, except for the areas with a tropical climate (Mansurova & Latypova, 1976). The target use of carrots is diverse. They are used as a raw material for carotene production. Roots are widely used in cooking as an independent dish and as a seasoning. The crop is a very valuable nutritional food for young cattle, poultry, calves, pigs and other animals. Importance of carrots in animal diets is confirmed by the results of numerous experiments (Chebotaev & Danko, 2010). Animals are attracted by sugar in this vegetable root (Kuznetsov et al., 2018). In medical cosmetics nutritional carrot masks for dry skin have long been popular (Petrova, 1968).

Increasing interest and demand for carrots are limited by its output. Farmers face a number of problems in carrot production. One of the main issues is getting higher yields. Among reasons of low productivity of farms there is an undeveloped carrot cultivation technology and other factors. Good yields of carrots can be obtained by proper selection of farming methods: crop rotation, rational use of fertilizers and plant nutrition, pesticides, plant density, harvest time. The harvest period has a crucial impact on the quality of root crops (Islamgulov et al., 2018). D'Hooghe et al. (2018) suggest considering a root crop diameter to determine a sowing rate of carrots in conditions of the West coast of Normandy. Reid et al. (2018) demonstrate higher potential of carrots at larger doses of nitrogen fertilizers without harmful consequences. At the same time, D'Haene et al. (2018) indicate the need to reduce the amount of nitrogen entering the surface water from carrots. Mineral fertilizers in large doses can lead to higher acidity (Khaibullin et al., 2018). Cotes et al. (2018) specify a special role of an insect control in the carrot cultivation technology. Villeneuve and Latour (2017) stipulate the role of the sowing time.

Higher crop productivity and carrot quality can be provided by correct variety selection with regard to specific soil and climatic conditions. In their studies, Cardoso et al. (2017) claim that expanded carrot variety can develop natural genetic diversity of this vegetable. Japanese scientists Takagi et al. (2017) underline the need to create carrot varieties with higher suitability for mechanized harvesting and high quality seeds and roots. Navez et al. (2017) write about the great impact of the variety on development of root quality, taste and juiciness.

Carrot is a relatively moisture-loving plant. It is very sensitive to the lack of moisture in the initial periods of growth and development (Roux et al., 2018). Carrot roots grow completely submerged in the soil, therefore, they require cultivated fertile soils with a powerful arable layer of light granulometric structure with good water-holding capacity. One of the methods to provide water availability for carrots is to use Vermiculite substrate. Vermiculite is a mineral of the hydrous mica group holding water between its numerous layers. Vermiculite is made from large brown or golden-yellow lamellar crystals formed as a result of hydrolysis and subsequent weathering of dark mica of biotite and phlogopite. High efficiency in water supply for carrots is described in the works of De Carvalho et al. (2018) as well as by Kovácik et al. (2018) describing this process in terms of vermicompost.

Choosing an effective preparation to control plant diseases is one of the ways to provide higher yields of carrots. The correct solution of this issue has a direct impact on crop output and quality as well as costs per unit of production. According to Rao et al. (2017) biological means to protect crops have high efficiency in crop cultivation. However, it should be taken into account that plant protection equipment needs further improvement (Khamaletdinov et al., 2018).

A review of the conducted researches on different technology elements in carrot cultivation shows the need for an additional investigation on the influence of new varieties and hybrids, substrate, biological products and herbicides on development of productivity and quality of carrot roots. In this regard, the purpose of our research (2015-2017) was to improve elements in cultivation technology for carrots of different target use in the natural conditions of the southern forest-steppe zone of the Republic of Bashkortostan.

Thus there was a set of tasks to be solved within the research. They were as follows: to develop crop productivity and technological qualities of carrots depending on varieties and hybrids; to study development of crop productivity and technological qualities of carrots depending on vermiculite applied; to analyze influence of Bisol-2 preparation on carrot yields and root quality; to examine effects of Prometryn and Stomp herbicides on productivity of carrot roots.

Material and Methods

Field studies were conducted as a part of a vegetable crop rotation in the peasant farm enterprise "Agli" located in the Chishminsky district of the Republic of Bashkortostan in 2015-2017. According to the agro-climatic zoning the experimental field is a moderately warm, relatively humidified area. The climate in the region is continental with dry air and high level of solar energy. The natural zone is characterized by relatively sharp weather fluctuations with a rapid change in air temperature. The southern forest-steppe is characterized as a zone with insufficient moisture. Annual rainfall is 471-581 mm. The sum of the effective temperatures is 2116-2311°C. The hydrothermal coefficient is 1.02-1.21. PAR (photosynthetically active radiation) is 1921-2882 kcal/ha.

The soil is leached black soil of heavy loamy granulometric composition with plowing depth of 26-28 cm. Humus layer was 41-45 cm, the total moisture storage in one meter layer of soil reached 312-342 mm. The plowing layer contained 8.1-9.0% of humus, 0.47% of total nitrogen, 0.17% of phosphorus, 0.65% of potassium. Farming technology used in the experiments was generally accepted for the zone. Carrot is cultivated in the special crop rotation: green manured fallow, winter grain crops, carrots, spring grain crops. The predecessor in the experiment was winter wheat. To achieve the goal of the research, 4 field experiences were conducted.

Experiment 1. Studying development of carrot productivity and technological qualities depending on varieties and hybrids. The scheme of one-factor experiment included: Factor A – varieties and hybrids. 1. Control (Losinoostrovskaya 13 variety); 2. Topaz (hybrid); 3. Cascad (hybrid); 4. Osenny korol (variety); 5. Sentiabrina (hybrid); 6. Callisto (hybrid).

Experiment 2. Studying development of carrot productivity and technological qualities depending on use of vermiculite. 1. Without vermiculite (control); 2. Vermiculite, 0.5 l/m^2; 3. Vermiculite, 1.0 l / m^2; 4. Vermiculite, 1.5 l/ m^2; 5. Vermiculite, 2.0 l /m^2.

Experiment 3. Studying effect of Bisol-2 on the yield and quality of carrot roots. The scheme of one-factor experiment included: Factor A – preparation. 1. Control (water); 2. Bisol-2 (1l/ha); 3. Bisol-2 (3 l/ha); 4. Bisol-2 (6 l/ha). Seed treatment before sowing.

Experiment 4. Studying effect of Prometryn and Stomp herbicides on carrot root productivity. The scheme of one-factor experiment included: Factor A – preparation. 1. Control – without treatment; 2. Promethryn (1.5 l); 3. Stomp (1.5 l/ha). Spraying of crops was carried out when three carrot leaves unfolded.

Field experiment was conducted four times in a systematic way. The area of plots is 110 m^2 (the control area is 24 m^2). In accordance with the generally accepted methods there were accounting, observation and analysis. Carrots are planted in raised beds. After harvesting the predecessor there were plowing (disking) using a disc cutter to a depth of 8-10 cm. In 10-14 days there was moldboard plowing to a depth of 30 cm. Then the surface of the soil was leveled out by plowing followed with harrowing in two tracks with heavy tooth harrows (BZTS – 1.0) crosswise plowing. In spring with workability the soil was harrowed at the depth of 5-7 cm by harrows BZTS-1.0 in two traces. Mineral fertilizers were applied with manure spreader AMAZONE and patched by cultivator KPS – 4 at the depth of 6-8 cm. After cultivation beds were developed by the help of a vegetable bed maker MACHIO. The bed had the following dimensions: height of 20 cm, width at the base of 75 cm and at the top 20 cm. After bed development immediately there was sowing carried out by a precision seeder MONOSEM. Two rows with a 10 cm distance between them were sown on each bed. Seeding depth was 2-3 cm, seeding rate – 1 million PCs/ha. At this seeding rate and seeding scheme, the distance between seeds in the row is 2.6 cm.

Results and Discussion

Recently there has been a significant decrease in productivity and quality of carrot varieties resulting in reduced planting acreage in the Republic of Bashkortostan. There is a need of new intensive varieties and hybrids intended for long storage, characterized by high yields with strong and well-developed top that doesn't lodge before stable frosts. It will enhance operation of top lifting harvesters. Roots of these varieties and hybrids must be characterized by high content of sugar and carotene.

To get an objective understanding of the impact of the variety and hybrid on development of carrot root productivity 2 varieties and 4 hybrids recommended for the southern forest-steppe zone of the Republic of Bashkortostan were used in the experiment. Losinoostrovskaia 13 being a recognized variety of domestic breeding was taken as a control crop. As it was proved by studies, carrot productivity in the experiment depended on the varieties and hybrids used. On average for 2015-2017 carrot yields ranged: 49.0-57.1 t/ha (Table 1).

Carrot root productivity depending on their variety was 51.6-57.1 t/ha being 105.3-116.5% compared to the control. Among studied hybrids only one cultivar Callisto F_1 could

Table 1. Carrot root productivity and quality for 2015-2017

Variants	Crop productivity, t/ha	Dry matter, %	Sugar content, %	Carotene, mg%
Losinoostrovskaia 13 (control)	49.0	11.8	7.0	23.88
Callisto F_1	51.6	11.9	7.8	17.18
Topaz F_1	55.3	12.5	8.3	15.54
Cascad F_1	52.3	12.6	8.2	16.85
Osennii korol	52.7	11.6	7.3	18.65
Sentiabrina F_1	57.1	12.8	8.9	23.76

Table 2. Shelf life of carrot varieties and hybrids within 6 months of storage in 2015-2017, %

Variety, hybrid	Output	Losses			Losses due to crop diseases		
		Total	Including		White rot	Gray rot	Phoma rot
			Loss in weight	Loss from diseases			
Losinoostrovskaia 13 (control)	94.3	5.7	2.7	3.0	0.0	2.2	0.8
Callisto F_1	95.4	4.6	2.3	2.3	1.4	0.6	0.3
Topaz F_1	93.5	4.7	3.1	1.6	0.0	0.4	1.2
Cascad F_1	94.0	6.0	2.5	3.5	0.0	0.7	2.8
Osennii korol	91.3	8.7	4.5	4.2	3.2	0.6	0.4
Sentiabrina F_1	97.0	3.0	2.1	0.9	0.0	0.9	0.0

raise its productivity close to the control one. The highest yield of carrots being 57.1 t/ha was shown in the experiment by the Sentiabrina hybrid cultivar F_1. Hybrids were more productive compared to the varieties. However, it should be noted that hybrid progeny is less resistant compared to those of varieties.

According to the results of biochemical analysis of carrot roots the dry matter content was 11.6-12.8%. A relatively high dry matter content (12.8%) was shown by the Sentiabrina F_1 hybrid, (12.6%) by Cascade F1 and (12.5%) by Topaz F1. Sugar content is one of the important indicators of carrot root quality being 7.0-8.9% in the experiment. The high sugar content of roots was in Sentyabrya F1 hybrid (8.9%), (8.3%) in Topaz F1 hybrid and (8.2%) in Cascade F1 hybrid. The lowest sugar content in the experiment had a variety Losinoostrovskaia 13 (7.0%). The carotene content was higher in Losinoostrovskaia 13 being 23.88 mg%. Sentiabrina was the only hybrid studied in terms of the standard variety (23.76 mg%).

The results of studies on carrot root shelf life are presented in Table 2.

All the hybrids and varieties are characterized by long shelf life. For three years the average commercial output ranged 91.3-97.0 % for the storage period of six months at temperature of 0…+1°C air humidity of 90-95%. Not all the hybrids had longer shelf life than the control crop. The highest storage life was performed by Sentiabrina F_1 (97%), Callisto F_1 hybrid (95.4%), Cascad F_1 hybrid (94.0%) with the control being 94.3%. During the experiment, there were found carrot varieties affected to different diseases. Callisto F_1 and Osennii Korol are more affected by white rot. These are 60.8% and 76.1% respectively of the total number of infected carrots. Gray rot affects mostly Losinoostrovskaia 13 variety, Sentiabrina F_1, Cascad F_1 hybrids (100%. 73%. 26% respectively). Phoma rot infects Cascad F_1 and Topaz F_1 (80%. 75% respectively). Commercial output of carrot varieties and hybrids correlates to the losses in weight at storage (r = -0.68) that characterizes respiration rate of carrot roots.

The research results on development of carrot productivity and technological qualities depending on Vermiculite application (experiment 2) showed that doses had an effect on productivity, morphological indicators and quality of carrot roots. Application of different doses of Vermiculite influenced growth rates and weight of carrots. Compared to the control the crop height was more at 5-13 cm weight increased at 700 g at the dose of 2 l/m² with the control being 101 g (Fig. 1).

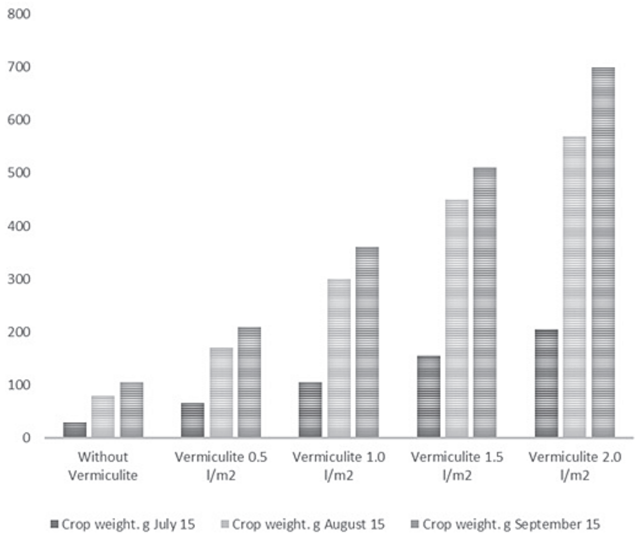

Fig. 1. Carrot weight depending on the Vermiculite doses at different growth periods

The average weight of carrot roots in the experiment ranged 90.0-131.0 g. Weight of crops varied depending on the Vermiculite dose applied. The highest average weight of carrot roots was 131.0 g at the dose of Vermiculite being 2.0 l/m² (Table 3).

Table 3. Morphological indicators and productivity of carrot roots

Variant	The average root weight, g	Root diameter, cm	Root length, cm	Crop productivity, t/ha
Without Vermiculite (control)	90	4	15	35.3
Vermiculite, 0.5 l/m^2	96	5	17	36.3
Vermiculite, 1.0 l/m^2	105	5	19	38.6
Vermiculite, 1.5 l/m^2	130	6	21	42.7
Vermiculite, 2.0 l/m^2	131	6	22	42.2

Carrots of all the studied variants satisfied the requirements of the Russian state standard GOST R 51782-2001 “Fresh garden carrot for retail”. The root diameter was 4-6 cm while the control was of the extra class. Application of Vermiculite enabled growth of the carrot diameter and lowered its class at the first one. The length analysis showed that application of Vermiculite influences on root development up to 17-22 cm with the control being 15 cm. The highest length of carrot roots was 22 cm at the dose of Vermiculite being 2.0 l/m^2. The highest productivity of carrot roots was 42.7 t/ha when the dose of applied Vermiculite was 1.5 l/m^2. There was an increase in productivity from the position of the control to the dose of Vermiculite being 1.5 l/m^2 as well as reduction in productivity at the increased dose of 2 l/m^2.

Besides productivity of carrot roots another important indicator is the quality of roots (Fig. 2). Nitrate content in carrot roots wasn’t higher than the maximum permissible concentration of 250 mg/kg.

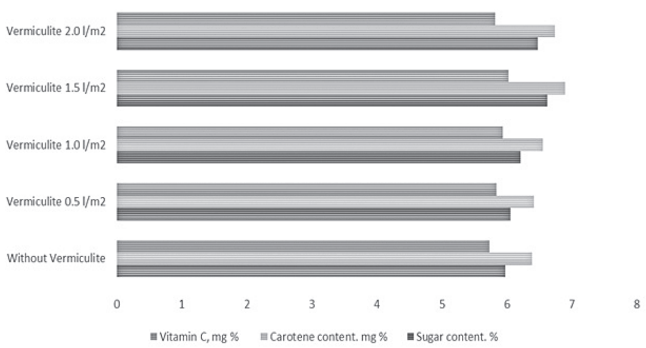

Fig. 2. Quality of carrot roots depending on Vermiculite doses

Sugar content in carrot roots usually varies 4-7%. Vermiculite doses affected the sugar content in the following way. The best sugar content was shown by the variant with 1.5 l/m^2 Vermiculite. This variant had the highest sugar content being 6.62% that is more at 0.64 % compared to the control. The least sugar content was in the control crop. The highest carotene and vitamin C content was observed in the experiment with the dose of Vermiculite being 1.5 l/m^2.

Studies on the effect of Bisol-2 preparation on productivity and quality of carrot roots (experiment 3) showed that these indicators were dependent on the rate of applied preparation (Table 4).

The conducted studies showed that dry matter content was 21.84-26.84%, Bisol-2 application increased dry matter content at the rate of 1 and 6 l/ha and decreased this indicator at the rate 3 l/ha. There is lower initial moisture at the rate of 1 l/ha. The best indicators in the experiment were at applying Bisol-2 preparation at the seed treatment rate of 1 l/ha.

Nitrate content in carrot roots wasn’t higher than the maximum permissible concentration of 250 mg/kg for all the studied variants at Bisol-2 application (Table 5).

The research results show that when using the preparation Bisol-2 at a dose of 1 l/ha, the nitrate content was the lowest, at the control level. An increase in the application rate of the preparation to 3 and 6 l/ha led to an increase in the nitrate content in root crops to 132.6 and 140.3 mg/kg, respectively. The nitrogen content in the roots of carrots was in the range of 0.512-0.783%, phosphorus – 0.110-0.114%, potassium – 0.460-0.500%. The highest rates in the experiment were obtained when using the preparation Bisol-2 with a seed treatment rate of 1 l/ha.

Table 4. Quality of carrot roots depending on the Bisol-2 application rate

№	Variant	Dry matter, %	Initial moisture, %	Content of		
				Sugar, %	Vitamin C, mg/kg (wet weight)	Carotene, mg/kg (wet weight)
1	Control (water)	22.34	75.61	10.57	11.8	260.12
2	Bisol-2 (1 l/ha)	26.84	73.16	11.40	13.8	281.63
3	Bisol-2 (3 l/ha)	21.84	78.16	10.66	12.8	272.75
4	Bisol-2 (6 l/ha)	24.50	75.50	10.50	11.5	259.72

Table 5. Content of nitrates and microelements in carrot roots at seed treatment with Bisol-2 preparation

№	Variant	Nitrates, mg/kg (MPC 250)	Nitrogen, %	Phosphorus, %	Potassium, %
1	Control (water)	130.2	0.512	0.111	0.490
2	Bisol-2 (1 l/ha)	131.6	0.588	0.114	0.500
3	Bisol-2 (3 l/ha)	132.6	0.783	0.110	0.480
4	Bisol-2 (6 l/ha)	140.3	0.483	0.110	0.460

When studying the effect of the herbicides Prometrin and Stomp on the productivity of carrot root crops (experiment 4), the effect of herbicides on the density of carrot seedlings (Table 6) was revealed.

The use of Stomp herbicide in the experiment led to the reduction in seedling density to the level of 742 thousand pcs/ha, at the control of 754 thousand pieces/ha. There is a decrease in weediness when using herbicides by 61.9-80.9%. As a result of the action of the Prometrin preparation, the greatest number of weeds died. The use of herbicides in the experiment had an impact on the morphological features of the structure of root crops (Table 7).

In the experiment, no effect of herbicides on the change in the shape of the root crop was noted. There was an increase in the length of root crops by 87.5-108.0% when using the herbicide Prometrin and 0-50% when applying the herbicide Stomp. There was a change in the length of the head and neck of carrot root vegetables, most when using the herbicide Stomp. There was also a change in the length of the root and the diameter of the carrot root. When applying the herbicide Prometrin, the greatest changes were observed – 7-19 cm and 4.6 cm. Under control: – 4-8 cm and 1-2 cm, respectively.

Fig. 3 shows the yield of carrot root crops depending on the use of herbicides.

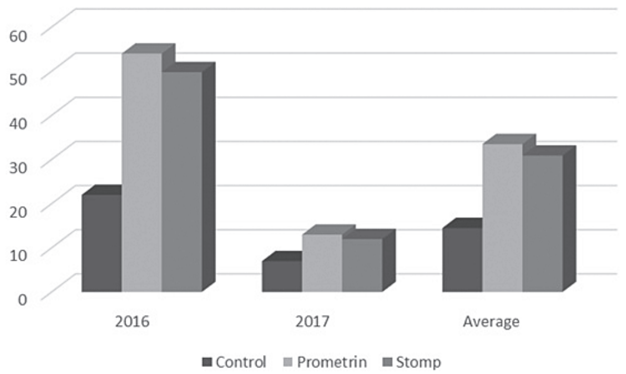

Fig. 3. The yield of carrots root crops, depending on the use of herbicides, t/ha 2016-2017

The experiment noted the positive effect of the use of herbicides Prometrin and Stump on the yield of carrot root crops. In general, for the 2016-2017, the yield of carrots when using the herbicide Prometrin was in the range of 13.0-54.0 t/ha, the herbicide Stomp – 12.0-49.8 t/ha, under control

Table 6. The effectiveness of the use of herbicides on carrot crops (2016 – 2017)

Variant	The rate of herbicide, l/ha	Density of shoots of carrots, thousand pcs/ha	Weediness		Reduction of weediness, % of control	
			pcs/m²	g/m²	quantity	mass
Control (without processing)	–	754	21	159	–	–
Prometrin	1.5	768	4	58	80.9	63.5
Stomp	1.5	742	8	98	61.9	39.3

Table 7. Morphological features of the structure of root crops depending on herbicides

Indeces	Description of root crops					
	Control (without processing)		Prometrin		Stomp	
	2016	2017	2016	2017	2016	2017
Shape of the root crops	conical		conical		conical	
Length of root crops, cm	12	8	25	15	18	12
Length of the head, cm	1	0.5	1.5	1	2	1
Length of the neck, cm	4	2.5	4.5	3	6	4
Length of the root crop itself, cm	8	4	19	7	10	4
Diameter of the root crop, cm	2	1	6	4	5	3

– 7.0-22.0 t/ha. When applying the herbicide Prometrin, the highest yield of carrot root crops was noted – 33.5 t/ha on average over 2 years of research.

The issue of carrot selection in the world is given special attention. So Indian scientists Singh et al. (2018) developed the Pusa Rudhira variety with long red fleshed roots with high juice content, sweetness and self-colored root crops that had a distinct advantage over the popular variety Desi Red. The particular attention is given in China to the creation of new varieties of carrots using the genetic engineering (Wang et al., 2018). An inbred line DC-27 was created, obtained by the method of self-pollination from the variety Kurodagosun using a combination of Roche 454 and HiSeq 2000 sequencing technology to achieve 32-fold coverage of the genome. In contrast to these studies, in Experiment 1, varieties and hybrids approved for use in the conditions of the Republic of Bashkortostan were studied. The soil and climatic conditions of the republic do not allow to successfully use the varieties from India and China. However, these solutions can be used in selection work when creating new Russian carrot varieties. The serious practical interest is represented by strengthening the Sentjabrina F_1 hybrid. Particular attention should be paid to the differences between hybrids and varieties in terms of degradation with each succeeding generation.

The use of Vermiculite contributed to the improvement of germination and protocorms development of Acianthera prolifera in studies of Koene et al. (2018). According to Chaudhary et al. (2018) it could be concluded that media containing cocopeat and Vermiculite either with soil or perlite observed to be the best substrate for growth, flowering and bulb production of Lilium. There is almost no data on the application of Vermiculite in the cultivation of carrots. This is a new direction. It should be noted that the use of Vermiculite has its limitations. There is an increase in yield in the experiment from zero to the dose of making Vermiculite 1.5 l/m^2 and a decrease in the yield of carrot root crops with an increase in dose to 2 l/m^2.

Of particular interest among researchers is the use of carrot growth simulators. To study the effect of gibberellins on the growth of carrots Wang et al. (2015) treated the carrots plants with gibberellic acid 3 (GA3). The results found that GA3 dramatically reduced root growth, but stimulated the growth of carrot seedlings. Scientists from India Shivakuma and Bhaktavatchalu (2017) note that plant growth in stressful conditions, on the contrary can be enhanced by the use of microbial inoculation, including rhizobacteria stimulating plant growth (PGPR). These microbes promote plant growth by regulating nutrition and hormonal balance, producing plant growth regulators, solubilizing substances and causing resistance against plant pathogens. The component of the Bisol-2 preparation is the N. N′- tetramethyl methylenediamine oxalate salt. The experiment in its application to carrots is search. It is noted that increasing the dose of the Bisol-2 preparation when treating carrot seeds above 1 l/ha had a lower efficiency.

The complexity of the work of herbicides in crops of carrots is the possibility of its damage due to improper selection of the dose of use of preparations. The experience of Correia and De Carvalho (2018) with Metribuzin shows that the herbicide has a serious effect, depending on the use in various phases of carrot development. So the application in the 5-leaf phase is marked by a depressing effect and the higher the dose, the more severe the oppression, while it is not observed when applied in the 2-leaf phase. In our experiments, the herbicides Prometrin and Metribuzin belong to the chemical class of triazinones. As in the experiments of Brazilian colleagues, the use of herbicides of this chemical class in the 3-leaf phase did not adversely affect the yield and quality of carrots, while the use of the herbicide Stomp from the chemical class of dinitro-anilines was less effective. It should be noted that the control variant was significantly inferior to both variants with the use of herbicides in yield.

Conclusions

The yield of beetroot, depending on the hybrid, was 51.6-57.1 t/ha, which amounted to 105.3-116.5% of the control. Among the studied hybrids in the experiment only one variety – Callisto F1 was able to generate yield close to the control variety. The highest yield of carrots in the experiment was shown by the Sentiabrina hybrid cultivar F_1-57.1 t/ha. The hybrids were able to show higher rates in contrast to grade. The high sugar content of root crops differed in the hybrid of Sentyabrina F1 (8.9%), hybrid Topaz F1 (8.3%) and hybrid Cascade F1 (8.2%). Not all hybrids in the experiment had preservation above the control variant. The high degree of preservation of root crops was distinguished in the hybrid of Sentyabrina F1.

The use of different doses of Vermiculite affected the growth processes of carrots and the mass of plants. The average weight of carrots in the experiment was in the range of 90.0-131.0 g. The maximum average weight of the roots was when Vermiculite was introduced with a dose of 2.0 l/m^2 – 131.0 g. The use of Vermiculite increased the diameter of the carrot and reduced its classiness to the position of class 1. The analysis of the length of the root showed that the use of Vermiculite affects the increased development of the root to 17-22 cm with the control of 15 cm. The highest yield of carrot roots 42.7 t/ha was obtained with a dose of Vermiculite of 1.5 l/m^2. In the experiment, an increase in the yield from the control position to the dose of Vermiculite 1.5 l/m[2] and a decrease in the yield of carrot root crops with an increase in the dose to 2 l/m[2] was noted.

In the experiments, the effect of the use of various norms of the Bisol-2 preparation on the yield and quality of carrots was noted. The use of the preparation Bisol-2 contributed to an increase in the yield of dry matter at a seed treatment rate of 1 and 6 l/ha and a decrease at a rate of 3 l/ha. The sugar content ranges 10.50-11.40%, vitamins vary 11.5-13.8 mg/kg, and carotene is 259.72-281.63 mg/kg. The best results in the experiment were obtained using the Bisol-2 preparation with a seed treatment rate of 1 l/ha.

The use of Stomp herbicide in the experiment led to a decrease in the density of seedlings to a level of 742 thousand pcs/ha, at the control of 754 thousand pcs/ha. A decrease in weediness with the application of herbicides is noted at 61.9-80.9%. As a result of the action of the Prometrin preparation, the greatest number of weeds died. In the experiment, the effect of herbicides on the change in the shape of the root crop was not observed. There was an increase in the length of root crops by 87.5-108.0% when using the herbicide Prometrin and 0-50% when applying the herbicide Stomp. When applying the herbicide Prometrin, the highest productivity of carrot root crops was noted – 33.5 t/ha, on average over 2 years of research.

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