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Yield and Quality of Table Beet Depending on Cultivation Technology Elements

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Abstract: The research was conducted in 2015-2017 to study the theoretical basis and farm practices of high-yield beet cultivation in the natural conditions of the Republic of Bashkortostan. To achieve the goal, 4 field experiments were performed. The study of the yield and technological qualities of 7 cultivars and 4 hybrids of table beet (experiment 1) has shown that beetroot yield depends on the varietal differences in the crop. The analysis of the table beet yields showed that, the values varied within the limits of 32.4-57.7 ton/ha. Red cloud hybrid demonstrated the highest yield rates and best marketable quality in the experiment. The study of table beet yield capacity and technological qualities in relation to sowing time (experiment 2) has revealed that sowing time has an effect on yield, marketable values and quality of table beet. The data analysis indicates that the early-middle sowing period ensures the highest yields (35.3 ton/ha). The 3rd experiment demonstrated that different amounts of potassium resulted in beet yield values varying from 34.7-59.8 ton/ha. The 4th experiment on the morphological indices of table beet and the beet intact state has shown that roots of Bohemia and Bikores cultivars have the greatest in-soil depth (37 and 36%, respectively) and Renovacultivar has the smallest (23%). Dvusemyannaya (two seeded) TSKhA beet cultivar demonstrated the best intactness quality.

Key words: Table beet, cultivar, yield, quality, cultivation technolog, roots

INTRODUCTION

Table beet (*Beta vulgaris* L.) is one of the most widespread vegetable crops in the world. It ranks 3rd among root crops in nutritional value. It is widely used in salads and soups. It is used as natural colourstuff in confectionery production (Ismagilov and Akhiyarov, 2011; Krug, 2000). In recent years, biological activity of red beet (*Beta vulgaris* rubra) andits potential utility as a health promoting and disease preventing functional food have gained increased attention. Beetroot is also being considered as a promising therapeutic treatment in a range of clinical pathologies associated with oxidative stress and inflammation. Clifford *et al*. (2015) report that its constituents, most notably the betalain pigments, display potent antioxidant, anti-inflammatory and chemo-preventive activity *in vitro* and *in vivo*.

The growing interest is impeded by table beet production rates which is associated with a number of problems faced by the farmers. One of the main problems is a low crop yield capacity. Insufficient adapted cultivation technology and other factors result in low table beet yields. A proper selection of agricultural techniques such as crop rotation, cultivar, irrigation, plant density, harvesting time, rational application of fertilizers is the key to high beet yields (Ermakov and Golubovich, 2015).

In developing a cultivation technology an account has to be taken of soil characteristics, climatic conditions, anthropogenic factors and consumer qualities. The table beet yield models developed by Borodychev and Mikhailov (2017) demonstrate that soil moisture and density have the greatest effect on yield capacity under various climatic conditions. Gomes *et al*. (2015) achieved good results in increasing table beet yields by irrigating the beet with wastewater combined with different amounts of nitrogen fertilizers. Khan *et al*. (1992) point that preplant conditioning improves yield in table beet and reduces root disease incidence.

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A proper selection of a cultivar made in line with specific soil and climatic conditions is the basis for improving yields and quality in crops. The experiment conducted by Niziol-Lukaszewska and Gaweda in Poland on 15 table beet cultivars has shown that a cultivar type has a great effect on both yield and ability to accumulate heavy metals in beetroots. Cultivars with cylindrical root shapes such as Rywal and Opolski demonstrated the lowest ability to accumulate heavy metals (Cd and Cr) (Niziol-Lukaszewska and Gaweda, 2016).

Studies by Islamgulov (2014) and Islamgulov and Islamgulov (2000) also, reported of the effect of the cultivar on yields and technological qualities in beetroots.

Application of mineral fertilizers is a challenging issue in table beet cultivation. Mampa *et al.* (2017) assessed nitrogen application at 0, 60, 90, 120 and 150 kg/ha and indicate that nitrogen application at 90 and 120 kg/ha increased fresh leaf weight, leaf number and fresh and dry root weight including root diameter and length with the exception of leaf area which was significantly higher at 120 kg/ha. Magnesium and iron leaf content and nitrogen root content were significantly improved by the application of 120 kg/ha N (Mampa *et al.*, 2017). Much attention to nitrogen application in table beet growing was paid by Feller and Fink (2004). They developed a model for the nitrogen application based on two-year studies of 55 combinations of nitrogen fertilizer levels (Feller and Fink, 2002). Mack (1989) concluded from his studies that an increase in nitrogen application from 56-224 kg/ha produces increased nitrogen concentration in leaves by increasing the rate of N while K concentration was decreased at a higher N rate. Similar patterns of lower beet root quality at high nitrogen rates were obtained by Islamgulov *et al.* (2014).

Many soils used for vegetable growing are usually heavily fertilized and thus have accumulated large P amounts and average K amounts (Peck and MacDonald, 1981). P and K application should be adjusted to obtain optimal plant response to their residual amount in the soil. Residual P and K in soil and PK fertilizers increased yield of root crops. Positive responses to yields were greater with the application of PK fertilizers than with band-applied P and K (Peck and MacDonald, 1981).

Makarychev found that Bordeaux table beet 237 had a positive response to the application of higher rates of sodium chloride (against NPK background) in the environment of the Altai Ob region which increased root crop yield and sugar production. An increase in dry matter, crude protein and vitamin C along with a decrease in crude fiber and nitrates was reported. Increased sodium chloride application produced reduced K amounts and increased amounts of nitrogen, phosphorus and sodium in the dry matter of table beet roots and tops (Vladimirovich *et al.*, 2015) Complete uptake of mineral fertilizers was found.

Dolgopolov and Timakov (2014) point at a high role of silicon in the stand establishment of table beet. Silicon plays an important role in plant metabolism, makes up plant structure and positively affects the stem strength. Application of silicon fertilizers is necessary to balance the element in agricultural ecosystems. A study of the effect of diatomite (the Kamyshlovsky field, Sverdlovsk Region) on table beet growth, development and yield contained three experiment designs: mineral fertilizers (N_{90}, P_{90} and K_{90} as the background, the background+diatomite at 2.0 ton/ha, the background+diatomite at 4 ton/ha. The study has revealed that application of diatomites in table beet cultivation in the Middle Urals environment enhances table beet yield by 4.6-6.6 ton/ha or 13-19%, improves marketable beet, increases root weight and by product output (Dolgopolova and Timakova, 2014).

Biochemical composition is the main quality factor of beetroot. It determines beetroot nutritional and taste values as well as dietary features. Marketable quality as the quantity of beet suitable for sale and storage is another quality parameter of beetroot (Burenin *et al.*, 2016). Marketable beetroots largely depend on cultivar type and seeding time. At present, cultivars and hybrids are very popular due to uniform beetroot size and shape. It is important to use table beet cultivars and hybrids specially selected for specific soil and climate conditions and supported by 2-3 years experimental evidence.

Haste should be avoided in beet sowing. As early beet sowing time at low temperatures may bring about complete vernalization processes in beet germs, beets quickly start shooting and blossoming without root building, so, beet are sown somewhat later than other root crops (carrots, parsley, parsnip, etc). Emergence of beet takes place in 14 days after sowing at an air and soil temperature of 8, ..., 100°C and in 5-7 days after sowing at 18°C (Krug, 2000; Litvinov, 2003).

For long-term storage beetroots should contain large amounts of sugar which ensures good beet keeping quality. Increased betanin in beetroot is important for beet when used as a food colourstuff in confectionery production. Increased vitamins and minerals are essential for beet when used for salads. Dyachenko (1979) came to the conclusion that the optimal seeding time is the early to middle spring sowing and Nesravnennaya (Incomparable) and Podzimnyaya (Early Winter) cultivars have the greatest accumulation of betanin (190 mg%) (Krug, 2000). In contrast, middle spring sowing time is optimal for Bordeaux 237 and DvusemyannayaTSKhA cultivars with betanin content at 582 and 592 mg%, respectively, compared to the Dutch cultivars (438-582 mg%).

Better dying pigments were found in monogermsamples such as Odnorostkovaya (207 mg), Odonsemyannaya (253 mg%) and Monogerm explorer (218 mg%).

The review of the studies on various elements of table beet cultivation technology demonstrates the need to study the effects of soil and climatic conditions, fertilizer application and sowing time on yield and quality of new beetroot cultivars and hybrids of Russian and foreign selection. The goal of our research (done in 2015-2017) was to develop the theoretical basis and farm practices for growing high-yield table beet in the natural conditions of the Southern forest-steppe zone of the Republic of Bashkortostan.

MATERIALS AND METHODS

Field experiments were performed on a vegetable rotation basis of the “Agli” farm of Chishminsky District of the Republic of Bashkortostan in 2015-2017. The field featured leached Chernozem (black soil), the arable layer depth was 28 cm. Conventional farm machinery was used in experiments. Spring wheat had been grown on the farm before the experiment. Four field experiments were performed to achieve the research goal.

Experiment 1: Yield capacity and technological qualities of table beet were studied in relation to cultivars and hybrids. The single-factor experiment design considered factor A as cultivars and hybrids. Control (DvusemyannayaTSKhA cultivar). Akela (cultivar). Bohemia (cultivar). Detroit (cultivar). Mulatto (cultivar). Bikores (cultivar). Red ball (cultivar). BejoF_1 (hybrid). Pablo F_1 (hybrid). Red cloud F_1 (hybrid). Cornell F_1 (hybrid).

Experiment 2: Yield capacity and technological qualities of table beet were studied in relation to sowing time. The single-factor experiment design considered factor A as sowing time. Early sowing time (28.04). Early to middle sowing time (5.05). Middle sowing time (12.05) (Control). Middle to late sowing time (19.05).

Experiment 3: Yield capacity and technological qualities of table beet were studied in relation to mineral fertilizers and cultivars (hybrids). The two factor experiment design considered factor A as a mineral fertilizers application rate. $N_{90}P_{80}K_{60}$. $N_{90}P_{80}K_{90}$ (control). $N_{90}P_{80}K_{120}$. $N_{90}P_{80}K_{180}$ $N_{90}P_{80}K_{210}$. Factor B was cultivars and hybrids. DvusemyannayaTSKhA (cultivar, control). Renova (cultivar). Red cloud F_1 (hybrid).

Experiment 4: Morphological indices and intactness of table beet roots in relation to the cultivar were studied. The single-factor experiment design considered factor A as a cultivar. Control (Dvusemyannaya TSKhA (cultivar). Bohemia (cultivar). Renova (cultivar). Bikores (cultivar).

The field experiment was performed in a systematic way in four replications. Fertilizers were applied in spring before the cultivation process. The plot area was 100 m^2 (account area was 20 m^2). Records, observations and analyses were performed based on the conventional techniques. Table beet were sown (8-10 kg/1 ha) in accordance with the sowing standards recommended for the Southern forest-steppe zone of the Republic of Bashkortostan. Monosem precision seed drill with a row spacing of 45 cm was employed for beet planting.

In terms of farm and climate zoning, the experimental field area belongs to a relatively warm, medium-moist region. The climate is continental with dry air and high solar energy input. The area features extreme changes in weather and air temperature.

The Southern forest-steppe falls within the insufficient moisture zone. The total of effective temperatures is 2115-2315°C. The annual precipitation is 474-579 mm. Precipitation is highly uneven. The hydrothermal coefficient is 1.03-1.22. The photosynthetically active radiation input varies from 1925 to 2885 kcal/ha. The humus accumulated horizon was 43-48 cm thick, the total moisture deposits in one meter soil layer reached 315-340 mm. The plow layer contained an average of 8.0-9.1% humus, a total of 0.48% nitrogen, 0.18% phosphorus, 0.17% potassium.

RESULTS AND DISCUSSION

The 7 cultivars and 4 hybrids recommended for use in the conditions of the southern forest-steppe zone of the Republic of Bashkortostan were used in Experiment 1 for an objective idea of the effect of cultivar and hybrid on the yield of beetroot crops. The recognized cultivar of domestic breeding. Dvusemyannaya TSKhA was taken as a control. As shown by the research, the yield of beetroot crops in the experiment depended on the cultivars and hybrids used.

The analysis of the yield of beetroot crops showed that on average it varied within 32.4-57.7 ton/ha over 2015-2017 (Fig. 1).

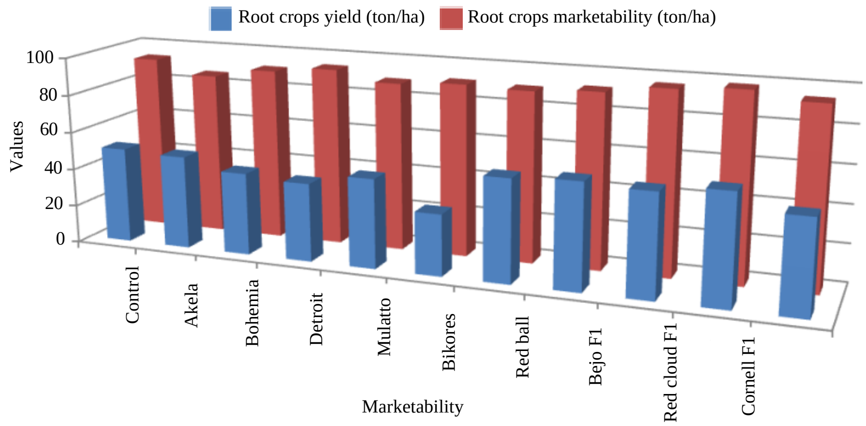

Fig. 1: Yield and marketability of beetroot cultivars and hybrids (2015-2017) (ton/ha)

Depending on the cultivar the yield of beetroot crops was 32.4-54.1 ton/ha which amounted to 64.0-106.9% of the control. Among the cultivars studied in the experiment, only one cultivar. Red ball was able to form a yield above the control cultivar. The lowest yield was obtained from Bikores cultivar (32.4 ton/ha) and Detroit cultivar (41.4 ton/ha). Depending on the applied hybrid the yield of beetroot crops was 49.1-57.7 ton/ha or 97.0-114.0% of the control. A hybrid of Red cloud F_1 formed the maximum yield of root crops in the experiment 57.7 ton/ha. Hybrids showed higher yield in contrast to the varieties. Only one hybrid cornell F_1 had 97% to the control while the rest showed from 106.9-114% to the yield of the control cultivar.

Marketability is the main quality parameter in the vegetable production. Marketability is determined in accordance with GOST R 51811-2001 "Fresh beetroot, sold in the retail trade network". The marketability indicators did not have a direct tendency with yields in the experiment.

On average the root crops marketability amounted to 86-98% over 2015-2017. The root crops marketability was 86-94% among the cultivars, 92-98% among hybrids with the control of 93%. Only Detroit cultivar was able to form marketability above control among the hybrids Pablo F_1, Red cloud F_1 and Cornell F_1. A hybrid of Red cloud F_1 formed the best indicators of beetroot crops marketability in the experiment 98%.**

According to the results of biochemical analysis of beetroot crops in the experiment, the dry matter content was 13.4-17.1% (Table 1). The relatively high dry matter content (17.1%) had Dvusemyannaya TSKhA cultivar and Detroit cultivar (16.8%). Among the hybrids, Pablo (16.2%) and red cloud (16.1%) had high dry matter content. One of the important indicators of root crops quality is their sugar content which was 10.0-14.75% in the experiment. Dvusemyannaya TSKhA control cultivar (14.7%) and Pablo F_1 hybrid (14.4%) and Red cloud F_1 hybrid (13.9%) had high sugar content of root crops. Bohemia cultivar had the lowest sugar content in the experiment 10.0%. According to the content of vitamin C in root crops, Bohemia cultivar was predominant 15.7 mg%. Detroit cultivar (14.1 mg%) and Pablo F_1 hybrid (13.7 mg%) were at the level of standard cultivar (Dvusemyannaya TSKhA).

Table 1: Quality of beetroot crops cultivars and hybrids (2015-2017) (%)

Cultivar	Dry matter content (%)	Sugar content (%)	Vitamin C content (mg %)
Dvusemyannaya TSKhA (control)	17.10	14.70	14.00
Akela	14.90	10.30	13.40
Bohemia	13.40	10.00	15.70
Detroit	16.80	11.60	14.10
Mulatto	15.60	13.80	13.00
Bikores	15.90	12.20	13.20
Red ball	14.30	10.80	12.40
BejoF_1	14.80	11.50	12.10
Pablo F_1	16.20	14.40	13.70
Red cloud F_1	16.10	13.90	13.50
Cornell F_1	13.70	10.60	9.60
LSD_{05}	0.07	0.09	0.04

The results of studying the formation of beetroot yield and technological qualities depending on the sowing time (Experiment 2) showed that the sowing time affects the yield, marketability and quality of root crops. The analysis of the obtained data indicates that the most productive option is the early-mid sowing time (May 5) (Table 2). With the later sowing time the yield of root crops decreased. This pattern is associated with the violation of the water consumption regime and nutrition. The lowest average yield over 2015-2017 was 35.3 t/ha or 69.8% of the control variant. Our studies have found that the increase in the mass of root crops occurs constantly but the rate of this process in different periods was not the same. The greatest beetroot weight by the end of

Table 2: Yield of Dvusemyannaya TSKhA beetroot cultivar depending on the sowing time (2015-2017)

Sowing time	Root crop yield (ton/ha)	To the control (%)	Marketable yield of root crops (ton/ha)	Root crop marketability (%)
Early (28.04)	35.30	69.80	32.80	93.00
Early-mid (5.05)	53.70	106.10	51.00	95.00
Middle (12.05) (control)	50.60	100.00	47.10	93.00
Mid-late (19.05)	45.60	77.40	42.00	92.00
Late (26.05)	38.90	76.90	35.40	91.00
LSD_{05}	1.92	0.44	1.89	0.95

Table 3: Quality of Dvusemyannaya TSKhA beetroot cultivar depending on the sowing time (2015-2017)

Sowing time	Dry matter content (%)	Sugar content (%)	Vitamin C content (mg %)
Early (28.04)	17.80	15.10	15.80
Early-mid (5.05)	17.90	15.20	16.10
Middle (12.05) (control)	17.00	14.70	14.00
Mid-late (19.05)	16.50	14.10	13.40
Late (26.05)	15.30	13.80	13.10
LSD_{05}	0.09	0.07	0.06

growth and development was 278 g at early sowing time (28.04) and 225 g at early-mid sowing time (05.05) and the lowest 174 g at late sowing time (26.05).

Marketable yield of root crops in the experiment was within the limits of 32.8-51.0 ton/ha. The root crop marketability varied depending on the sowing time. Maximum root crop marketability was at early-mid sowing time 95.0%. It was revealed that at early, middle and late sowing time the root crop marketability decreased to 93.0, 92.0 and 91.0%, respectively.

The quality of beetroot crops is estimated by their appearance the roots are fresh whole without damage by agricultural pests, typical shape and color for the given cultivar, root crop size the largest transverse diameter 5-14 cm, smell and taste characteristic of this botanical cultivar without foreign smell and taste. Our studies have shown that, the sowing time largely determines the formation process of the beetroot yield. The diameter is among the main root crop characteristics. Depending on the sowing time the largest beetroot diameter was at early sowing time and amounted to 11.4 cm, the smallest diameter was at the late sowing time (8.1 cm).

According to the results of biochemical analysis of beetroots in the experiment, the dry matter content was 15.3-17.9% (Table 3). The relatively high dry matter content (17.9 %) was at mid-early sowing time with the control of 17.0%. The study showed that beetroot quality varies depending on the sowing time. The content of dry matter, sugar and vitamin C was the highest at the early and mid-early sowing time. The best quality indicators were obtained at mid-early sowing time (05.05). This is due to the fact that the processes of substance accumulation occur under optimal conditions low temperatures and sufficient amount of moisture. At early sowing time there is increased temperature and low water supply. At late sowing time soil moisture increases before harvesting which leads to increased dirtiness of root crops.

In general, according to the experiment the sugar content of root crops was approximately 13.8-15.2% over 3 years. Early-mid sowing time was noted for high sugar content of root crops. The lowest rates of sugar content were observed at late sowing time held on May 26. According to the content of vitamin C in root crops, 2 sowing periods were distinguished early and early-mid, with early-mid dominance (16.1 mg%). When sowing beetroot at a later date, the content of vitamin C decreased.

As a result of studying beetroot yield formation and technological qualities depending on mineral fertilizers with different content of potassium and cultivar (hybrid), it was revealed that this element affects the indicators under study. The use of various potassium doses from 60-210 was studied in Experiment 3 with a total nitrogen and phosphorus content of 90 and 80 (Table 4).

The beetroot crop yield depending on mineral fertilizers with different potassium content amounted to 34.7-59.8 ton/ha. It was revealed that the application of potash fertilizer with a dose of 60 does not contribute to obtaining high yields. A significant increase in yield is observed when making potassium norm of 120-210 which provided yield at the level of 49.6-59.8 ton/ha with the control of 46.9-57.7 ton/ha (K_{90}). Red cloud F þeetroot hybrid formed the best root crop yield over 2015-2017. The experiment showed a decrease in the root crop yield with an increase in the potassium rate application from 180-210 with all three cultivars (hybrids) under study. The best yields of Renova cultivar, unlike Dvusemyannaya TSKhA cultivar and red cloud F_1 hybrid ($N_{90}P_{80}K_{180}$) were obtained by the application of $N_{90}P_{80}K_{120}$. This in turn, indicates the peculiarities of cultivar (hybrid) development when high doses of potasssium fertilizers are received and their direct influence on yields.

Root crop marketability also varied depending on the cultivar and dose of potash fertilizers. With the increase in doses of potash fertilizers root crop marketability also increases. The highest root crop marketability was formed by red cloud F_1 hybrid (87-96%), the lowest by Renova cultivar 87-92% with the control of 87-94%. Marketable yield of root crops in the experiment was 30.2-56.8%. The highest index was obtained by using Red cloud F_1 hybrid when applying mineral fertilizers with the norm of $N_{90}P_{80}K_{180}$.

When analyzing the root crops grown at different rates of potash fertilizers, the dry matter content in the root crops varies (Table 5).

Table 4: Yield and marketability of beetroot crops depending on the dose of potash fertilizers and cultivar (hybrid) (2015-2017)

Variant				
Cultivar (hybrid)	Dose of potash fertilizers (kg ra/ha)	Root crop yield (ton/ha)	Root crop marketability (%)	Marketable yield of root crops (ton/ha)
Dvusemyannaya TSKhA (control)	$N_{90}P_{80}K_{60}$	39.4	89	35.1
	$N_{90}P_{80}K_{90}$ (control)	50.6	93	47.1
	$N_{90}P_{80}K_{120}$	53.8	92	49.5
	$N_{90}P_{80}K_{180}$	55.6	93	51.7
	$N_{90}P_{80}K_{210}$	55.2	94	51.9
Renova	$N_{90}P_{80}K_{60}$	34.7	87	30.2
	$N_{90}P_{80}K_{90}$ (control)	46.8	88	41.2
	$N_{90}P_{80}K_{120}$	49.6	90	44.6
	$N_{90}P_{80}K_{180}$	49.1	92	45.2
	$N_{90}P_{80}K_{210}$	48.7	92	44.8
Red cloud F_1	$N_{90}P_{80}K_{60}$	41.3	87	35.9
	$N_{90}P_{80}K_{90}$ (control)	57.7	96	55.4
	$N_{90}P_{80}K_{120}$	58.6	93	54.5
	$N_{90}P_{80}K_{180}$	59.8	95	56.8
	$N_{90}P_{80}K_{210}$	59.1	94	55.6

Table 5: Dry matter and sugar content in beetroot crops depending on the rate of application of potash fertilizers and cultivar (hybrid) (2015-2017)

Variant			
Cultivar (hybrid)	Dose of potash fertilizers	Dry matter content (%)	Sugar content (%)
Dvusemyannaya TSKhA (control)	$N_{90}P_{80}K_{60}$	14.4	10.3
	$N_{90}P_{80}K_{90}$ (control)	16.3	12.7
	$N_{90}P_{80}K_{120}$	17.6	13.4
	$N_{90}P_{80}K_{180}$	18.1	13.9
	$N_{90}P_{80}K_{210}$	18.7	14.6
Renova	$N_{90}P_{80}K_{60}$	10.6	8.6
	$N_{90}P_{80}K_{90}$ (control)	12.1	10.9
	$N_{90}P_{80}K_{120}$	12.7	11.4
	$N_{90}P_{80}K_{180}$	13.2	11.7
	$N_{90}P_{80}K_{210}$	13.6	12.1
Red cloud F_1	$N_{90}P_{80}K_{60}$	13.9	10.5
	$N_{90}P_{80}K_{90}$ (control)	16.1	12.4
	$N_{90}P_{80}K_{120}$	17.2	12.9
	$N_{90}P_{80}K_{180}$	17.8	13.7
	$N_{90}P_{80}K_{210}$	18.4	14.2

The dry matter content in the experiment was 10.6-18.7%. With the increase in the potassium rate application, an increase in dry matter content was noted. When using Dvusemyannaya TSKhA cultivar (control) with an increase in potassium rate from 90 to 210, the dry matter content increased from 16.3 to 18.7, in Renova cultivar this index was 12.1-13.9 in Red cloud F_1 hybrid it was equal to 16.1-18.4. The highest potassium content in the experiment was obtained at the rate of $N_{90}P_{80}K_{210}$. Dvusemyannaya TSKhA cultivar provided the best results.

On average, over the years of the trial Dvusemyannaya TSKhA cultivar had the highest sugar content of root crops 14.6% ($N_{90}P_{80}K_{210}$), the lowest Renova 8.6% ($N_{90}P_{80}K_{60}$). Thus, the cultivars studied differ in sugar content of root crops. With the increase in the potassium rate application, an increase in sugar content of root crops was noted. The highest sugar content indices of root crops in the experiment were obtained at a rate of $N_{90}P_{80}K_{210}$. DvusemyannayaTSKhA cultivar showed the best results.

Vitamin C is involved in the redox regulation, carbohydrate metabolism, enzyme activation, etc. Root crops of Renova cultivar contained the highest amount of vitamin C. Potassium dose affects the content of vitamin C in the beetroot crops. The higher the dose, the more vitamin C is in the root crops. This connection was observed in all variants of the experiment during all the years of testing. Potash fertilizers increased root crop preservation capacity during winter storage along with the quality improvement.

In terms of suitability for the mechanized beetroot cultivation morphological characteristics are of primary importance: the size and shape of the leaf rosette, the uniformity and in-soil depth of beetroots. The method of beetroot crop harvesting depends on in-soil depth of beetroots. If the root goes deep more than half of its size, you can use the machines of KS-6 and RKS-6 type, if in-soil depth of beetroots is not great then use the machines of EM-11 and MMT-1type. Thus, the less is in-soil depth of beetroots, the easier it is to pull it out.

On the basis of Experiment 4 on the morphological characteristics of beetroot crops and their preservation capacity depending on the cultivar, it was determined that the greatest in-soil depth of roots was observed in Bohemia and Bikores cultivars 37 and 36% ,respectively and the smallest in Renova cultivar (23 %). The root crops of Renova cultivar go strongly above the soil which facilitates their harvesting (Table 6).

Experimental data have shown that, the head length of the root crop indicates how large it is and whether a particular cultivar is suitable for mechanized harvesting of root crops and tops. DvusemyannayaTSKhA cultivar formed the smallest head length of the root crop 1.0 cm.

The root neck length was 4.4 cm in Bohemia cultivar, 11.8 cm in Renova cultivar and 5.3 cm in DvusemyannayaTSKhA cultivar. Renova cultivar had the

Table 6: Morphological characteristics of beetroot crops (2015-2017) (%)

Cultivar	In-soil depth (%)	Head length (cm)	Neck length (cm)	Own root length (cm)
Bohemia	37	1.1	4.4	4.6
Renova	23	1.4	11.8	3.0
Dvusemyannaya TSKhA (control)	33	1.0	5.3	3.5
Bikores	36	1.2	4.6	4.7

largest root neck length which was associated with the prolonged root shape. The root length which determines the in-soil depth of the root was 4.7 cm in Bikores cultivar, 4.6 in Bohemia cultivar, 3.0 cm in Renova cultivar and 3.5 cm in DvusemyannayaTSKhA cultivar. The root index affects harvesting input and harvest related losses. Round shape beetroots are more adapted to mechanized harvesting (they are less damaged, do not get stuck in machine units and are easier to transport) than prolonged and flat shape roots. Bohemia cultivar features round and round-flat root shapes, the cultivar root index is 0.95. DvusemyannayaTSKhA cultivar features round root shapes, the root index is 0.98. Renova cultivar has a cylindrical root shape, the root index is 2.8.

The research has shown that the cultivar type affects dirtyness of roots. Renova cultivar had 0.34% of dirty beetroots, DvusemyannayaTSKhA cultivar -0.48%, Bikores cultivar -0.54% and Bohemia cultivar had 0.58% of dirty beetroots. The lowest value was found in Renova cultivar which was closely related to the in-soil depth of beetroots and the root length.

Taste qualities are known to depend on chemical compounds, sugars and betaine in particular. Table beet taste quality assessment revealed the best taste qualities in DvusemyannayaTSKhA cultivar. Boiled beetroots of the cultivar have dark red, tender and sweet texture (4.5 points). Bohemia and Bikores cultivars fall slightly behind in taste qualities. These cultivars have medium textured and less sugary roots (4.1 points). Renova cultivar falls behind in colour and texture. The cultivar got tasting score of 4.02.

Table beet feature good storage qualities. Suberization at mechanical damage is an essential property in table beet. An ability to go into a quiescent state is another important quality in root crops.

Table beet do not go into a deep quiescent state and tend to sprout immediately after harvesting. In this regard, it is important to provide conditions for keeping beet in a quiescent state in the post harvesting period. Quick lowering of temperatures in storage facilities ensures the necessary result.

Table beet preservation assessment showed that the tested cultivars possess good intactness qualities with the marketable output of from 80.7-87 6% (Table 7). Beetroots of DvusemyannayaTSKhA cultivar (control)

Table 7: Table beet keeping capacity after 6 months of storage (2015-2017)

Index (%)	Cultivar: Bohemia	Renova	Dvusemyannaya TSKhA (control)	Bikores
Intactness	85.7	83.1	87.6	80.7
Natural loss	8.7	9.5	8.3	8.0
Disease incidence	5.6	7.4	4.1	11.3

had the best preservation values, Bohemia cultivar demonstrated good preservation values of 85.7%. Natural root loss was within normal limits of from 8.0 to 9.5% depending on the cultivar. Renova cultivar showed the highest natural loss values (9.5%), the control being at 8.3%. Storage related losses were primarily caused by the weight loss due to water evaporation, consumption of nutrients for respiration and development and manifestation of phytopathological and physiological processes. Beet root disease related damage was analysed and minimum damage was revealed in Dvusemyannaya TSKhA cultivar (control) (4.1%). The highest disease incidence values were found in Bikores cultivar (11.3%).

CONCLUSION

Yield in table beet roots depending on the cultivar was 32.4-54.1 ton/ha which was 64.0-106.9% in relation to the control. Only Red ball cultivar had the yield higher than the control among the tested cultivars. Bicores and Detroit cultivars showed the lowest yield values of 32.4 ton/ha 41.4 ton/ha, respectively. Depending on the hybrid used the yield in table beet roots was 49.1-57.7 ton/ha or 97.0-114.0% in relation to the control. Red Cloud F_1 hybrid had the highest yield value of 57.7 ton/ha in the experiment. In general, hybrids demonstrated higher yield values in contrast to cultivars. Dvosemyannaya Tckha cultivar (control), Pablo $F_1$and Red Cloud F_1 hybrids had high sugar values standing at 14.7, 14.4 and 13.9%, respectively.

The data analysis indicates that early-mid sowing time (May 5) produces the highest yields. Later sowing results in decreased yields in table beet. Early sowing (April 28) produces the lowest yield values of 35.3 ton/ha or 69.8% on average in relation to the control for the period of 2015-2017. Early sowing time ensured the largest beetroot weight of 278 g at the end of growth and development, the early-mid sowing time resulted in the beetroot weight of 225 g. Late sowing time (May 26) resulted in the smallest beetroot weight of 174 g. Beet root sown at early-middle time had high sugar values.

Application of fertilizers containing various potassium amounts and the hybrid type produced table beet yield of 34.7-59.8 ton/ha. Potassium at 60 kg ai/ha is reported to have no effect on high yields. Red cloud F_1 hybrid demonstrated the highest yields when applied $N_{90}P_{80}K_{180}$ on average between 2015 and 2017.

Beetroots of Bohemia and Bikores cultivars are reported to have the greatest in-soil depth at 37 and 36%, respectively and beetroots of Renova cultivar have revealed the smallest at 23 %. Beetroots of Renova cultivar go above the soil layer which helps harvesting. DvusemyannayaTSKhA cultivar is reported to have the shortest root length of 1.0 cm. This cultivar (control) demonstrated the best intactness of beet and the highest taste qualities.

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