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Comparative Characteristics of Growth and Development of Rosehip in the Plantations of the Almaty Region

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Abstract: The object of research is the varieties and forms of rosehip, growing in the mountains of the Almaty region at an absolute height of 1,450 m above sea level. The aim of the research is the study the possibility of rosehip cultivation in the mountains and a comparative assessment of the growth and development of different rosehip varieties and forms grown in the same agricultural background. The research results have shown that the growth and development of 26-year-old rosehip plants are very dynamic. The observed taxational parameters of the bushes indicate their normal state. The varieties and forms of rosehip differ in all the studied parameters: The size of plants, as well as leaf blades and fruits, which is due to differences in varieties and forms. The study of the accumulation of heavy metals such as cadmium, lead, and zinc in rosehip grown in both mountain and urban conditions does not reveal an excess of the maximum permissible concentrations. The data presented in the paper on such old plantations of rosehip is new and original.

Keywords: Fruits, Heavy Metals, Leaves, Rosehip

Introduction

Rosehip is a valuable raw material for the production of highly effective natural multivitamin preparations with high biological activity (Fascella *et al*., 2019). Its fruits have long been known due to the high content of ascorbic acid, oil, and other active substances and their effect on the human body. They are widely used as promising sources of biologically active compounds and as traditional drugs with antioxidant and antimicrobial activity (Hernández and Gil, 2021). These properties are associated with the content of secondary metabolites, which may depend on the genotype and harvest period (Fascella *et al*., 2019). Leaf extracts of four rose species (*Rosa canina* L., *R. corymbifera* Borkh., *R. micrantha* Borrer ex Sm, *R. sempervirens* L.) grown in Sicily were analyzed to assess the possibility of their use as natural antioxidants (Fascella *et al*., 2019; Hernández and Gil, 2021).

Flowers of several varieties, such as *Rosa gallica* and *Rosa damascena*, have long been used to produce rose oil and rose water in Anatolia. Fruits (rosehips) of several other species are of economic value and are also used for medicinal purposes.

Rosehip has been the focus of many recent studies because of its potential positive effect on the treatment and prevention of several diseases. In their studies, Gozlekci determined the bioactive content of several substances, including ascorbic acid, phenolic compounds, flavonoids, and carotenoids, as well as antioxidant activity of agrestic *Rosa dumalis* genotypes in Erzurum province, eastern Anatolia. The results showed that the fruits of different genotypes of *Rosa dumalis* were rich in vitamin C, the content of which varied from 402 to 511 mg per 100 g of fresh weight. The total phenol content varied from 297 to 403 mg per 100 g of fresh weight. The E-09 genotype had the highest total flavonoid content (229 mg quercetin equivalent per 100 g of fresh weight) and the lowest value was found in the E-04 genotype (143 mg quercetin equivalent per 100 g of fresh weight. The antioxidant activity of genotypes was 12.9-28.6 μg of Trolox per ml in samples.

The concentration of Heavy Metals (HM) (As, Cd, Cu, Fe, Pb, and Zn) in soil and various parts of plants has been determined by many researchers (Bravo *et al*., 2017; Kalinovic *et al*., 2019; Radojevic *et al*., 2017). Each soil-plant system has certain absorption parameters for various minerals in the soil, depending on several factors. One of these factors, perhaps the most important, is pH. Mineral elements accumulate in leaves depending on soil pH. It affects the ionic form in which an element is present in the soil.

Research results showed that the selected soils were heavily contaminated with as and Cu, as the obtained concentrations exceeded the corresponding limiting and restoration values. According to elemental analysis, branches, leaves, and roots of *Rosa* species contained higher concentrations of the studied elements than fruits. Soil samples from the areas closest to the mining and metallurgical enterprises or located in the prevailing wind directions had the highest content of the analyzed elements (Ahmad *et al*., 2016; Celik *et al*., 2013; Changizi Ashtiyani *et al*., 2013; Cheng *et al*., 2016; Daneshmand *et al*., 2016; Farajpour *et al*., 2017; Kalinovic *et al*., 2019).

Rosehip as a multivitamin plant is widely used in the pharmaceutical, food, and cosmetic industries. Studies have revealed a high content of vitamins and microelements in various organs of the rosehip: leaves, fruits, stems, roots, and flowers (Fattahi *et al*., 2017; Jemaa *et al*., 2017; Jiménez *et al*., 2016; Kikuchi *et al*., 2017; Ognyanov *et al*., 2016; Sanderson and Fillmore, 2014). Plant fruits accumulate less heavy metals than leaves and stems. The total pollution of plants with heavy metals depends on the proximity of pollution sources (Beyer *et al*., 1985; Trubina *et al*., 2014; Bakessova *et al*., 2018). The maximum permissible concentration of heavy metals in the fruits of berry crops are as follows: As 0.2 mg/kg, Cd 0.03, Cu 5.0, Pb 0.4, and Zn 10.0 mg/kg (Burgasov, 1986).

In Kazakhstan, natural thickets do not satisfy the need of the national economy for fruits because of their low productivity. Therefore, the solution of problems associated with the collection and use of rosehips can be solved through the creation of special industrial plantations.

Rosehip has wide adaptive capabilities, good fitness, and low soil requirements. Thus, industrial plantations can be created in almost any natural and climatic zone of Kazakhstan, excluding deserts and locations higher than 2,500 m. A wide range of forms and varieties makes it possible to choose the most economically valuable species and forms for cultivation (Besschetnov and Kentbaev, 2018; Akoyev *et al*., 2018).

At the end of the 1980s, the "Klon" agricultural enterprise created an experimental rosehip plantation with a total area of 2 h with a wide assortment of varieties and forms, both local and introduced. It is located in the mountainous region of southeast Kazakhstan in the "Soldatskoye" stow of the Talgar branch of the Ile-Alatau State National Natural Park at an absolute height of 1,450 meters (Besschetnov and Kentbaev, 2018).

The soil was cultivated using the winter tillage system. Plowing to a depth of 27-30 cm was performed in the fall. The next year in the spring, disking with two rows was carried out. Before planting, the surface soil layer was mellowed by cultivation to the depth of 12-15 cm with simultaneous harrowing.

Planting was performed in May. The pattern of seedlings placement was 4.5 × 1.2 m; the number of seedlings per 1 ha was 1,850. Seedlings were planted in pits of size 30 × 30 × 30 cm. Planting material-standard one-year-old cutting seedlings grown from green cuttings rooted in plastic greenhouses with automated irrigation. Before planting, the roots of the seedlings were puddled in soil batter. Seedlings were planted on plantations on one of every two to three rows and for better pollination and increased fruiting, rows with the different varieties and forms were interspersed with each other. Weeding and spudding in the rows were carried out four times during the summer. After four years, inter-row spacings were cultivated four times using the KRN-2.8 cultivator.

It is generally believed that small-fruit plantation crops can be used for 10-15 years. In our research, we demonstrate that 26-year-old rosehip plantations under study are characterized by normal growth and development.

Materials and Methods

The studies were conducted from 2016 to 2019. The object of research was six varieties and forms of rosehip: “Yubileiny”, “Vitamin VNIVI”, “1-6-3”, “F-3”, “Rossiysky” and “Yablochnaya”, grown on plantations in the “Soldatskoe” stow of the Talgar branch of the Ile-Alatau State National Natural Park at an absolute height of 1,450 m above sea level. Rosehip plantings were also studied in the industrial conditions of Almaty for comparison of the observed parameters.

On the rosehip plantation, 10 plants of each variety and form were studied, which provided 5% accuracy in the experiment. This was per the instructions of Romeder and Shenbakh (Tsarev *et al*., 2014), according to whom, 10-30 individuals are sufficient to obtain an accurate average value in experiments with tree and shrub species. According to Dospekhov (1985), it is possible to equate a separate tree with the experimental plot in an experiment, which was accepted in our study of rosehip.

The height of the plants was determined using a measuring rod with an accuracy of 5 cm. The crown diameter was determined in two directions along and across the row with an accuracy of 5 cm. The shoot length was measured with a tape measure with an accuracy of 1 cm and the shoot diameter was measured at the base with a caliper with an accuracy of 1 mm.

Experimental trees were selected using the method of randomization. Thirty leaves were collected from each of them. Reconnaissance measurements showed that this sample size was sufficient, as the accuracy of the studies did not exceed the permissible 5% level. The length and width of the leaf blades were measured with a ruler with an accuracy of 1 mm.

Fruits were harvested manually during the phase of industrial ripeness (orange or red color). The method and conditions of drying raw fruits are of great importance.

Air drying or fire drying can be used. Air-solar drying, carried out in solar dryers, is rarely used, for example, when processing small batches, if the weather is clear and sunny. Artificial convection drying is the main method of extracting seeds from fruits, in which the fruits in special chambers are penetrated by a drying agent air-heated to a certain temperature. During fire drying, the air is heated using a fired stove heater. When dried using air, the fruits were scattered in a thin layer under a canopy, in a well-ventilated room. The main drying was carried out in the oven. Dry fruits are odorless, sour-sweet to taste, orange or brownish-red in color, with a wrinkled surface and moisture content not higher than 15-20%. Properly dried fruits do not crumple but spring (Gordienko, 2019).

For air drying, the fruits were dispersed in a thin layer in a shed in a well-ventilated area. The main drying was carried out in an oven. Dry fruits are odorless, the taste is sweet and sour, the color is orange or brownish-red, the surface is wrinkled and humidity is not higher than 15-20%. Properly dried fruits do not crumple and are elastic.

The shrinkage of the fruit to an air-dry state is particularly important for production, as the products are sold to consumers in this form.

Shrinkage of fruits is the loss of moisture during storage and is expressed in weight reduction during storage as a percentage of the weight of freshly picked fruits and is determined using the formula:

$$V = \left(P_{fr} - P_{dry}\right) \times 100\%$$

where V is the shrinkage percent, P_{fr} is the weight of freshly harvested fruits and P_{dry} is the weight of dried fruits.

The selection of leaves for the determination of HM content was carried out using the average sample method at the end of the vegetation period. Samples were taken from five bushes of each variety and form. The HM content in the fruits was determined using the method of dry mineralization, based on the complete decomposition of organic substances by burning plant samples in a muffle furnace at a temperature of 500°C. The content of chemical elements in the fruits was determined using the atomic absorption spectrophotometer AA-7000F (Shimadzu, Japan) in the Laboratory of Food and Environmental Safety of the Kazakhstan-Japan Innovation Center of the Kazakh National Agrarian University. The Maximum Permissible Concentration (MPC) of HM in plants, according to SanPiN (Sanitary Regulations and Standards) 42-123-4089-86 dated 03/31/86, is as follows: Cd - 0.03, Pb - 0.4, Zn - 10 mg/kg (Bakessova *et al*., 2018).

For the calculation of the average values of statistical parameters, the collected digital information was processed using the methods of mathematical statistics (Dospekhov, 1985). The organization of the work involved the use of widely used schemes of field stationery and laboratory methods, as well as generally accepted approaches to sampling (Besschetnova and Besschetnov, 2017).

To process the experimental data, the software package Excel MS Office and Statistica 6.0 were used (Dodge and Stinson, 2003; Khalafyan, 2007).

Results

From 2016 to 2019, were performed various biometric measurements of the linear parameters of varieties and forms of rosehip on plantations, including the parameters of leaf blades. Leaf-blades can provide a large amount of information. The state of the whole plant can be evaluated according to the state of the leaves, i.e., leaves can be used as indicators of individual development.

Table 1 shows the results of measurements of the size of the bushes averaged over years. The table shows that the “Rossiysky” variety and the “1-6-3” form had an average height of 294.5 and 248.4 cm, respectively. The height difference between the two samples was estimated as significant (t >3). Coefficients of variation indicated low variability of the studied trait.

The “Yubileiny” variety was characterized by a relatively spreading crown: The average diameter (calculated from the two dimensions) was 270.4 cm. The “1-6-3” form had a more compact crown: The average diameter was 230.7 cm. The variability of the crown diameter was estimated at a low level and was in the range of 6-10%.

The shoots showed significant annual growth. During one vegetation period, rosehip formed shoots with lengths from 126.9 cm ("Vitamin VNIVI" variety) to 130.4 cm ("Yubileiny" variety). The diameters of shoots at the base varied from 1.80 cm ("Form-3") to 2.99 cm ("Yablochnaya"). By mid-August, shoot maturation ended with the formation of generative and vegetative buds.

With age, the growth of crowns in diameter slightly increased. On plantations planted in 1992, it increased from 24 to 30 cm per year in the “Vitamin VNIVI” variety and from 22.5 to 24.5 cm per year in the form “1-6-3”. Consequently, closure of crowns of plants grown from seedlings placed 1.2 m apart in the rows can be expected in 4-5 years.

Considering this, we can recommend using smaller distances between the plants in rows to increase their total number by 1 ha. Usually, it is recommended to plant 2,220 rosehip seedlings per 1 ha on mountain plantations using a 3×1.5 m placement pattern. However, to use the fruit picking machines, the row spacing has to be increased to 4.5 m. In this case, the total number of plants will sharply decrease to 1,500 per 1 ha. We propose to reduce the distance between the plants in rows to one meter. In this case, the closure of crowns in the rows will begin during the fourth year and become complete during the sixth year, after which the crowns will begin to grow across the rows. Therefore, continuous rows of bushes are formed, well-lit from two sides and convenient for harvesting. At the same time, the number of plants per 1 ha will be 2,222, which is close to the recommended value.

Leaf-blades of plants provide significant information about the state of the plant and its acclimatization under various conditions, including anthropogenic conditions.

In this regard, observations of leaves of different rosehip varieties and forms in two contrasting ecological areas were made. Table 2 shows the results of biometrical measurements of leaf blades of rosehip varieties and forms for 2017-2018.

Table 2 shows that there were differences between rosehip varieties and forms, which were significant in most cases. The "Vitamin VNIVI" variety formed the longest leaves (47.8 mm) and relatively short leaf blades were observed in the "Yubileiny" variety-35.0 mm. Variation coefficients varied in the range of 9-12%, which was estimated as low variability.

Significant variation was also noted for the width of the leaves: The "Vitamin VNIVI" variety had the largest width of the leaves (37.2 mm) and the average width of the leaves in the form "1-6-3" was 27.1 mm. The total variability of the leaf width was in the range of 6-15% and was characterized as very low and low.

Generally, according to the combination of the two studied parameters, the largest leaves were observed in the "Vitamin VNIVI" variety and the smallest was observed in the "Yubileiny" variety.

Table 3 shows data on the size of rosehips (Fig. 1) collected in different parts of the experimental industrial plantation. This data indicates that, within the same area, the quantitative parameters of fruits of the same variety were almost the same and the observed differences were within the margin of error of the arithmetic mean.

The largest length of fruits was recorded in the "Yablochnaya" variety (26 mm) and the fruits of the "Rossiysky" variety were the shortest (17.4 mm). The fruits of the "Yubileiny" variety had the largest diameter (22.6 mm) and the fruits of the "Rossiysky" variety had the smallest diameter (9.2 mm).

Table 4 provides data on the shrinkage of rosehips. Information on the shrinkage of fruits should be taken into account when delivering rosehips to the consumer and allows to estimate dry harvests of finished products based on the harvests of fresh fruits.

Depending on the age of the plantation and variety, the shrinkage of the fruits to an air-dry state ranged from 50.3 to 72.3%. Moreover, it was noted that the shrinkage of the fruits from a younger plantation was slightly lower than that of fruits from an older one. This is explained by the fact that in the first case the crowns of the bushes are not dense yet, the fruits are more exposed to the sun, the flow of the wind around the fruits is better and they dry faster while still on the plants than on the older plantations. Thus, the shrinkage of rosehips depends on the age of the plantation and variety and varies significantly.

As is well-known, the chemical composition of plants reflects the elemental composition of soils. Therefore, the excessive accumulation of HM by plants is primarily due to their high concentrations in soils. For most plants, the first barrier is the roots where the largest number of HM is retained, the next accumulation location is the stems and leaves and finally, the last are the reproductive organs of plants (most often seeds and fruits).

Another way of HM entry into the plants is non-root absorption from air currents. This occurs with precipitation when metals from the atmosphere deposit on the leaf apparatus and happens most often near large industrial enterprises and large highways. The entry of elements into plants through the leaves occurs mainly by penetration through the cuticle. After that, absorbed by the leaves, they can be transferred to other organs and tissues and included in the general metabolism.

A high concentration of HM in the organs of plants primarily harms the plant itself. Additionally, increased content of toxic compounds in the fruits can be harmful to the health of people when they are consumed. Fruits and rosehips, in particular, are harvested from the plantations within the city and they are very often used as a medicine or for food. How dangerous are the fruits harvested from urban rosehip?

The content of HM in fruits is usually much lower compared to other morphological groups of raw materials, associated with the presence of a cutinized membrane, which is well washed by rain. Shiny, smooth and bare fruits contain less HM than matte ones with sparse hairs: For example, the difference in lead content is 1.4 times.

We studied the fruits of six rosehip varieties and forms from two areas with contrasting levels of pollution (Table 5).

Table 5 shows that the content of chemicals in the fruits of the studied rosehip varieties and forms did not exceed the MPC. Moreover, the concentration of HM in the fruits of urban-grown rosehip was slightly higher than that of fruits from the mountain plantations but, at the same time, these values did not exceed the MPC. Among the studied rosehip varieties and forms in two contrasting ecological areas, only fruits of "Form-3" from urban plantings had cadmium content that slightly exceeded the norm (0.0302 mg/kg).

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Table 1: Biometric parameters of varieties and forms of rosehip

No. Plantations	Varieties and forms	Parameters, cm	Average values, M ± m	Variation coefficient, C_v, %	Experiment accuracy, P, %
1	"Yubileiny"	height	256.80±7.23	9.60	2.8
		crown diameter	270.40±5.22	6.30	1.9
		shoot length	30.40±1.01	10.10	3.2
		shoot diameter	2.24±0.12	9.70	2.9
2	"Vitamin VNIVI"	height	251.90±6.07	7.40	2.1
		crown diameter	250.20 ±6.08	8.30	2.4
		shoot length	26.90±1.01	12.20	3.7
		shoot diameter	2.88±0.06	7.80	2.2
3	"1-6-3"	height	248.40±7.016	9.00	2.8
		crown diameter	230.70±7.09	10.90	3.1
		shoot length	27.30±0.89	10.40	3.3
		shoot diameter	3.41±0.13	12.70	3.8
4	"Form-3"	height	281.10±5.47	6.00	1.9
		crown diameter	252.50±6.76	8.30	2.7
		shoot length	29.30±0.82	9.70	2.8
		shoot diameter	2.80±0.06	7.60	2.3
5	"Rossiysky"	height	294.50±9.41	10.90	3.1
		crown diameter	263.90±7.91	9.40	3.0
		shoot length	27.7±1.01	12.20	3.9
		shoot diameter	2.98±0.13	11.80	3.4
6	"Yablochnaya"	height	272.20±12.05	14.70	4.4
		crown diameter	243.90±5.41	7.60	2.2
		shoot length	28.40±0.65	7.50	2.3
		shoot diameter	2.99±0.10	11.10	3.4
Street plantings in the city of Almaty					
1	"Yubileiny"	height	251.60±7.77	9.70	3.0
		crown diameter	212.00 ±8.10	12.00	3.8
		shoot length	20.10±0.85	13.40	4.2
		shoot diameter	1.93±0.06	10.10	3.2
2	"Vitamin VNIVI"	height	226.60±7.08	9.80	3.1
		crown diameter	214.40±7.52	11.10	3.5
		shoot length	18.90±0.73	12.20	3.8
		shoot diameter	2.06±0.08	11.50	3.6
3	"1-6-3"	height	231.00±6.98	9.60	3.0
		crown diameter	211.9±7.42	11.10	3.5
		shoot length	18.1±0.52	9.10	2.9
		shoot diameter	2.03±0.06	9.40	3.0
4	"Form-3"	height	250.50±10.28	13.00	4.1
		crown diameter	200.8±6.5	10.20	3.2
		shoot length	19.6±0.57	9.18	2.9
		shoot diameter	2.06±0.05	7.30	2.3
5	"Rossiysky"	height	252.5±10.9	13.60	4.3
		crown diameter	225.5±7.12	10.00	3.2
		shoot length	19.5±0.51	8.40	2.6
		shoot diameter	2.25±0.07	9.60	3.0
6	"Yablochnaya"	height	230.10±9.74	13.40	4.2
		crown diameter	213.00±7.88	11.70	3.7
		shoot length	21.60±0.67	9.80	3.1
		shoot diameter	2.29±0.07	9.70	3.0

Table 2: Average parameters of leaf blades of rosehip varieties and forms

		Leaf length, mm		Leaf width, mm	
No.	Varieties and forms	Variation M ± m	Average size, coefficient, C_v, %	Average size, M ± m	Variation coefficient, C_v, %
Plantations					
1	"Form-3"	41.7±1.14	9	29.9±1.05	11
2	"Rossiysky"	43.1±1.17	12	36.3±1.01	9
3	"1-6-3"	45.2±0.68	5	27.1±0.95	11
4	"Vitamin VNIVI"	47.8±1.03	9	37.2±0.74	6
5	"Yubileiny"	35.0±0.99	9	29.2±0.85	8
6	"Yablochnaya"	40.6±1.13	10	31.5±1.46	15
Street plantings in the city of Almaty					
1	"Form-3"	40.8±0.78	8	29.3 ± 0.37	6
2	"Rossiysky"	42.3±0.76	8	35.0 ± 0.46	6
3	"1-6-3"	44.8±0.65	6	27.2 ± 0.59	10
4	"Vitamin VNIVI"	48.2±0.74	7	38.2 ± 0.52	6
5	"Yubileiny"	35.8±0.61	8	28.8 ± 0.42	6
6	"Yablochnaya"	39.5±0.42	5	30.6 ± 0.38	6

Table 3: Size of the fruits harvested from the plantation

Varieties and forms	Parameters, mm	Average, M	Standard error, m	Mean square deviation, δ	Variation coefficient, C_v, %	Experiment accuracy, P, %
Plantations						
“Form-3”	length	25.6	0.37	2.3	9.1	1.4
	diameter	15.9	0.29	1.9	11.7	1.8
“Rossiysky”	length	17.4	0.33	2.1	12.1	1.9
	diameter	9.2	0.27	1.7	18.5	2.9
“1-6-3”	length	18.7	0.50	3.2	17.0	2.7
	diameter	11.2	0.27	1.7	15.1	2.4
“Vitamin VNIVI”	length	23.4	0.49	3.1	13.9	2.2
	diameter	22.3	0.48	3.1	13.7	2.2
“Yubileiny”	length	22.7	0.58	3.7	16.3	2.6
	diameter	22.6	0.49	3.1	13.6	2.2
“Yablochnaya”	length	26.0	0.38	2.4	9.2	1.5
	diameter	16.3	0.24	1.5	9.2	1.5
Street plantings in the city of Almaty						
“Form-3”	length	25.5	0.28	1.2	4.9	1.1
	diameter	15.4	0.20	0.9	5.9	1.3
“Rossiysky”	length	17.2	0.25	1.1	6.6	1.5
	diameter	9.1	0.16	0.7	7.7	1.7
“1-6-3”	length	18.7	0.26	1.2	6.3	1.4
	diameter	11.2	0.17	0.7	6.7	1.5
“Vitamin VNIVI”	length	23.4	0.29	1.3	5.5	1.2
	diameter	22.2	0.29	1.2	5.8	1.3
“Yubileiny”	length	22.8	0.31	1.4	6.0	1.4
	diameter	22.7	0.34	1.5	6.8	1.5
“Yablochnaya”	length	26.3	0.37	1.7	6.4	1.4
	diameter	16.2	0.23	1.0	6.3	1.4

Table 4: Shrinkage of rosehips

Varieties	Parameters	Fruit weight after drying, g M ± m, %	C_v, %	P, %	Shrinkage, %
Plantations					
“Yablochnaya”	air dry weight	27.7±1.0	19.1	3.6	72.3
	absolute dry weight	23.5±1.1	12.8	4.6	76.5
“Yubileiny”	air dry weight	19.9±1.0	8.8	5.1	80.1
	absolute dry weight	17.8±0.9	9.0	5.2	82.2
“Rossiysky”	air dry weight	49.7±1.8	13.2	3.9	50.3
	absolute dry weight	45.7±1.6	13.6	3.5	54.3
“1-6-3”	air dry weight	30.4±0.8	8.2	2.6	69.6
	absolute dry weight	25.0±0.9	12.0	3.8	75.0
“Vitamin VNIVI”	air dry weight	50.3±0.9	5.9	1.8	49.7
	absolute dry weight	45.4±1.2	8.3	1.2	54.6
Street plantings in the city of Almaty					
“Yablochnaya”	air dry weight	26.4±0.8	10.0	3.2	73.6
	absolute dry weight	21.4±1.0	14.4	4.5	78.6
“Yubileiny”	air dry weight	18.1±0.8	14.9	4.7	81.9
	absolute dry weight	15.2±0.7	15.2	4.8	84.8
“Rossiysky”	air dry weight	44.8±0.8	5.4	1.7	55.2
	absolute dry weight	40.4 ±0.7	5.5	1.7	59.6
“1-6-3”	air dry weight	28.4±0.9	9.9	3.1	71.6
	absolute dry weight	26.2±1.0	11.5	3.6	73.8
“Vitamin VNIVI”	air dry weight	47.2±0.9	6.3	2.0	52.8
	absolute dry weight	44.3±1.4	10.3	1.4	55.7

Table 5: Content of HM in rose hips (2018)

No. 1	Varieties and forms 2	Parameter 3	Actual results (mg/kg) 4
Plantations			
1	"Yablochnaya"	cadmium	0.0108
		lead	0.0054
		zinc	0.2589
2	"1-6-3"	cadmium	0.0153
		lead	0.0117
		zinc	0.5874
3	"Form-3"	cadmium	0.0183
		lead	0.0055
		zinc	0.3274
4	"Rossiysky"	cadmium	0.0218
		lead	0.0076
		zinc	0.4738
Street plantings in the city of Almaty			
1	"Yablochnaya"	cadmium	0.0218
		lead	0.0076
		zinc	0.2972
2	"1-6-3"	cadmium	0.0273
		lead	0.0210
		zinc	0.6326
3	"Form-3"	cadmium	0.0302
		lead	0.0124
		zinc	0.4333
4	"Rossiysky"	cadmium	0.0267
		lead	0.0185
		zinc	0.5137

Fig. 1: Fruiting of rosehip

Discussion

The results of our research are fully consistent with the data of foreign scientists indicating that mineral elements accumulate in the organs of plants (Bravo *et al*., 2017; Kalinovic *et al*., 2019; Radojevic *et al*., 2017). The research data and the obtained results demonstrate the practical possibility of plantation cultivation of introduced and local varieties and forms of rosehip in Kazakhstan, which is consistent with the aim of our research. The introduction of rosehip varieties and forms into the mountain conditions of the southeast parts of Kazakhstan and their introduction into the habitat with a uniform agricultural background made it possible to carry out a comparative study of their properties and perform an assessment of their main parameters. The observed significant values of the modification changes of the analyzed characteristics can be primarily explained by the differences between the varieties and forms.

Based on the obtained results, we concluded that rosehips, both in a mountain and urban conditions, did not contain high amounts of HM and were not toxic. This is confirmed by the data of several researchers (Beyer *et al*., 1985; Kalinovic *et al*., 2019; Radojevic *et al*., 2017). Thus, for example, research by Trubina *et al*. (2014) found that plants growing close to industrial enterprises accumulate a significant amount of heavy metals in all parts but their content in fruits is much lower. Of the six types of berry crops studied, the rosehip in all cases was distinguished by the lowest content of heavy metals, which indicates its general ecological stability. Other authors also came to the same general conclusions based on the example of *Corylus* spp. (Radojevic *et al*., 2017). The research found that in parts of Rosa spp. branches, leaves, and roots contained higher concentrations of the studied elements than fruits. Based on the values of biological factors, it can be concluded that Rosa spp. limits the absorption of elements from the soil (Kalinovicc *et al*., 2019; Vural, 2015).

In general, the usefulness of rosehip is not limited only to fruits because leaves, flowers, buds, stems, and roots contain a sufficient amount of various vitamins and are used in the pharmaceutical industry. In this regard, the study of all parts of the plant is an urgent task. The content of vitamins in leaves is often higher than in fruits (Myasishcheva, 2018).

Thus, we proved experimentally that rosehips grown in the technogenic conditions of the city and environmentally friendly mountain conditions of the Almaty region had approximately equal content of HM and were safe for human consumption.

Conclusion

The above research results clearly show that rosehip varieties and forms in the 26-year-old plantation stands continue to grow and develop normally, as indicated by the taxational characteristics of the plants. Rosehip varieties and forms provide high yields annually and the fruits are characterized by stable parameters. The mountain conditions of the Zailiysky Alatau are suitable for rosehip plantation growing, as evidenced by the fact that 26 summer crops of this plant were harvested at an altitude of 1,450 m.

Author’s Contributions

All authors equally contributed to this study.

Ethics

This article is original and contains unpublished material. The corresponding author confirms that all other authors have read and approved the manuscript and no ethical issues have been involved.

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