INFLUENCE OF ROOTSTOCKS ON THE PRODUCTIVITY AND CHEMICAL COMPOSITION OF PRUNUS DOMESTICA L. FRUITS

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ABSTRACT
The influence of seedling and clonal rootstocks of different spreads on Prunus domestica L. plum fruits quality and productivity of Yaichnaya Sinyaya and Utro varieties was studied. The significant change of productivity and the fruit weight of the varieties under study was to determine under the influence of the rootstock. Depending on the scion-stock combination the plum tree's productivity varied from 7.5 kg/tr. (Utro/140-1) to 15.1 kg/tr. (Yaichnaya Sinyaya /Novinka) at the mean value of 11.5 kg/tr. Medium-growing rootstocks Novinka and OPA-15-2 provided the maximum value of the varieties productivity The significant productivity decrease relatively to seedling rootstock was stated for the combinations with low-growing rootstock 140-1. Soluble solids content in the fruits of Yaichnaya Sinyaya variety is higher than in the fruits of Utro variety, moreover, the highest values were determined on Novinka and OPA-15-2 rootstocks: on 4 – 4.5% higher in comparison with the fruits on the seedling rootstock at average. The rootstock causes less influence on titratable acids. The antioxidant activity of Yaichnaya Sinyaya variety fruits is 30% higher than that of Utro variety fruits on average. The maximum values of antioxidant activity in Yaichnaya Sinyaya variety fruits were fixed on OPA-15-2 rootstock (16.37%), the minimal ones – on Skorospelka Krasnaya rootstocks (14.68%). In the fruits of Utro variety the highest values were stated on OP-23-23 rootstock (13.16%), and the lowest ones – on the seedling rootstock (10.93%). The content of phenolic compounds sum is 60% higher in the fruits of Yaichnaya Sinyaya variety than in Utro variety ones on average. The decrease of the content of phenolic compounds sum was stated in the fruits of Utro variety on all the rootstocks in comparison with the combination Utro/seedling rootstock. The decreasing series of ash elements accumulation (K > P > Ca > Mg > Mo > S > Zn > Si) was determined. The strongest variety differences on total mineral element content were overvalued on medium-growing clonal rootstocks (Novinka, OP-23-23 and OPA-15-2), OPA-15-2 and OP-23-23 rootstocks provided the highest fruit quality on the combination of economic and biochemical parameters.

Keywords: Prunus domestica L; scion-stock combinations; productivity; fruits chemical composition

INTRODUCTION
The popularity of domestic plum (Prunus domestica L.) in different horticultural zones of Russia is connected with ecological plasticity, winter resistance, early maturity, and stable productivity of cultivated varieties (Upadyseva, 2015; Eremin and Brizhino, 2011). New clonal stocks are used to duplicate new valuable varieties of fruit crops and to create intensive plantations because they favorably influence on adaptivity, early maturity, and productivity of grafted plants (Upadyseva, 2017; Eremin et al., 2000). The spread, the start of fruiting, and the productivity of grafted plants depend on the rootstock (Blazek and Pustekova, 2012; Hatton et al., 2015).

Fruits quality is a genetically associated character for each variety, but in the scientific literature there are data about the significant influence of a rootstock on the weight and quality of fruits (Usenik et al., 2010; Orazem, Stampar, Hudina, 2011; Bartolini et al., 2014; Reig et al., 2018; Iglesias et al., 2019; Radovića et al., 2020; Karakaya et al., 2021).

Seeding rootstocks (seedlings of domestic plum and aluacha) and clonal ones of different growing spread (strong-growing – 13-113, medium-growing – OPA-15-2, OP-23-23, SVG-11-19 and Novinka and low-growing – 140-1, VVA-1) are used for plums cultivation in the Central region of Russia (Eremin, 2000). Many questions devoted to plum varieties propagation and scion-stock combination selection are successfully solved in the world; at the same time, the life length of grafted plants and the harvest quality depending on a variety and a rootstock are not studied enough.
The major part of the researches of the biochemical composition of plum fruits scion-stock combinations was connected with the rootstock influence on the content of soluble solids and titratable acids in the fruits (Daza et al., 2008; Rato et al., 2008; Reig et al., 2018).

The main component of plum fruits’ chemical composition is minerals. Among them, K, P, Mg, and Ca are found in big quantities, whereas other minerals such as Fe, B, Cr, Mn, Cu, and Zn are present in much fewer quantities (Cosmulescu et al., 2017). The mineral composition changes and the content of bioactive compounds in fruits Prunus domestica L. depending on the rootstock were practically understudied. In scientific literature, the data about the stock influence on the leaves mineral composition are only presented (Meland, 2010; Milošević and Milošević, 2011; Ionica et al., 2013; Reig et al., 2018). The accurate forecast of plum scion-stock combinations germinability and productivity and the stock influence on the nutrients and bioactive substances accumulation in plum fruits is very important for the output yield of high quality.
That is why this work aimed to determine the influence of different growing strength rootstocks on the fruits chemical composition and productivity of the domesticated plum varieties bred by Horticulture. 2 Federal State Budget Scientific Institution «Federal Scientific Selection and Technological Center of Horticulture and Nursery Breeding» (Federal Horticultural Research Center).

Scientific hypothesis
The domesticated plum (Prunus domestica L.) fruits productivity and quality, their biological composition depending on the used rootstocks are not studied enough. We have checked the influence of the strong-growing seedling and medium and low-growing clonal rootstocks on the fruit productivity, quality, and nutritional value of the plum varieties, i.e. Utro and Yaichnaya Sinyaya grown in Moscow region conditions. We supposed that on the base of the field and laboratory experiments the optimal stock for each variety that will provide the high productivity and valuable bioactive substances accumulation in the plum fruit will be found.

MATERIAL AND METHODOLOGY
Conditions of plant growing
The field researches were held in 2018 – 2019 on the experimental Prunus domestica L. plantations, located at laboratory plot of Federal Horticultural Research Center for Breeding, Agrotechnology and Nursery in Moscow region (55° 56’ of North latitude, 37° 64’ East longitude). The plantation overall area was 0.5 ha. The garden of intensive type was set out in 2010 using the scheme 5 x 2.5 m. The soil in the row spacing was black fallow (Figure 1).

Biological material
The fruits of Utro and Yaichnaya Sinyaya varieties on 6 stocks, i.e. strong-growing P. domestica L. seedlings, medium-growing clonal rootstocks Skorospelka Krasnaya (Prunus domestica L.), Novinka (Prunus bessyi L.H. Bailey x Prunus ussuriensis Kovalev& Kostina), OP-23-23 (Prunus pumila L. x Prunus salicina Lindl. x Prunus persica Stokes), OPA-15-2 (Prunus pumila L. x Prunus salicina Lindl. x Prunus cerasifera Ehrh) and low-growing clonal rootstock 140-1 (Prunus bessyi L.H. Bailey x Aflatania ilmifolia L.) were the object of the scientific studies. The samples were taken at the ripeness stage (Figure 2).

The biochemical studies were held in the laboratory of biochemistry and physiology of Federal Horticultural Research Center for Breeding, Agrotechnology, and Nursery.

Chemicals
All chemical substances chosen for the analysis were of an analytical sort and were bought from Sigma Aldrich (USA).

Figure 3 ESD-analysis protocol.
Sample preparation

From representative not less than 500 g fruits probe, 300 g of fruit without stone were prepared. The mass was homogenized using the analytical homogenizer IKAA11 basic (Germany). Then it was extracted by double distilled water (to determine antioxidant activity and phenol compounds sum) and by pure methanol (to study the metabolites composition) and centrifugated at 4000 g (Sigma, Germany) within 10 min. The supernatant was used for measurement purposes. We performed all extractions in triplicate independent samples.

Basic chemical analyses

General biochemical parameters, i.e. soluble solids content (SSC) and total titratable acidity (TTA). SSC was determined via refractometric method according to (GOST ISO 2173, 2013), the values were expressed in %. TTA was estimated via the potentiometric method by pH meter HI 2211 HANNA (Germany) via titrating with 10 N NaOH and expressed in the equivalent of apple acid, % (GOST ISO 750, 2013).

Total phenolic compounds analysis

The total phenolics amount was determined with Folin–Ciocalteu reagent according to the method described by Velioglu et al. (1998). A standard curve with gallic acid was used. Different concentrations of gallic acid were prepared in distilled water, and absorbance was recorded at 750 nm. 100 μL of the diluted sample (1:10) was dissolved in 500 μL of Folin–Ciocalteu reagent and 1000 μL of distilled water. The solutions were mixed and incubated at room temperature for 1 min. After 1 min, 1500 μL of 20% sodium carbonate (Na2CO3) solution was added. The final mixture was shaken and then incubated for 2 h in the dark at room temperature. The absorbance was measured at 750 nm using a Helios Y UV–vis spectrophotometer and the results are expressed in mg of gallic acid (GAE) calculated on the wet weight of plants.

Total antioxidant capacity

The scavenging activity on the 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical was determined spectrophotometrically according to the method described by Brand-Williams et al. (1995). The principle of the analysis was based on the colour change of DPPH solution from purple to yellow as the radical was quenched by antioxidants. The homogenized leaves were mixed with distilled water and methanol. The samples were put on the shaker Lab-PU-01 (Russia) for 6 hours, and then they were filtered and the antioxidant activity was measured in 10 minutes after interaction between the extract and the reagent. The absorbance was recorded at 517 nm to determine the concentration of the remaining DPPH. All measurements were performed in triplicate. The radical-scavenging activity was calculated as a percentage as follows:

\[
\text{DPPH radical-scavenging (\%)} = \left(\frac{[\text{AC} - \text{AAt}]}{\text{AC}}\right) \times 100,
\]

Where:

\[\text{AC} \quad \text{– DPPH solution absorption; AAt – absorption at the antioxidant presence.}\]

The lower absorbance of the reaction mixture indicates a higher level of free radical scavenging activity.

EDS - analysis

The chemical composition of the basic ash components (Mg, Si, P, S, K, Ca, Zn, Mo) was determined by the method of energy dispersive spectrometry (ESD) on the analytical raster electron microscope JEOL JSM 6090 LA according to the methodology (Motyleva, 2018). X-ray microanalysis data are presented in the form of standard protocols which contain the microstructure picture of the sample under study, the table of the data in weighting and atomic correlation, spectra, and histograms presented in Figure 3.

Metabolic analysis by gas chromatography-mass spectrometry

The metabolites analysis was fulfilled using the method of gas chromatography-mass spectrometry (GC-MS) via GCMS chromatograph JMS-Q1050GC («JEOL Ltd», Japan). Capillary column DB-5HT (Agilent, USA): length 30 m, inner diameter – 0.25 mm, the film thickness – 0.52 μm, and gas-carrier — helium) was used. The temperature gradient during the analysis was within 40 – 280 °C, the injector and interface temperature – 250 °C, the ion source – 200 °C. Gas flow in the column was equal to 2.0 mL/min⁻¹, split-flow injection mode, sample injected in volume 1 – 2 μL of the evaporated extract. The analysis was held for 45 min. The derivation was held using silylation reagent N,O bis (trimethylsilyl) trifluoracetamide (BSTFA) following the method described by Robbins (2003). The substances identification was done according to NIST-5 National Institute of Standards and Technology (USA) retention behavior and mass spectra the scanning range was 33 – 900 m/z. The substance identification credibility was within 75 – 98%.

Number of repeated analyses: 3
Number of experiment replication: 2

Statistical analysis

All the analyses were performed in triplicate. The results were expressed as mean values (n = 3) in standard deviation (SD). Statistical analyses were carried out through the Excel package (Microsoft Excel, v. 2016).

RESULTS AND DISCUSSION

We studied the plum trees' productivity of different scion-stock combinations in the field conditions, determined the fruit average weight, fulfilled the fruits organoleptic and degustation estimation. As a result of our studies, it was stated that during 2018 – 2019 the plum tree's productivity was 11.5 kg/tree on average, and depending on scion-stock combination it changed from 7.5 kg/tree (Utro/140-1) to 15.1 kg/tree (Yaichnaya Sinyaya/Novinka). This parameter was above average at the understudied varieties grafted on medium-growing clonal rootstocks Novinka and OPA-15-2. The minimum parameters were stated at the combinations with low-growing rootstock 140-1 (Table 1).

The rootstock influence on P. domestica L. productivity is discussed in the papers (Ciobanu et al., 2009; Kaufmane et al., 2007; Popova et al., 2020).

Studied varieties belong to large-fruited ones with fruits weight more than 30 g. The Utro variety's average fruit weight is 31.2 g, but depending on the stock it varied from...
29.7 g (seedlings *P. domestica* L.) to 33.8 g (OP-23-23). The understudies varieties fruits were significantly larger under OP-23-23 rootstock influence. The Utro variety fruit stone was separated from the flesh well, its portion in the fruit weight was 6% on average with variation from 5.7% (Novinka) to 6.5% (seedlings *P. domestica* L.).

The Yaichnaya Sinyaya variety fruit stone was larger and was near 7% of the fruit weight for all the combinations, it separated from the fruit flesh well. According to the degustation results, the understudied varieties of fruits were characterized with balanced sour-sweet taste and smell (4.2 – 4.8 scores). The degustation estimation had
the maximum score at Utro/OPA-15-2 and Yaichnaya Sinyaya/OPA-23-23 combinations (Fig. 4). The soluble solids content (SSC), total titratable acidity (TTA), antioxidant activity (AA), phenolic compounds (PC) sum, and mineral composition change of the understudied plum varieties fruits on different rootstocks were studied in laboratory conditions.

Depending on the variety and the rootstock SSC in the fruits varied from 12.72% (Utro/Skorospelka Krasnaya) to 17.48% (Yaichnaya Sinyaya/Novinka). In the Utro variety fruits on Novinka, OPA-15-2 and 140-1 rootstocks SSC was on 1 – 1.3% higher in comparison with the fruits on the seedling (Figure 4). In the Yaichnaya Sinyaya variety fruits, SSC was higher than in the Utro variety ones; SSC maximum values were determined on Novinka, Skorospelka Krasnaya, and OPA-15-2 rootstocks, i.e. on 4 – 4.5% higher than in the fruits on the seedling at average.

In the understudied scion-stock combinations samples TTA varies within the range 1.1 – 1.7% (Figure 5).

The Yaichnaya Sinyaya variety TTA depended on a scion-stock combination a little. The maximum TTA content was noted at the fruits of Utro variety on Skorospelka Krasnaya, Novinka, OP-23-2,3 and 140-1 rootstocks (1.6 – 1.7%). Lopez-Ortega et al. (2016) informed that between the stocks there was no significant difference in SSC accumulation. However, Gonçalves et al. (2006) and Usenik et al. (2010) found out that at sweet-cherry trees the rootstock influenced SSC and at dwarfing rootstocks SSC was higher. Besides, in the papers of Daza et al. (2008) and Rato et al. (2008), it was stated that at plum trees a rootstock affected such quality features as SSC and TTA. While studying the rootstock influence on Prunus rosseta Erem. Fruits, it was noticed that a rootstock influenced SSC, but did not affect TTA greatly (Motyleva et al., 2019).
### Table 3: The ash composition of Utro variety fruits on different rootstocks.

| Scion/rootstock combinations          | Mg    | Si    | P     | S     | K     | Ca    | Zn    | Mo    | \( \sum \) |
|---------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|
| Utro/Skorospelka Krasnaya             | 2.09  | 0.12  | 3.46  | 0.34  | 27.77 | 3.29  | u/o   | 2.11  | 39.18     |
| Utro/Novinka                          | 1.95  | 0.04  | 4.34  | 0.15  | 28.30 | 1.53  | 0.45  | 1.49  | 38.25     |
| Utro/OP-23-23                         | 1.37  | 0.07  | 2.69  | 0.18  | 26.84 | 1.14  | 0.62  | 1.37  | 34.28     |
| Utro/OPA-15-2                         | 1.83  | 0.08  | 3.68  | 0.23  | 30.76 | 1.04  | 0.46  | 1.75  | 39.83     |
| Utro/140-1                            | 1.88  | 0.29  | 4.16  | 0.11  | 28.95 | 1.26  | 0.25  | 1.15  | 38.05     |
| Utro/seedlings *P. domestica*         | 1.76  | 0.11  | 3.29  | 0.16  | 29.73 | 1.34  | 0.17  | 1.42  | 37.98     |
| Min                                   | 1.37  | 0.04  | 2.69  | 0.11  | 26.84 | 1.04  | 0.17  | 1.15  |           |
| Max                                   | 2.09  | 0.49  | 4.34  | 0.34  | 30.76 | 3.29  | 0.62  | 2.11  |           |
| V, %                                  | 12.5  | 35.9  | 15.7  | 38.6  | 4.9   | 18.8  | 39.6  | 19.7  |           |

### Table 4: The ash composition of Yaichnaya Sinyaya variety fruits on different rootstocks.

| Scion/rootstock combinations          | Mg    | Si    | P     | S     | K     | Ca    | Zn    | Mo    | \( \sum \) |
|---------------------------------------|-------|-------|-------|-------|-------|-------|-------|-------|-----------|
| Yaichnaya Sinyaya/OPA-15-2            | 1.13  | 0.06  | 3.39  | 0.29  | 25.94 | 0.45  | 0.42  | 0.99  | 32.67     |
| Yaichnaya Sinyaya/OP-23-23            | 1.30  | 0.18  | 4.63  | 0.18  | 27.91 | 0.72  | 0.48  | 1.23  | 36.63     |
| Yaichnaya Sinyaya/Skorospelka Krasnaya| 1.55  | 0.13  | 3.90  | 0.15  | 30.14 | 1.19  | 0.38  | 1.45  | 38.89     |
| Yaichnaya Sinyaya/seedlings *P. domestica* | 0.88  | 0.16  | 2.96  | 0.06  | 18.99 | 0.62  | 0.19  | 1.19  | 25.05     |
| Yaichnaya Sinyaya/Novinka              | 0.81  | 0.10  | 2.90  | 0.11  | 20.72 | 0.73  | 0.29  | 0.83  | 26.49     |
| Yaichnaya Sinyaya /140-1               | 1.70  | 0.11  | 4.23  | 0.37  | 26.60 | 0.28  | 0.29  | 2.90  | 36.48     |
| Min                                   | 0.81  | 0.06  | 2.9   | 0.06  | 18.99 | 0.28  | 0.19  | 0.83  |           |
| Max                                   | 1.7   | 0.18  | 4.63  | 0.37  | 30.14 | 1.19  | 0.48  | 2.9   |           |
| V, %                                  | 26.1  | 35.0  | 19.1  | 30.0  | 7.2   | 16.6  | 30.7  | 12.4  |           |

### Table 5: The comparative content of the main compounds, found in Yaichnaya Sinyaya variety on different rootstocks, % scale.

| Substances               | Seedling Prunus | Skorospelka Krasnaya | Novinka | OP-23-23 | OPA-15-2 | 140-1 |
|--------------------------|-----------------|----------------------|---------|----------|----------|-------|
| 10:02 L-Norleucine       | 18              | 15                   | 9       | 18       | 10       | 1     |
| 10:30 Succinic acid      | 9               | 5                    | 4       | 4        | 5        | <1    |
| 10:53 Fumaric acid       | 30              | 30                   | 28      | 27       | 17       | 1     |
| 11:19 Malic acid         | 8               | 50                   | 40      | 40       | 40       | 11    |
| 11:34 Malonic acid       | 8               | 8                    | 43      | 40       | 5        | 14    |
| 16:06 Levoglucosan       | 4               | 22                   | 28      | 11       | 8        | 4     |
| 16:35 D(-)-Fructofuranose| 70              | 75                   | 80      | 80       | 80       | 75    |
| 17:03 D-Allofuranose     | 25              | 10                   | 40      | 25       | 20       | 20    |
| 17:07 Quinic acid        | 80              | 85                   | 94      | 90       | 95       | 20    |
| 17:27 b-D-Glucopyranose  | 70              | 92                   | 90      | 80       | 90       | 90    |
| 17:41 Acrylic acid       | 10              | 25                   | 32      | 7        | 5        | 8     |
| 17:51 D-Sorbitol         | 25              | 30                   | 30      | 50       | 38       | 40    |
| 18:23 D-Glucose          | 70              | 75                   | 70      | 88       | 75       | 40    |
| 17:59 D(+)-Talofuranose  | 1               | 2                    | 10      | 12       | 10       | 40    |
| 19:15 Myo-inositol       | 18              | 17                   | 12      | 17       | 20       | 10    |
| 24:18 Sucrose            | 90              | 95                   | 92      | 92       | 90       | 90    |
Widely spread substances-antioxidants, contained in plants, belong to different classes of chemical compounds. They play a significant role in human nutrition as protective factors that decrease the risk of various diseases (Fazzari et al. 2008; Usenik et al., 2008). These bioactive compounds concentration varies depending on different factors, i.e. climate, soil, rootstocks (Spinardi et al. 2005), copra (Mozetic, Trebse and Hribar, 2002; Usenik et al. 2008).

Our study results confirm the rootstock influence on bioactive substance synthesis in Prunus domestica L fruits. The antioxidant activity of Yaichnaya Sinyaya variety fruits is 30% higher than Utro variety fruits on average (Table 2). The maximum AA values are determined in Yaichnaya Sinyaya variety fruits on the rootstocks OPA - 15-2 (16.37%) and 140-1 (16.58%), and the minimal ones – on Skorospelka Krasnaya rootstock (4.68%). The highest AA values in Utro variety fruits were registered on Skorospelka Krasnaya (13.9%) and OP-23-23 (13.16%) rootstocks, and the lowest ones – on the seedlings (10.93%).

PC content in Yaichnaya Sinyaya variety fruits was 60% higher than in Utro variety ones on average (Table 2). The maximum PC content was registered in Yaichnaya Sinyaya variety fruits on Skorospelka Krasnaya and 140-1 rootstocks, i.e. 0.94 and 0.91 mg g⁻¹ of the fruits equivalent of gallic acid relatively, and the minimum PC content were stated on OP-23-23 rootstock, i.e. 0.43 mg g⁻¹ of the fruits equivalent of gallic acid.

In Utro variety fruits on all the rootstocks, the decrease of PC sum content was stated in comparison with Utro/seedling combination, and on Skorospelka Krasnaya, OPA-15-2, and 140-1 rootstocks the content was twice less.

The mineral substances are an important component of human nutrition, they are a part of enzymes and have antioxidant activity; they are not synthesized in the human organism, but get inside it only with meals. Eight main elements, i.e. Mg, Si, P, S, K, Ca, Zn, Mo, were determined in the plum fruits. K is the main element in the plum fruits. Its content varied from 26.84 mass % (Utro/OP-23-23) to 30.76 mass % (Utro/OPA-15-2) (Table 3). K content variation coefficient is low (4.88%) that speaks about the insignificant influence of the rootstock on this element accumulation. P content varied within the range from 2.69 mass % (Utro/OP-23-23) to 4.34 mass % (Utro/Novinka). P content variation coefficient is 16.7%, which speaks about a stable input of this element in plum fruits.

The portion of Ca in Utro variety fruits is from 1.04 mass % (Utro/OPA-15-2) to 3.29 mass % (Utro/Skorospelka Krasnaya). This element variation coefficient is medium. The portion of Mn and Mo in plum fruits does not exceed 2.1 mass %, these elements maximum accumulation is registered in Utro/Skorospelka Krasnaya combination, i.e. 2.09 and 2.11 mass % relatively. Mn variation coefficient is low, i.e. 13.49%, and Mo coefficient is medium, i.e. 21.74%.

Si maximum accumulation is registered in Utro/140-1 combination fruits, i.e. 0.29 mass %.

Zn content varied from 0.17 mass % (Utro/seedlings) to 0.62 mass % (Utro/OP-23-23). The highest values of all the elements sum are registered in Utro/Skorospelka Krasnaya (39.18 mass %) and Utro/OPA-15-2 (39.83 mass %) scion-stock combinations.

In Yaichnaya Sinyaya variety fruits K is accumulated on 4% less than K and twice less than Ca than in Utro variety fruits (Table 4).

The content of Mg, P, S, K, and Zn on all the rootstocks is higher than on seedlings. Among all the scion-stock combinations we can distinguish the fruits of the following combinations on all the elements sum content: Yaichnaya Sinyaya/OP-23-23 (36.63 mass %), Yaichnaya Sinyaya/140-1 (36.48 mass %), and Yaichnaya Sinyaya/ Skorospelka Krasnaya (38.89 mass %).

Significant differences in mineral elements sum content were determined in the fruits between the varieties and the scion-stock combinations of varieties and rootstocks. The greatest differences in the mineral substances sum content were registered on the medium-growing clonal rootstocks Novinka, OP-232-3, and OPA-15-2.

Higher accumulation of Ca, Mg, and K were determined in the fruits of both varieties on Skorospelka Krasnaya rootstock in comparison with other rootstocks. The decreasing series of the accumulation of the elements in plum fruits is as follows: K > P > Ca > Mg > Mo > S > Zn > Si.

The data given in the scientific literature about the mineral element content in plum fruits are limited, especially regarding the influence of the rootstock. The results on the content of K, Ca, P, and Mg, Mn, Cu, and Zn are presented in the papers of Rop et al. (2009), Cosmulescu et al. (2017), Milosevic and Milosevic (2012) and Motyleva, Upadaysheva and Tumaeva (2021).

K, Ca, and P values received by us as a result of this study correlate to the data given in the scientific literature in a proportional relation. The differences for some elements content can be connected with the environmental conditions, such as the soil type, the precipitation depth, and the fertilizers application (Kabata-Pendias, Mukherjee and Trace, 2007).

The component composition of plum fruits methanol extracts is illustrated by Yaichnaya Sinyaya variety (Table 5). The main components of plum fruits metabolomic profiles are 16 individual chemical compounds, i.e. L-Norleucine, Succinic acid, Fumaric acid, Malic acid, Malonic acid, Levoglucosan, D(-)-Fructofuranose, D-Allofuranose, Quinic acid, b-D-Glucopyranose, Acrylic acid, D-Sorbitol, D-Glucose, D(+)-Talofuranose, Myo-inositol, Sucrose, 9 of which are carbohydrates and their derivatives. The main carbohydrates are saccharose, glucose and fructose. Rootstocks influence the ratio of the metabolite (Table 5). On the medium-growing rootstocks, we registered the increase of monosaccharides on 5 – 7%, Quinic acid on 3 – 5%, and Myo-inositol on 2.5 – 3% in comparison with strong- and low-growing rootstocks. The high biological role of Quinic acid and Myo-inositol as proved by many types of research (Akesson et al., 2005; Font i Forcada et al., 2019; Sciejeannu et al., 2019). The maximum content of Quinic acid and Myo-inositol was marked in Yaichnaya Sinyaya variety fruits on OPA-15-2 rootstock. The same results were received during Utro variety fruits analysis.
CONCLUSION
The present study stated the rootstock influence on the plants’ productivity and bioactive substances accumulation in Prunus domestica L. fruits. Under the influence of medium-growing rootstocks, i.e. OPA-15-2, Novinka, and OP-23-23, the increase of not only main economic parameters (output yield, the fruit size, and weight, sensor evaluation, SSC and TTA) but biologically important compounds (antioxidants, metabolites, macro, and microelements) was registered as well. The optimal rootstocks for Yaichnaya Sinyaya and Utro varieties are medium-growing rootstocks OPA-15-2, Novinka, and OP-23-23.

REFERENCES
Bartolini, S., Leece, A., Iacona, C., Andreini, L., Viti, R. 2014. Influence of rootstock on fruit entity, quality and antioxidant properties of fresh apricots (cv. ‘Pisana’). N. Z. J. Crop Hortic. Sci., vol. 42, no. 4, 265-274. https://doi.org/10.1080/01140671.2014.894919

Blazek, J., Pisteckova, I. 2012. Final estimation of nine plum cultivars grafted onto two rootstocks in a trial established in 1998 at Holovousy. Hortic. Sci., vol. 39, no. 3, p. 108-115. https://doi.org/10.17221/150/2011-HORTSCI

Brand-Williams, W., Cuvelier, M. E., Berchet, C. 1995. Use of a free radical method to evaluate antioxidant activity. Lebensmittel-Wissenschaft und-Technologie, vol. 28, p. 1, 25-30. https://doi.org/10.1016/S0022-6278(95)80008-5

Ciobanu, A., Cichi, M., Iancu, S., Iancu, D. 2009. Plum trees development appearances in the central area of Oltenia depending on the graft/rootstock used biosystem. Annals of the University of Craiova-Agriculture., vol. 39, no. 1, p. 70-75.

Cosmulescu, S., Trandafir, I., Nour, V., Botu, M. 2017. Variation in minerals of skin and pulp of different cultivars of plum. Acta Hortic. vol. 1175, 93-98. https://doi.org/10.17660/ActaHortic.2017.1175.17

Daza, A., Garcia-Galavis, P., Grande, M., Santamaría, C. 2008. Fruit quality parameters of ‘Pioneer’ Japanese plum produced on eight different rootstocks. Sci Hortic., vol. 118, no. 3, p. 206-211. https://doi.org/10.1016/j.scienta.2008.06.003

Eremin, G. V. 2000. Biological potential of stone fruit crops and ways to implement it Biological potential of garden plants and ways to implement it. Moscow, Russia, p. 108-115.

Eremin, G. V., Provorchenko, A. V., Gavrish, V. F., Podorozhny, V. N., Eremin, V. G. 2000. Stone fruit crops. Cultivation on clonal rootstocks and own roots. Rostov-on-Don: Feniks, 256 p. ISBN 5-222-00537-2. (in Russian)

Eremin, G., Brizhivin, A. 2011. Estimation of varieties andclonal rootstocks for creation of early appearance of fruit orchards of prunus domestica. Fruit Growing and viticulture of South Russia, vol. 11, no 5, p. 14-21.

Fazzari, M., Fukumoto, L., Maza, G., Livrea, M., Tesoriere, L., DiMarco, L. 2008. In vitro bioavailability of phenolic compounds from five cultivars of frozen sweet cherries (Prunus avium L.). J Agric Food Chem, vol. 56, no. 10, p. 3561-3568. https://doi.org/10.1021/jf073536a

Font i Forcadà, C., Reig, G., Gimenez, R., Mignard, P., Mestre, L., Moreno, M. 2019. Sugars and organic acids profile and antioxidant compounds of nectarine fruits influenced by different rootstocks. Sci. Hortic. vol. 248, p. 145-153. https://doi.org/10.1016/j.scienta.2018.12.010

Gonçalves, B., Moutinho-Pereira, J., Santos, A., Silva, A. P., Bacelar, E., Correia, C., Rosa, E. 2006. Scion–rootstock interaction affects the physiology and fruit quality of sweet cherry. Tree Physiol., vol.26, p. 93-104. https://doi.org/10.1093/treephys/26.1.93

GOST ISO 2173. 2013. Fruit and vegetable products. Refractometric method for determination of soluble solids content.

GOST ISO 750. 2013. Fruit and vegetable products. Determination of titratable acidity.

Hatton, R., Amos, J., Witt, A. W., Hoblyn, T. 2015. Plum rootstocks; their varieties. propagation. and influence upon cultivated varieties worked thereon. J. of Pomology and Horticultural Science, vol. 7, no.1, p. 63-99. https://doi.org/10.1080/03683621.1928.11513332

Iglesias, I., Gine-Bordonaba, J., Garanto, X., Reig, G. 2019. Rootstock affects quality and phytochemical composition of ‘Big Top’ nectarine fruits grown under hot climatic conditions. Sci. Hortic., vol. 256, p. 10856. https://doi.org/10.1016/j.scienta.2019.10856

Jonica, M., Nour, V., Trandafir, I., Cosmulescu, S., Botu, M. 2013. Physical and chemical properties of some European plum cultivars (Prunus domestica L.). Not. Bot. Horti Agrobot., Cluj-Napoca, vol. 41, no. 2, p. 499-503. https://doi.org/10.15835/nbha4129354

Kabata-Pendas, A., Mukherjee, A., Trace, B. 2007. Elements from Soil to Human 2007. ISBN 978-3-540-32713-1 https://doi.org/10.1007/978-3-540-32714-1

Karakaya, O., Ozturk, B., Aglar, E., Balik, H. 2021. The Influence of the Rootstocks on Biochemical and Bioactive Compound Content of ‘0900 Ziraat’ Sweet Cherry Fruit. Erwerbs-Ostbau. vol. 63, no. 3, p. 247-253. https://doi.org/10.1034/j.1034-0210.200542-0

Kaufmane, E., Scrivele, M., Rubauskis, E., Ikase, L. 2007. The yield and fruit quality of two plum cultivars on different rootstocks. Sodininikstè ir Daržininikstè, vol. 26, no. 3, p. 10-15.

Lopez-Ortega, G., Garcia-Montiel, F., Bayo-Canhãa, C., Frutos-Ruiza, C., Frutos-Tomas, D. 2016. Rootstock effects on the growth, yield and fruit quality of sweet cherry cv. ‘Newstar’ in the growing conditions of the Region of Murcia. Sci. Hortic., vol. 198, p. 326-335. https://doi.org/10.1016/j.scienta.2015.11.041

Meland, M. 2010. Performance of six European plum cultivars on four plum rootstocks growing in a northern climate. Acta Agr. Scand. B-S.P., vol. 60, no. 4, p. 381-387. https://doi.org/10.1080/09064710903103917

Milošević, T., Milošević, N. 2011. Growth, fruit size, yield performance and micro- nutrient status of plum trees (Prunus domestica L.). Plant Soil Environ., vol. 57, no.12, p. 559-564. https://doi.org/10.17221/470/2011-PE

Milošević, T., Milošević, N. 2012. Factors influencing mineral composition of plum fruits. J. Elem., vol.17, no.3, p. 453-464. https://doi.org/10.5601/jelem.2012.17.3.08

Motyleva, S. M. 2018. The methodic recommendations for the ash elements and mineral inclusions in the plants organs analysis fulfillment via the method of energy dispersive spectrometry on analytical REM. Moscow, p. 40. ISBN 978-5-00140-010-3

Motyleva, S., Upadysheva, G., Kulikov, I., Upadyshev, M., Medvedev, S., Panischeva, D. 2019. Plum (Prunus rossoica Erem.) fruit field and laboratory researches depending on the scion-stock combinations. Potravinarstvo Slovak Journal of Food Sciences, vol 13, no. 1, p. 993-1000. https://doi.org/10.5219/1208

Motyleva, S., Upadysheva, G., Tumaeva, T. 2021. The mineral composition of cherry (Prunus cerasus MILL.) fruits depending on the scion-stock combination. Potravinarstvo
Mozeiček, T., Brest, P., Hribar, J. 2002. Determination and quantitation of anthocyanins and hydroxycinnamic acids in different cultivars of sweet cherries (Prunus avium L.) from Nova Gorica region (Slovenia). Food Technol Biotechnol, vol. 40, p. 207-212.

Orazem, P., Stampar, F., Hudina, M. 2011. Fruit quality of Redhaven and Royal Glory peach cultivars on seven different rootstocks. J. Agric. Food Chem., vol. 59, 17, p. 9394-9401. https://doi.org/10.1021/jf2009588

Popova, V., Sergeeva, N., Yaroshenko, O., Kuznetsova, A. 2020. Physiological state of plants and quality of plum fruits grafted on the rootstocks of various strength of growth depending on the plant nutrition mode. Potravinarstvo Slovak Journal of Food Sciences vol. 14, no. 1, p. 1075-1087. https://doi.org/10.15219/1469

Radovič, M., Milatović, D., Tešić, Z., Tostic, T., Gajić, U., Đođinović, B., Zagorac, Dabić, D. 2020. Influence of rootstock on the chemical composition of the fruits of plumcultivars. Journal of Food Composition and Analysis, vol. 92, p. 103480. https://doi.org/10.1016/j.jfca.2020.103480

Rato, A., Agulheiro, A., Barroso, J., Riquelme, F. 2008. Soil and rootstock influence on fruit quality of plums (Prunus domestica L.). Scientia Horticulae, vol. 118, no. 3, p. 218-222. https://doi.org/10.1016/j.scienta.2008.06.013

Reig, G., Forcada, C. F., Mestre, L., Jimenez, S., Betran, J. A., Moreno, M. A. 2018. Horticultural, leaf mineral and fruit quality traits of two 'Greengage' plum cultivars grafted on plum based rootstocks in Mediterranean conditions. Sci. Hortic. vol. 232, p. 84-91. https://doi.org/10.1016/j.scienta.2017.12.052

Robbins, R. 2003. Phenolic acids in foods: an overview of analytical methodology. Journal of Agricultural and Food Chemistry, vol. 51, no. 10, p. 2866-2887. https://doi.org/10.1021/jf026182t

Rop, O., Jurikova, T., Mlicek, J., Kramarova, D., Sengee, Z. 2009. Antioxidant activity and selected nutritional values of plums (Prunus domestica L.) typical of the White Carpathian Mountains. Sci. Hortic., vol. 122, no. 4, p. 545-549. https://doi.org/10.1016/j.scienta.2009.06.036

Scârjeanu, V. G., Madjar, R. M., Stânciă, F., Peticilă, A. G. 2019. An overview on chemical composition and health importance of kiwifruit. Proc. Rom. Acad., Series B, vol. 21, no. 1, p. 73-81.

Spinardi, A., Visai, C., Bertazza, G. 2005. Effect of rootstock on fruit quality of two sweet cherry cultivar. Acta Hortic., vol. 667, p. 201-206. https://doi.org/10.17660/ActaHortic.2005.667.29

Upadysheva, G. 2015. Features of growth and production process in plum (Prunus domestica L.) during the formation of small-scaled crowns. Methods and technologies in plant breeding and crop production. Kirov, Russia, p. 487-490

Upadysheva, G. 2017. Efficiency of propagation of the cherry plum hybrid on clonal rootstocks in the Moscow area. J. Horticulture and Viticulture, vol. 4, p. 25-29.