УДК 635.11:631.524.01

ОЦЕНКА РАЗЛИЧНЫХ ГЕНОТИПОВ СВЕКЛЫ СТОЛОВОЙ НА ПРОДУКТИВНОСТЬ И СОХРАНЯЕМОСТЬ

ASSESSMENT OF DIFFERENT GENOTYPES OF TABLE BEET FOR PRODUCTIVITY AND STORABILITY

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Эксперименты проводили в течение двух последовательных сезонов 2015/2016 и 2016/2017 годов в Казахском научно-исследовательском институте картофелеводства и овощеводства, Алматинская область, Казахстан. Эксперимент был нацелен на изучение эффективности 117 различных образцов свеклы по полевой продуктивности и сохраняемости. Для изучения сохраняемости, по 20 корнеплодов свеклы в двух повторениях без внешних симптомов заболевании от каждого сортообразца были заложены на хранение. Сырая свежая масса корнеплодов свеклы, закладываемой на хранение, варьировала от 132 г до 320 г в зависимости от формы и размера корней. Свекла хранилась в полипропиленовых мешках, которые помещались на решетчатую полку высотой 30-35 см. Температура хранения в осенний и весенний периоды колебалась от 3-5° до 6-8° С, а в зимний период она установилась на уровне 1-2° С. Полученные результаты показали, что валовой сбор свеклы столовой варьировал от 25,0 до 105,4 т/га, товарная – от 16,7 до 74,9 т/га, товарность – от 33,8 до 97,2%. Сохраняемость корнеплодов свеклы столовой в основном зависела от генотипа образцов с различными естественной убылью массы и заболеваемостью корневыми гнилями. Естественная убыль массы варьировала от 0,0 до 12,3%, суммарные потери от заболеваний корнеплодов составляли от 0,0 до 90,0%. Анализ показал, что связь между урожайностью и параметрами хранения неустойчивая и слабая (R = -0,042-0,144). Корреляционная зависимость сохраняемости и от корневой гнили значительно сильнее (R = -0,516-0,644), чем от естественного снижения массы (R = -0,115).

Ключевые слова: *оценка, свекла, сортообразец, селекция, продуктивность, хранение.*

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The experiments were performed during the two successive seasons of 2015-2016 and 2016-2017 at the Kazakh Research Institute of Potato and Vegetable Growing, Almaty Region, Kazakhstan. The experiment was aimed to study the efficiency of 117 different beetroot accessions for productivity and storability. To study the storability, 20 beetroot roots without any external sings of diseases were taken in two replications from each variety accession and left to be stored. The wet fresh weight of beetroots placed into storage varied from 132 g to 320 g depending on the shape and the size of roots. Beetroots were stored in polypropylene bags, which were placed on barred shelves 30-35 cm high. The storing temperature in autumn and spring period of time fluctuated from 3-5o to 6-8°, but in winter period it was 1-2°. The observed results showed that the gross yield of beetroot accessions ranged from 25.0 to 105.4 t/ha, marketable yield – 16.7 to 74.9 t/ha, marketability – 33.8 to 97.2%. Storability of beet roots mostly depended on accession genotype with different natural decrease of weight and root rot diseases. Natural decrease of weight varied from 0.0 to 12.3%, total losses from root diseases were from 0.0 to 90.0%. The analysis carried out showed that the link between yield capacity and storage characteristics was weak, R= -0,042-0,144. The correlation between storability and root rot was R = -0,516-0,644, that was stronger than it was in natural decrease of weight, R = -0.115.

Keywords: *assessment, beetroot, accession, breeding, productivity, storability.*

Introduction

In Kazakhstan, beetroot (*Beta vulgaris* L.) is cultivated universally and widely consumed, its area in 2015 amounted to 5,6 thousand hectares and with a production volume of 146,9 thousand tons. Over half (54%) of table beet production area is concentrated in the southern and southeastern regions of the country. The northern and north-eastern regions account for 34%, and the western region of the country occupies 12% of the production area of beetroot. The main suppliers of table beet in the country are Almaty (22,5%) and South-Kazakhstan (11,2%) regions [1].

As of 2016, there were 14 open pollinated varieties and hybrids F_1 of table beet, including two cultivars – 'Kyzylkonyr' and 'Dariya' of domestic breeding program, included in the Register of selection achievements permitted for use in the Republic of Kazakhstan [2]. In recent years, the Kazakh Research Institute of Potato and Vegetable Growing (KazNIIKO) has expanded selection work on the creation and introduction of competitive varieties that are well adapted to local agroecological conditions. In Kazakhstan table beet is stored for fresh market for as long as 7-8 months, so the disease resistance of the crop, in particular in storage season is of great importance. In table beet breeding of great importance is the original material, selected as a result of a comprehensive study of productivity, resistance to diseases, both during the growing season and during storage. Successful use of the integrated approach in selection is facilitated by studying the correlation dependence of the studied parameters of productivity, resistance to diseases and the storability of the products.

It is known that the most effective method of plant protection against infectious diseases is to develop and release of disease resistant varieties for fresh market, which would greatly reduce the yield loss during storage. In recent years, root rot has occurred more frequently and is becoming a lim-iting factor in table beet production. Root rot reduces both yield and quality of beets, causing serious problems in storage. Damage and losses due to this disease are expressed as abnormally shaped roots of undesirable size and roots with external or internal rot. Pathogenic fungi known to cause root rot of both table beet and sugar beet include *Pythium spp., Rhizoctonia solani, Aphanomyces cochlioides*, and *Phoma betae* [3-6].

Improving the postharvest storability of beetroot varieties or breeding selections has been part of the breeding program. The goal of these studies was to evaluate the beetroot accessions during the two successive seasons of 2015/2016 and 2016/2017.

Materials and methods

In the experiments table beet breeding selections was grown at the Kazakh Research Institute of Potato and Vegetable Growing experimental field. Growing of beetroot breeding selections in field nurseries was conducted on raised beds, with the cultural practices being applied as recommended for the region. Over the two seasons of 2015/2016 and 2016/2017 roots of 117 table beet accessions were allocated for storage, which allowed to obtain consistent findings in studies on linkage between beetroot crop yielding capacity and storability parameters.

To study the storing ability 20 beetroot roots in two replications with no outward signs of dis-ease from each accession were set into storage. The fresh weight of beetroots allocated for storage varied widely from 132 g to 320 g depending on the shape and size of roots. Beetroots were stored in polypropylene bags, which were placed bulk on the lattice shelf with height of 30-35 cm. Storage temperature in the autumn and spring seasons ranged from 3-5° to 6-8° C, and in the winter season it was at 1-2° C. Observations and surveys were done in accordance with the recommended instruction guides. In the spring after prolonged storage (October to April) the natural decline in weight, losses from diseases and storability percentage of the stored root mass were assessed. The research results were subjected to correlation analysis using software Microsoft Excel 2010 application.

Results and discussion

Due to the large scale of the data on the extent of productivity (gross yield, marketable yield, marketability) and storability (the natural decline in mass, damages from disease and storability) pa-rameters of beetroot breeding selection material, the obtained characteristics were grouped tentatively.

Table 1 – Grouping of table beet accessions by gross yield

Grouping by gross yield	Accessions
1 – very high (>70,0 t/ha) – 23 accessions	BR299, BR626, BR628, BR632, BR678, BR680, BR682, BR692, BR708, BR727, BR769, BR798, BR817, BR831, BR839, BR842, BR843, BR848, BR868, BR876, BR897, BR928, BR930
2 – high (50,1-70,0 t/ha) – 48 accessions	BR004, BR019, BR027, BR069, BR393, BR474, BR592, BR636, BR641, BR662, BR676, BR685, BR686, BR687, BR688, BR694, BR696, BR698, BR702, BR709, BR714, BR715, BR722, BR723, BR739, BR746, BR759, BR782, BR794, BR810, BR814, BR815, BR824, BR832, BR834, BR840, BR857, BR861, BR873, BR881, BR882, BR883, BR890, BR899, BR907, BR922, BR924, BR929
3 – medium (35,1-50,0 t/ha) – 38 accessions	BR262, BR289, BR401, BR580, BR629, BR643, BR647, BR679, BR689, BR691, BR700, BR703, BR707, BR712, BR720, BR721, BR726, BR730, BR732, BR734, BR738, BR761, BR765, BR779, BR780, BR784, BR816, BR818, BR835, BR837, BR874, BR888, BR891, BR896, BR910, BR914, BR917, BR918
3 – low (<35,0 t/ha) – 8 accessions	BR733, BR717, BR904, BR697, BR905, BR774, BR777, BR681

Table 2 – Grouping of table beet accessions by marketability

Grouping by marketability	Accessions
1 – very high (>95,0%) – 3 accessions	BR592, BR715, BR930
2 – high (80,1-95,0%) – 54 accessions	BR027, BR722, BR721, BR815, BR928, BR784, BR897, BR777, BR700, BR904, BR818, BR708, BR882, BR759, BR696, BR707, BR678, BR689, BR832, BR739, BR730, BR835, BR717, BR780, BR662, BR779, BR643, BR727, BR632, BR262, BR580, BR774, BR924, BR848, BR888, BR681, BR289, BR676, BR734, BR769, BR896, BR691, BR019, BR782, BR647, BR876, BR698, BR694, BR692, BR765, BR814, BR697, BR069, BR641
3 – medium (60,1-80,0%) – 45 accessions	BR839, BR686, BR873, BR628, BR702, BR629, BR891, BR636, BR881, BR723, BR918, BR733, BR726, BR890, BR874, BR714, BR679, BR685, BR761, BR732, BR299, BR798, BR746, BR687, BR712, BR899, BR703, BR914, BR840, BR401, BR907, BR626, BR688, BR738, BR720, BR917, BR910, BR868, BR709, BR004, BR680, BR816, BR817, BR883, BR831
4 – low (<60,0%) – 15 accessions	BR861, BR843, BR810, BR905, BR857, BR837, BR682, BR393, BR824, BR842, BR794, BR922, BR834, BR474, BR929

The studied table beet accessions differed significantly in terms of productivity: gross yield ranged from 25,0 to 105,4 t/ha, marketable yield – 16,7 to 74,9 t/ha, marketability – 33,8 to 97,2%. The highest gross yields were obtained for accessions BR843 – 105,4 t/ha; BR839 – 90,5 t/ha; BR842 – 88,8 t/ha and BR798 – 87,5 t/ha. The lowest rates of gross yield were observed in accessions BR905 – 30,0 t/ha; BR774 – 28,1 t/ha; BR777 – 26,9 t/ha and BR681 – 25,0 t/ha (Table 1). The cultivars 'Bordo 237' (BR069) and 'Kyzylkonyr' (BR019) taken as test-standards showed the gross yield of 59,6 and 67,5 t/ha, respectively.

With high marketable yields of storage roots were distinguished breeding selections BR930 – 74,9 t/ha; BR632 – 73,1 t/ha and BR839 – 72,1 t/ha. With the lowest commodity productivity were documented beetroot accessions BR681 – 20,9 t/ha; BR922 – 19,9 t/ha and BR905 – 16,7 t/ha. The marketable yields of cultivars 'Bordo 237' (BR069) and 'Kyzylkonyr' (BR019) were at the level of 48,3 and 55,7 t/ha, respectively. By the marketability the studied table beet accessions ranged from 33,8 to 97,2% (Table 2).

The best indices in this character were observed for the accession numbers BR930 – 97,2%; BR715 – 97,0% and BR592 – 95,8%, the worst – for the beetroot accessions BR834 – 39,0%; BR474 – 36,8% and BR929 – 33,8%, whereas, the marketability of the standard cultivars 'Bordo 23'7 (BR069) and 'Kyzylkonyr' (BR019) were 81,1% and 82,5%, respectively.

In our experiments, performance of the beetroot genotypes depended on the type of infection character. As there were some complications in perfect identification of particular pathogens on roots of the beetroot breeding selections because of the presence of multiple pathogens, we decided to summarize the results into two main diseases – dry rot and soft rot by external symptoms. It should be noted that in this study under the category of a storable roots were recognized only those beetroot ac-cessions that were suitable for seed reproduction.

It is interesting to notice that of the set of 117 varieties three beetroot accessions (BR069, BR715 and BR834) showed no losses in natural decline in weight. Of the studied beet-seed varieties, 71,8% had external symptoms of dry rot, 56,4% were susceptible to soft rot, wilting of root crops was observed in 31,6% of beetroot accessions. Overall, the total losses from diseases and wilting were rec-orded in 92,2% of the accessions from 117 studied.

With a very high susceptibility to dry rot were distinguished 19 beetroot accessions during storage, three of which had the highest incidence of this disease (Table 3, Figure 1). No dry rot

Table 3 – Grouping of table beet accessions by dry rot resistance in storage

Grouping by dry rot resistance in storage	Accessions
1 – Highly susceptible (<25,0%) – 19 accessions	BR891, BR897, BR917, BR474, BR004, BR868, BR848, BR839, BR393, BR680, BR881, BR876, BR628, BR922, BR842, BR930, BR924, BR580, BR896
2 – medium sus-ceptible (10,1-25,0%) – 29 accessions	BR910, BR918, BR824, BR798, BR928, BR289, BR834, BR890, BR782, BR702, BR929, BR784, BR874, BR678, BR632, BR843, BR861, BR882, BR907, BR727, BR299, BR703, BR708, BR714, BR840, BR720, BR769, BR019, BR914
3 – low susceptible (0,1-10,0%) – 36 ac-cessions	BR817, BR694, BR810, BR722, BR774, BR759, BR688, BR738, BR777, BR682, BR837, BR685, BR679, BR899, BR732, BR831, BR815, BR835, BR816, BR626, BR689, BR765, BR262, BR698, BR832, BR691, BR712, BR662, BR401, BR696, BR904, BR761, BR726, BR717, BR636, BR739
4 – not susceptible (0,0%) – 33 accessions	BR715, BR592, BR027, BR721, BR700, BR818, BR707, BR730, BR780, BR779, BR643, BR888, BR681, BR676, BR734, BR647, BR692, BR814, BR697, BR069, BR641, BR686, BR873, BR629, BR723, BR733, BR746, BR687, BR709, BR883, BR905, BR857, BR794

Figure 1 – Some examples of table beet accessions by dry rot resistance in storage a) highly susceptible BR897 (<25,0%), b) medium susceptible BR907 (10,1-25,0%) , c) low susceptible BR679 (0,1-10,0%), d) not susceptible BR592 (0,0%).

symp-toms were found on roots of 33 studied table beet breeding selections.

The highest lost from the soft rot was observed on beetroot breeding accessions BR580 – 49,8%; BR896 – 37,5%; BR474 – 29,4%; BR857 – 27,2%; and BR708 – 25,6%. If the lost from the soft rot for the standard cultivars 'Bordo 237' (BR069) was 33,8%, whereas on the roote of cv 'Kyzylkonyr' (BR019) there were no signs of soft rot (Table 4).

The surveys to identify promising beetroot accessions for productivity and storability during prolonged storage showed that the magnitude of crop yields and losses during storage varied considerably depending on the genotype of the beetroot breeding selections.

Studies have suggested that following harvesting storability of beet roots is associated with root rot caused by various pathogens of fungal and bacterial nature [3-8]. In the experiments have

Table 4 – Grouping of table beet accessions by soft rot resistance in storage

Grouping by storability	Accessions
1 – Highly susceptible (<25,0%) – 6 accessions	BR580, BR896, BR069, BR474, BR857, BR708
2 – medium sus-ceptible (10,1-25,0%) – 25 accessions	BR842, BR691, BR848, BR626, BR692, BR882, BR861, BR843, BR709, BR840, BR907, BR592, BR678, BR905, BR794, BR393, BR401, BR888, BR815, BR876, BR873, BR262, BR628, BR720, BR824
3 – low susceptible (0,1-10,0%) – 35 ac-cessions	BR868, BR715, BR928, BR707, BR697, BR922, BR817, BR738, BR721, BR632, BR641, BR910, BR782, BR897, BR717, BR299, BR714, BR918, BR891, BR930, BR643, BR899, BR890, BR904, BR629, BR662, BR679, BR784, BR698, BR685, BR733, BR686, BR636, BR289, BR004
4 – not susceptible (0,0%) – 51 accessions	BR917, BR839, BR680, BR881, BR924, BR798, BR834, BR702, BR929, BR874, BR727, BR703, BR769, BR019, BR914, BR694, BR810, BR722, BR774, BR759, BR688, BR777, BR682, BR837, BR732, BR831, BR835, BR816, BR689, BR765, BR832, BR712, BR696, BR761, BR726, BR739, BR027, BR700, BR818, BR730, BR780, BR779, BR681, BR676, BR734, BR647, BR814, BR723, BR746, BR687, BR883

Table 5 – Grouping of table beet accessions by storability

Grouping by stor-ability	Accessions
1 – very high storability (<95,0%) – 8 accessions	BR027, BR814, BR883, BR818, BR723, BR734, BR765, BR730
2 – high storability (80,1-95,0%) – 49 accessions	BR816, BR832, BR647, BR746, BR676, BR831, BR835, BR682, BR721, BR687, BR689, BR700, BR715, BR837, BR904, BR696, BR899, BR722, BR761, BR739, BR726, BR810, BR697, BR679, BR643, BR707, BR019, BR914, BR636, BR774, BR694, BR685, BR873, BR717, BR769, BR727, BR888, BR712, BR738, BR733, BR662, BR592, BR641, BR794, BR874, BR714, BR759, BR905, BR698
3 – medium storability (60,1-80,0%) – 39 accessions	BR929, BR401, BR299, BR703, BR834, BR815, BR702, BR681, BR686, BR890, BR262, BR798, BR692, BR720, BR709, BR632, BR857, BR784, BR918, BR928, BR782, BR691, BR881, BR732, BR930, BR289, BR840, BR069, BR910, BR907, BR922, BR861, BR626, BR843, BR817, BR680, BR882, BR678, BR924
4 – low storability (<60,0%) – 21 accessions	BR708, BR839, BR628, BR004, BR876, BR868, BR688, BR917, BR779, BR629, BR393, BR842, BR824, BR777, BR848, BR891, BR897, BR896, BR474, BR580, BR780

shown that storability of beet roots is mostly conditioned by the genotype of the studied varieties, by the year, the growth and storage conditions [9-11].

As results of our studies showed, the lowest natural decline in weight were observed in acces-sions of beetroot BR899 – 0,4% and BR765 – 0,4%, whereas selection numbers BR715, BR834 and test cv 'Kyzylkonyr' (BR019) ' had no natural decline in weight. The highest natural decline in weight were observed for beetroot accessions BR780 – 12,3%; BR687 – 9,1%; BR777 – 8,9% and BR629 – 8,4%.

The minimum storability rate were observed in beetroot breeding selections BR580 – 9,2% and BR780 – 9,0%; the highest – for the selection numbers BR027 – 98,6%, BR814 – 98,3%, BR883 – 97,3% and BR818 – 97,1% (Table 5).

In order to identify if there is any relationship between crop yielding capacity and storability characteristics of the table beet accessions pair correlation analysis was carried out. The analysis showed that the relationship between crop yielding and storability parameters was unsustainable and insignificant (R = -0,042-0,144). The correlation relationship between storing ability and root rot inci-dence was much stronger (R = -0,516-0,644) than it was between the natural decline in weight (R = -0,115).

Thus, the economic value of studied table beet breeding selections was summarized into 5 in-dices that included gross yield at >50 t/ha, marketability at >80%, natural weight loss at <5%, total loss from diseases and wilting at <20%, and storability at >80% during prolonged storage. The inte-grated indices shows the best performance of table beet accessions BR027, BR814, BR 832, BR715, BR722, BR 019, BR694, BR769, BR727, BR592 and BR698.

Conclusions

The results of the studies have shown that beetroot field productivity indices, and its natural decline in weight, losses from diseases and wilting in long term storage varied considerably depending on the genotype of the studied breeding selections.

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