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MORPHOLOGICAL AND BIOLOGICAL PECULIARITIES OF SWEET CHERRY PRODUCTIVITY DEVELOPMENT IN THE SOUTH OF THE NON-CHERNOZEM ZONE

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Abstract

Sweet cherry (*Cerasus avium* L. Moench) is a valuable fruit crop; its industrial planting is concentrated mainly in the South of Russia because of insufficient winter hardiness. Nowadays, 16 varieties have been adapted in the Non-Chernozem zone, and 11 varieties bred in the Russian Lupin Research Institute are under the testing. A deep understanding of the patterns of development and formation of the yield components allows for a better use of genetic potential of the species. This study, for the first time, revealed the significant variability in morphobiological indices of new sweet cherry varieties in the Non-Chernozem zone conditions, which provides new possibilities for genotype selection and commercial planting. The yield components are shown to be related to each other but only some correlations are significantly valid. The cluster analysis grouped the varieties by growth and fruiting similarity, and the factors with the highest contribution were found. The work aimed to study morphobiological parameters determining productivity of sweet cherry plants and to highlight genotypes which are valuable for breeding and commercial use. The experiment estimated 23 sweet cherry varieties for 9 morphobiological traits, i.e., the number of annual shoots, the average length of annual shoots, the number of sprays ("May bouquets"), the number of flower buds per annual shoot, the number of flower buds per sprays, the number of flowers per flower bud, yield, crown width, trunk circle (the garden experimental plots, the All-Russian Lupine Research Institute, Bryansk Province, 1991-1996). Estimation of variation coefficients allowed us to classify the varieties into two groups. The first group consists of varieties with high variation degree (more than 10 %) of such correlated traits as the number of annual shoots, the average length of annual shoots, the number of sprays, the number of flower buds per annual shoots and the number of flower buds per sprays. In this group, the varieties Podarok Petelinu, Teremoshka, Bryanochka, 2-3-67, 2-6-36, 2-3-45, Odrinka, Krasnaya plotnaya, Yantarnaya, 2-5-2 and 2-3-35 formed correlation pleiades. The pleiades had different power and strength. The varieties of this group are appropriate for breeding for a complex of economic valuable traits. The all tested genotypes made the second group with the variation degree for the number of flowers per flower bud (Cv = 1.0-6.0 %), crown width (Cv = 2.0-5.0 %), and trunk circle (Cv = 0.3-0.4 %) less than 6 %. Only seven of 36 pair correlations are significant. The significant pair correlations are the average length of annual shoots—the number of annual shoots (r = –0.49, p = 0.016); the average length of annual shoots—the number of sprays (r = 0.73, p = 0.000); the average length of annual shoots—crown width (r = 0.74, p = 0.000); the average length of annual shoots—trunk circle (r = 0.42, p = 0.044); the number of annual shoots—the number of flower buds per annual shoots (r = 0.77, p = 0.000); the number of sprays—crown width (r = 0.59, p = 0.003); crown width—trunk circle (r = 0.54, p = 0.008). There is no link between the yield and its components. The cluster analysis resulted in four clusters grouping the varieties that are similar in terms of the generalized indicator of the studied traits. It makes easier to select initial lines for breeding. The lack of the significant valid correlations between yield and morphological traits made us to apply the factor analysis which revealed four factors with eigenvalues of > 1. The contributions of these factors to the observed variability are 35.9, 18.6, 11.9, and 11.5 %. The other four factors can be regarded as scree ones.

Keywords: sweet cherry, varieties, variability, productivity, correlation, clustering, factor analysis, the Russian Non-Chernozem zone

Sweet cherry, as a fruit crop, recently appeared in the variety of the Non-Chernozem zone. The first zoned sweet cherry varieties were Bryanskaya rosovaya, Iput, and Revna (1983) bred at the Russian Lupin Research Institute (RLRI). Nowadays, the industrial range of such zone includes 16 varieties bred in the Russian Lupin Research Institute, for which copyright certificates have been obtained, 3 varieties bred in the Federal Horticultural Research Center for Breeding, Agrotechnology and Nursery (FHRCBAN), and one variety bred at the Institute for Fruit Growing [1].

The selection of fruit crops abroad is carried out in accordance with the European Breeding Program [2]. In Russia, programs for breeding and research on varieties of fruit, berry and nut crops have been developed for these purposes [3, 4]. The biological characteristics of the growth and fruiting of sweet cherries are insufficiently studied. The authors of previous studies on southern varieties characterize sweet cherries as vigorous with weak branching and predominant fruiting (70-75% of fruit buds) on sprays ("May bouquets") [5-7]. In central Russia, fruiting is concentrated mainly on annual shoots and sprays [8, 9]. Most of these works are of a general nature and do not contain sufficient information on the quantitative relationships of biological traits affecting the productivity of sweet cherries.

Yield is a complex trait, mainly due to its defining morphobiological parameters and their ability to withstand environmental stress factors [10]. In sweet cherries, the process of crop formation lasts from the differentiation of fruit buds in July to ripening of fruits in June-July of the next year. For this reason, there is a high risk of annual exposure to abiotic and biotic stressors at any stage of the annual plant development cycle. [11-13]. Reduced yield of fruit crops is caused by low cold resistance of plants [14-16], high temperature during flowering reducing fruit set [17, 18], disturbance of stages of morphogenesis [19], instability of fruiting [20-22], and abnormal temperatures during formation flower buds [23-25].

Many researchers emphasize the role of the variety, its yield ability, and stability [26-28] in the formation of crop in case of weather anomalies, which can lead to freezing of trees and the defeat of plantations by fungal diseases [29-31]. In recent years, considerable attention has been paid to the selection and use of vegetatively propagated rootstocks for fruit crops both abroad [32-34] and in Russia [35-37]. Their influence has been shown not only on growth and productivity [38, 39], but also on disease resistance [40] and product quality [41-43].

Recently, biplot analysis is used for in-depth study of genotypes in multivariate experiments. This is a two-level graph, where samples are displayed as dots and variables as vectors, which makes it possible to more fully interpret the interaction of the genotype and the environment [44]. The integral indicator of the breeding value of the genotype provides a comprehensive assessment of the yield and its stability, which is important when selecting the starting material [45, 46].

This study, for the first time, revealed the significant variability in morphobiological indices of new sweet cherry varieties in the Non-Chernozem southern zone conditions, which provides new possibilities for genotype selection and commercial planting. It was found that yield components are interconnected, but only some of them have reliable correlations. By means of cluster analysis, the varieties were grouped by growth and fruiting similarity. The factors with the highest to the formation of yield have been identified.

The work aimed to study morphobiological parameters determining productivity of sweet cherry plants and to highlight genotypes which are valuable for breeding and commercial use.

Materials and methods. The study was conducted in 1991-1996 on a garden experimental plot of the Russian Lupin Research Institute (Bryansk Province).

The experiment estimated 23 sweet cherry (Cerasus avium L. Moench) varieties for nine morphobiological traits. The length of parent branch and all branching of the 2nd and subsequent orders by age-specific zones has been measured. Structural elements were counted for each variety on four parent branches of the lower crown layer (based on technical capabilities). The number and length of annual shoots, the number of fruit buds on annual shoots, sprays, and flowers in a fruit bud were determined. The productivity per 1 running (linear) meter of the parent branch was assessed, the crown width and the trunk circle were measured, and the yield was determined [6].

The experimental data were statistically processed according to the recommendations [3, 4] using one-way ANOVA test [47], and multidimensional statistical methods (cluster and factor analyzes) [48, 49] in the STATISTICA 7.0 package (StatSoft, Inc., USA). The mean values for the traits (*M*), standard deviations (±SD), and coefficients of variation (*Cv*) were calculated.

Results. The use of a limited range of varieties and forms in breeding results in nuclear and cytoplasm uniformity of hybrids, reducing their adaptability and increasing genetic vulnerability. Involvement in breeding of varieties and hybrids of various economically valuable traits increases the variance of traits and creates the possibility of selecting valuable genotypes.

An extremely important characteristic of the starting material is the degree of its variability. In this study, the diversity of varieties was assessed using two indices — the limit (lim) and the coefficient of variation (Table). The minimum and maximum number of annual shoots in the specimens differed 7.4-fold, the number of sprays 21.3-fold, the average length of annual shoots, crown width, trunk circle, the number of fruit buds on annual shoots, the number of sprays, flowers in the bud and yield 1.6-4.0 times.

Coefficient of variation (*Cv*) allows comparing traits with different units of measurement and largely reflects the reaction of genotypes to external influences. According to the variability of traits, the studied genotypes were divided into two groups. The first group comprises varieties with a high degree of variation of the number of annual shoots (8 genotypes, *Cv* = 12-28%), the average length of annual shoots (9 genotypes, *Cv* = 11-23%), the number of sprays (13 genotypes, *Cv* = 11-24%), the number of flower buds per annual shoots (9 genotypes, *Cv* = 11-26 %), and the number of flower buds per sprays (17 genotypes, *Cv* = 7.0-49 %). In the rest genotypes, variability of these traits did not exceed 10 %. In this group, the varieties with high (> 10%) coefficient of variability of correlated traits forming the correlation Pleiades have been identified: Podarok Petelinu ($V_2V_3V_4$), Teremoshka ($V_1V_3V_4$), Bryanochka ($V_1V_2V_3$), 2-3-67 ($V_1V_2V_4$), 2-6-36 ($V_2V_3V_4$), 2-3-45 (V_1V_3), Odrinka (V_2V_4), Krasnaya plotnaya (V_2V_4), and Yantarnaya (V_3V_4), 2-5-21 (V_1V_3), 2-3-35 (V_1V_2).

All tested genotypes made the second group with the variation degree not exceeding 6% for the number of flowers per flower bud (*Cv* = 1.0-6.0 %), crown width (*Cv* = 2.0-5.0 %), and trunk circle (*Cv* = 0.3-0.4 %).

Comparison of the coefficients of variation denotes significant opportunities for selection of varieties for breeding according to the first group of traits and less - according to the second group of traits, which are probably under stricter genetic control.

Statistical characteristics of the structure of the yield of sweet cherry (*Cerasus avium* L. Moench) varieties in the south of the Non-Chernozem zone of the Russian Federation (Bryansk Province, settlement Michurinskii, 1991-1996)

Variety	Index for 1 lin.m. of parent branch										Number of flowers per bud, units		Yield, dt/ha		Crown width, m		Trunk circle, cm	
	annual shoots				Number of sprays		Number of fruit buds											
	number		average length, cm				on annual shoots		on sprays									
	M±SD	*Cv*, %	*M*±SD	*Cv*, %	*M*±SD	*Cv*, %	*M*±SD	*Cv*, %	*M*±SD	Cv, %	*M*±SD	*Cv*, %	*M*±SD	*Cv*, %	*M*±SD	*Cv*, %	*M*±SD	*Cv*, %
Podarok Pitelinu	27.5±0.99	3	18.3±2.34	13	40.3±5.60	14	102.6±26.78	26	133.3±9.31	7	3.0±0.48	5	39.5±1.13	0.4	4.6±0.14	3	38.2±0.85	0.4
Teremoshka	23.9±3.82	16	13.8±0.42	3	8.2±1.60	20	69.6±7.70	11	22.1±4.40	20	2.9±0.15	1	59.8±1.41	0.2	3.0±0.18	5	33.1±2.11	0.4
2-5-21	23.5±3.82	16	12.9±1.69	13	4.6±0.55	11	130.0±13.00	10	22.2±6.16	28	3.7±0.03	4	38.9±2.69	0.4	4.0±0.28	4	35.4±2.54	0.4
Veda	23.2±0.64	3	29.6±1.50	5	49.2±1.62	3	122.3±8.54	7	136.5±12.24	9	2.7±0.15	5	53.6±1.56	0.3	4.6±0.21	3	35.2±0.23	0.4
2-3-35	22.4±5.09	23	18.8±2.66	14	5.8±0.06	1	127.8±1.28	10	22.2±2.86	13	4.4±0.14	6	34.7±3.22	0.6	4.6±0.24	3	40.8±1.84	0.3
Ovstuzhenka	21.6±1.98	2	26.0±1.82	7	52.3±5.72	11	84.4±2.52	3	146.4±17.52	12	3.0±0.26	5	75.5±1.06	0.2	4.8±0.25	3	35.8±1.13	0.4
Zolotaya loshchitskaya	20.6±1.98	10	18.7±0.95	5	32.8±7.92	24	78.2±3.90	5	131.4±31.44	24	4.1±0.15	4	31.0±2.12	0.5	3.2±0.10	4	35.1±0.42	0.4
2-3-67	18.6±0.85	5	29.3±6.67	23	88.5±13.32	14	103.3±19.57	19	354.5±169.92	48	3.1±0.16	5	19.0±0.99	0.7	5.0±0.28	3	43.7±2.57	0.3
Raditsa	14.7±1.41	10	22.2±1.54	7	42.7±7.31	17	125.5±6.30	5	192.8±30.72	16	3.3±0.15	2	57.0±4.24	0.3	4.6±0.21	3	42.6±2.26	0.3
2-7-39	14.7±0.54	4	28.3±0.28	1	39.3±0.39	1	64.6±9.75	15	118.2±57.82	49	3.5±0.04	4	62.0±0.35	0.2	5.4±0.28	3	54.3±1.41	0.3
2-8-28	14.4±2.83	20	14.1±0.84	6	22.0±0.88	4	52.5±3.18	6	60.3±24.60	41	3.0±0.14	5	27.5±1.70	0.5	4.2±0.28	3	37.5±3.25	0.4
Revna	12.3±1.13	9	25.5±0.26	1	60.3±3.60	6	61.9±0.62	1	265.4±26.50	10	3.5±0.15	4	45.3±1.13	0.3	4.4±0.14	3	40.7±0.85	0.3
2-7-5	11.4±1.41	12	22.2±1.47	7	29.0±3.77	13	57.9±5.22	9	76.6±6.84	9	3.2±0.14	4	64.3±0.42	0.2	3.0±0.14	5	38.1±0.54	0.4
2-6-36	11.2±0.42	4	27.1±4.59	17	35.4±3.96	11	66.1±5.28	8	96.5±11.52	12	3.4±0.12	5	54.0±0.50	0.3	5.8±0.33	2	47.4±0.85	0.3
2-6-32	10.8±0.57	5	26.7±1.89	7	46.0±2.76	6	41.7±5.04	12	124.3±13.64	11	3.1±0.17	5	20.8±0.44	0.7	5.0±0.27	3	34.4±3.52	0.4
Odrinka	11.8±0.42	4	25.6±3.38	13	45.7±10.12	22	46.8±10.34	22	146.7±8.76	6	2.8±0.15	6	38.2±0.14	0.4	4.4±0.24	3	41.1±0.71	0.3
Rozovyi zakat	10.5±2.97	1	23.5±0.72	3	51.9±4.16	8	73.5±9.00	15	260.5±58.80	33	2.3±0.17	4	51.9±2.69	0.3	5.4±0.14	2	34.3±1.56	0.4
2-3-30	11.0±0.14	1	16.6±3.34	22	32.0±3.20	10	50.3±3.57	7	99.3±34.65	35	3.5±0.09	4	70.8±2.12	0.2	4.0±0.28	4	36.2±2.97	0.4
2-3-45	10.1±1.48	15	37.8±2.66	7	97.9±13.72	14	60.0±1.80	3	274.5±38.36	14	3.4±0.14	1	64.5±2.47	0.2	6.6±0.21	2	41.8±0.99	0.4
Tyutchenka	8.4±1.27	15	26.9±1.35	5	56.3±2.80	5	40.3±4.40	10	242.4±108.90	45	2.9±0.30	5	60.5±3.25	0.2	5.2±0.21	3	44.5±1.56	0.3
Krasnaya plotnaya	4.8±0.28	6	35.4±7.00	20	31.3±2.79	9	53.7±6.48	19	110.6±16.50	15	2.9±0.14	5	51.0±2.83	0.3	5.2±0.28	3	39.9±2.81	0.4
Yantarnaya	4.7±0.14	3	30.2±0.60	2	32.8±5.82	16	33.3±4.65	14	98.2±20.58	21	3.0±0.14	5	31.3±1.41	0.5	5.0±0.33	3	39.1±1.56	0.4
Bryanochka	3.7±0.71	20	27.0±2.97	11	25.7±3.25	13	50.8±5.10	10	83.3±5.81	7	3.0±0.15	5	62.7±2.83	0.2	4.6±0.28	3	38.6±3.67	0.4
lim	3.7-27.5		12.9-3.78		4.6-97.9		33.3-130.0		22.1-354.5		2.3-4.4		19.0-75.5		3.0-6.6		33.1-54.3	
min/max	7.4		2.9		21.3		3.9		16.0		1.9		4.0		2.2		1.6	

All studied traits that form the yield correlate although with the different degree of the relationship (Fig. 1).

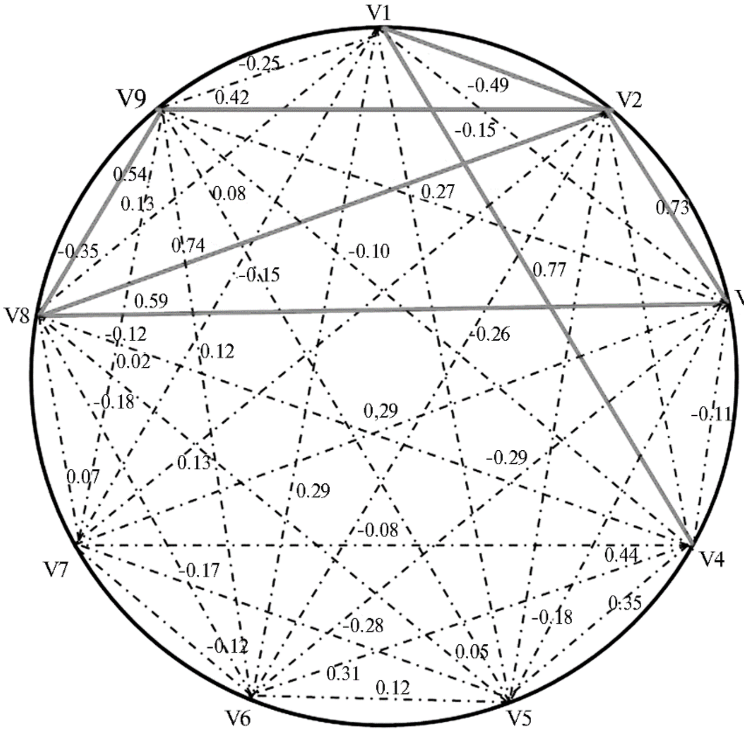


Fig. 1. Matrix of complete correlations of structural fruiting traits in 23 varieties of sweet cherry (*Cerasus avium* L. Moench) in the south of the Non-Chernozem zone of the Russian Federation: solid lines represent reliably significant relationships, dash-dotted lines unreliable relationships; V1 — the number of annual shoots, V2 — average length of annual shoots, V3 — the number of bouquet branches, V4 — the number of fruit buds on annual shoots, V5 — the number of fruit buds on bouquet branches, V6 — number of flowers in a fruit bud, V7 — yield, V8 — crown width, V9 — trunk circumference (trait values are given per 1 linear meter) (Bryansk Province, settlement Michurinskii, 1991-1996).

Only seven of 36 pair correlations were significant: the average length of annual shoots—the number of annual shoots (V_2—V_1) (r = –0.49, p = 0.016); the average length of annual shoots—the number of sprays (V2—V3) (r = 0.73, p = 0.000); the average length of annual shoots—crown width (V_2—V_8) (r = 0.74, p = 0.000); the average length of annual shoots—trunk circle (V_2—V_9) (r = 0.42, p = 0.044); the number of annual shoots—the number of flower buds per annual shoots (V_1—V_4) (r = 0.77, p = 0.000); the number of sprays—crown width (V_3—V_8) (r = 0.59, p = 0.003); crown width—trunk circle (V_8—V_9) (r = 0.54, p = 0.008). For most traits, correlations were weak and statistically insignificant. No link between the yield and its components is of special interest. Indeed, vegetative traits do not directly affect the crop, but they indirectly determine its formation. For instance, the length of annual shoots is so important that it is used to classify varieties. Such varieties as Teremoshka, Zolotaya loshchitskaya 2-8-28, 2-5-21, 2-3-30 were characterized by the shortest shoots (13-19 cm). This type of branching promotes restrained growth of the tree. The longest shoots (30-38 cm) were specific for varieties Veda, Krasnaya plotnaya, Yantarnaya, Ovstuzhenka, 2-3-45, 2-3-67. The amount of annual growth determines not only the habitus of the tree, but also serves as the basis for the formation of fruit buds.

It should be noted that there are groups of traits that were interconnected by high correlation coefficients, called correlation pleiades. The correlated traits of the pleiades are characterized by power (G) and strength (D) indices. The most powerful and strong pleiade was $V_2V_3V_8$ (G = 3.0; D = 0.69), slightly inferior to it in strength $V_2V_8V_9$ (G = 3.0; D = 0.57), the weakest was $V_2V_1V_4$ (G = 3.0; D = 0.34). Probably, the close relationships between the traits of these pleiads were largely controlled genetically.

The data obtained through cluster analysis are very informative. The grouping of varieties by the nature of growth and fruiting is shown on the dendrogram obtained by the Ward's method of clustering, where the Euclidean distance was the measure of the relationship (Fig. 2). The resulting cluster included two groups.

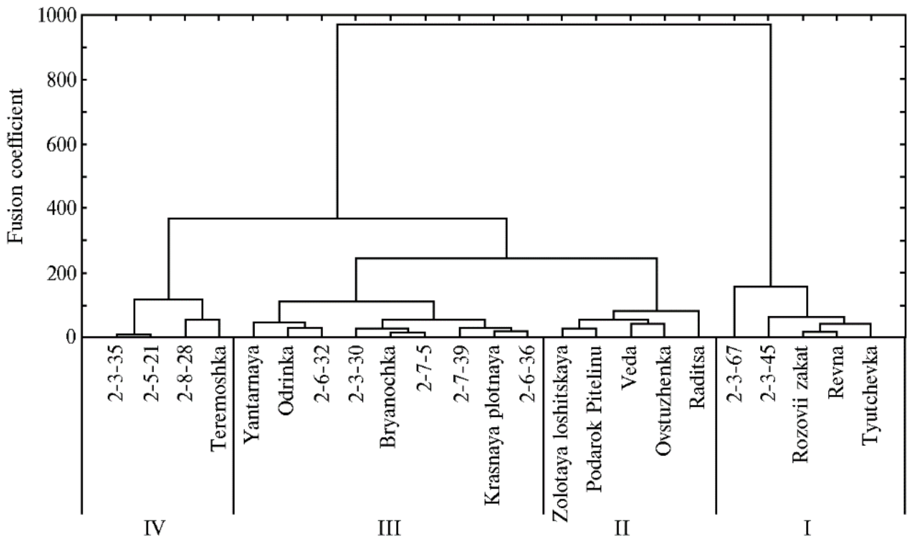
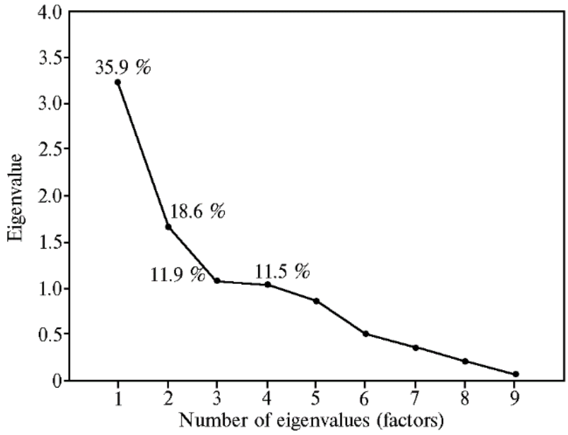


Fig. 2. The dendrogram of similarities and differences between sweet cherry (*Cerasus avium* L. Moench) varieties with regard to the generalized index of productivity elements (Ward's method): I-IV — groups of the same type of growth and yielding (Bryansk Province, settlement Michurinskii, 1991-1996).

The first group (I sub-group) comprised 5 varieties: Tyutchevka, Revna, Rozovyi zakat, 2-3-45, 2-3-67 with long shoots (24-38 cm) and 77-86 % flower buds on sprays. The second group included three sub-groups of varieties (II, III, and IV). Sub-groups II and III included 14 varieties heterogeneous in terms of growth and fruiting. They were highly branched, had medium-sized shoots, mixed fruiting (53-60% of flower buds were located on sprays, and 40-47% on annual growth). The subgroup IV included 4 varieties with predominant fruiting at one-year growth: 2-8-28 (71%), Teremoshka (76%), 2-3-35 (81%), 2-5-21 (86%). The emergence of varieties with this type of fruiting was associated with their inbred origin. The increased homozygosity contributes to the manifestation of hidden recessive genes controlling this trait.

Since there were varieties in each group that were similar in terms of the generalized index of the studied traits, varieties of different groups and subgroups, significantly different in terms of productivity, should be used as initial pairs for crosses. The difference in varieties by the nature of growth and fruiting must be taken into account when forming the crown, pruning trees and carrying out other agro-technical measures.

The lack of the significant valid correlations between yield and morphological traits made us to apply the factor analysis. This method allows identification of hidden, but objectively existing patterns affecting the formation of yield and characterizing factors in accordance with the contribution of each variable.



from Fig. 3. Influence of factor load on "yield" trait of sweet cherry (*Cerasus avium* L. Moench) varieties with regard to contribution of each variable (Bryansk Province, settlement Michurinskii, 1991-1996).

Fig. 3 shows the curve derived from the spectrum of eigenvalues. The number of chosen factors was determined by the break in the linear dependence curve on the graph of eigenvalues of the primary data matrix at point 4 (Y = 1.04; > 1). According to criteria, Kaiser and Cattell [50, 51] indicated factors with eigenvalues exceeding 1. The larger the eigenvalue, the greater the factor contributes to the total variability, which indicates its significance. In our work, the following first four factors with the most significant contribution to the observed variability have been revealed: factor 1 (35.9 % of total variability) mainly characterizing the length of shots, crown width, and the number of sprays; factor 2 (18.6%) — number of shots, number of fruit buds on shots; factor 3 (11.9 %) — trunk circle, number of flowers per bud; and factor 4 (11.5 %) — yield and number of buds on spray. The remaining factors (see Fig. 3) had an insignificant share of the total variance and belonged to the so-called factorial or "stony" scree [51].

By its genetic nature, sweet cherry belongs to crops of the southern regions. Thanks to the creation of winter-hardy varieties of sweet cherry, it became possible to promote this culture to the northern regions. It has recently appeared in the range of the Non-Chernozem zone (1). Sweet cherry has a high yield potential, which is realized in optimal weather conditions. According to the literature, the period of laying and differentiation of fruit buds lasts 117-130 days (from July of the current year to April of the next year); the studies identified five stages of organogenesis, or phenological phases, when plants are most sensitive to stress, which leads to a reduction in yield components [10, 11]. Unfavorable conditions during this period lead to the death of flower rudiments and loss of crop production [10].

Studies of Upadysheva [9] conducted for two years on three varieties of sweet cherry has shown that the active growth of shoots and fruit formations (sprays) serves the basis for increasing productivity. Works of other authors studying the fruiting nature of sweet cherry also emphasize the significant contribution of the load of trees with flower buds, their placement on annual branches and sprays of different ages [9, 10, 35], the number of flowers in fruit buds, trunk circle and crown size [37, 42] in the formation of productivity. At the Russian Lupin Research Institute, the work was carried out for 6 years on 23 sweet cherry varieties by 9 traits to give a deeper assessment of the link between morphobiological traits and the productivity of sweet cherry. It was established that varieties significantly differed in the nature of fruiting (see Fig. 2). Based on our data, the number of flower buds on annual shots varied from 33.3 to 130 and on the sprays from 22.1 to 354.5. In Tyutchevka, Revna, Rozovyi zakat, 2-3-45, 2-3-67 cultivars, sprays were mainly fruiting (77-86 %). Another 14 varieties had a mixed type of fruiting: 53-60 % of flower buds were located on sprays, 40-47 % on annual shots. Teremoshka, 2-8-28, 2-5-21, 2-3-35 varieties had flower buds on annual shots (71-86 %). The manifestation of this trait is associated with the inbred origin of these varieties. In addition, these varieties are distinguished by moderate tree growth. The latter is considered as a significant economic characteristic in industrial plantings.

Therefore, we have revealed a significant morphological variability of 23 sweet cherry varieties under the conditions of the Non-Chernozem zone of the Russian Federation, which allow us to select valuable genotypes for breeding and production. High degree of variability (over 10%) by the number of annual shots, average length of annual shots, number of flower buds on annual shots, and the number of sprays was noted in the varieties Podarok Petelinu, Teremoshka, Bryanochka, Odrinka, Krasnaya plotnaya, Yantarnaya, and 2-3-35. Low degree of variability (less than 6%) by the number of flower buds, number of flowers on flower buds, crown width, and trunk circle was revealed in all studied varieties. Herewith, Ovstuzhenka, 2-3-45, Bryanochka, Tyutchevka, 2-7-5, 2-7-39, Teremoshka, and 2-3-45 were distinguished in terms of yielding. The link between the yield indices was different. The "yield" as a trait variable did not correlate with any of the studied yield structure elements. Factor analysis identifies hidden but objectively existing patterns that affect the yield formation. Our findings identified four factors with the most significant contribution to yield formation. Cluster analysis grouped the varieties with regard to their growth and fruiting features. Four clusters identified according to the generalized index of the studied characteristics will facilitate the selection of breeding forms. Varieties of different groups and clusters with significant differences in productivity elements should serve as pairs for crosses.

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