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Ecological plasticity and productive potential of tobacco in Central Forest Steppe of Ukraine

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Twenty tobacco varieties of different geographical origin were evaluated according to the main biometric features (plant height, number and size of leaves), biological properties, productivity and marketability of tobacco raw materials. The adaptive potential of tobacco collecting samples has been analyzed and valuable sources for variety breeding in the Central Forest Steppe of Ukraine have been identified. To identify the most similar and distant parental forms, clustering was performed using the "nearest-neighbor" method. The evaluation of the collection samples shows that the highest yield (2.99–4.30 t/ha) and merchantability (85.6–91.3%) of tobacco raw materials were found in Large-leaved type variety samples. According to the analysis results of adaptive potential and ecological stability of tobacco variety samples, the most adapted genotypes to the conditions of the Central Forest Steppe of Ukraine were determined. High yielding varieties of Yellow Sharp-leaved 3 and Burley 7433 were distinguished, which had the highest levels of homeostatic (Hom=0.67, Hom=0.43) and agronomic stability (As=94.00, As=92.43). Tobacco samples also have a high level of agronomic stability: Ternopilskyi 7, Large-leaved 52, Sharp-leaved ruby, Yellow Sharp-leaved 3, Sharp-leaved jubilee new, Burley 7433, Virginia 27, Virginia 202, Virginia seed leaf, and Temp 321, within 72.84–94.00%. Therefore, they can be involved in the breeding process to create adaptive genotypes. On the basis of tobacco variety classification, seven clusters were conditionally distinguished, which had differences in the complex of morphological parameters and the economically valuable features activity.

Keywords: Tobacco; Collection sample; Variety of tobacco type; Cluster analysis; Yield; Ecological plasticity

Introduction

Tobacco cultivation in Ukraine has become traditional due to its geographical location, favourable climatic conditions, availability of fertile land large areas, professional labour resources. Tobacco industry was one of the most profitable agricultural sectors with a profitability level of 28–40% (Kovtunyk et al., 2001), but now there is a steady tendency to decrease the production of tobacco raw materials. The operation of tobacco factories is absolutely dependent on the import of raw materials, and its own production provides the needs of the industry by only 5% (Bialkovska, 2013). Support for its own producer is possible due to the introduction into the production of new competitive varieties of domestic breeding with improved quantitative and qualitative productivity indices (Morgun et al., 2019).

One of the effective ways of creating high yielding tobacco varieties is to select economically valuable traits of donors and combine them optimally in new plant genotypes (Khomutova et al., 2014). The sources for selection and creation of such donors are gene pool collections, which focus on source material of different geographical origin with a complex of valuable breeding and genetic traits. The manifestation level of these traits is modified by the cultivation conditions and the genotype response to the environmental influence (Ivanitskii, 2009; Ivanitskii et al., 2012). The collection gene pool is the main source of patterns knowledge and variability of breeding and genetic traits, the creation of promising tobacco breeding material that meets the requirements of agricultural production and tobacco industry (Ivanitskii et al., 2018; Kovalchukova et al., 2018).

Now-a-days, the problem of starting material is especially urgent in order to increase the adaptive potential of the manufactured tobacco varieties, and the study of the collection material in different hydrothermal conditions allows us to obtain information about the peculiarities of the genotypes reaction to changing environmental conditions (Ivanitskii & Salamatin, 2010).

The strategic task of research is to create the varieties that are able to maximize the use of their genetic potential in a specific region, to be resistant to stressful environmental conditions, to ensure a high realization of the genetic potential of productivity. (Ivanitskii et al., 2014). Due to global climate change, in the conditions of the Central Forest Steppe of Ukraine with unstable humidification and high temperatures, the main focus of breeding is to create varieties not only with high productivity potential but also resistance to changing weather conditions. The study of variety interaction with soil and climate conditions of cultivation in terms of plasticity, stability and adaptability solves the question of its functional purpose (Zhuchenko, 2001). According to (Zhuchenko, 2003) the ability of certain types of plants to counteract local stressful environmental factors has a decisive influence on their geographical distribution and crop formation.

Materials and Methods

The study was conducted during 2017–2019 under the conditions of the Central Forest Steppe of Ukraine at the Tobacco Research Station of the National Scientific Centre " Institute of Agriculture of the National Academy of Agrarian Sciences of Ukraine " (Cherkasy region, Uman). The starting material was 20 varieties of tobacco of different geographical origin: Ternopilskyi 7, Ternopilskyi 14, Ternopilskyi perspective, Burley 9, Burley 38, Burley 46, Bravyi 200, Spectrum, Large-leaved 52, Virginia 27, Temp 321, - from Ukraine (NAAS Yuriev V. Ya. Institute of Crop Growing), Sharp-leaved giant, Sharp-leaved ruby, Yellow Sharp-leaved 3, Sharp-leaved jubilee new, White Burley, Burley 7433, Virginia 202, Virginia joyner, Virginia seed leaf - from Russia (All-Russian Research Institute of Tobacco, Shag and Tobacco Products).

The climate of the region is temperate continental, with an average annual air temperature of 7.4°C. Periods with an average daily air temperature of more than 5°C last 205–215 days, more than 10°C – 161–170, and with a temperature above 15°C – 106–110 days. The sums of active temperatures are 2580–2900 °C and hydrothermal index is 1.0–1.2. The relative humidity is 64–88%, according to the Uman weather station. In spring-summer period it decreases to 60–70%, and in autumn-winter period it increases to 80–85%. Average rainfall is 633 mm during the year and from 334 to 412 mm during the period with temperatures above 10 °C.

Soil – chernozen podzolized heavy-loamed with high natural fertility, favourable for the growth and development of plants by neutral reaction of soil solution, good physical properties and nutritional regime. Humus content is 3.2–3.4%.

The years of research varied in weather conditions. Thus, 2017 has been quite warm and arid. In May, the average daily temperature was 15°C, and in summer months – 20–22°C. The average monthly rainfall from May to August was 46.4, 41.0 and 59.2 mm, respectively, which is 8.6–46.0 mm less than the annual average.

Meteorological conditions in 2018 contributed to the optimal growth and development of tobacco plants, both in the seedling and field periods. Air temperature in May was 18°C and in the summer months – 20–22°C. Rainfall was uneven, but sufficient for normal plant growth. In June and July it was within long-term indicators (82.4 and 92.9 mm), and in August it was significantly deficient (2.6 mm).

The weather in 2019 was arid and hot. Rainfall dropped far below the long-run annual averages and their distribution over time was rather uneven. Rainfall in summer was one of the lowest in recent years. In May, the temperature was 17°C, and in the summer months – 20–22.4°C. Due to the severe drought, the plant vegetation season in 2019 was slightly shorter than in other years of research.

Seedlings were grown in a breeding-greenhouse complex according to the conventional technology, taking into account the peculiarities of agriclimatic conditions of the Central Forest Steppe of Ukraine (Figure 1). Tobacco sowing was performed with seeds germinated in thermostats. The formation of optimal plant density (30 pcs/dm^2) was performed manually. Tobacco seedlings reached a standard size for 45–60 days of vegetation. In the field it was planted in the second and third decades of May according to the scheme 70 × 30 cm. The area of the accounting plot was – 9.7 m^2, the repetition - three times.

Tobacco breeding studies were conducted according to (Kosmodemianskyi et al., 1974), and the starting material was classified by (Psareva, 1964). Morphological features and biological properties were evaluated by (Volkodav, 2001; Savina et al., 2002).

Figure 1. Tobacco seedlings growing in greenhouse.

During the plants vegetation, phenological observations were made; and quantitative and qualitative traits were recorded, and biological features were studied. The plant type was evaluated in acordance with its height, habitus, leaf coverage and other features compared to the standards. The collection and accounting of leaves was carried out in the phase of their technical maturity on the tiers. The leaves were dried in a closed, well-ventilated area (Figure 2).

Figure 2. Tobacco leaves drying.

On the basis of the tobacco raw materials yield, statistical parameters were calculated (arithmetic averages ($\bar{x}$), ecological plasticity coefficient (bi), stability variant (Si2), ecological coefficient of variation (Ve), agronomic stability coefficient (As), homeostatic indices (Hom) (Litun et al., 2009; Kozachenko et al., 2012).

The following formulas were used to determine the statistical parameters (Litun et al., 2009):

Arithmetic mean:

$$\bar{x} = \sum x/n, \quad (1)$$

where x is the variant, n is the number of variants (indicators);

Environmental plasticity (regression coefficient):

$$bi = \Sigma(\bar{x}\ ijlj)/\Sigma lj2, \quad (2)$$

where $\bar{x}i$- average value by collecting samples, $\bar{x}j$ - average value under growing conditions, lj – index of research conditions, determined by:

$$lj = \bar{x}j-\bar{x} \quad (3)$$

Variance (standard deviation) characterizes the value of the one that varies from the average of specific variational series:

$$S2 = \Sigma(\bar{x}-x)2 / (n-1), \quad (4)$$

Variance S2 and standard deviation $S=\sqrt{S}2$ is an estimate of the random error of an individual observation;

Environmental coefficient of variation, characterizing the degree of trait variability, is determined by:

$$Ve = 100\,(S/\bar{x}), \quad (5)$$

Homeostatic is an indicator of the breeding value of the genotype, calculated by:

$$Hom = \frac{\bar{x}}{Ve}, \quad (6)$$

The Coefficient of agronomic stability is determined by:

$$As = 100- Ve. \quad (7)$$

Multivariate statistics method, namely cluster analysis using the STATISTICA 10.0 computer program, was used to collectively evaluate tobacco collections. This helps to shorten the breeding process through a more comprehensive evaluation of the factors that affect the realization of the genetic plants potential.

Results

As a result of complex screening of collecting samples by variety of tobacco types, it is established that the main morphological features that affect the yield of tobacco raw materials are: plant height, number and size of leaves.

Tobacco plant height is a very variable feature, which depends on the variety and weather conditions of cultivation. Under favourable conditions, plant height can reach 200 cm and more (Woras et al., 1996). The research analysis shows that the total height of the plants in the collection samples varied from 126 to 222 cm (Table 1). The maximum height (204–222 cm) was in six varieties: Ternopilskyi 7, Ternopilskyi 14, Large-leaved 52, Sharp-leaved ruby, Yellow Sharp-leaved 3 and Temp 321. It should be noted that five of them belonged to Large-leaved variety of tobacco type and Temp 321 to Virginia one. Plant of Sharp-leaved giant, Sharp-leaved jubilee new, Bravyi 200, Spectrum, Virginia 27 and Virginia 202 varieties came short of height with indicators 180–199 cm. The average height of plants (165–180 cm) was in four varieties of tobacco: Ternopilskyi perspective, Burley 9, White Burley and Virginia 202. The short-growing plants (126–144 cm) were basic for Burley – Burley 38, Burley 46, Burley 7433, and Virginia seed leaf (Virginia variety of tobacco type).

One of the main economically valuable tobacco features, which affects the yield of raw materials and hardly changes under the environment influence is the number of leaves on a plant. In the collection samples, the total number of leaves was 15–34 pieces per plant (Table 1). In this case, 80% of variety samples were characterized by a very large number of them, and the maximum number (>26 pcs) was characteristic of Large-leaved 52, Sharp-leaved giant, Sharp-leaved ruby, Yellow Ruby 3, Burley 9, Virginia 202 and Temp 321 varieties. Burley 7433 and Virginia seed leaf varieties were characterized by an average number of leaves –15 and 18 pieces per plant respectively. Consequently, Burley variety of tobacco type samples were dominated by leaf coverage.

The size of tobacco leaves varies greatly from the outside growing conditions, but the characteristic length to width ratio remains. Collection samples of Burley and Virginia variety of tobacco types were characterized by an average leaf length (34.3–43.2 cm), and the leaders were Large-leaved variety of tobacco type samples with values from 50.3 to 53.5 cm. The width of leaves varied from 23.1 to 33.0 cm. The average width of the leaf lamina (24.0–26.6 cm) was characterized by Burley variety of tobacco type samples, except for Spectrum, which index was 38.2 cm.

Table 1. Biometric indicators of tobacco collection samples by variety of types, (average value for 2017–2019).

Variety	Plant height, cm	Leaves number, psc	Leaf size, cm		Vegetation season, days
			length	width	
Large-leaved variety of tobacco type					
Ternopilskyi 7 (st.)	212	25	52.0	31.0	98
Ternopilskyi 14	204	25	51.6	31.7	98
Ternopilskyi perspective	176	23	53.3	30.3	105
Large-leaved 52	215	31	52.6	33.7	112
Sharp-leaved giant	193	28	53.5	32.3	105
Sharp-leaved ruby	222	31	52.7	33.0	100
Yellow Sharp-leaved 3	215	27	53.3	32.7	116
Sharp-leaved jubilee new	187	24	50.3	29.7	100
Bravyi 200	180	21	53.0	30.3	102
Burley variety of tobacco type					
Burley 38 (st.)	144	34	34.0	25.7	103
Burley 46	139	33	35.3	24.9	102
Burley 9	177	28	35.0	25.1	100
Burley 7433	143	18	37.3	26.1	101
White Burley	170	33	34.3	24.0	101
Spectrum	194	33	38.2	26.6	103
Virginia variety of tobacco type					
Virginia 27 (st.)	199	26	37.0	25.0	116
Virginia 202	181	28	34.7	24.3	102
Virginia joyner	165	20	33.2	23.5	114
Virginia seed leaf	126	15	32.3	22.5	116
Temp 321	204	32	41.7	29.4	120

The vegetation season duration of tobacco plants has a direct dependence on the breed biological characteristics and average daily air temperatures. During the years of research, the vegetation season in the collection variety samples ranged from 98 to 116 days, so they can be regarded as medium-ripening breeds. The smallest vegetation season (98 days) was observed in two samples - Ternopilskyi 7 and Ternopilskyi 14, the largest (112–120 days) in six – Large-leaved 52, Yellow Sharp-leaved 3, Virginia 27, Virginia joyner, Virginia seed leaf and Temp 321. Analysis of the productive potential of the starting tobacco samples according to the cultivation area and identification of sources of yield signs and marketability of tobacco raw materials showed that the studied

samples differently realized their genetic potential of productivity in conditions of unstable humudification of the Central Forest Steppe. The average yield of tobacco raw materials during the years of research was 3.53 t/ha (2017 – 3.08 t/ha, 2018 – 4.59 t/ha, 2019 – 2.93 t/ha) (Table 2). Four variety samples of Large-leaved 52, Sharp-leaved ruby, Yellow Sharp-leaved 3 and Sharp-leaved jubilee new were distinguished from Large-leaved variety of tobacco type with indicators of 4.06–4.40 t/ha. The lowest yield was in the Ternopilskyi perspective variety sample – 2.99 t/ha. From Burley variety of tobacco type, three variety samples had the best yields (3.60–3.96 t/h): Burley 46, White Burley and Spectrum, and Virginia, Virginia 202 and Temp 321, respectively, 3.48 and 3.91 t/ha, respectively. Commodity indices of tobacco raw materials depended on both breed characteristics and weather conditions (Table 3). It should be noted that weather conditions had a significant effect on the output of commodity raw materials. So, in 2018 it was the highest – 79.7–95.0%, and in 2019 the lowest – 70.7–90.3% depending on the variety. Samples of Ternopilskyi 14, Sharp-leaved ruby, Yellow Sharp-leaved 3, Sharp-leaved jubilee new and Bravyi 200 were distinguished in the Sharp-leaved variety compared to the Ternopilskyi 7 standard, which were respectively 88.4, 91.3, 87.4, 89.9 and 87.1%. White Burley and Spectrum, out of Burley variety, had a significant difference with the standard. Virginia variety has two samples – Virginia seed leaf and Temp 321 with 82.1 and 90.5% respectively.

The climate conditions of the Central Forest Steppe of Ukraine require the creation of varieties resistant to the unpredictable conditions of spring and summer vegetation. Therefore, in tobacco selection, a special attention should be paid to the adaptive properties and stability of starting material with high genetic yield potential. According to the results of the analysis of adaptive potential and ecological stability of tobacco variety samples, the most adapted genotypes to the conditions of the Central Forest Steppe of Ukraine were identified (Table 4).

Table 2. Yield of tobacco raw materials by variety of tobacco types, t/ha.

Variety	Research year			Average for 3 years	By standard, ±
	2017	2018	2019		
Large-leaved variety of tobacco type					
Ternopilskyi 7 (st.)	3.34	5.18	3.30	3.94	–
Ternopilskyi 14	2.43	5.04	2.44	3.30	-0.64
Ternopilskyi perspective	2.18	4.22	2.57	2.99	-0.95
Large-leaved 52	3.88	4.83	3.48	4.06	+0.12
Sharp-leaved giant	3.20	5.28	2.67	3.72	-0.22
Sharp-leaved ruby	3.87	5.38	3.65	4.30	+0.36
Yellow Sharp-leaved 3	3.96	4.26	3.78	4.00	+0.06
Sharp-leaved jubilee new	3.90	5.57	3.72	4.40	+0.46
Bravyi 200	3.34	5.28	2.61	3.74	-0.20
Burley variety of tobacco type					
Burley 38 (st.)	2.76	4.70	2.98	3.48	–
Burley 46	3.27	5.66	2.96	3.96	+0.48
Burley 9	2.09	4.03	2.67	2.93	-0.55
Burley 7433	3.37	3.51	3.02	3.30	-0.18
White Burley	2.99	4.90	2.92	3.60	+0.12
Spectrum	3.18	5.62	3.05	3.95	+0.47
Virginia variety of tobacco type					
Virginia 27 (st.)	2.74	4.09	3.40	3.41	–
Virginia 202	3.87	4.61	3.25	3.91	+0.50
Virginia joyner	2.10	2.90	1.41	2.14	-1.27
Virginia seed leaf	2.09	2.44	1.62	2.05	-1.36
Temp 321	3.14	4.22	3.07	3.48	+0.07
HIP05	0.15	0.23	0.15	–	–

According to raw materials yield, high-plastic variety samples of tobacco intensive type with regression coefficient from 1.02 to 1.65 were distinguished – varieties of Ternopilskyi 7, Ternopilskyi 14, Ternopilskyi perspective, Sharp-leaved giant, Sharp-leaved ruby, Sharp-leaved jubilee new 46, Bravyi 200, Burley 38, Burley 46, Burley 9, White Burley and Spectrum. The next group consisted of variety samples with bi values close to zero (Large-leaved 52, Yellow Sharp-leaved 3, Burley 7433, Virginia 27, Virginia 202, Virginia joyner, Virginia seed leaf, and Temp 321), which almost did not react to changes in environmental conditions. Highly stable tobacco variety samples included Yellow Sharp-leaved 3, Burley 7433, Virginia seed leaf, medium stable – Large-leaved 52, Sharp-leaved ruby, Burley 9, Virginia 27, Virginia 202, Virginia joyner, Temp 321 and low stable – Ternopilskyi 7, Ternopilskyi 14, Ternopilskyi perspective, Sharp-leaved giant, Sharp-leaved jubilee new, Bravyi 200, Burley 38, Burley 46, White Burley, Spectrum.

The ecological variation coefficient characterized the degree of arithmetic mean variability (up to 10% – low, 10–20% – medium and >20 – high). The studied varieties varied significantly in the amplitude of yield changes. The largest yield changes (coefficient of variation Ve >20%) had varieties of Ternopilskyi 7, Ternopilskyi 14, Ternopil perspective, Sharp-leaved giant, Sharp-leaved ruby, Sharp-leaved jubilee new, Bravyi 200, Burley 38, Burley 46, Burley 9, White Burley, Spectrum, Virginia joyner, and the smallest – Yellow Sharp-leaved 3 and Burley 7433.

Homeostatic (Hom) characterizes the breeding value of a variety genotype, that is, its expediency of involvement in breeding process. It was found that the most stable yields were of Yellow Sharp-leaved 3 and Burley 7433 breeds, which had the highest levels of homeostatic and agronomic stability. The least stable among the studied varieties were Ternopilskyi 14, Ternopilskyi perspective, Burley 9 and Virginia joyner.

Table 3. Marketability of tobacco raw materials by variety of tobacco types, %.

Variety	Research year			Average for 3 years	By standard, ±
	2017	2018	2019		
Large-leaved variety of tobacco type					
Ternopilskyi 7 (st.)	88.1	91.0	81.4	86.8	–
Ternopilskyi 14	87.5	93.2	84.6	88.4	+1.6
Ternopilskyi perspective	85.2	90.9	80.6	85.6	-1.2
Large-leaved 52	75.9	86.9	71.6	78.1	-8.7
Sharp-leaved giant	86.2	90.0	82.9	86.4	-0.4
Sharp-leaved ruby	89.6	94.0	90.3	91.3	+4.5
Yellow Sharp-leaved 3	86.5	92.1	83.7	87.4	+0.6
Sharp-leaved jubilee new	90.1	95.0	84.5	89.9	+3.1
Bravyi 200	87.1	90.9	83.2	87.1	+0.3
Burley variety of tobacco type					
Burley 38 (st.)	76.2	83.7	74.3	78.1	–
Burley 46	77.4	82.1	73.0	77.5	-0.6
Burley 9	74.5	84.0	72.1	76.9	-1.2
Burley 7433	75.6	81.4	70.7	75.9	-2.2
White Burley	81.3	83.8	80.9	82.0	+3.9
Spectrum	84.1	94.3	83.5	87.3	+9.2
Virginia variety of tobacco type					
Virginia 27 (st.)	80.6	84.2	79.3	81.4	–
Virginia 202	79.4	82.8	77.2	79.8	-1.6
Virginia joyner	75.1	79.7	72.3	75.7	-5.7
Virginia seed leaf	82.1	84.7	79.5	82.1	+0.7
Temp 321	89.8	93.1	88.5	90.5	+9.1
HIP05	4.1	4.4	3.9	–	–

Table 4. Adaptive potential of tobacco varieties by raw materials yield.

Variety	bi	Si2	Ve, %	Hom	As
Large-leaved variety of tobacco type					
Ternopilskyi 7 (st.)	1.19	1.07	27.16	0.14	72.84
Ternopilskyi 14	1.65	1.50	45.45	0.07	54.55
Ternopilskyi perspective	1.16	1.08	36.12	0.08	63.88
Large-leaved 52	0.76	0.69	16.99	0.23	83.01
Sharp-leaved giant	1.51	1.38	37.10	0.10	62.90
Sharp-leaved ruby	1.05	0.94	21.86	0.20	78.14
Yellow Sharp-leaved 3	0.28	0.24	6.00	0.67	94.00
Sharp-leaved jubilee new	1.14	1.02	23.18	0.19	76.82
Bravyi 200	1.50	1.38	36.90	0.10	63.10
Burley variety of tobacco type					
Burley 38 (st.)	1.16	1.06	30.46	0.11	69.54
Burley 46	1.63	1.48	37.37	0.10	62.63
Burley 9	1.02	0.99	33.79	0.09	66.21
Burley 7433	0.23	0.25	7.57	0.43	92.43
White Burley	1.24	1.12	31.11	0.11	68.89
Spectrum	1.60	1.45	36.71	0.11	63.29
Virginia variety of tobacco type					
Virginia 27 (st.)	0.63	0.67	19.65	0.17	80.35
Virginia 202	0.71	0.68	17.39	0.22	82.61
Virginia joyner	0.76	0.74	30.83	0.07	69.17
Virginia seed leaf	0.40	0.41	20.00	0.10	80.00
Temp 321	0.72	0.64	18.39	0.19	81.61

By agronomic stability coefficient, the most valuable for production are tobacco varieties with As=70%. According to this indicator, the following tobacco samples are identified: Ternopilskyi 7, Large-leaved 52, Sharp-leaved ruby, Yellow Sharp-leaved 3, Sharp-leaved jubilee new, Burley 7433, Virginia 27, Virginia 202, Virginia seed leaf and Temp 321.

In order to establish distance and affinity between the variety groups and to substantiate the selection of parental pairs and hybridization, a cluster analysis was applied to classify tobacco varieties by a set of trait indicators. To identify the most similar and distant parental forms, clustering was performed using the method of "nearest neighbour". The clusters formation indicates the similarity of tobacco samples. Based on the conducted research, seven clusters were conditionally identified (Figure 3).

The first cluster formed Virginia seed leaf variety (C_19), which was farthest from all other samples. Among the studied varieties, it was characterized by the lowest plant height (126 cm) and the lowest number of leaves (15 pcs). The leaf size was medium (leaf lamina length – 32.3 cm and width – 22.5 cm). The yield of tobacco raw materials was 2.05 t/ha with a marketability of 82.1%. The

duration of vegetation period of the plants – 116 days. The second cluster included three tobacco varieties that were related to Burley variety of tobacco type: Burley 7433 (C_13), Burley 46 (C_11) and Burley 38 (C_10). The plants of this group are short-growing (from 139 cm to 144 cm), with medium (Burley 7433 (C_13) – 18 pieces) and very large (Burley 46 (C_11) – 33 pieces, Burley 38 (C_10) – 34 pieces) number of leaves. Leaf size is medium (lamina length – 34.0–37.3 cm, width – 24.9–26.1 cm). The yield of tobacco raw materials was 2.76–3.37 t/ha with a marketability of 75.9–78.1%. The vegetation period of plants – 101–103 days.

Virginia joyner (C_18) is typical for the third cluster. It is a medium-growing variety (plant height – 165 cm) with a large number of leaves (20 pieces) and their average size (lamina length – 33.2 cm, width – 23.5 cm). The yield of tobacco raw materials was 2.14 t/ha with a marketability of 75.7%. Medium ripening breed (vegetation period – 114 days).

The fourth cluster included two tobacco varieties of Large-leaved type: Yellow Sharp-leaved 3 (C_7) and Large-leaved 52 (C_4). These varieties are characterized by very high plants (215 cm) with a large number of leaves (27–31 pieces) and their size (lamina length 52.6–53.3 cm, width – 32.7–33.7 cm). The duration of vegetation period of plants was 112–116 days, and the yield of tobacco raw materials – 4.00–4.06 t/ha with a marketability of 78.1–87.4%.

The fifth cluster was formed by six tobacco varieties: Temp 321 (C_20), Virginia 27 (C_16), Spectrum (C_15), White Burley (C_14), Virginia 202, Burley 9 (C_12). Plants of this group are high-growing – Whiter Burley (C_14), Burley 9 (C_12), Virginia 202 (C_17) - 170-181 cm and very high-growing - Virginia 27 (C_16), Spectrum (C_15), Temp 321 (C_20) – 194–204 cm. All of them are characterized by a large number of leaves (from 26 to 33 pieces), but their average size (lamina length – 35.0–41.7 cm, width – 24.0–29.4 cm). These are medium ripening breeds – 100–120 days. The yield of tobacco raw materials was from 2.93 t/ha to 3.91 t/ha, and the marketability was 76.9–90.5%. The sixth cluster included four varieties belonging to Large-leaved variety of tobacco type: Sharp-leaved giant (C_5), Sharp-leaved jubilee new (C_8), Bravyi 200 (C_9), Ternopilskyi perspective (C_3). Plants of this group are high-growing and very high-growing (from 176 cm to 193 cm). They are characterized by a large number of leaves (from 21 pieces to 28 pieces) and their large size (lamina length – 50.3–53.5 cm, width – 29.7–32.3 cm). The duration of vegetation period of the plants was 100–105 days. The varieties are characterized by a high yield (2.99–4.40 t/ha) and raw materials marketability (85.6–89.9%).

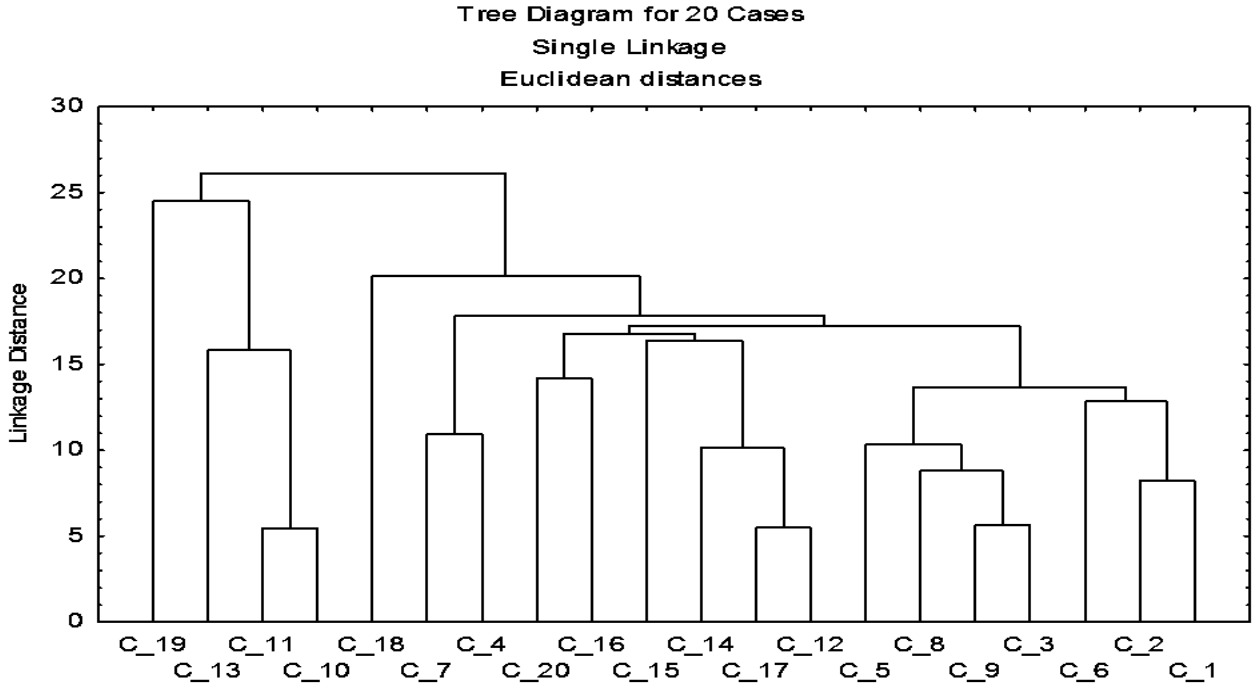

Figure 3. Clustering of tobacco varieties according to the complex of morphological parameters and economically valuable features (plant height, number and size of leaves, duration of vegetation season, yield and marketability of raw materials), 2017–2019.

The seventh cluster was formed by three varieties belonging to Large-leaved variety of tobacco type: Sharp-leaved ruby (C_6), Ternopilskyi 14 (C_2), Ternopilskyi 7 (C_1). Their plants were very high-growing (from 204 cm to 222 cm), with a large number of leaves (from 25 pieces to 31 pieces) and their size (lamina length – 51.6–52.7 cm, width – 31.0–33.00 cm). The duration of the vegetation period of the plants was 98–100 days. The varieties were characterized by a high yield (3.30–4.30 t/ha) and marketability of raw materials (86.8–91.3%).

Conclusion

In the collection seedbed, among the 20 tobacco varieties according to the adaptive potential and ecological stability, the most adapted genotypes to the conditions of the Central Forest Steppe of Ukraine were identified. According to the yield the most stable varieties are Yellow Sharp-leaved 3 and Burley 7433, which have the highest levels of homeostatic (Hom=0.67, Hom=0.43) and agronomic stability (As=94.00, As=92.43). According to the agronomic stability, tobacco samples are distinguished: Ternopilkyi 7, Large-leaved 52, Sharp-leaved ruby, Yellow Sharp-leaved 3, Sharp-leaved jubilee new, Burley 7433, Virginia 27, Virginia 202, Virginia seed leaf, and Temp 321, with indicators within 94.00%, 72.84%, 72.84%, 72.84%, which are recommended to involve into the breeding process to create adaptive genotypes. The method of cluster analysis determined the affinity of tobacco collection variety samples by the complex of morphological parameters and manifestation of economic and valuable features, which enables early evaluation, distribution and selection of parental components of hybridization in the early stages of the breeding process to create new competitive varieties.

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