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Hibridologichen analysis of inhetitance of plant height and number of leaves in hybrid combination of Burley tobacco

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Abstract

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The way of inheritance, the manifestations of heterosis, transgression and depression, minimal number of genes by which parental forms differ, degree of dominance, manifestations of epistasis and coefficient of heritability and efficiency of selection with regard to plant height and number of leaves, on Burley tobacco samples are established. For the purpose are researched the population of P_1, P_2, F_1 and F_2 of seven hybrid combinations. The results show that in the height of plants and number of leaves inheritance is preferably overdominantly and always in the direction of the parent with the higher values of investigated parameters. With respect to the height of the plants was observed and incompletely dominantly, and when the number of leaves and an additive. Manifestations of heterosis and transgression are more pronounced in relation to the number of leaves and have significant values of economic importance, only by this indicator. Data from hybridological analysis showed that the minimal number of genes determining the expression of the trait plant height is greater than the number of leaves. Epistatic interactions are more strongly manifested in the determination of the trait height of plant, but only in the number of leaves negative ones are observed. The relatively low to medium values obtained in terms of the coefficient of heritability in the studied crosses Burley tobacco show that a low share of genotype influence on the manifestation of the studied trait is observed, which means that the selection for plant height will be more effective in the later hybrid generations. The established even lower values for the index number of leaves show the crucial importance of the influence of the environment on the determination of the trait and suggest an effective selection in even later hybrid generations, which makes the selection activity difficult. The study shows that, in general, the selection for the trait number of leaves is more complex and longer than that for the height of the plants.

*Keywords***:** Burley tobacco; plant height; number of leaves; hybridological analysis; inheritance; heterosis heredit-ability

Introduction

As with Burley tobacco, as with all other types of tobacco, plant height and number of leaves are some of the most important biological parameters (Butorac et al., 2004; Nikolova & Drachev, 2006; Popova et al., 2007; Kocoska & Pelivanovska, 2017; Mitreski et al., 2017, 2018; Pearce et al., 2014, 2019). The number of leaves is decisive for the size of the yield in tobacco (Butorac, 2000, 2001; Bozhinova, 2006; Bridges et al., 2011).

The height of tobacco plants is a polygenic trait that is strongly influenced by environmental conditions (Dimanov, 2003; Risteski et al., 2010; Kocoska, 2018). Masheva (2007) found that for the trait plant height, additive effects are decisive in the expression of the trait in some combinations, while in others its inheritance is complexly determined. Sas-

try & Prasada Rao (1980), in Burley tobacco established that dominant gene effects are of predominant importance for the trait. According to Metha et al. (1985), and according to Torrecila & Barroso (1980), in cigar tobacco, both additive and non-additive (dominant and epistatic) gene effects are observed in the inheritance of plant height. Chang & Shyu (1976), in Virginia tobacco for the trait plant height found that the main type of inheritance is additive.

Sastry & Prasada Rao (1980) reported that for the mode of inheritance of the number of leaves in the Virginia type, dominant gene effects are of greatest importance. Chang & Shyu (1976), and Sastry & Prasada Rao (1980), in Burley tobacco crosses found that dominant gene effects preponderated in the number of leaves. Butorac et al. (1999); Korubin – Aleksoska (2016); Korubin – Alesoska & Dojcinov (2019) and Aleksoski (2022) are reported for similar results in Fcv Tobacco. Torrecila & Barroso (1980), found that in the inheritance of the number of leaves characteristic, additive gene effects are decisive. Metha, et al. (1985) reported that leaf number is controlled by both additive and nonadditive effects.

A number of authors obtained high heritability in a broad sense for plant height and number of leaves (Stankev, 2001; Shyu et al., 1975; Amarnath, 1987; Naumovski, 1988; Kara & Esendae, 1995; Peksuslu et al., 2002; Ahmed & Mohammad, 2017), which enables their rapid stabilization in the next generations.

Heterosis in large-leaf tobaccos is extremely widely used. Heterosis cultivars currently account for the majority of Burley tobacco production. A heterosis effect in this tobacco is established regarding all relevant morphological, biological, economic and chemical parameters (Korubin-Aleksoska, 2008; Patel et al., 2012; Qaizar et al., 2016; Ganachari et al., 2018; Kinay & Kurt, 2022). While there are many studies on heterosis in tobacco, they are quite scarce on tragression (Stankev, 2001). Transgressive phenomena in tobacco are not well studied.

The purpose of the study is to establish, through hybridological analysis, the mode of inheritance, the nature of gene interactions, the minimal number of genes that differentiate the parental forms, the coefficient of heritability and efficiency of selection, as well as the manifestations of heterosis, transgression and depression in relation to the height of the plants and the number of leaves in hybrid combinations of Burley tobacco, with a view to using the obtained results in the breeding activity.

Material and Methods

In order to achieve the intended goal during the period 2019–2021, in the educational and experimental field of TTPI – Markovo, the populations of P_1, P_2, F_1 and F_2 of seven hybrid combinations of Burley tobacco are studied, namely: Hybrid 1464 (Linia 1189 × Banquet 102); Hybrid 1465 (Linia 1390 × Kentucky 908); Hybrid 1467 (Burley 1344 × Kentucky 908); Hybrid 1468 (Burley 1317 × B 1344); Hybrid 1469 (Linia 1322 × Kentucky 907); Hybrid 1470 (Linia 1145 x Tennessee 90). The subject of study and analysis are the height of the plants and the number of leaves. Only the technically viable leaves of a plant are included in the study. For this purpose, 20 plants from the parental forms are measured in 2019, 100 plants from the F_1 populations in 2018, and 200 plants from the F_2 populations in 2021.

The following are determined: arithmetic mean ($\bar{x}$), error of the arithmetic mean (S %), degree of dominance (d/a) according to Mather & Jinks (1985), heterosis effect in relation to the better parental form (HP) and depression by Omarov (1975). Also the following are established: transgression index (Tn), minimum number of genes by which the parental forms differ (N), dominance (D), epistasis, (E), trait heritability coefficient (H2), efficiency coefficient of the selection of genotypes by phenotypic manifestation of the trait (Pp) according to Sobolev (1976).

Results and Discussion

In the studied samples of Burley tobacco, the inheritance of plant height is overdominantly and most strongly expressed in Hybrid 1465 it is incompletely dominantly. Inheritance is always in the direction of the parent with higher values of the investigated indicator (Table 1).

Table 1. Biometric data on plant height (2019–2021)

Parents/ Crosses	P_1 $\bar{x}\pm S\bar{x}$	P_2 $\bar{x}\pm S\bar{x}$	F_1 $\bar{x}\pm S\bar{x}$	F_2 $\bar{x}\pm S\bar{x}$	d/a	HP, %	Depression, %
Hybrid 1464 (L 1189 × Bt 102)	156.7 ±0.71	168.7 ±0.78	174.4 ±0.80	172.6 ±0.80	5.7	103.4	1.03
Hybrid 1465 (L 1390 × Ky 908)	174.8 ±0.80	170.4±0.78	173.5 ±0.80	169.5.±0.78	0.4	99.26	2.31
Hybrid 1467 (B 1344 × Ky 908)	165.5 ±0.76	170.4±0.78	176.8±0.81	167.0 ±0.77	6.4	103.8	5.5
Hybrid 1468 (B 1317 × Б 1344)	167.9 ±0.77	165.5 ±0.76	170.9 ±0.78	167.4±0.77	3.5	101.8	2.05
Hybrid 1469 (B 1322 × Ky 907)	163.8 ±0.75	166.3 ±0.76	168.5±0.78	168.1±0.77	2.2	101.3	0.23
Hybrid 1470 (L 1145 × Tn 90)	161.2 ±0.74	171.4 ±0.79	173.0±0.80	170.3±0.78	1.6	100.9	1.73

Regarding the height of the plants, the manifestation of heterosis is very weakly expressed (Table 1). None of the investigated hybrid combinations showed heterosis exceeding the significance limit. A relationship is observed between the degree of dominance and the manifestation of the heterosis effect. The depression in F_2 is very weak and has the highest values in Hybrid 1467 (B 1344 × Ky 908) (Table 1). The values for the transgression coefficient in relation to plant height, for all hybrid combinations, are insignificant (Table 2).

The data from the hybridiological analysis show that the minimal number of genes that differentiate parental forms and influence the manifestation of indicator the plant height are relatively few and do not vary greatly – from 14 to 26 (Table 2). The phenotypic expression of number of leaves is influenced by dominant genes, the effects of which are significantly reduced by positive epistatic interactions.

For the height of plants, heritability coefficient values ranged from low to medium (Table 2), not exceeding 50% in any cross. This suggests that environmental conditions have a stronger influence on the manifestation of the trait. For this reason, we assume that the selection will be effective in the later hybrid generations ($F_3 – F_4$).

In the studied Burley tobacco crosses, inheritance of number of leaves is overdominantly, except for Hybrid 1468, where it is additive. As with the height of the plants, the inheritance of the number of leaves is always in the direction of the parent with higher values of the investigated trait (Table 3).

Regarding the number of leaves, the manifestation of heterosis is more pronounced. Heterosis with significant values regarding the number of leaves is observed in five of the seven investigated crosses (Table 3). In all of them, however, the heterosis barely exceeds the 5% significance level. In this case, no relationship between the degree of dominance and the manifestation of the heterosis effect is observed. The depression in F_2 regarding the number of leaves has greater values than the other studied indicator, but it is also weakly manifested and again, as with the height of the plants, it has the highest values in Hybrid 1467 (B 1344 × Ky 908) (Table 1).

The values of coefficient of transgression for number of

Table 2. Genetic characteristic of plant height

Crosses	Tn	N	D	E	H^2	Pp
Hybrid 1464 (L 1189 × Bt 102)	0.51	26.31	7.41	9.26	0.37	4.32
Hybrid 1465 (L 1390 × Ky 908)	-0.26	21.40	6.35	8.38	0.43	5.62
Hybrid 1467 (B 1344 × Ky 908)	0.64	14.37	8.16	9.75	0.48	6.15
Hybrid 1468 (B 1317 × Б 1344)	-0.39	22.22	6.53	7.88	0.35	4.28
Hybrid 1469 (B 1322 × Ky 907)	-0,20	16.94	7.28	8.59	0.44	5.74
Hybrid 1470 (L 1145 × Tn 90)	0.88	18.65	6,10	7.42	0.42	5.55

Table 3. Biometric data of number of leaves (2019–2021)

Parents/ Crosses	P_1 $\bar{x}\pm S\bar{x}$	P_2 $\bar{x}\pm S\bar{x}$	F_1 $\bar{x}\pm S\bar{x}$	F_2 $\bar{x}\pm S\bar{x}$	d/a	HP, %	Depression, %
Hybrid 1464 (L 1189 × Bt 102)	26.9 ±0.30	29.7 ±0.33	31.6 ±0.35	30.3 ±0.33	1.9	106.3	4.11
Hybrid 1465 (L 1390 × Ky 908)	31.6 ±0.35	30.4±0.33	32.1 ±0.35	31.4±0.35	1.8	101.6	2.18
Hybrid 1467 (B 1344 × Ky 908)	31.5 ±0.35	30.4±0.33	33.4±0.37	30.0 ±0.33	4.5	106	10.18
Hybrid 1468 (B 1317 × Б 1344)	28.3 ±0.31	31.5 ±0.35	33.1 ±0.37	31.8±0.35	0	105.1	3.92
Hybrid 1469 (B 1322 × Ky 907)	28.7 ±0.31	27.8 ±0.30	30.7±0.33	28.8±0.31	2	107	6.19
Hybrid 1470 (L 1145 × Tn 90)	27.3 ±0.30	29.6 ±0.30	31.5±0.35	30.6±0.33	1.9	106.4	2.86

Table 4. Genetic characteristic of number of leaves

Crosses	Tn	N	D	E	H^2	Pp
Hybrid 1464 (L 1189 × Bt 102)	0.76	6.76	2.85	-2.54	0.28	2.76
Hybrid 1465 (L 1390 × Ky 908)	0.31	8.43	3.72	3.21	0.22	2.49
Hybrid 1467 (B 1344 × Ky 908)	0.82	5.90	2.51	-2.10	0.34	3.31
Hybrid 1468 (B 1317 × Б 1344)	0.80	7.12	3.37	2.77	0.26	2.60
Hybrid 1469 (B 1322 × Ky 907)	0.67	6.82	3.05	-2.47	0.30	3.06
Hybrid 1470 (L 1145 × Tn 90)	0.93	8.40	4.12	3.65	0.27	2.64

leaves are also higher than those for height of plant. With the exception of Hybrid 1465, for all studied hybrid combinations in the available homozygous progeny, plants with 1 number of leaves more than the starting parental forms could be selected (Table 4). In this study, the occurrences of transgression for leaf number were associated with the occurrences of heterosis.

The data from the hybridiological analysis show that the minimal number of genes determining the manifestation of the indicator number of leaves is smaller than the height of the plants and hardly varies – from 6 to 8 (Table 4). The phenotypic expression of number of leaves is influenced by dominant genes, whose effects are influenced by positive and negative epistatic interactions.

With regard to studies of the trait number of leaves, the values obtained of heritability coefficient are even lower compared to those obtained for plant height (Table 4). This is an indication of a low share of the influence of the genotype on the manifestation of the investigated trait. Environmental conditions have a decisive influence on the determination of the trait. Therefore, the selection will be effective in even later hybrid generations ($F_4 – F_5$), which makes breeding work even more difficult.

While our studies in terms of the mode and character of inheritance in plant height and number of leaves are similar to most other analogous studies, in terms of the obtained coefficient of heritability for the two studied parameters, they differ significantly from those of other authors mentioned in the introductory part.

Conclusion

In the hybrid combinations Burley tobacco studied by us, the overdominantly inheritance of plant height and number of leaves is prevailed, and it is always in the direction of the parent with higher values of the investigated indicator.

Heterosis and transgression, as genetic phenomena, are more pronounced in relation to the number of leaves. Manifestations of heterosis and transgression are of economic importance, only for the symptom number of leaves and to a small extent.

The minimal number of genes controlling the manifestation of the plant height trait is two to three times greater than those determining the number of leaves. Epistatic interactions are more strongly manifested in the determination of the trait plant height than the number of leaves, but only in the second indicator are positive ones observed, which makes selection by this trait difficult.

The low values of the heritability coefficient found in the studied Burley tobacco crosses regarding plant height and especially the number of leaves suggest effective selection in later hybrid generations.

The established low values of the coefficient of heritability in the studied crosses Burley tobacco regarding the height of the plants and especially the number of leaves are showed the greater importance of the influence of the environment on the determination of the two studied parameters and suggest effective selection in later hybrid generations.

Although the minimum number of genes determining the number of leaves is smaller, due to the varied degree of dominance, the manifestations of negative epistasis and, above all, due to the lower coefficient of heritability, the selection for this indicator is more complex and longer than in the height of the plants.

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