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Use of heterosis and transgression events to optimize sizes of leaves in variety group Burley tobacco

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Abstract: The manifestations of heterosis and transgression regarding the length and width of the leaves in ten hybrid combinations of Burley tobacco are investigated. The results of the study show that in almost all variants and in both indicators, the values of the hypothetical heterosis exceed those of the real one. According to length of leaves heterosis with economic significance is observed only in one of the investigated hybrid combinations. Transgressive manifestations for this indicator are even less pronounced and are not significant in any of the studied options. In contrast to length of leaves the manifestations of heterosis are of economic importance in six of the ten crosses studied and could be successfully used to increase of width of leaves. Transgressive events in width of leaves are less pronounced than heterosis, but much more pronounced than those in the length. Direction of crossing affects the heterosis manifestations only of the length of the leaves but not those concerning their width. In terms to width of leaves, the manifestations of heterosis and transgression are related. Of all the studied variants, the one with the highest selection value regarding sizes of leaves is Hybrid 1555.

Key words: Burley tobacco; heterosis; transgeression; sizes of leaves; length and width

INTRODUCTION

The sizes of the leaves of tobacco are the most important indicator determining both the yield and the quality of the finished product (Butorac et al., 1999; Nikolova & Drachev, 2006; Nikolova et al., 2008; Wilhoit & Duncan, 2012; Risteski et al., 2017; Mitreski et al., 2018; Bozhinova & Hristeva, 2022).

Given the dynamics of the market for tobacco and tobacco products, it is necessary to look for effective methods for creating new varieties of tobacco (Bridges et al., 2011; Nikolov et al., 2022).

The heterosis method provides very good and effective opportunities for creating new varieties (Yankulov, 1996; Schnable & Spinger, 2013; Korubin-Aleksoska, 2016; Korubin-Alesoska & Dojcinov, 2019; Kınay & Kurt, 2022). Heterosis selection in large-leaf tobaccos holds great reserves for an effective increase in production (Stankev, 1985; Butorac, 2000). Its application helps to intensify the selection process and therefore the work with it should be expanded (Shabanov & Tomov, 1989; Risteski et al., 2017). This is one of the main tasks in the selection of large-leaf tobaccos (Popkhristev, 1977; Dexter-Boone & Lewis, 2019; Boaretto et al., 2020).

Although heterosis in tobacco is first described by Friman as early as 1924 and in Bulgaria, work on heterosis in this crop began only in 1951 (Gelemerov, 1990). Heterosis is a biological phenomenon that occurs in first-generation hybrids and is expressed in an increase in power, viability and productivity of the hybrids compared to those of the origin parent forms (Kara & Esendae, 1995; Prasannasimha Rao, 1995; Gixhari & Canllari, 2004). The manifestation of the heterosis effect is influenced not only by the hereditary predispositions of the selected parents, but also by favorable climatic conditions (Ahmed et al., 2016). Often a given hybrid behaves as heterozygous under some conditions and not under others (Yankulov, 1996). The heterosis effect is best manifested when using ecologically different varieties (Shabanov et al., 1975). The direction of crossing not infrequently influences the manifestations of heterosis in relation to one or another indicator (Shabanov & Tomov 1989; Prasannasimha Rao, 1995; Dexter-Boone & Lewis, 2019). Heterosis is possible only in the first hybrid generation (Gelemerov, 1990; Aleksoski et al., 2023). Disintegration in subsequent generations leads to a reduction and loss of the heterosis effect, as well as to the loss of varietal qualities (Shabanov et al., 1975; Popkhristev, 1977; Enchev, 1990). Therefore, in the second generation, it is appropriate to choose transgressive forms, as transgression is also defined as residual heterosis (Montgomery, 1982). For the first time, the phenomenon of transgression in tobacco is described in 1912 and can be defined as the superiority of individual hybrids of the second and subsequent generations for a certain indicator compared to the parent that is better for the corresponding indicator (Stankev, 1988).

Success in the detection of transgressive forms lies in the ability to select the largest number of plants in the second generation (F_2) that outperform the better parent (Stankev & Trancheva, 1987; 1989). Once defended, these forms are easily stabilized because transgression is a favorable combination of genes with polymer action (Stankev, 1988). Transgression has degree and frequency. Degree means superiority of the trait in F_2 and in subsequent generations over that of the better parent. The frequency is determined by the number of hybrid plants in the second generation exceeding the superior parent for the given trait. Both rate and frequency are expressed as percentages. For selection, it is important to know that the degree determines the selection, and the frequency - the number of selected transgressive forms (Didenko, 1974; Stankev & Trancheva, 1987).

The study of transgression in F_2 in tobacco is the subject of a limited number of studies (Montgomery, 1982; Stankev & Trancheva, 1987; 1989; Stankev, 1988; 2001). The detection and stabilization of transgressive forms is one of the most promising directions in the selection of tobacco (Didenko, 1974; Manolov, 2000).

The aim of our research is to establish the manifestations of heterosis and transgression in terms of sizes of leaves (length and width) in Burley tobacco samples and their use in the selection of tobaccos from this varietal group.

MATERIALS AND METHODS

The experimental work is carried out in the period from 2020 to 2022 at the experimental field of Tobacco and Tobacco Products Institute - Markovo. Ten hybrid combinations in F_1 created by us are tested. Each hybrid combination is represented by the straight and the reverse hybrid combination - the variant that is the maternal component in the straight is the paternal component in the reverse cross. „A“ indicates the corresponding reciprocal cross. In the crosses, both our selected varieties and lines and introduced varieties are involved as parental components. For all variants, biometric measurements are taken for leaf length and width from the middle leaf belt, which is most representative in Burley tobacco. According to the methods for determining heterosis and transgression 50 plants of each variant in F_1 and 200 in F_2 are measured. The experimental tobacco was grown according to the accepted methodology for growing Burley tobacco.

The years during which the survey is conducted (2020–2022) vary in the amount of rainfall that has fallen from the time of transplanting to harvesting Burley tobacco (Table 1). For all three years of the study, the amount of precipitation for all other months during the vegetative period is below the norm, except for the month of June, 2020 and month of August, 2021 (Kyuchukova et al., 1983). The rainfall that falls during the period of study is insufficient for the growth and development of tobacco. The values of the average daily temperatures are almost the same in the three experimental years and are optimal for Burley tobacco cultivation (Koleva & Peneva, 1990).

In relation to the investigated indicator, the arithmetic mean $\overline{x}$, error of the arithmetic mean

$S_{\bar{x}}$ %, hypothetical heterosis and true heterosis effect in relation to the better parental form [HP] according to Omarov (1975) are calculated. According to the formula of Voskresenskaya & Shpota (1967), degree [Td] and frequency of transgression [Tf] are established.

RESULTS AND DISCUSSION

Regarding the indicator length of leaves, the values of the hypothetical heterosis are superior to those of the real one in all studied variants. In breeding practice, the manifestations of true heterosis are

Table 1. Meteorological data - Plovdiv, 2020-2022

Month	Norm*	Average day and night temperature, ^{0}C		
		2020	2021	2022
June	20,9	20,9	20,3	20,1
July	23,2	24,2	23,6	21,6
August	22,7	22,9	23,1	24,1
		Amount of rainfall, l/m^2		
Month	Norm**	2020	2021	2022
June	63	64	52	49
July	49	27	46	41
August	31	23	34	30

**by Koleva and Peneva, 1990*
***by Kyuchukova et al., 1983*

Table 2. Manifestations of heterosis in relation to the trait of length of leaves

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$_2$ $\bar{x}\pm S\ \bar{x}$%	HP hypothetical %	HP real %
Hybrid 1551 (B 1317 x AM 284)	60,3±0,19	59,1±0,19	60,6±0,19	60,2±0,19	1,5	0,5
Hybrid 1551A (AM 284 x B 1317)	59,1±0,19	60,3±0,19	61,7±0,20	61,4±0,20	3,4	2,3
Hybrid 1552 (B 1344 x AM 284)	61,8±0,20	59,1±0,19	62,2±0,20	61,7±0,20	2,9	0,6
Hybrid 1552A (AM 284 x B 1344)	59,1±0,19	61,8±0,20	62,4±0,20	61,6±0,20	3,2	1,0
Hybrid 1553 (Va 509 x B1317)	59,6±0,19	60,3±0,19	61,7±0,20	61,5±0,20	2,9	2,3
Хибрид 1553A (B 1317 x Va 509)	60,3±0,19	59,6±0,19	61,1±0,20	60,4±0,19	1,9	1,3
Hybrid1554 (L 1321x Ky 8959)	59,5±0,19	59,4±0,19	60,1±0,19	59,2±0,19	1,1	1,0
Hybrid 1554A (Ky 8959 x L1321)	59,4±0,19	59,5±0,19	59,8±0,19	58,9±0,19	0,6	0,5
Hybrid 1555 (L 1322 x B 1317)	60,6±0,19	60,3±0,19	63,7±0,20	63,1±0,20	5,7	5,1
Hybrid 1555A (B 1317 x L1322)	60,3±0,19	60,6±0,19	61,6±0,20	60,9±0,19	1,9	1,7

of greater importance, and therefore in the present study we will comment on this type as a priority.

Heterosis of economic significance is observed only in the cross Hybrid 1555, and its values are just at the limit of significance (Table 2). This study shows that heterosis, as a selection method, is of little importance for increasing of length of leaves. Crossing direction affects to some extent the heterosis manifestations of length of leaves in the studied hybrid combinations.

Transgressive events in F_2 regarding length of leaves are even less pronounced and are not significant in any of the studied variants. In half of the variants even a negative transgression is observed, which in this case is extremely undesirable. The frequency of transgression is also negligible (Table 3). Crossing direction did not affect the transgressive manifestations of length of leaves in the studied hybrid combinations. The relationship between the manifestations of heterosis and transgression are also not well expressed, due to the low percentages obtained for both selection methods.

The obtained results in the present study show that heterosis and transgression, as selection methods for increasing length of leaves, are almost irrelevant and cannot be used effectively in selection for this parameter.

And with regard to the trait width of leaves, the values of the hypothetical heterosis are superior to those of the real one in all studied variants except for the hybrid pair Hybrid 1554 and Hybrid 1554A, where it is the opposite (Table 4). Heterosis of economic importance was observed in six of the ten hybrid combinations included in the study. Again, it is most strongly manifested in Hybrid 1555, which is the only variant where the heterosis values exceed 10%. This shows that unlike length of leaves, heterosis can be successfully used to increase the width of leaves. No influence of the crossing direction on the heterosis manifestations is observed.

Table 3. Manifestations of degree and frequency of transgression in relation to the trait length of leaves

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 $\bar{x} \pm S_{\bar{x}}$%	Td degree %	Tf frequency %
Hybrid 1551 (B 1317 x AM 284)	60,3±0,19	59,1±0,19	60,6±0,19	60,2±0,19	-0,2	-
Hybrid 1551A (AM 284 x B 1317)	59,1±0,19	60,3±0,19	61,7±0,20	61,4±0,20	2,3	7,3
Hybrid 1552 (B 1344 x AM 284)	61,8±0,20	59,1±0,19	62,2±0,20	61,7±0,20	-0,2	-
Hybrid 1552A (AM 284 x B 1344)	59,1±0,19	61,8±0,20	62,4±0,20	61,6±0,20	-0,3	-
Hybrid 1553 (Va 509 x B1317)	59,6±0,19	60,3±0,19	61,7±0,20	61,5±0,20	2	9,4
Хибрид 1553A (B 1317 x Va 509)	60,3±0,19	59,6±0,19	61,1±0,20	60,4±0,19	0,2	5,9
Hybrid1554 (L 1321x Ky 8959)	59,5±0,19	59,4±0,19	60,1±0,19	59,2±0,19	-0,5	-
Hybrid 1554A (Ky 8959 x L1321)	59,4±0,19	59,5±0,19	59,8±0,19	58,9±0,19	-1,0	-
Hybrid 1555 (L 1322 x B 1317)	60,6±0,19	60,3±0,19	63,7±0,20	63,1±0,20	4,1	14,7
Hybrid 1555A (B 1317 x L1322)	60,3±0,19	60,6±0,19	61,6±0,20	60,9±0,19	0,5	6,9

Table 4. Manifestations of heterosis in relation to the trait of width of leaves

Parents/Crosses	P_1 $\bar{x}$±S $\bar{x}$%	P_2 $\bar{x}$±S $\bar{x}$%	F_1 $\bar{x}$±S $\bar{x}$%	F_2 $\bar{x}$±S $\bar{x}$%	HP hypothetical %	HP real %
Hybrid 1551 (B 1317 x AM 284)	30,1±0,13	29,4±0,13	31,6±0,14	30,6±0,13	6,2	5,0
Hybrid 1551A (AM 284 x B 1317)	29,4±0,13	30,1±0,13	32,8±0,14	32,5±0,14	10,3	9,0
Hybrid 1552 (B 1344 x AM 284)	33,2±0,14	29,4±0,51	34,5±0,15	33,4±0,14	10,2	3,9
Hybrid 1552A (AM 284 x B 1344)	29,4±0,13	33,2±0,14	34,9±0,15	34,2±0,14	11,5	5,1
Hybrid 1553 (Va 509 x B1317)	30,4±0,13	30,1±0,13	32,6±0,14	32,0±0,14	7,8	7,2
Хибрид 1553A (B 1317 x Va 509)	30,1±0,13	30,4±0,13	31,7±0,14	31,4±0,14	4,8	4,3
Hybrid1554 (L 1321x Ky 8959)	29,8±0,13	29,5±0,13	30,6±0,13	29,5±0,13	1,2	2,7
Hybrid 1554A (Ky 8959 x L1321)	29,5±0,13	29,8±0,13	30,4±0,13	29,7±0,13	0,5	2,0
Hybrid 1555 (L 1322 x B 1317)	30,3±0,13	30,1±0,13	33,6±0,14	33,3±0,14	11,3	10,9
Hybrid 1555A (B 1317 x L1322)	30,1±0,13	30,3±0,13	32,2±0,14	31,4±0,13	6,6	6,3

Table 5. Manifestations of degree and frequency of transgression in relation to the trait width of leaves

Parents/Crosses	P_1 $\bar{x}$±S $\bar{x}$%	P_2 $\bar{x}$±S $\bar{x}$%	F_1 $\bar{x}$±S $\bar{x}$%	F_2 $\bar{x}$±S $\bar{x}$%	Td degree %	Tf frequency %
Hybrid 1551 (B 1317 x AM 284)	30,1±0,13	29,4±0,13	31,6±0,14	30,6±0,13	1,6	9,1
Hybrid 1551A (AM 284 x B 1317)	29,4±0,13	30,1±0,13	32,8±0,14	32,5±0,14	8,0	23,4
Hybrid 1552 (B 1344 x AM 284)	33,2±0,14	29,4±0,51	34,5±0,15	33,4±0,14	0,6	7,2
Hybrid 1552A (AM 284 x B 1344)	29,4±0,13	33,2±0,14	34,9±0,15	34,2±0,14	3,0	11,8
Hybrid 1553 (Va 509 x B1317)	30,4±0,13	30,1±0,13	32,6±0,14	32,0±0,14	5,3	18,9
Хибрид 1553A (B 1317 x Va 509)	30,1±0,13	30,4±0,13	31,7±0,14	31,4±0,14	3,3	12,5
Hybrid1554 (L 1321x Ky 8959)	29,8±0,13	29,5±0,13	30,6±0,13	29,5±0,13	-1,0	-
Hybrid 1554A (Ky 8959 x L1321)	29,5±0,13	29,8±0,13	30,4±0,13	29,7±0,13	-2,3	-
Hybrid 1555 (L 1322 x B 1317)	30,3±0,13	30,1±0,13	33,6±0,14	33,3±0,14	10	28,7
Hybrid 1555A (B 1317 x L1322)	30,1±0,13	30,3±0,13	32,2±0,14	31,4±0,13	3,6	15,6

The finding of some researchers that the heterosis effect is strongly manifested when using ecologically distant varieties and lines is not confirmed (Shabanov & Tomov, 1989; Popkhristev, 1977; Enchev, 1990; Gelemerov; 1990; Yankulov, 1996).

Transgressive manifestations in F_2 in relation to the studied indicator are less pronounced and are of economic importance in three of the ten variants included in the experiment. Again, they are most strongly manifested in Hybrid 1555 (Table 5). Compared to the length of the leaves in relation to the width of the leaves, it is much more strongly manifested. However, in general, transgression is not of great importance as a selection method for increasing width of leaves. In the hybrid pair Hybrid 1554 and Hybrid 1554A even a negative transgression is observed. The higher the percentage of transgression is, the higher is the percentage of its frequency of manifestation.

In this case, the direction of crossing is also of greater importance and influences to an average degree the manifestations of transgression. A positive correlation is observed between the manifestations of heterosis and transgression.

The results obtained regarding the manifestations of heterosis and transgression in Burley tobacco generally correspond with those of other authors who worked on this subject in tobacco and cited in the introductory part.

The results obtained in the present study show that heterosis, as a selection method, is important for increasing the size of the leaves only in terms of their width. This applies to a lesser extent to the manifestations of transgression.

CONCLUSION

The present study shows that heterosis, as a selection method, is of little importance for increasing length of leaves.

The obtained results show that unlike length of leaves, heterosis events are of economic importance and can be successfully used to increase width of leaves.

Crossing direction affects to some extent the heterosis manifestations of length of leaves in the studied hybrid combinations and does not affect those concerning their width.

In the case of width of leaves, a pronounced positive relationship is observed between the manifestations of heterosis and those of transgression. The higher is the percentage of transgression, the higher is the percentage of its frequency of manifestation.

The values for the manifestations of hypothetical and intrinsic heterosis effect and also of transgression, both in degree and in frequency, show that Hybrid 1555 is the variant with the highest selection value regarding the studied indicators.

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