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# Hybridological analysis of inheritance of length and width of leaves in hybrid combinations Burley tobacco

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**Abstract**
The way of inheritance, the coefficient of heritability, the manifestations of heterosis, transgression and depression in terms of the length and width of the leaves in hybrid combinations Burley tobaco are established. For that purpose are studied, the $P_1$, $P_2$, $F_1$ and $F_2$ populations of eight crosses Burley tobacco. The obtained results suggest that inheritance of the length or leaves is overrdominantly, incompletely dominantly or additive, and of the width of leaves is incompletely dominantly and overrdominantly,, as in both indicators it is always in the direction of the parent with higher values. Manifestations of heterosis and transgression are of economic importance only in terms of leaf width. The minimal number of genes that control the expression of the studied indices is small and uniform and the length and width of the leaves. The phenotypic expression of leaf size is strongly influenced by negative epistatic interactions, especially pronounced at their width. The established medium to higher values of the coefficient of heritability of the length of the leaves are an indication of a relatively equal share of influence of genotype and environmental conditions on the phenotypic manifestation of leaf length, which suggests that the selection on this indicator to be effective in earlier hybrid generations. The selection of width of the leaves will be effective in later hybrid generations due to lower values coefficient of the heritability, for this indicator. This shows that the coefficient of heritability and the related coefficient of efficiency of the selection is different in both indicators, making it difficult selection work.

**Key words:** Burley tobacco; hybridological analysis; inheritance; heritability; heterosis; size of leaves

## INTRODUCTION

One of the most important indicators of Burley tobacco is the dimensions of the leaves: length and width. They are directly related to both the yield and the quality of the finished product (Bozhinova & Hristeva, 2022; Nikolova & Drachev, 2006; Risteski et al., 2010; Pearce et al., 2014, 2019; Korubin – Aleksoska, 2016; Mitreski et al., 2017; Mitreski et al., 2018; Korubin – Alesoska & Dojcinov, 2019; Nikolov et al., 2022; Kınay & Kurt, 2022; Kurt., 2023).

Mehta et al. (1985) reported for dominantly and overdominantly inheritance in length of leaves, while Aleksoski (2022) observed rather incompletly dominantly. According to Espino & Gill, (1980) and Torrecila & Barroso (1980) the inheritance of length of leaves is determined by additive and dominant gene effects. Width of leaves is inherited overdominantly (Kaneva, 1980), dominantly (Palakarcheva & Yancheva, 1986) or incompletely dominantly Aleksoski (2022). Sastry & Prasada Rao (1980) found that in Burley tobacco, the dominant gene effects leading to the expression of the trait length of the leaves, and the epistatic ones are prevailing in the trait of the width of the leaves. In the studies of Mehta et al. (1985) in Virginia tobacco, it is found that the leading in the expression of the characteristics of the dimensions of the leaves, both for the length and for the width, are the additive gene effects. However, other authors (Murthy et al., 1972; Moses et al., 1976) reported leading non-additive gene effects for these traits.

Nizam Uddin & Newaz (1983) and Peksuslu et al, (2002) found high heritability in a broad sense for length of leaves – 83%. Shyu et al. (1975) found a heritability for width of leaves of 84%, and Nizam Uddin & Newaz, (1983) reported heritability coefficients of 96% for width of leaves, allowing for their rapid stabilization in subsequent generations. Stankev (2001) and Ahmed & Mohammad (2017) also is obtained similar results for heritability by sizes of leaves.

Although leaf size is the most important economic indicator in tobacco, studies on heterosis manifestations are relatively few (Aleksoska, 2008; Aleksoski, 2014; Dexter-Boone & Lewis, 2019), and transgressive ones are almost absent (Stankev, 1985, 1988, 2004; Stankev & Trancheva, 1987).

The purpose of the study is to establish and compare through hybridological analysis, the nature of gene interactions, the minimal number of genes by which the parental forms differ, the heritability and the selection effect, as well as the manifestations of heterosis and transgression and depression in terms of length and width of the leaves, in hybrid combinations of Burley tobacco, as well as to determine the influence of the crossing direction on their manifestation.

## MATERIAL AND METHODS

To achieve the intended goal, during the period 2016 - 2018, in the educational and experimental field of TTPI - Markovo, are studied the populations of $P_1$, $P_2$, $F_1$ and $F_2$ of eight hybrid combinations of Burley tobacco. Each hybrid combination is represented by its direct and reverse cross – the variant that appears as a maternal component in the direct is a paternal component in the reverse. The subject of research and analysis is the length and width of the leaves from the middle harvesting belt, which is the most representative of large-leaf tobaccos. For each hybrid combination, 20 plants are used as parental components. For this purpose, 20 plants from the parental forms are measured in 2016, 100 plants from the $F_1$ populations in 2017, and 200 plants from the $F_2$ populations in 2018.

The following are determined: arithmetic mean ( $\overline{x}$ ), error of the arithmetic mean (S $\overline{x}$ %), degree of dominance (d/a) according to Mather & Jinks (1985), heterosis effect in relation to superior parental form (HP) and depression (a/c) according to Omarov (1975). The following are found: transgression index (Tn), minimal number of genes by which the parental forms differ (N), dominant genes (D), epistasis, genes (E), coefficient for heritability of the trait ($H^2$), efficiency coefficient of the selection of

**Table 1.** Biometric data of length of leaves in Burley tobacco (average 2016-2018)

| Parents/ Crosses | $P_1$ $\overline{x}$ ±S $\overline{x}$ | $P_2$ $\overline{x}$ ±S $\overline{x}$ | $F_1$ $\overline{x}$ ±S $\overline{x}$ | $F_2$ $\overline{x}$ ±S $\overline{x}$ | d/a | Heterosis HP % | Depression a/c % |
|---|---|---|---|---|---|---|---|
| Hybrid 1611 (L 1466 x Coker 46) | 60.4 ±0.20 | 60.7 ±0.20 | 62.2±0.21 | 60.8 ±0.20 | 1.5 | 2.5 | 2.25 |
| Hybrid 1611A (Coker 46 x L 1466) | 60.7 ±0.20 | 60.4 ±0.20 | 62.8 ±0.21 | 61.3±0.20 | 15 | 3.5 | 2.4 |
| Hybrid 1612 (L 1400 x L 1458) | 61.8 ±0.20 | 62.6±0.21 | 63.0 ±0.21 | 61.4 ±0.20 | 0.2 | 0.6 | 2.5 |
| Hybrid 1612A (L 1458 x L 1400) | 62.6±0.21 | 61.8 ±0.20 | 62.4±0.21 | 61.1±0.20 | 0 | -0.3 | 2.1 |
| Hybrid 1613 (L 1458 x L 1362) | 62.6±0.21 | 62.3 ±0.21 | 63.6±0.21 | 62.4±0.21 | 5 | 1.6 | 1.25 |
| Hybrid 1613A (L 1362 x L 1458) | 62.3 ±0.21 | 62.6±0.21 | 63.2±0.21 | 62.1±0.21 | 0.6 | 0.95 | 1.7 |
| Hybrid 1614 (L 1362 x L 1527) | 62.3 ±0.21 | 61.5 ±0.20 | 62.4±0.21 | 60.2±0.20 | 1.25 | 0.2 | 3.5 |
| Hybrid 1614A (L 1527 x L 1362) | 61.5 ±0.20 | 62.3 ±0.21 | 62.9±0.21 | 60.4±0.20 | 0.6 | 1 | 4 |

genotypes by phenotypic manifestation of the trait (Pp) according to Sobolev (1976).

## RESULTS AND DISCUSSION

In the studied hybrid combinations of Burley tobacco, the inheritance of length of leaves is varied: in four crosses it is over dominantly, in another three it is incompletely dominantly, and in Hybrid 1612 A it is additive. It is always in the direction of the parent with a longer length of leaves (Table 1). The direction of hybridization has a strong influence on the mode of inheritance of this indicator.

Regarding length of leaves, significant heterosis is no observed. Depression is also manifested in a weak degree in all hybrid combinations (Table 1). The transgression coefficient values are also insig-

**Table 2.** Genetic characteristic of length of leaves in Burley tobacco

| Crosses | Tn | N | D | E | $H^2$ | Pp |
|---|---|---|---|---|---|---|
| Hybrid 1611 (L 1466 x Coker 46) | 0.29 | 3.84 | 3.63 | -10.45 | 0.47 | 0.38 |
| Hybrid 1611A (Coker 46 x L 1466) | 0.38 | 3.69 | 3.51 | -10,26 | 0.52 | 0.43 |
| Hybrid 1612 (L 1400 x L 1458) | -0.17 | 3.94 | 3.80 | -11.13 | 0.54 | 0.45 |
| Hybrid 1612A (L 1458 x L 1400) | -0.35 | 4.18 | 3.96 | -11.22 | 0.49 | 0.41 |
| Hybrid 1613 (L 1458 x L 1362) | 0.16 | 3.77 | 3.65 | -10.78 | 0.48 | 0.40 |
| Hybrid 1613A (L 1362 x L 1458) | 0.11 | 3.98 | 3.81 | -10.66 | 0.46 | 0.37 |
| Hybrid 1614 (L 1362 x L 1527) | -0,13 | 4.04 | 3.89 | -11.08 | 0.52 | 0.44 |
| Hybrid 1614A (L 1527 x L 1362) | -0,22 | 4.26 | 4.12 | -10.92 | 0.55 | 0.48 |

**Table 3.** Biometric data of width of leaves in Burley tobacco (average 2016-2018)

| Parents/ Crosses | $P_1\ \overline{x} \pm S\ \overline{x}$ | $P_2\ \overline{x} \pm S\ \overline{x}$ | $F_1\ \overline{x} \pm S\ \overline{x}$ | $F_2\ \overline{x} \pm S\ \overline{x}$ | d/a | Heterosis HP % | Depression a/c % |
|---|---|---|---|---|---|---|---|
| Hybrid 1611 (L 1466 x Coker 46) | 32.5 ±0.12 | 30.8 ±0.11 | 32.7 ±0.12 | 30.4 ±0.11 | 1.2 | 0.6 | 10.1 |
| Hybrid 1611A (Coker 46 x L 1466) | 30.8 ±0.11 | 32.5±0.12 | 33.2 ±0.12 | 30.7±0.11 | 0.7 | 2.15 | 7.5 |
| Hybrid 1612 (L 1400 x L 1458) | 31.2 ±0.12 | 32.7 ±0.12 | 34.8±0.13 | 33.7±0.12 | 2.1 | 6.4 | 3.2 |
| Hybrid 1612A (L 1458 x L 1400) | 32.7 ±0.12 | 31.2 ±0.12 | 33.6±0.12 | 32.2±0.12 | 2.2 | 2.75 | 4.2 |
| Hybrid 1613 (L 1458 x L 1362) | 32.7 ±0.12 | 33.3 ±0.12 | 35.3±0.13 | 34.5±0.13 | 2 | 6 | 2.3 |
| Hybrid 1613A (L 1362 x L 1458) | 33.3 ±0.12 | 32.7 ±0.12 | 34.9±0.13 | 34.3±0.13 | 6.3 | 4.8 | 1.7 |
| Hybrid 1614 (L 1362 x L 1527) | 33.3 ±0.12 | 32.4 ±0.12 | 33.3±0.12 | 30.2±0.11 | 1 | 0 | 9.3 |
| Hybrid 1614A (L 1527 x L 1362) | 32.4 ±0.12 | 33.3 ±0.12 | 33.8±0.13 | 30.6±0.11 | 0.5 | 1.5 | 9.4 |

nificant (Table 2). The direction of crossing is irrelevant for the manifestations of heterosis, depression and transgression.

From the performed hybridological analysis, it is established that the minimal number of genes affecting the manifestation of the leaf length trait is low and hardly varies – 3 or 4, and they are mainly dominant genes (Table 2). The phenotypic expression of the studied indicator is strongly influenced by negative epistatic interactions, which makes selection by this trait difficult.

The values of the heritability coefficient and the related coefficients of efficiency of selection obtained for length of leaves varied little among individual hybrid combinations and were all around 50% (Table 2). This is an indication of a relatively equal share of influence of genotype and environmental conditions on the phenotypic manifestation of length of leaves. Therefore, leaf length selection will be effective in the earlier hybrid generations ($F_3$ – $F_4$).

The direction of hybridization does not affect the number of genes, the nature of gene interactions and the heritability coefficient for this indicator.

In the studied hybrid combinations of Burley tobacco, the inheritance of width of leaves is incompletely dominantly or overdominantly depending on the cross, with the latter prevailing. It is always in the direction of the parent with the larger width of leaves (Table 3). The direction of hybridization does not affect the mode of inheritance for this indicator.

Regarding the width of leaves, heterosis with significant values is observed in Hybrid 1612 and Hybrid 1613. Depression, although more pronounced than that in length of leaves, is not expressed to a strong degree (Table 3). The values of the transgression coefficient for most variants are also insignificant. Only in Hybrid 1612 and Hybrid 1613 in the available homozygous progeny, plants with 1 cm greater width of leaves, compared to the parent parental forms, could be selected (Table 4). In these crosses the manifestations of heterosis and those of transgression are related. The direction of crossing affects the manifestations of heterosis and transgression in a hybrid pair - Hybrid 1612 and Hybrid 1612 A. Heterosis is of greater importance in width of leaves than in their length.

From the made hybridological analysis, it is found that the minimal number of genes influencing the manifestation of the leaf width trait is low and hardly varies - from 2 to 3 (Table 4). Dominant genes have a weak influence on the phenotypic expression of research indicators, the effects of which are greatly reduced by negative epistatic interactions, which greatly complicates selection by this trait.

The heritability coefficient values and the associated coefficients of efficiency of selection, obtained for width of leaves are low (Table 4). There is

**Table 4.** Genetic characteristic of width of leaves in Burley tobacco

| Crosses | Tn | N | D | E | $H^2$ | Pp |
|---|---|---|---|---|---|---|
| Hybrid 1611 (L 1466 x Coker 46) | 0.15 | 2.59 | 1,16 | -19.79 | 0.17 | 0.13 |
| Hybrid 1611A (Coker 46 x L 1466) | 0.39 | 2.67 | 0.93 | -19.91 | 0.19 | 0.14 |
| Hybrid 1612 (L 1400 x L 1458) | 0.94 | 2.38 | 0.88 | -20.14 | 0.16 | 0.12 |
| Hybrid 1612A (L 1458 x L 1400) | 0.44 | 2.31 | 0.95 | -20.32 | 0.15 | 0.11 |
| Hybrid 1613 (L 1458 x L 1362) | 0.82 | 2.78 | 0.69 | -20.16 | 0.20 | 0.16 |
| Hybrid 1613A (L 1362 x L 1458) | 0.49 | 2.82 | 0.60 | -19.97 | 0.18 | 0.15 |
| Hybrid 1614 (L 1362 x L 1527) | 0.04 | 3.02 | 1.18 | -20.21 | 0.18 | 0.14 |
| Hybrid 1614A (L 1527 x L 1362) | 0,30 | 2.85 | 1.25 | -20.40 | 0.16 | 0.13 |

a much lower proportion of impact of genotype on the manifestation of the investigated indicator than on length of leaves. We assume that selection for width of leaves will be effective in even later hybrid generations ($F_5 – F_6$). The direction of hybridization does not affect the minimal number of genes, the nature of gene interactions, and the coefficient of heritability and selection for this indicator.

While our studies on the nature of inheritance of the sizes of leaves correspond more or less to those of the other authors mentioned in the introduction, they differ seriously in regard to the heritability of index studies.

Significant differences are observed in the pattern of inheritance between the length of leaves and the width of leaves in the studied Burley tobacco crosses. The results of the study show that the selection process is more difficult according to the trait width of leaves.

## CONCLUSION

In the studied hybrid combinations of Burley tobacco, the inheritance of the length of leaves is diverse and, depending on the cross, is overdominantly, incompletely dominantly or additive and is always in the direction of the parent with greater leaf length. Inheritance of the width of leaves is incompletely dominantly and overdominantly and is always in the direction of the parent with greater leaf width.

The manifestations of heterosis and transgression are manifested to a small extent in relation to the width of the leaves and are insignificant for the other trait - the length of the leaves.

The minimal number of genes controlling the manifestation of length and width of leaves is small and is the same for both indicators. The phenotypic expression of sizes of leaves is strongly influenced by negative epistatic interactions, more strongly affecting the manifestation of the trait width of leaves.

The obtained average to higher values of the coefficient of heritability for the length of the leaves is an indication of a relatively equal share of the impact of the genotype and the environmental conditions on the phenotypic manifestation of this trait, which suggests that the selection for this indicator will be effective in the earlier hybrid generations.

The selection for the width of leaves will be effective in later hybrid generations due to found low values of heritability coefficient. The selection for this indicator is more complicated than for the length of the leaves.

The direction of hybridization has a strong influence on the manner of inheritance of the length of leaves, but not so much on their width.

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