

## THE MODE OF INHERITANCE OF QUANTITATIVE CHARACTERS AND HETEROTIC EFFECT IN F1 HYBRIDS IN A DIALLEL OF DIFFERENT TOBACCO TYPES

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### ABSTRACT

The paper concerns the mode of inheritance and assessment of heterotic effect in six diallel F1 crosses of four parental genotypes (large – leaf variety Burley B – 2/93 and the oriental Suchum S1 with pink flowers, Suchum S2 with white flowers and Prilep P – 84), for the following characters: stalk without inflorescence, leaf number per stalk, middle belt leaf area, green mass yield and dry mass yield per stalk. The trial was set up in the field of Scientific tobacco institute – Prilep, in randomized blocks with four replications during 2007, 2008 and 2009 and traditional cultural practices were applied in tobacco growing.

The analysis of variance was used to determine statistically significant differences between parents and their hybrids for the characters investigated during the three – years period. Positive heterosis with poor heterotic effect was recorded in S1 x S2 hybrid for stalk height without inflorescence and for green/dry mass yields per stalk, while in S2 x P-84 only for height of the stalk without inflorescence. Negative heterosis with poor heterotic effect was recorded in hybrids S1 x P-84 for leaf number and for green/dry mass yields and S2 x P-84 for leaf number and green mass yield per stalk. The low heterotic effect indicates that utilization of heterosis in investigated tobacco genotypes is without economical justification, but in the same time it points out to the eventual breeding activities for creation of new more superior varieties.

**Keywords:** tobacco *Nicotianatabacum*L., diallel crosses, mode of inheritance, heterosis, heterotic effect.

## НАЧИН НА НАСЛЕДУВАЊЕ НА КВАНТИТАТИВНИТЕ СВОЈСТВА И ПРОЦЕНКА НА ХЕТЕРОТИЧНИОТ ЕФЕКТ КАЈ F1 ХИБРИДИТЕ КАЈ ДИЈАЛЕЛ НА РАЗЛИЧНИ ТИПОВИ ТУТУН

Трудот опфаќа проучувања за начинот на наследување и проценка на хетеротичниот ефект кај шест еднонасочни дијалелни крстоски на четири родителски генотипови (крупнолисната сорта Берлеј Б - 2/93 и ориенталските сорти Сухум S1 со розови цветови, Сухум S2 со бели цветови и Прилеп П - 84), за својствата: висина на стракот без соцветие, бројот на листови по страк, површина на листовите од средниот појас, принос на зелена маса по страк и принос на сува маса по страк. Опитот беше поставен на опитното поле при Научниот институт за тутун – Прилеп по сличаен блок – систем во четири повторувања во 2007, 2008 и 2009 година. Со анализа на варијансата беа утврдени статистички значајни разлики помеѓу родителите и нивните хибриди за својствата во трите години на истражувања.

Позитивен хетерозис со слаб хетеротичен ефект е утврден кај крстоската S1 x S2 за висината на стракот без соцветие и приносот на зелена и сува маса по страк и кај S2 x П-84 само за висината на стракот без соцветие. Негативен хетерозис со слаб хетеротичен ефект е утврден кај крстоските S1 x П-84 за бројот на листови по страк и за приносот на зелена и сува маса по страк и S2 x П-84 за бројот на листови и принос на зелена маса по страк.

Нискиот хетеротичен ефект укажува на економската неоправданост на искористувањето на хетерозисот кај проучуваните генотипови тутун, но истовремено укажува на можни идни селекциони активности за создавање на нови сорти посупериорни од родителите.

**Клучни зборови:** тутун - *Nicotiana tabacum* L., диалелни крстоски, начин на наследување, хетерозис, хетеротичен ефект.

## INTRODUCTION

The phenomenon in F1 when progenies of genetically divergent lines are more vigorous and achieve higher yields than parents is called heterosis. It is used in mass production especially of self-fertilizing cultures, in which it is difficult to obtain homogenous and stable varieties and where each subsequent reproduction differs from the previous ones due to the free fertilization.

Heterosis is not used in the production and breeding of oriental tobacco because it is considered as economically unjustified measure. However, genetic investigations on inheritance of characters in various crops have always been completed by determination of the heterotic effect in F1 hybrids. Genetic mechanism of the heterosis enables early prognosis of the breeding value of hybrid combinations. There is great probability that new lines with preferred characters can be obtained from the varieties with high heterotic effect.

Hybrid vigor of F1 hybrids in different tobacco varieties has been investigated in many papers, but we only present those in which oriental tobaccos are included. Marani and Sachs (1966) obtained positive heterosis for height and leaf number in hybrids of oriental tobacco. Matzinger and Wernsman (1968) recorded positive heterosis only for stalk height in flue-cured and oriental varieties. Tomov (1975) found strong positive heterotic effect for stalk height in domestic varieties of oriental tobacco. Jung et al. (1982), in

diallel analysis of six oriental and fifteen F1 hybrids revealed positive heterosis for stalk height, leaf number and yield, with strong heterotic effects in hybrids Samsun x Izmir and Xanthi x Izmir). Terrill et al. (1982) revealed positive heterosis for stalk height and yield in 12 varieties of sun-cured, flue-cured, dark-fired, Burley, Maryland and cigar tobacco and their diallel F1 hybrids. Lee & Chang (1984) found positive heterosis for leaf length and width and for leaf mass yield in their analysis of local and oriental Korean varieties and 28 F1 hybrids. Kara & Esendal (1995) in six oriental varieties and their 15 F1 hybrids (excluding reciprocal crosses) revealed negative heterosis for leaf number and significant heterosis for yield (the average yield of the hybrids was 15.2% higher than the parents). Korubin-Aleksoska (2008) in analysis of three oriental varieties and one semi-oriental and their diallel F1 progenies found positive heterosis for stalk height (YV 125/3 x FO), for middle belt leaf area and dry mass yield (P 12-2/1 x P-2 and P-2 x YV 125/3) and for green mass yield (P 12-2/1 x P-2). The cross P-2 x YV 125/3 showed negative heterosis for leaf number per stalk. The authors reported that application of heterosis in tobacco production is economically unjustified, except for hybrids resistant to some disease.

The aim of the investigations was to reveal heterosis and to estimate its effect on major quantitative characters in F1 progenies of different tobacco types, in

order to contribute to the genetics of this crop and to predict the perspectiveness of

the new lines in the diallel.

## MATERIALS AND METHODS

Investigations on major quantitative characters and heterotic effect in F1 progeny was performed with four tobacco varieties, one of which were large-leaf variety (Burley B- 2/93 in CMS form) and three were oriental (Suchum S1 with pink flowers, Suchum S2 with white flowers and Prilep P-84 with red flowers). The diallel crossings provided the maximum number of combinations that can be made between some parental genotypes.

Crossings were made in the Experimental field of Tobacco Institute-Prilep during 2006, 2007 and 2008. The seed from six combinations for F1 generation was obtained by hand castration and pollination. The trial was set up during 2007, 2008 and 2009 in randomized blocks with four replications. Investigations included parental genotypes and progenies of the following F1 hybrids:

1. Burley B-2/93 x Suchum S1
2. Burley B-2/93 x Suchum S2
3. Burley B-2/93 x Prilep P-84
4. Suchum S1 x Suchum S2
5. Suchum S1 x Prilep P-84
6. Suchum S2 x Prilep P-84

Each replication was performed at an area of 147.6 m<sup>2</sup>. The whole trial was

set up at of 590.4 m<sup>2</sup> usable area, i.e. at 838 m<sup>2</sup> total area, together with the paths.

All suitable cultural practices were applied during the growing season.

Analysis was made on the following quantitative traits: stalk height without inflorescence, leaf number per stalk, middle belt leaf area, green mass yield per stalk and dry mass yield per stalk.

The first two characters were investigated in the period of tobacco flowering, at the end of July and August. 50 stalks from each replication were measured, or a total of 200 stalks from the whole trial, with the same number of leaves from the middle primings.

Leaf area was calculated by multiplication of their length and width with the coefficient  $k=0,6354$ .

Green mass yield was measured after each harvest. Total weight of tobacco from each plot was added and the addition was divided with the number of stalks from which tobacco leaves were picked. The same method was used to calculate dry mass yield per stalk, i.e. tobacco was measured after manipulation and formulae for corrected yield were applied.

## Processing of results

Data obtained from measurements of each character by combinations for parental genotypes and their F1 progeny were processed by the variational-statistical method.

Mode of inheritance was estimated according to the test-significance of the mean value of F1 progeny compared to the parental average Borojević (1981).

Significantly higher mean value of the hybrid obtained from parent with higher average value denotes the appearance of positive heterosis (+h), whereas significantly lower mean value of the hybrid obtained from parent with lower average value denotes negative heterosis (-h).

Heterosis (h) is a phenomenon in which the progeny of the first generation possesses more strongly expressed characters, both positive and negative, compared to the parents. Its effect is estimated as follows:

$$h = \bar{F1} - \bar{BP}$$

where:

$\bar{F1}$  - mean value of F1 generation

$\bar{BP}$  - mean value of the better parent

Standard error of heterosis in relation to  $\bar{BP}$  is estimated by the formula:

$$Se(h) = \sqrt{h \text{ of variance}}$$

The significance of  $\bar{F1}$  generation in relation to  $\bar{BP}$  is tested with t-test:

$$t = \frac{\bar{F1} - \bar{BP}}{SE(h)}$$

### Meteorological data

Manifestation of quantitative characters greatly depends on the effect of

environmental factors. In 2007, during tobacco growth in field (May-September), mean monthly temperature was 20.88°C and the number of rainy days was 41, with total amount of precipitation 229.9 mm. In the same period in 2008, mean monthly temperature was 19.91°C and the number of rainy days was 39, with total amount of precipitations 235.4 mm. In the same period in 2009, mean monthly temperature was 19.89°C and the number of rainy days was 42, with total amount of precipitations 240,6 mm.

Values of the above parameters indicate optimum climate conditions for production of oriental tobaccos. They reveal approximately identical conditions in the three investigating years.

## RESULTS AND DISCUSSION

The most common mode of inheritance in F1 hybrids, where one of the parents is the large leaf variety B-2/93, is partial dominance. In these crosses, inheritance of height is intermediary, and that of the number of leaves is negatively dominant. In crosses where both parents are of oriental type, all possible modes of inheritance are present, but heterosis is predominant.

Heterosis (h) is a consequence of heterozygosity of F1 progeny, in which some diallel and non-allelic genes in interaction affect certain character, exceeding the parents in positive or negative direction. Expression of the strength of this phenomenon is called heterotic effect. It is manifested only in F1 generation, while in the successive generations it disappears, due to impossibility of its fixation.

The reveal of heterosis is based on previous investigations on inheritance of the characters. In our three-year

investigation, the highest among parents was the large-leaf variety B-2/93, and P-84 was the shortest. Among hybrids, B-2/93 x Suchum S1 was the highest, while S1 x P-84 and S2 x P-84 were the shortest. The highest leaf number among parental genotypes was observed in P-84 and the lowest in B-2/93, while among hybrids this character was highest in S1xS2 and lowest in crossings where B-2/93 was one of the parents. The largest leaves and highest yield of green and dry mass were observed in B-2/93, whereas the smallest leaf and lowest green and dry mass yields were found in P-84. Among hybrids, predominant for all three characters were those in which B-2/93 was one of the parents. The smallest leaf area and lowest green and dry mass yield was noticed in S1 x P-84 and S2 x P-84, in which negative heterosis appeared. Values for the quantitative characters in parents and F1 progeny are presented at Table 1.

**Table 1. Inheritance of some quantitative characters from parents of the F1 progeny and appearance of heterozis**

Parents and F1 hybrids	Quantitative characters														
	Height of the stalk without inflorescence (cm)			Number of leaves / stalk			Middle belt leaf area (cm <sup>2</sup> )			Green mass yield / stalk (g)			Dry mass yield / stalk (g)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
<b>1. Burley B-2/93</b>	147	142	145	36	34	36	1264	1138	1282	1099	1017	1055	185	178	182
<b>2. Sochoumi S1</b>	70	68	69	47	45	45	230	205	220	267	210	253	26	25	25
<b>3. Sochoumi S2</b>	69	67	70	47	45	46	239	220	225	260	208	220	26	25	26
<b>4. PrilepP-84</b>	58	57	58	53	52	52	146	138	142	160	158	160	24	24	24
<b>5. B - 2/93 x S1</b>	105 i	103 i	104 i	35 -d	34 -d	35 -d	1063 pd	1016 pd	1050 pd	813 pd	800 pd	809 pd	132 pd	130 pd	131 pd
<b>6. B - 2/93 x S2</b>	102 i	102 i	103 i	36 -d	34 -d	36 -d	1074 pd	988 pd	1040 pd	811 pd	808 pd	810 pd	133 pd	130 pd	133 pd
<b>7. B - 2/93 x II - 84</b>	100 i	91 i	95 i	37 -d	35 -d	36 -d	903 pd	832 pd	888 pd	795 pd	790 pd	789 pd	122 i	117 i	120 i
<b>8. S1 x S2</b>	70 +h	69 +h	71+h	47 i	45 i	46 +d	233 pd	210 pd	225 +d	269 +h	211 +h	275 +h	26 +h	26 +h	27 +h
<b>9. S1 x P - 84</b>	71+d	69 +d	70 +d	43 -h	42 -h	42 -h	185 i	173 i	180 i	133 -h	130 -h	135 -h	23 -h	23 -h	23 -h
<b>10. S2 x P - 84</b>	72 +h	70 +h	73 +h	45 -h	43 -h	43 -h	174 pd	158 pd	170 pd	135 -h	133 -h	137 -h	24 -d	24 -d	25 i

Positive significant heterotic effect for stalk height without inflorescence appeared in S1 x S2 and in S2 x P-84. Positive heterotic effect for this character was also reported: Marani and Sachs (1966), Matzinger and Wernsman (1968), Tomov (1975), Jung, Hwang and Son(1982), Terrill, Aycock, Link and Conner (1982) and Korubin - Aleksoska (2008).

Negative heterotic effect for leaf number was observed in S1 x P-84 and S2 x P-84. The same effect for this character was also reported Karaand Esendal (1995) and Korubin - Aleksoska (2008).

Positive heterotic effect for green and dry mass yields in our investigations was observed in S1 x S2. The same effect for this character was also reported Jung, Hwang and Son(1982), Terrill, Aycock, Link and Conner (1982), Lee and Chang

(1984), Kara and Esendal (1995) and Korubin - Aleksoska (2008). Negative heterotic effect for green and dry mass yields was found in S1 x P-84, and only for green mass yield in S2 x P-84.

Heterotic effect of the characters that were subject of our investigation is presented in Table 2.

**Table 2. Heterotic effect of quantitative characters in F1 hybrids**

Parents and F1 hybrids	Quantitative characters														
	Height of the stalk without inflorescence (cm)			Number of leaves / stalk			Middle belt leaf area (cm <sup>2</sup> )			Green mass yield / stalk (g)			Dry mass yield / stalk (g)		
	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009	2007	2008	2009
<b>5. B - 2/93 x S1</b>															
<b>6. B - 2/93 x S2</b>															
<b>7. B - 2/93 x II - 84</b>															
<b>8. S1 x S2</b>	+ 0.22	+ 1.02	+1.12							+ 2.17	+ 0.86	+21.62	+ 0.37	+ 0.26	+1.22
<b>9. S1 x P - 84</b>				- 4.91	- 2.41	-3.26				- 26.49	- 27.62	-25.14	- 0.87	- 0.94	-0.97
<b>10. S2 x P - 84</b>	+ 2.26	+ 2.03	+2.94	- 4.91	- 1.99	-2.92				- 24.62	- 24.61	-23.03			

## CONCLUSIONS

- Selected parents (Burley B-2/93, Suchum S1, Suchum S2 and P-84) are genetically homogeneous and significantly different;
- The modes of inheritance of investigated quantitative characters are different. In crosses where one of the parents is B-2/93 partial dominance is prevailing, whereas in crosses from oriental varieties heterosis is predominant, but other modes of inheritance are also present.
- Positive heterotic effects for stalk height without inflorescence, as well as for green and dry mass yields, were observed in hybrid S1 x S2, and only for the stalk without inflorescence in S2 x P-84. Negative heterotic effect for leaf number per stalk and for green and dry mass was found in hybrid S1 x P-84, whereas for leaf number and green mass yield it was observed in S2 x P-84. The positive heterotic effect is low and economically unjustified;
- F1 hybrids are the basis from which, through successive selection in future, perspective lines will be selected, with improved characters which will be stabilized very soon.

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