Study of inheritance of some agronomic and morphological traits in burley tobacco by graphic analysis of diallel cross

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ABSTRACT

The mode of inheritance of yield, topping height, leaf number, days to flowering, leaf length and width was studied by means of graphic analysis in a half diallel cross test of four burley tobacco varieties (Saturn, TN 86, Bs 92 and Bols 100) in 1998 and 1999. The trial was set up according to the RCBD at four replications in the experimental field of Tobacco Institute Zagreb in Pitomača. Overdominance in inheritance of all studied traits, except leaf length and width in 1998, was found by the graphic method. No interallelic interaction and epistasis were present as seen from testing regression coefficients for all investigated traits and years. The distribution of parental genotypes on a scatter diagram along the expected regression line points to the genetic divergence of the parents. Parent Bs 92 appeared to have the most dominant alleles for yield and leaf length and parent Saturn for topping height, leaf number and leaf width.

Keywords: *Nicotiana tabacum* L.; burley; agronomic and morphological traits; graphic analysis

Since tobacco is produced for its vegetative portions, the value of the crop is determined, among other things, by leaf yield, number of harvestable leaves, length, width and shape of leaves. These traits are of quantitative nature. Individual gene effects contributing to the expression of a quantitative character are too small to be recognized and evaluated separately. The diallel cross technique is used as one of the basic procedures to study the problem of inheritance of quantitative traits. Our investigations were carried out on burley tobacco because of its importance for the production of blend type cigarettes. Unfortunately, quantitative inheritance of major traits of this tobacco type has been studied on domestic genetic material in Croatia only to a little extent. Thus, the goal of our investigations was to estimate the manner of inheritance of agronomic (yield) and morphological traits (topping height, leaf number, leaf length and width) and days to flowering of burley tobacco using the graphic analysis of diallel cross.

Some studies using graphic analysis indicate that nonadditive variance plays a somewhat greater role in the inheritance of plant height (Šmalcelj 1983, Shoai Daylami and Honarneja 1996, Butorac et al. 1999) and days to flowering (Espino and Gil 1980, Ibrahim and Avravtovscukova 1982, Pandeya et al. 1983, Butorac et al. 1999). In most papers, independently of tobacco type, additive variance in inheritance of leaf number (Shamsuddin et al. 1980, Šmalcelj 1983, Shoai Daylami and Honarneja 1996) and leaf width was estimated (Gopinath et al.1966, Espino and Gil 1980, Ibrahim and Avravtovscukova 1982). The graphic method indicates overdominant inheritance of yield (Jung et al. 1982, Šmalcelj 1983, Butorac et al. 1999), and also the participation of partial dominance (Gopinath et al. 1966, Shamsuddin et al. 1980, Pandeya et al. 1983). Leaf length is also inherited overdominantly (Ibrahim and Avravtovscukova 1982, Butorac 1997) and partially dominantly (Gopinath et al. 1966, Pandeya et al. 1983).

Ukai (1991) investigated the influences of environmental variations involved in the values of a diallel table on the (Wr Vr) graph. He found that the influences on Vr and Wr were not uniform, but varied with parents, being greater for parents with a larger number of recessive alleles.

MATERIAL AND METHODS

Two-year investigations (1998–1999), in which 10 burley tobacco genotypes were included, were carried out in the experimental field of Tobacco Institute Zagreb in Pitomača. Along with four line cultivars, viz. German line cultivar Saturn, American line cultivar TN 86 (Miller 1987), Swiss line cultivar Bs 92 and Croatian line cultivar Bols 100, the trial also included their six F_1 hybrids grown from seeds obtained a year earlier (Saturn × TN 86, Saturn × Bs 92, Saturn × Bols 100, TN 86 × Bs 92, TN 86 × Bols 100 and Bs 92 × Bols 100).

The trial was set up according to the randomised complete block design at four replications. Standard agrotechnical practices for this tobacco type were applied during tobacco growing.

The studied traits included the yield of tobacco leaves, topping height, number of leaves, days to flowering, leaf length and leaf width. Tobacco was harvested when it reached technical maturity. Curing was done by the standard procedure for burley tobacco. Topping height was measured from the ground to the topping level. Leaf number was determined at the end of the growing season. Days to flowering were estimated visually, the appearance of 25% of opened flowers serving as a criterion. Leaf length was measured from the leaf top to the leaf base and leaf width on the widest part of the leaf lamina of 12^{th} leaf.

Data were taken on a sample of 80 plants for each genotype and for each year. The acquired data for all studied traits and for each year were statistically processed by the analysis of variance and *LSD* test was performed. Graphic analysis was applied to the data for each year according to the methods of Jinks (1954), Hayman (1954) and Mather and Jinks (1971).

RESULTS

Significant differences between parents and F_1 hybrids were found in all investigated traits and all years (Table 1). The average performance of all parents and F_1 hybrids from 1998 to 1999 is presented in Table 2.

Wr Vr graphic analysis was performed for all studied traits and for both years (Figures 1 to 6). In 1998 the intercepts of regression lines for leaf length and leaf width were located above the origin, while for yield, topping height, leaf number and days to flowering these intercepts fell below the origin. This indicated that the gene action for the first two traits was in the partial dominance range, for the latter four traits a certain degree of overdominance might have been present. The regression coefficients did not differ significantly from unity revealing that nonallelic interactions and epistasis were not important for the expression of all studied traits. However, the regression coefficients differed significantly from zero only for leaf length and days to flowering. The test of homogeneity of Wr – Vr was not significant for all studied traits. The dominance type was positive for studied traits. Parental array points were scattered along the regression line indicating genetic diversity of the parents. No parental line was located at the intersection between the regression line and the parabola suggesting that none of the parents contained either all dominant or all recessive alleles. Parent Saturn (1) appeared to have most dominant alleles for leaf width, parent TN 86 (2) for days to flowering, parent Bs 92 (3) for yield and leaf length and parent Bols 100 (4) for leaf number, while parent Saturn (1) had most recessive alleles for leaf length, parent Bs 92 (3) for topping height and leaf number and Bols 100 (4) for yield, days to flowering and leaf width. In 1999 the expected regression line for all studied traits cut the Wr axis below the origin, which points to the participation of overdominance in the inheritance of these traits. Since regression coefficients did not differ significantly from $b = 1$, no interallelic interactions and epistasis were present for all studied traits. However, the regression coefficients differ significantly from zero only for yield and leaf number. The test of homogeneity of Wr – Vr was not significant for all studied traits. The dominance type was positive for all studied traits, except for days to flowering and leaf width. The distribution of parent genotypes on a scatter diagram along the expected regression line pointed to genetic divergence of the parents. The highest numbers of dominant genes were found for topping height and leaf number for the parent Saturn (1), for yield and leaf length for the parent Bs 92 (3) and Bols 100 (4) for the days to flowering. On the contrary, the highest numbers of recessive genes were found for the parent TN 86 (2) for days to flowering and leaf width, for the parent Bs 92 (3) for topping height and leaf number and for parent Bols 100 (4) for yield. The reason why the parents TN 86 (2) and Bols 100 (4) completely reversed their position for days to flowering in 1998 and 1999 was earlier flowering caused by different environmental conditions.

DISCUSSION

Since most tobacco traits important for successful breeding are of quantitative nature, the estimation of the mode of inheritance contributes to their better understanding thereby enabling rational and

Table 1. Analysis of variance for agronomic and morphological traits of burley tobacco in 1998 and 1999 (*F*-values)

Year	Source of variation	Yield	Topping height	Leaf number	Days to flowering	Leaf length	Leaf width
1998	crosses	8.50*	17.41*	7.13*	6.57*	12.66*	22.69*
1999	crosses	6.52*	8.93*	5.68*	8.12*	11.42*	20.68*

*statistically significant on $P = 5\%$

Table 2. Means of parents and F_1 hybrids of burley tobacco for agronomic and morphological traits in 1998 and 1999

Trait	Year	Saturn	TN 86	Bs 92	Bols 100	Saturn × TN 86	Saturn × Bs 92	Saturn × Bols 100	TN 86 × Bs 92	TN 86 × Bols 100	Bs 92 × Bols 100	*LSD* 5%
Yield (kg/ha)	1998	2971	2562	2579	1871	3469	3003	2679	3279	3175	2772	469.24
	1999	2745	2772	2825	2161	3297	3019	2706	3363	3062	2933	193.17
Topping height (cm)	1998	189	170	161	189	191	178	170	173	174	198	8.86
	1999	170	159	152	174	172	165	161	160	163	180	8.78
Leaf number	1998	23	24	20	23	22	23	24	25	24	24	1.58
	1999	23	24	21	24	23	23	24	24	25	24	1.53
Days to flowering	1998	80	83	83	74	81	84	82	81	81	80	3.37
	1999	77	80	78	74	69	79	75	70	72	73	4.25
Leaf length (cm)	1998	57	60	68	55	64	68	56	69	65	63	4.65
	1999	62	67	65	54	55	65	57	70	66	67	5.26
Leaf width (cm)	1998	28	26	35	33	31	34	34	34	36	42	2.92
	1999	31	32	33	34	24	32	31	32	33	40	2.63

targeted combining of desirable genes into future cultivars. Similarity of parents and progenies greatly depends on the knowledge of the relationship between the additive and nonadditive components of variance and mitigates the selection of the investigated materials for creating hybrids or line cultivars. Quantitative traits are characterised by continuous distribution and are strongly affected not only by effects of genes but also by environmental effects and the effects resulting from the genotype × environment interaction. Discrete effects of genes, however, cannot be measured directly, but the nature of their action may be detected by various statistical methods. One of these methods is graphic analysis of diallel cross.

Some previous investigations of the inheritance of major tobacco traits (yield, plant height, leaf number, days to flowering, leaf length and width) using graphic analysis show contradictory results. Starting from yield, a major tobacco trait, according to the studies made so far overdominant inheritance was estimated by graphic analysis (Jung et al. 1982, Šmalcelj 1983, Butorac et al. 1999), but partial dominance was also found (Gopinath et al. 1966, Shamsuddin et al. 1980, Pandeya et al. 1983). In our present investigations, according to the graphic analysis, yield was inherited overdominantly in both years of investigation.

According to the previous investigations, the inheritance of plant height (Šmalcelj 1983, Shoai Daylami and Honarneja 1996, Butorac et al. 1999) and days to flowering (Espino and Gil 1980, Ibrahim and Avravtovscukova 1982, Pandeya et al. 1983, Butorac et al. 1999) is more influenced by nonadditive variance, too. Our present results also point to the same conclusion.

Leaf number is one of the strongly genetically conditioned traits. According to most studies using graphic analysis, this trait is inherited additively (Shamsuddin et al. 1980, Šmalcelj 1983, Shoai Daylami and Honarneja 1996). However, the role of nonadditive variance is not negligible either (Butorac et al. 1999). Graphic analyses in our present investigations also manifest the presence of nonadditive variance in the inheritance of this trait.

Generally speaking, previous investigations point to the role of additive and also nonadditive variance in the inheritance of leaf parameters (leaf length and width). Different results were obtained depending on the investigated traits, and also on the genetic materials as well as the leaf position on the stalk. In most studies additive variance in the inheritance of leaf width was estimated (Gopinath et al. 1966, Espino and Gil 1980, Ibrahim and Avravtovscukova 1982). According to our results, leaf width was inherited overdominantly in one year and partly dominantly in the other year. Pandeya et al. (1983) and Butorac (1997), using the graphic method, also

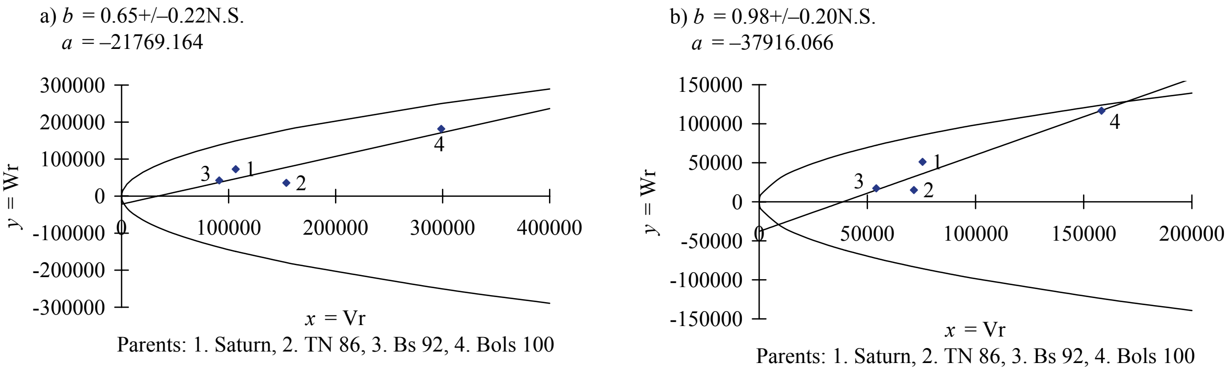

Figure 1. Wr Vr plots for yield (kg/ha) in 1998 (a) and 1999 (b)

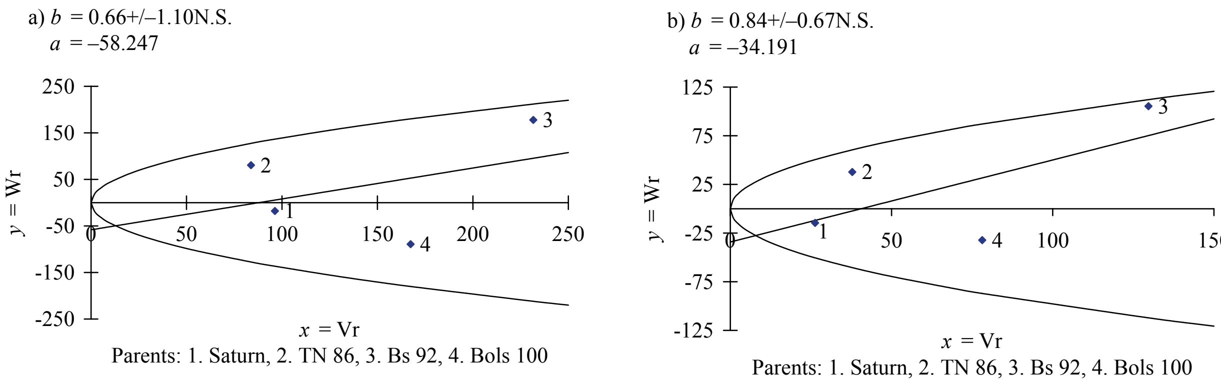

Figure 2. Wr Vr plots for topping height (cm) in 1998 (a) and 1999 (b)

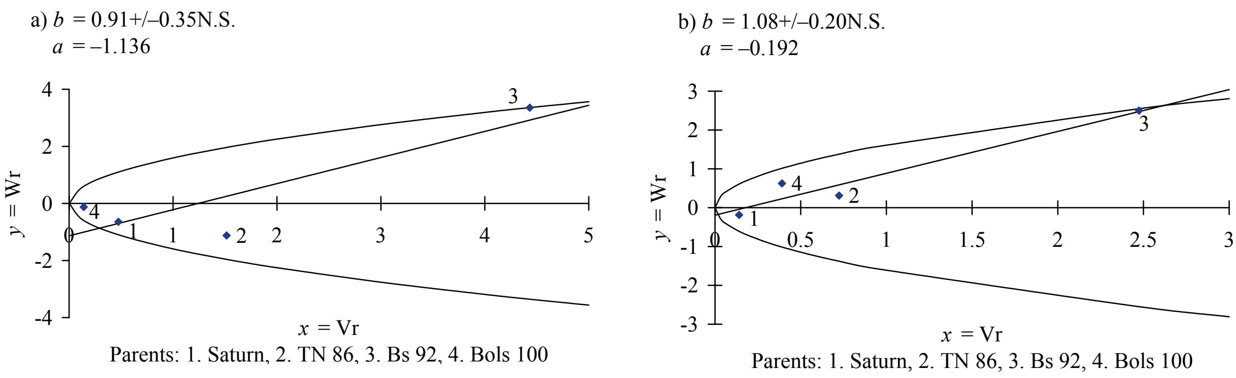

Figure 3. Wr Vr plots for leaf number in 1998 (a) and 1999 (b)

found the presence of partial dominance in the inheritance of leaf width. No interallelic interaction was present, which is in agreement with our present results. Gopinath et al. (1966) and Pandeya et al. (1983) studied the inheritance of leaf length using the graphic method. According to their results, this trait is inherited partly dominantly and there is no interallelic interaction. In our present investigations partial dominance was also estimated by the same method in the first year. In the second year this trait was inherited overdominantly. These results are in agreement with the results of some previous investigations (Ibrahim and Avravtovscukova 1982, Butorac 1997).

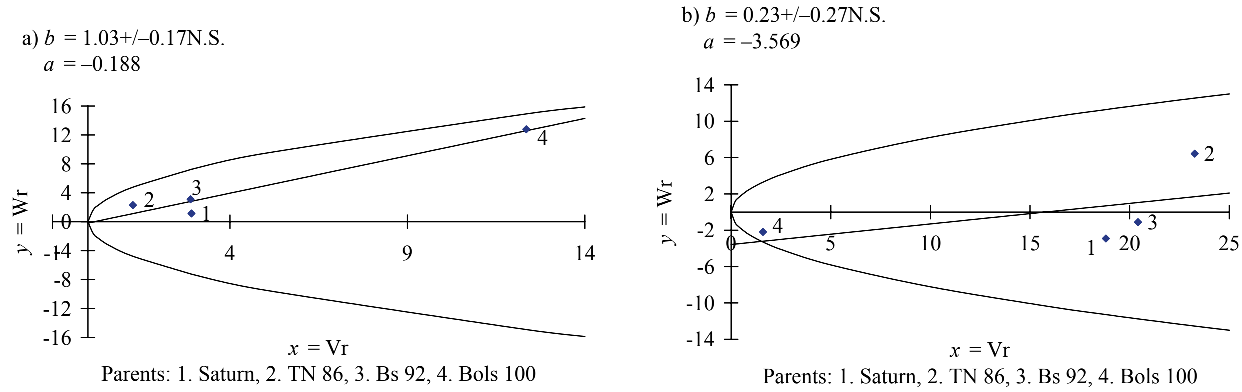

Figure 4. Wr Vr plots for days to flowering in 1998 (a) and 1999 (b)

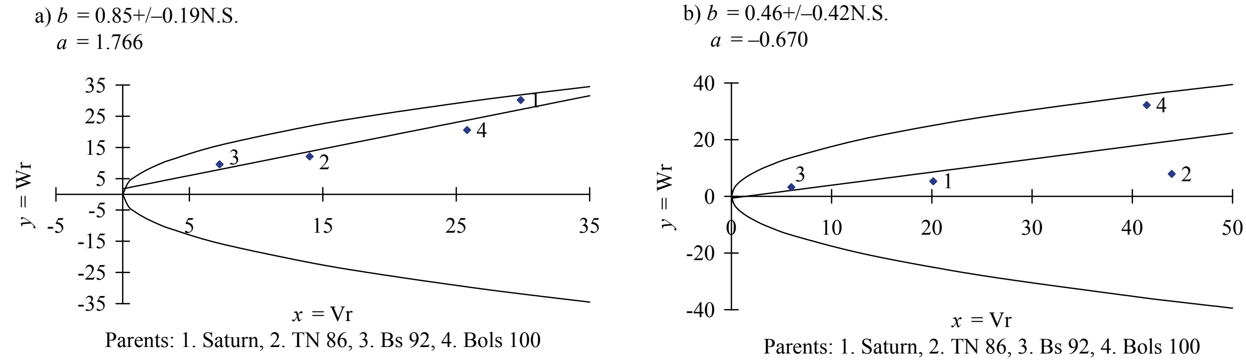

Figure 5. Wr Vr plots for leaf length in 1998 (a) and 1999 (b)

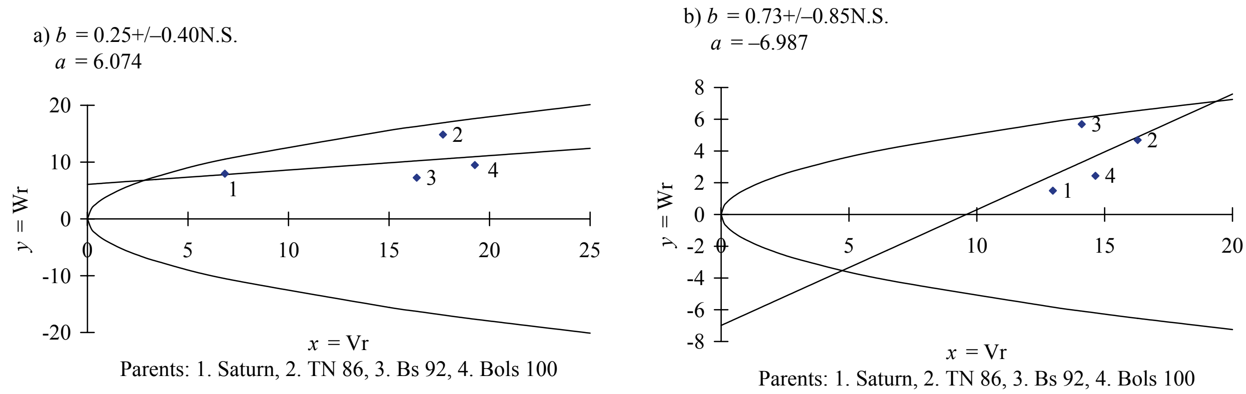

Figure 6. Wr Vr plots for leaf width in 1998 (a) and 1999 (b)

Conclusively, it can be said for the majority of the investigated traits in our present investigations that they are inherited nonadditively. So, the selected genetic material would be oriented to create F_1 hybrids. That is to say, a significant heterosis effect could be expected (Butorac and Beljo 2001).

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ABSTRAKT

Studium dědičnosti vybraných agronomických a morfologických znaků u tabáku typu burley pomocí grafické analýzy dialelního křížení

Způsob dědičnosti výnosu, výšky odvětvování, počtu listů, počtu dní do květu, délky a šířky listů jsme sledovali grafickou analýzou pomocí polovičního dialelního křížení čtyř odrůd tabáku typu burley (Saturn, TN 86, Bs 92 a Bols 100) v letech 1998 a 1999. Pokus byl založen podle schématu náhodných kompletních bloků ve čtyřech opakováních na pokusném pozemku záhřebského Ústavu pro tabák v lokalitě Pitomača. Grafická analýza odhalila superdominanci v dědičnosti všech sledovaných znaků s výjimkou délky a šířky listů v roce 1998. Testování regresních koeficientů pro všechny sledované znaky a roky nenaznačilo přítomnost ani interalelických interakcí, ani epistáze. Rozložení rodičovských genotypů na grafu podél očekávané regresní přímky ukazuje na genetickou divergenci rodičovských složek. Ukázalo se, že rodič Bs 92 má nejvíce dominantních alel pro výnos a pro délku listů, rodič Saturn pro výšku odvětvování, počet listů a šířku listů.

Klíčová slova: *Nicotiana tabacum* L.; typ burley; agronomické a morfologické znaky; grafická analýza

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