Heritability of Quantitative Traits in F1 and F2 Progenies of some Domestic and Foreign Tobacco Varieties

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Summary

Aim of this paper was to investigate heredity of plant height, number of leaves per plant, middle zone leaf area, green mass yield and dry matter yield per plant in F1 and F2 progeny of four tobacco varieties: Prilep – P12-2/1, Pobeda – P-2, Jaka –YV125/3 and Forchheimer Ogrodowny – FO. In F1 progeny the highest narrow-sense heritability value was estimated for dry matter yield per plant while in F2 progeny was for middle zone leaf area. In both investigated generations the highest broad-sense heritability value was estimated for green mass yield per plant, while the lowest narrow and broad-sense heritability was estimated for number of leaves per plant.

Key words

tobacco (*Nicotiana tabacum* L.), heredity, quantitative traits, intermediate, partial dominance, dominance, heterosis, narrow-sense heritability, broad-sense heritability (h^2)

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Received: May 7, 2009 | Accepted: November 14, 2012

Introduction

Heritability (h^2) reflects the level of inheritance of quantitative traits. In the narrow sense, it refers to the ratio between genetic and environmental variance, while in broader sense to the ratio between total genetic and phenotypic variance.

Environmental factors greatly affect the development and expression of quantitative traits.

Heritability was investigated by a number of researchers. In diallel cross analysis of eight flue-cured varieties (Povilaitis, 1966), low heritability was reported for leaf number and yield per stalk, and leaf area was the highest in the top section of the stalk. In analysis of seven dark tobacco varieties (Espino & Capote, 1976), medium level of heritability was reported for stalk height and leaf number and low heritability for yield per stalk. In five flue-cured varieties and ten F1 hybrids (Ibrahim & Avratovscukova, 1984), high to moderate broad sense heritability was reported for stalk height and yield, and moderate heritability for leaf number. In 25 cigar wrapper tobacco genotypes, high heritability for leaf number was obtained (Dobhal, 1987). In 55 genotypes of *N. rustica* L. (hookah and chewing tobaccos), moderate heritability was obtained for stalk height and yield (Dobhal & Nageswara, 1988). High level of heritability for leaf number was reported in diallel crosses of oriental tobacco (Naumovski, 1987). Sufficiently high level of heritability to justify the breeding process was found in seven homozygous dark tobacco genotypes and flue-cured varieties and their 21 F1 hybrids (Legg, 1989). High heritability for leaf number and yield per stalk was also reported in 72 genotypes of *N. rustica* L. for hookah tobacco (Chaubey et al., 1990). In investigations of four Burley parental varieties and their F1, F2, BC1 and BC2 progenies (Butorac, 1999), the level of broad sense heritability was higher than the narrow sense heritability. The highest heritability for leaf area and leaf weight was obtained in the 6th leaf.

Carriers of the inheritance of quantitative traits are groups of genes called polygenes. Changes of environmental factors affect the parameters of these traits, i.e. to a certain limit they affect the phenotype of each genotype. It is very important for the breeders to get good knowledge on the heritability level, because it will make them certain that selection of individuals is in accordance with the breeding program.

The aim of this investigation was to estimate the heritability level of certain quantitative traits in F1 and F2 progenies. The results of investigations will be applied by breeders in the selection of parental genotypes and in creation of new varieties.

Materials and methods

Investigation included four tobacco varieties and their diallel crosses in F1 and F2 generation. Of these, Prilep P 12-2/1 (Fig. 1), Pobeda P-2 (Fig. 2) and Yaka YV 125/3 (Fig. 3) are oriental varieties and Forchheimer Ogrodowny FO (Fig. 4) is semi-oriental.

The trial was set up in 2006 at the field of Tobacco Institute - Prilep in randomized block design with four replications. The total experimental area was about 940 m^2, i.e. 235 m^2 for each replication. In the period of growing, all suitable cultural practices were applied, including digging, nitrogen fertilization, two irrigations and preventive protection from pests and diseases.

Figure 1. Prilep P 12-2/1

Figure 2. Pobeda P-2

Figure 3. Yaka YV 125/3

Figure 4. Forchheimer Ogrodowny FO

Average temperature in this period was 19.4^{0}C and total amount of precipitations was 164.1 mm.

The following traits were subject of our investigations: stalk height, leaf number per stalk, middle belt leaf area and green and dry mass yield per hectare. The data obtained for each trait in F1 and F2 generations were estimated by the analysis of variance. Estimation of the mode of inheritance was based on the mean value test in F1 and F2 progenies in relation to the parents according to Borojević (1981).

Heritability (h^2) refers to the ratio of phenotypic variance that can be attributed to the genotype variance, and the obtained values are presented in percentage (%). For calculation of the narrow sense heritability for certain crosses, the Allard's formula (1960) was used.

$$h^2 = VA / VP \text{ or } h^2 = \frac{\sigma^2 F_2 - \frac{\sigma^2 P_1 + \sigma^2 P_2 + \sigma^2 F_1}{3}}{\sigma^2 F_2} \cdot 100$$

The broader sense heritability for all combinations in F1 and F2 refers to the ratio between total genetic variance (the sum of the additive and dominant variance) and phenotypic variance, and it was calculated by the formula of Mather & Jinks (1974),

$$h^2 = (VA + VH) / VP \text{ or } h^2 = \frac{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{4}H_2 - \frac{1}{2}F}{\frac{1}{2}D + \frac{1}{2}H_1 - \frac{1}{4}H_2 - \frac{1}{2}F + E}$$

Also the genetic components D, H and F were estimated by the formula of Mather & Jinks (1974).

Results and discussion

All modes of inheritance of investigated traits could be observed in F1 and F2 generations (Table1). F1 progeny was characterized by high level of uniformity. The most represented mode was intermediary inheritance, and it was followed by partial dominance. Positive heterosis for stalk height was detected in YV 125/3 x FO, for middle belt leaves and dry mass yield in P 12-2/1 x P2 and P-2 x YV 125/3 and for green mass yield in P 12-2/1 x P-2. Negative heterotic effect was detected in P-2 x YV 125/3 for the number of leaves per stalk.

In F2, due to nonuniform properties, intermediarity was also the most represented mode of inheritance, and it was followed by partial dominance. Positive heterosis for inheritance of stalk height was detected in P-2 x FO and YV 125/3 x FO and for green mass yield in P 12-2/1 x P-2. Negative heterosis was detected for inheritance of number of leaves in P-2 x YV 125/3.

There are two types of heritability (h^2): narrow sense and broad sense heritability. The former refers to the ratio between additive and phenotypic variances (VA/VP) and the latter refers to the ratio between total genotypic variance and phenotypic variance [(VA+VH)/VP)]. Heritability is applied as genetic index for prediction of results in selection and it can be used to determine the intensity of selection between two successive generations.

In our investigations, the investigated quantitative traits showed high narrow and broad sense heritability values, indicating the existence of high genetic and low environmental variance. For this reason, these traits are considered to be highly heritable. Values obtained for F1 and F2 generations are approximately similar for both types of heritability in the above traits, so that their manifestation and stabilization in future generations can be predicted with a great certainty.

In F1 generation, the highest narrow sense heritability value was estimated for dry mass yield per stalk (98.41%) and the lowest for leaf number per stalk (85.27%), whereas the broad sense heritability was the highest for green mass yield (99.97%) and the lowest for leaf number (99.78%) (Table 2.).

In F2 generation (with broad spectrum of various individuals and initiation of the selection process), the highest narrow sense heritability was estimated for middle belt leaf area (97.06%), and the lowest for leaf number (93.74%).The broad sense heritability was identical to that in F1, showing the highest values for green mass yield (99.97%) and the lowest for leaf number per stalk (99.79%) (Table 2).

Table 1. The mode of inheritance of quantitative traits in F1 and F2 generations

Parents and hybrids	Stalk height (cm)	Leaf number per stalk	Leaf area (cm²)	Green mass yield (g/stalk)	Dry mass yield (g/stalk)
P 12-2/1	52.52	32.25	220.62	96.09	15.10
P-2	99.37	43.14	132.36	102.86	16.15
YV 125/3	115.04	41.78	168.93	123.03	17.77
FO	110.80	21.16	597	187.21	29.27
			F1 progeny		
P12-2/1 x P-2	72.12 i	31.29 -d	274.52 +h	111.02 +h	16.55 +h
P12-2/1 x YV 125/3	76.44 i	36.97 i	194.76 i	109.25 i	16.61 pd
P12-2/1 x FO	73.22 pd	28.08 i	386.58 i	146.21 i	23.65 i
P-2 x YV 125/3	103.15 pd	37.55 -h	234.28 +h	111.89 i	18.12 +h
P-2 x FO	108.62 pd	27.87 pd	440.08 pd	148.42 i	23.97 i
YV 125/3 x FO	128.24 +h	32.67 i	346.57 i	153.35 i	24.33 i
			F2 progeny		
P12-2/1 x P-2	77.52 i	35.99 pd	177.05 i	107.62 +h	15.53 i
P12-2/1 x YV 125/3	78.15 i	37.18 i	167.39 -d	110.05 i	16.87 pd
P12-2/1 x FO	77.05 i	27.02 i	331.21 pd	131.22 i	20.14 pd
P-2 x YV 125/3	101.92 pd	37.97 -h	167.65 +d	110.21 pd	16.69 i
P-2 x FO	116.15 +h	28.95 pd	364.25 i	142.17 i	21.55 i
YV 125/3 x FO	123.55 +h	32.44 i	351.58 i	155.25 i	23.89 i

Table 2. The heritability of quantitative traits in the progenies of F1 and F2 generations

Heritability (%)	Stalk height	Leaf numberper stalk	Leaf area	Green mass yield	Dry mass yield
Narrow sense heritability - F1	92.93	85.27	90.86	98.33	98.41
Broad sense heritability - F1	99.83	99.78	99.86	99.97	99.83
Narrow sense heritability - F2	94.52	93.74	97.06	96.69	96.95
Broad sense heritability - F2	99.81	99.79	99.87	99.97	99.80

Conclusions

Uniform F1 progeny was obtained by crossing of the parental varieties P 12-2/1, P-2, YV 125/3 and FO. The most frequently found modes of inheritance were the intermediate and partial dominance. Positive heterosis for stalk height was detected in YV 125/3 x FO, for middle belt leaf area and dry mass yield in P 12-2/1 x P-2 and P-2 x YV 125/3 and for dry mass yield in P 12-2/1 x P-2. Negative heterotic effect was observed in P-2 x YV 125/3 for leaf number per stalk. All modes of inheritance were also found in F2 generation, but intermediarity and partial dominance were the most frequent.

The highest narrow sense heritability in F1 generation was estimated for dry mass yield per stalk, and in F2 for middle belt leaf area. The highest broad sense heritability in both F1 and F2 progenies was obtained for green mass yield per stalk. The lowest narrow and broad sense heritability value in F1 and F2 progenies was estimated for leaf number per stalk.

The high values for heritability in narrow and broad sense indicate the presence of high genetic and low environmental variances. For this reason, the investigated quantitative traits are considered to be highly heritable, which means that their stabilization is expected in future generations.

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