ISSN 0494-3244

Тутун/Tobacco,Vol. 64, N⁰ 7-12, 13-18, 2014 UDC: 633.71-152.75:581.192

Original Scientific paper

HYBRIDOLOGICAL ANALYSIS OF THE INHERITANCE OF CHEMICAL COMPOSITION IN VIRGINIA TOBACCO (*NICOTIANA TABACUM L.*) CROSSES

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ABSTRACT

Investigations were made on the degree of dominance, heterosis and inheritability of chemical composition in Virginia tobacco plants. For that purpose, P_1, P_2, F_1 and F_2 populations of six crosses of introduced Virginia tobaccos were studied. It was found that the inheritance of nicotine and sugar contents is overdominat, incompletely dominant or additive, and that of total nitrogen and proteins was overdominant or incompletely dominant. The direction of inheritance is toward the parent with higher levels of investigated trait. Only the inheritance of total nitrogen content is both from the parent with lower values and from those with higher values. There are high values for heritability coefficient of nicotine, suggesting that genetic factor is a crucial determinating factor for this trait. Therefore, the selection of this trait is effective in early generations. The contents of sugar, total nitrogen and protein showed low values of heritability coefficient, suggesting higher efficiency of selection in later generations.

Keywords: Virginia tobacco, heritability, inheritance, nicotine, sugars, total nitrogen, proteins.

АПСТРАКТ

Истражувани се степенот на доминантност, хетерозисот и наследувањето на хемискиот состав кај некои сорти тутун од типот вирџинија. За таа цел, проучувани се P_1, P_2, F_1 и F_2 генерациите кај шест крстоски од интродуцирани вирџиниски сорти. Утврдено е дека во наследувањето на содржината на никотин и шеќери се јавува супердоминантност, парцијална доминантност и адитивност, а во наследувањето на вкупниот азот и протеините преовладуваат супердоминантноста и парцијалната доминантност. Наследувањето е во насока на родителот со повисок степен на истражуваното својство. Само вкупната содржина на азот се наследува и од родителите со пониски вредности и од оние со повисоки вредности. Постојат високи вредности за коефициентот на наследување на никотинот, што укажува на тоа дека генетскиот фактор е клучен одредувачки фактор за ова својство. Затоа, селекцијата на својството е ефикасна во почетните генерации. Коефициентот на наследувањена содржината на шеќери, вкупен азот и протеини има ниски вредности, што укажува на поголема ефикасност на селекцијата во подоцнежните генерации.

Клучни зборови: вирџиниски тутун, херитабилност, наследување, никотин, шеќери, вкупен азот, протеини.

INTRODUCTION

The chemical composition of tobacco is a major quality trait (Davis and Nielsen, 1999; Dimitrieski et al., 2006; Tso, 1988). The most important chemical indicators in Virginia tobacco are nicotine, total nitrogen, sugars and proteins (Kirkova, 2005; Stoilov et al., 2002). The most important of these is the role of nicotine (Stoilov et al., 2002; Nikolov et al., 2004).

The use of genetic analysis of these indicators will improve the efficiency of the selection process. There are few studies in this field worldwide (Lukrapov, 1958; Matzinger and Wernsman, 1968; Vandenberg 1970; Povilaitis 1971; Korubin-Aleksoska, 2001; Dagnon and Dimanov, 2007). They reveal that in F_1 hybrids inheritance of nicotine is most often negative, as the main type is overdominant and intermediate with a negative sign (Stankev and Trancheva, 1989). Overdominant positive inheritance was observed less often (Manolov, 1979, Nikolov et al., 2004). The literature also refers to additive inheritance of nicotine. In sugars, additive type of inheritance is the most common (Nikolov et al., 2004; Bing-Guang et al., 2005).

The purpose of this study is to apply hybridological analysis to determine the character and extent of gene interactions, inheritance and the number of genes that differ in initial parental forms, inheritability coefficient and the expressions of heterosis and transgression regarding the chemical composition of Virginia tobacco in terms of their use in the selection of this type of tobacco.

MATERIAL AND METHODS

Investigations included P_1, P_2, F_1 and F_2 populations of six crosses, along with the introduced Virginia tobacco varieties: Hybrid 714 (K 730 x K 254), Hybrid 715 (K 730 x K 358), Hybrid 719 (RG 8 x K 358), Hybrid 725 (K340 x K 358), Hybrid 726 (K 358 x NC 729) and Hybrid 727 (K 358 x K 254). The trial was carried out in the Experimental field of the ITTP in Markovo in the period 2007-2011.

The contents of nicotine, sugars, total nitrogen and proteins were estimated using the arithmetic mean ($\bar{x}$), error of the arithmetic mean ($S\bar{x}$), degree of dominance (d/a) using Mather's formula (Mather,1985), occurrence of heterosis (HP) according to Omarov (1975). The method of Sobolev (1976) was used for estimation of: occurrence of transgression (Tn), number of genes by which parental forms differ (N), heritability coefficient (h^2) and coefficient of genotypes selection efficiency in phenotypic expression of the trait (Pp).

RESULTS AND DISCUSSION

Inheritance of nicotine content is overdominant, incompletely dominant and additively dominant depending on the cross (Table 1). The direction of inheritance is toward the parent with higher values. The number of genes determining the expression of the trait in all crosses varies within narrow limits - from 3 to 5.

Heterosis occurrence is variable and depends on the cross. Strong positive heterosis was observed in Hybrid 715 (K 730 x K 358) and Hybrid 726 (K 358 x NC 729), where its values reached 23-24%. Relatively high values were observed in Hybrid 719 (RG 8 x 358 K). Hybrid 727 (K 358 x K 254) has a weak presence of negative heterosis. Coefficients of transgression depend on the manifestations of heterosis and show that from the available homozygous genotypes of the decaying generations in Hybrids 715 and 726, plants can be selected which will exceed the nicotine rate of the parents by 0.8%.

Medium to high heritability coefficients were found, especially in Hybrid 719 (RG 8 x K 358). The most important role in determining this trait has the genotype and the role of environment is weaker. In this case, the selection of the desired trait can start in earlier generations.

Table 1.Data on the inheritance of nicotine content

Parent/Cross/Index	P_1	P_2	F_1	F_2	d/a	HP	Tн	N	h^2	Pp
Hybrid 714 (K 730 x K 254)	2,6	2,2	2,7	2,4	1,5	103,8	-0,02	3,23	0,56	0,471
Hybrid 715 (K 730 x K 358)	2,6	2,5	3,2	3,0	13	123,1	0,78	4,64	0,66	0,588
Hybrid 719 (RG 8 x K 358)	2,1	2,5	2,8	2,8	0,3	112	0,34	3,60	0,75	0,683
Hybrid 725 (K340 x K 358)	2,4	2,5	2,6	2,4	0,1	104	0,01	4,49	0,47	0,451
Hybrid 726 (K 358 x NC 729)	2,5	1,9	3,1	2,9	0,3	124	0,83	3,51	0,52	0,570
Hybrid 727 (K 358 x K 254)	2,5	2,2	2,4	2,8	0,33	96	-0,07	4,84	0,60	0,532

The inheritance of sugar content is monogenic-overdominat or incompletely dominant, while in Hybrid 726 (K 358 x NC 729) it is additive (Table 2). The direction of inheritance is always toward the parent with higher values and in this case it is favorable. Significant heterosis effects were observed in hybrids 715 and 727 and especially in Hybrid 725 (K340 x K 358). The coefficients of transgression show that from the available homozygous genotypes of the decaying generations in Hybrids 715 and 725, plants can be selected which will exceed the percentage of sugars in the parents by over 1%.

Relatively low values of the heritability coefficient were observed, especially in Hybrid 719 (RG 8 x 358 K), where it was less than 30%. In determination of this trait, environment has a more important role. In this case, the selection of sugars may start in later generations.

Table 2. Data on the inheritance of sugars content

Parent/Cross/Index	P_1	P_2	F_1	F_2	d/a	HP	Tн	N	h^2	Pp
Hybrid 714 (K 730 x K 254)	14,6	15,4	15,6	15,3	0,2	101,3	0,061	1,32	0,350	0,413
Hybrid 715 (K 730 x K 358)	14,6	15,8	17,3	17,1	1,5	109,5	1,053	1,52	0,323	0,382
Hybrid 719 (RG 8 x K 358)	16,4	15,8	16,8	16,5	2,3	102,4	0,037	1,28	0,294	0,467
Hybrid 725 (K340 x K 358)	14,8	15,8	18,1	17,9	2,8	114,6	1,343	1,19	0,402	0,655
Hybrid 726 (K 358 x NC 729)	15,8	17,2	17,3	17,2	0	100,6	0,003	1,25	0,417	0,530
Hybrid 727 (K 358 x K 254)	15,8	15,4	16,8	16,9	6	106,3	0,887	1,13	0,345	0,428

Total nitrogen content is most often inherited with incomplete dominance, only in Hybrid 726 (K 358 x NC 729) it is overdominant. The direction of inheritance is toward the parent with higher nitrogen content, except for Hybrid 725 (K340 x K 358), which is dominated by the parent with lower values. In this case, more factors are responsible for determination of the investigated trait - from 6 to 12.

Significant heterotic effect was observed in all crosses and in Hybrid 725 (K 340 x K 358) it was with a negative sign. It achieved very high values (over 35%) in Hybrid 726 (K 358 x NC 729). Heterotic effect can be used in the selection of Virginia tobacco both to increase and to reduce the nitrogen content. The coefficient of transgression depends on occurrence of heterosis and it also has significant values.

Lower values were recorded for the coefficient of heritability in all crosses. In this case, the coefficient of efficiency of the selection shows that it may start in later generations.

Table 3. Data on the inheritance of total nitrogen content

Parent/Cross/Index	P_1	P_2	F_1	F_2	d/a	HP	Тн	N	h^2	Pp
Hybrid 714 (K 730 x K 254)	1,4	1,9	2,2	1,9	0,3	115,8	0,661	8,17	0,272	0,365
Hybrid 715 (K 730 x K 358)	1,4	1,7	2,1	2,2	0,4	123,5	0,783	6,38	0,369	0,470
Hybrid 719 (RG 8 x K 358)	1,6	1,7	2,0	1,8	0,3	117,6	0,650	10,62	0,285	0,288
Hybrid 725 (K340 x K 358)	2,0	1,7	1,8	1,7	-0,33	90	-0,57	7,48	0,290	0,423
Hybrid 726 (K 358 x NC 729)	1,7	1,6	2,3	2,2	13	135,3	1,021	9,10	0,402	0,481
Hybrid 727 (K 358 x K 254)	1,7	1,9	2,3	1,9	0,4	121,1	0,771	11,64	0,342	0,396

Inheritance of protein content is overdominant or incompletely dominant, with preponderance of the former. The direction of inheritance is always toward the parent with higher values (Table 4). No variation was observed in the number of genes determining the sign - they are 2 or 3. In all crosses significant heterotic effect was observed and for hybrids 714 and 727 it was more than 20%. Heterosis can be successfully used to increase the protein content in Virginia tobacco. Coefficients of transgression were also significant in all crosses and show that, depending on the cross, selected generations can exceed the protein content of the parents by 0.5 to 1.2%.

The values of heritability coefficient in all crosses were insignificant. In this case, the influence of environment in phenotypic expression of the trait is very high. As with total nitrogen content, the effect of the selection will occur in later generations.

Table 4. Data on the inheritance of proteins content

Parent/Cross/Index	P_1	P_2	F_1	F_2	d/a	HP	Тн	N	H^2	Pp
Hybrid 714 (K 730 x K 254)	5,2	5,4	6,5	6,2	1,1	120,4	0,929	2,23	0,181	0,351
Hybrid 715 (K 730 x K 358)	5,2	6,1	6,7	6,6	0,75	109,8	0,677	2,35	0,242	0,326
Hybrid 719 (RG 8 x K 358)	6,2	6,1	6,9	6,7	15	111,3	0,684	2,77	0,196	0,347
Hybrid 725 (K340 x K 358)	5,1	6,1	6,6	6,5	2	108,2	0,514	2,42	0,156	0,297
Hybrid 726 (K 358 x NC 729)	6,1	6,3	7,2	7,2	0,9	114,3	0,812	3,06	0,153	0,380
Hybrid 727 (K 358 x K 254)	6,1	5,4	7,4	7,0	4,71	121,3	1,236	2,24	0,268	0,322

CONCLUSIONS

1. The inheritance of nicotine and sugar contents was overdominant, incompletely dominant or additive, and that of total nitrogen and proteins was overdominant or incompletely dominant. The direction of the inheritance of nicotine, sugars and protein is toward the parent with higher value, and that of total nitrogen goes both toward the parent with higher and to the one with lower value.
2. The number of genes influencing the expression of the investigated traits by which parental forms are distinguished is small and varies negligibly.
3. Manifestations of heterosis and transgression in significant values were found in all chemical indices.
4. Medium to high heritability coefficients were found for the content of nicotine and

low to negligible values for sugars, total nitrogen and proteins. The efficiency of selection in the content of nicotine will be higher in earlier generations, and for sugars, total nitrogen and proteins in later generations.

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