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Inheritance of plant height and leaves number in hybrid genotypes Virginia tobacco

Наследяване на височината на растенията и броя на листата при хибридни комбинации тютюн Виржиния

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ABSTRACT

The aim of current research is to determine genetic effects in relation to inheritance of plant height and leaves number regard to their use for the Virginia tobacco breeding. The experimental work was carried out on the field of the Tobacco and tobacco products Institute, Markovo, Bulgaria. Coefficient of heritability and selection, the number of genes, transgressions and heterosis of plant height and leaves number were studied. For this purpose P_1, P_2, F_1 and F_2 populations of seven hybrid combinations were analyzed. The data from conducted analysis showed that inheritance of the plant height and tobacco leaves number is overdominantly, in the direction of the parent with the higher trait values. The number of genes influencing the plant height expression varies in a wide range (14-17) and genes number affecting tobacco leaves is 1 or 2. Negative epistasis was observed for the plant height inheritance, while epistatic interactions of genes controlling leaves number was weaker but positive one. There were establish high values for heritability coefficient of plant height and average one of leaves number. Based on the conducted analysis it was found that the mass selection by phenotype for studied traits would be more effective in the F_5-F_6 hybrid generations.

Keywords: inheritance, leaves number, plant height, productive potential, tobacco breeding

SAŽETAK

Целта на настоящото проучване е да се установи характерът на унаследяване на височината на растенията и броят на листата при хибридни комбинации тютюн Виржиния, във връзка с тяхното използване в селекционно-подобрителната работа при тази култура. Експериментът е извършен на територията на Институт по тютюна и тютюневите изделия, Марково, България. Определени са унаследяването, коефициентите за наследяемост и отбор, броят на гените, проявите на трансгресия и хетерозис по отношение на изследваните признаци при кръстоски тютюн Виржиния. За целта са проучени P_1, P_2, F_1 и F_2 популациите на седем хибридни комбинации. Данните от хибридологичния анализ показват, че при изследваните в настоящото проучване образци, унаследяването на височината на растенията и броя на листата е свръхдоминантно винаги в посока на родителя, проявяващ по-висока стойност на признака. Броят на гените, влияещи върху проявлението на признака височина на растенията е от 14 до 17, а при брой листа – 1 или 2. По отношение височината се наблюдава отрицателен епистаз, а при броя на листата, по-слаб, но положителен такъв. Установени са високи стойности за коефициента на наследяемост за височината на растенията и средни стойности относно признака брой листа от растение. Коефициентите за наследяемост и за ефективност на масовия отбор по фенотип показват, че отборът на

генотипове с по-големи стойности на височината на растенията и на генотипове с по-голям брой листа ще бъде по-ефективен в F_5-F_6 генерациите.

Ключови думи: брой на листата, височина на растенията, наследяемост, продуктивен потенциал, селекция на тютюн

INTRODUCTION

Tobacco is an important culture for Bulgarian economy, but the county ranks last in production of tobacco. Bulgaria is traditional producer of oriental varieties. Besides them there are grown large leaf types such as Virginia and Burley. Implemented currently varieties do not meet modern requirements, neither of the farmers nor the industry. The lack of high productive and quality varieties is one of the reasons for the unsatisfactory situation of the large leaf tobacco production in Bulgaria. This makes it difficult to enforce, as a competitive manufacturer in the international market, which indicates the need of breeding research to improve the varieties, establishment and implementation of new highly productive genotypes.

Tobacco is industrial culture grown for its leaf mass. Yield is most desirable breeding characteristic. Plant height and leaves number are one of the important traits determing the productive potential of the culture (Kirkova et al., 2015; Risteski et al., 2012).

The plant height is quantitative trait, strongly influenced by environmental conditions (Peksuslu et al., 2002). Korubin-Aleksoska et al. (2013) reported intermediate and semi-dominant inheritance, dominant and overdominant inheritance of the studied trait was reported by other authors as well. According to Zhou et al. (2013) and Hayes (1913) the inheritance of plant height was observed as additive and notadditive.

Nikolov (2000) found among large-leaf tobacco populations that majority of the traits are dominant. It has been reported overdominant mainly, dominant and semi-dominant inhritance of parental forms with lthe arger leaves number (Vasilev, 2000; Petrova, 1993). Korubin-Aleksoska (2010) found that additive genetic effects prevail.

The aim of current research is to determine nature of genetic effects in relation to inheritance of economically valuable traits such as plant height and leaves number, and predicting the effect of selection in consecutive hybrid generations in order to increase the efficiency of Virginia tobacco breeding process.

MATERIALS AND METHODS

The scientific work was conducted at the field of the TTPI - Markovo, Bulgaria in 2010 and 2011 vegetation years. The experimental field of the TTP Institute is located of the cental part of south Bulgaria. The planting of tobacco on the experimental field for both investigated years was on May 22 to 23th. During tobacco vegetation in field conditions (May - Sept 2010), mean monthly air temperature was 20.91 ˚C and the total amount of precipitations (in 39 rainy days) was 275.44 mm. In the same period in 2011, mean monthly air temperature was 19.98 ˚C and the total amount of precipitations (in 42 rainy days) was 246.8 mm. The experiment was held in a randomized complete block design in four repetitions with a plots size of 100 m^2. For all variants was applied uniform technology of planting and cultivation.

Current research involves biometric analysis of P_1, P_2, F_1 and F_2 populations of seven Virginia tobacco crosses: Hybrid 652 (Line 607 x V 326), Hybrid 653 (Line 607 x K 254), Hybrid 665 (Virginia 250 x Line 42), Hybrid 688 (Line 842 x Virginia 250), Hybrid 690 (Line 843 x K 326), Hybrid 694 (Line 607 x Virginia 250) and Hybrid 697 (Line 843 x Virginia 250). Subject to biometric measurement were main yield traits such as plant height and leaves number. There were measured 300 plants of each population.

The arithmetic mean ($\bar{x}$), index of accuracy ($S\bar{x}$%), coefficient of variation (S%), using the variation analysis; degree of dominance (d/a) according to Mather's formula (1985), heterosis effect (HP) in reference to the parental form with higher trait values (Omarov, 1975); transgression indicator (Tn), number of genes differentiating the

parental forms (N), dominance (D), epistasis (E), heredity coefficient (H^2), and selection efficiency coefficient (Pp) were calculated for all of studied traits. Genetic analysis of parental and hybrid genotypes by elements of productivity was carried out according to Sobolev (1976).

Following formulas were used to calculate degree of dominance (d/a) and heterosis effect (HP) of plant height and leaves number.

Degree of dominance:

$$a = \frac{P_1 - P_2}{2} \qquad MP = \frac{P_1 + P}{2}$$

$$d = F_1 - MP$$

Heterosis:

$$H(\text{real}) = \frac{F_1 - P(\text{best})}{P(\text{best})} * 100$$

RESULTS

Data about environmental conditions with high importance for tobacco growth such as temperature and rainfall amount were obtained during the period of study - from June 1 to 31 August 2010 and 2011 (Table 1., Table 2.), coinciding with the observed vegetation period of plants. Meteorological conditions during the first year of study generally did not prevent the normal course of research work. The agro-climatic conditions in the Markovo region are optimal for the development of barley in the early phases of vegetation.

In terms of temperature sum there wasn't any differences between the years of study, while on the amount of rainfall significant ones could be observed. The experimental work was conducted on a meadow cinnamon soil in the region of Plovdiv, at the experimental field of the TTPI - Markovo. Concerning mechanical composition of soil, the predominant share is the grit fraction followed by that of the fine sand. The humus content is high, while the soil reaction is slightly alkaline.

There were providing optimal scientifically justified agro technical manipulations according culture requirements, such as suitable plant protection and soil treatments. It was carried out timely sowing for all of observed P_1, P_2, F_1 and F_2 breeding populations.

Values of genetic parameters present in following tables were calculated with series of formulas set in Excel.

The values of d/a index revealed nature of inheritance of quantitative traits. For studied hybrid combinations Virginia tobacco, inheritance of plant height is overdominance (d/a>1), strongly expressed in Hybrid 688 (L 842 x V 250) (d/a-13.75). Heterosis effect observed among F_1 hybrid progeny in all crosses is insignificant in relation to plant height (Table 3.).

Positive values of D index (D 8.72; 6.45; 5.78; 6.37; 8.59; 7.07 and 8.42) showed that inheritance of higher stem was determined by dominant alleles (Table 4.).

Table 1. Temperature and rainfall amount for vegetation period in 2010

Month	Daily average temperature °C	Norma *	Rainfall amount l/m²	Norma **
June	21.5	20.9	60.6	63.0
July	24.3	23.2	120.3	49.0
August	25.9	22.7	23.7	31.0

* Koleva and Penev (1990), ** Kyuchukova (1983)

Table 2. Temperature and rainfall amount for vegetation period in 2011

Month	Daily average temperature °C	Norma *	Rainfall amount l/m²	Norma **
June	21.8	20.9	14.6	63.0
July	24.9	23.2	41.4	49.0
August	23.7	22.7	69.0	31.0

* Koleva and Penev (1990), ** Kyuchukova (1983)

Table 3. Plant height in consecutive generations, d/a values and heterosis

Crosses	P_1 $\bar{x} \pm S\bar{x}$	P_2 $\bar{x} \pm S\bar{x}$	F_1 $\bar{x} \pm Sx\%$	F_2 $\bar{x} \pm Sx\%$	d/a	HP
Hybrid 652	171.5±0.59	157.7±0.74	172.4±0.67	166.7±0.89	1.13	100.5
Hybrid 653	171.5±0.59	158.6±0.66	174.1±0.78	167.6±0.92	1.4	101.5
Hybrid 665	165.7±0.72	167.0±0.88	169.3±0.85	163.2±1.12	1.65	101.4
Hybrid 688	167.3±0.62	165.7±0.76	177.5±0.83	168.5±0.97	13.75	106.1
Hybrid 690	161.4±0.70	157.7±0.74	170.2±0.69	162.8±0.87	5.76	105.5
Hybrid 694	171.5±0.59	165.7±0.72	173.5±0.82	164.5±1.05	1.7	101.2
Hybrid 697	161.4±0.70	165.7±0.72	175.0±0.76	164.8±0.94	9.3	105.6

Table 4. Values of the genetic parameters characterizing plant height

Crosses	Tп	N	D	E	H^2	Pp
Hybrid 652	0.18	13.64	8.72	-84.81	0.574	0.612
Hybrid 653	0.23	16.57	6.45	-55.42	0.656	0.643
Hybrid 665	0.07	17.13	5.78	-71.61	0.703	0.711
Hybrid 688	0.67	15.29	6.37	-66.82	0.521	0.583
Hybrid 690	-0.54	15.87	8.59	-93.54	0.767	0.875
Hybrid 694	-0.04	14.40	7.07	-87.17	0.594	0.602
Hybrid 697	0.61	17.22	8.42	-62.33	0.624	0.664

The values of transgression (Tп) were relatively low. Differences between gene numbers (N) that distinguished the parental forms in relation to plant height varied in a narrow range (from 14 to 17). There are established high values for the coefficient of heritability (H^2 varies from 0.521 to 0.767) which determined higher role of genotype on the plant height phenotypic expression. Negative values of epistasis (E) indicated that the selection of plants would be more effective in later hybrid generations (F_5-F_6) or by applying multiple individual selection.

At studied variants the leaves number is inherited overdominantly (d/a>1), as in all crosses dominate parental forms with a larger leaves number (Table 5.). Compared with plant height, leaves number heterosis (HP) effect is significant. Economic importance of heterosis was observed in hybrid combinations Hybrid 688 (HP 13%) and Hybrid 690 (HP 21%). This is an indication that heterosis can be used as a possibility of increasing the leaves number in Virginia tobacco.

Values of the genetic parameters characterizing leaves number is present on Table 6. Data shows that the number of genes controlling studied trait indicate that difference in parental forms is very low (N varies from 1 to 2 genes), which facilitates the selection on this trait.

Transgressions (Tп) with significant values were observed in three of the studied hybrid combinations. Among hybrid progeny of Hybrid 688 (L 842 x 250), Hybrid 694 (L 607 x 250) and Hybrid 690 (L 843 x K 326) could be selected genotypes with more leaves.

It have been studied that the influence of positive epistatic interactions (E from 5.67 to 8.26) enhance the phenotypic expression of dominant genes for leaves number of the plant.

Table 5. Leaves number in consecutive generations, d/a values and heterosis

Crosses	P_1 $\bar{x} \pm S\bar{x}$	P_2 $\bar{x} \pm S\bar{x}$	F_1 $\bar{x} \pm Sx\%$	F_2 $\bar{x} \pm Sx\%$	d/a	HP
Hybrid 652	29.6±0.09	26.8±0.15	29.9±0.14	28.2±0.18	1.2	101
Hybrid 653	29.6±0.09	25.8±0.12	30.7±0.13	29.5±0.17	1.58	103.7
Hybrid 665	27.8±0.16	28.5±0.14	29.7±0.14	28.3±0.19	1.2	104.12
Hybrid 688	28.9±0.08	27.8±0.16	32.7±0.13	30.3±0.17	7.9	113.1
Hybrid 690	26.7±0.13	26.8±0.15	32.4±0.12	30.6±0.16	5.6	121
Hybrid 694	29.6±0.09	27.8±0.16	30.9±0.15	29.8±0.19	2.4	104.4
Hybrid 697	26.7±0.13	27.8±0.16	30.5±0.16	28.6±0.20	2.7	109.7

Table 6. Values of the genetic parameters characterizing leaves number

Crosses	T_n	N	D	E	H^2	Pp
Hybrid 652	0.21	1.65	3.41	7.62	0.488	0.225
Hybrid 653	0.28	1.42	5.17	5.67	0.532	0.400
Hybrid 665	0.35	1.86	5.34	8.34	0.575	0.524
Hybrid 688	1.24	1.27	4.67	6.18	0.494	0.196
Hybrid 690	1.69	2.21	3.93	5.89	0.592	0.095
Hybrid 694	0.30	1.50	6.04	8.26	0.519	0.514
Hybrid 697	1.06	1.83	5.45	6.61	0.536	0.105

There are average values of the coefficient of heritability (H^2). This is an indication that the environmental conditions and the effects of genotype have relatively equal influence on the leaves number expression. In conclusion leaves number selection will be more effective in the later hybrid generations (F_4-F_5).

DISCUSSION

Heterosis of the large leaf tobacco varieties in Bulgaria is widely used. There are commonly used in the practice Virginia 0454 and Virginia 514 hybrids. Current research showed usage of heterosis to increase leaves number as one of the most important element of yield. Perspective breeding lines in this direction are Hybrid 688 (Line 842 x Virginia 250) and Hybrid 690 (Line 843 x K 326), with 13% HP and 21% HP respectivly.

Transgressive phenomena in Virginia tobacco have not been studied so far. According to Manolov (2000) the use of transgression is a promising direction in the selection mainly of Oriental tobacco. Current research shows the presence of transgressive gene interaction in terms of number of leaves of Virginia hybrids as well.

The results for the overdominantly inheritance of plant height and leaves number confirm other authors statements (Vasilev, 2010; Stoeva, 2006; Hayes, 1913; Tomov, 1991). However, not a few authors mention additive iheritance for studies traits (Masheva, 2016; Petrova, 1993) and also incomplete dominantly (Korubin-Aleksoska, 2010).

There were established relatively high heritability in terms of number of leaves and mainly of plant height indicating that environmental conditions do not heavily

influence on determines the trait. These results are similar to those of other authors who also received a high degree of heritability for the plant height and number of leaves (Peksuslu et al., 2002; Stankev, 2001). They contrast with those of Nikolov (2000) and Masheva (2016) which found that the environment strongly influences the expression of the characteristics plant height and number of leaves, which limits opportunities for rapid consolidation of the traits. Korubin-Aleksoska (2010) found in the F_1 hybrid combinations of tobacco Virginia that the most significant influence on the inheritance of the trait plant height have epistatnite gene interactions.

Significant variation of quantitative traits in tobacco depending on the genotype, environmental conditions and the interaction genotype environment require furder specific studies of the structure of genetic effects in complex quantitative traits in order to increase the efficiency of breeding process.

CONCLUSION

Genetic analysis of quantitative traits among studied Virginia tobacco Hybrid 652, 653, 665, 688, 690, 694 and Hybrid 697 reveals that plant height and leaves number are overdominantly inherited, and always dominate the parents with higher values of the investigated traits.

The number of the genes differing initial parental forms in relation to plant height is much bigger than number of genes determine leaves number. Impact epistatic interactions have negative effect on phenotypic expression of plant height, while the number interallelic interactions have a positive influence on the leaves number expression.

Studied indexes, especially values of the coefficients of heritability (H^2), efficiency of breeding by phenotype (Pp) and the negative epistatic interactions indicates that the selection of higher plants and those with larger leaves number will be more effective in F_5-F_6 generation.

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