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THE EFFECT OF BACKCROSS METHOD IN TOBACCO BREEDING

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Abstract

The paper encompasses investigations of four oriental tobacco varieties (P10-3/2, P-23, P-84 and YK 7-4/2) and their diallel F1, F2, BC1 (P1) and BC1 (P2) crosses in the course of 2016 and 2017, for the characters leaf number per stalk and dimensions of the middle belt leaves. The research was carried out on the experimental field of the Scientific Tobacco Institute - Prilep in randomized block system with four replications. The measurements were made in the stage of rapid growth (butonization), and the values obtained were processed by variational-statistical analysis. Heritability (h2) of the traits was calculated using the Mather and Jinks method.

The aim of the research is to study the effect of backcross breeding on improving the quantitative traits of tobacco, to open up the possibility of selecting individuals at the maximum number of crosses enabled by the diallel of parental genotypes and to offer directions for further selection.

The obtained results showed different modes of inheritance in all generations studied. Heritability of the crosses was over 95%, which is a sign of high heritability of the studied traits. The offered pattern for further successive selection can also be used for other plant species to improve a range of traits, including the resistance to diseases.

Key words: *tobacco (Nicotiana tabacum L.), backcross, diallel, heritability*

INTRODUCTION

Plant breeding is considered to be one of the oldest skills that man has occupied. It dates back 10,000 years ago with the cultivation of wild species, which will mean the beginning of agriculture. However, the creativity from this area of science is more recent and begins with gender studies in species. In Europe first explorations for the sexes of plants are published by Camerarius (1694). At that time the ever-present desire of the breeder to create varieties more superior than the existing ones is born. All actions in this direction are called breeding and they lead the selection forward towards ever-increasing success. According to Borojevic (1992) breeding is man's work for improvement and creation of new varieties of plants, in order to meet the needs of people and domestic animals.

Oriental tobacco, like the rest of the agricultural crops where breeding and selection is continuous process, is a strategic crop with a centuries-old tradition of production and high quality. Oriental tobacco is mainly grown in Prilep and Yaka types or Dzebel and Basmak on smaller areas which is due to the pleasant aroma and a high price on the international market.

The main aim of the breeders at the Scientific Tobacco Institute in Prilep is to create new varieties and improve the existing ones by applying appropriate methods, including the Backcross Method - a process that improves the existing commercial varieties with some desired traits, such as resistance to diseases.

The Back-crossing Method is defined by a large number of scientists including: Gornik (1973) – Backcross is a method for fast and secure improvement or addition of traits that are not present in the existing varieties or not sufficiently expressed; Matthew (2012) – Backcross breeding is a method that can be used to insert a particular trait, such as disease resistance, from one line, often inferior, to another that is usually an elite line for improvements; Pavlica et al., (2013) – Backcross is crossing of hybrid (individual of the F1 generation) with one of the parents or individual of the parent genotype, and so on. In The Free Dictionary (2014) Back-cross means to cross (a hybrid) with one of its parents or with an individual genetically identical to one of its parents; while in Wikipedia (2017) – Backcrossing is a crossing of a hybrid with one of its parents or an individual genetically similar to its parent, in order to achieve offspring with a genetic identity which is closer to that of the parent. In this direction, several selection programmes were realized. For example, Korubin-Aleksoska (2007) in research for resistance to blue mould (Peronospora tabacina Adam) found dominant inheritance in the oriental variety Pobeda 2 and its application in the Backcross Method for transferring the resistance on to the current varieties. Dimitrieski et al. (2012) examined two varieties and eight lines of Oriental tobacco for resistance to blue mould and black shank as ones of the most dangerous tobacco diseases and discovered a line resistant to blue mould (P 123-65/82) and two lines resistant to black shank (YK 20-23/10 и P 65-54/09) which can be used in projects for breeding of oriental tobacco. Korubin-Aleksoska and Aleksoski (2015), in an experiment with 10 varieties, of which one flue-cured and nine oriental, found that YK 10-7/1 is characterized by the dominance in the inheritance of resistance to the black shank (Phytophthora parasitica var. nicotianae) and with the application of Backcross Method improved the large-leaf variety MV-1.

The aim of this paper is to explain the Backcross Method as one of the methods for breeding the plants, and to show the way and effect of its application.

MATERIAL AND METHODS

Breeding of tobacco is done in order to obtain new and more superior varieties that are homozygous with a stable inheritance of the traits: yield, dry leaf quality, chemical components, technological characteristics and resistance to diseases. Tobacco processing methods are those that apply to the selection of self-sufficient plants (Martincić & Kozumplik, 1996), such as: Mass Selection, Individual Selection, Pedigree Method, Bulk Method, Single seed descent Method and Baeckcross Method - subject to this work. This method is carried out with series of backcrossing with the variety to be improved. The efficiency of this method is greater if it is done for the breeding of only one or two traits where are one gene or one pair of major genes is responsible for the inheritance. The procedure is different, depending on the manner of inheritance.

As a working material we took three Oriental varieties of the type Prilep (P10-3/2, P-23 and P-84) and one Oriental variety of Yaka type (YK 7-4/2).

Prilep P 10–3/2 (Fig. 1) – Originated from the local tobacco variety Djumaj–bale from Gorna Djumaja – Bulgaria. Released in mass production by Gornik, in the 30-ies of the last century. Characterized by cup-like habitus, average stalk height 50cm, with 30-36 sessile leaves, dry mass yield averages 1200 kg/ha (Korubin – Aleksoska, 2004).

Prilep P–23 (Fig. 2) – created by Kostadin Nikoloski and Milan Mitreski, through hybridization and selection in Tobacco Institute – Prilep; recognized by the Ministry of Agriculture, Forestry and Water Management of the Republic of Macedonia in 1995 (Korubin – Aleksoska A., 2004). It has elliptical–conical habitus, average stalk height 65 cm, with about 55 densely arranged leaves, dry mass yield 2000–2500 kg/ha (Korubin – Aleksoska, 2004).

Prilep P–84 (Fig. 3) – created by Kiril Naumovski and Ana Korubin–Aleksoska, through hybridization and selection; recognized in 1988 in former Yugoslavia, as one of the first varieties of the type Prilep. Characterized by cylindrical – elliptical habitus, average stalk height 65 cm, with approximately 40 – 42 sessile leaves, elliptical in shape, dry mass yield 2500–3200 kg/ha (Korubin – Aleksoska, 2004).

Yaka YK 7–4/2 (Fig. 4) – released in mass production in 1932 by Gornik. Originated from Xanthian Yaka originating from Xanthy – Greece; a plant with narrow, spindle shaped–elliptic habitus; average stalk height 100cm, with 26–32 sessile leaves, dry mass yield averages 1000 kg/ha (Korubin – Aleksoska, 2004).

Figure 1. Prilep, P 10–3/2

Figure 2. Prilep, P–23

Figure 3. Prilep, P–84

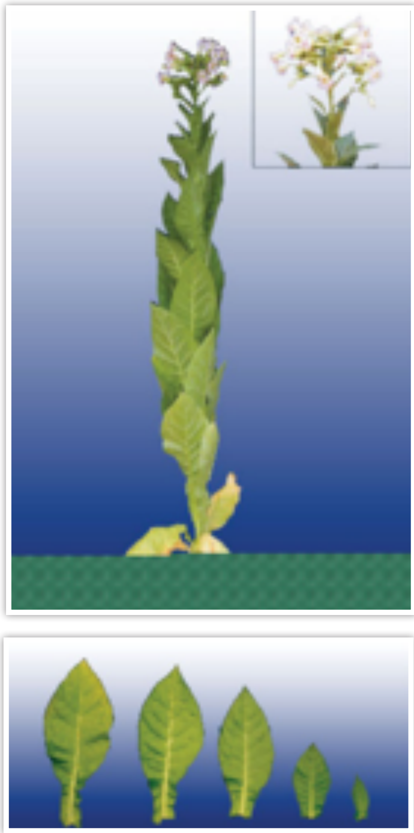

Figure 4. Yaka, YK 7–4/2

In the course of 2015, we made diallel crosses, and in 2016 we set up an experiment in a field with the parents and their 6 F1 hybrids. The paper presents data from the measurements for the number of leaves per stalk, as well as the length and width of the middle belt leaves. Besides measurements, we isolated the plants for the F2 generation and made two-way reciprocal crossings, with the first and the second parent. In 2017 we set up an experiment with parental varieties and the offspring of F1, F2, BC1 (P1) and BC1 (P2) generations. The experiment took place in the Experimental Field of Scientific Tobacco Institute – Prilep by random block system in four repetitions. During the vegetation common agrotechnical measures were applied. The measurements were carried out in the early stage of flowering. The obtained data is statistically processed through parameters of traits variability. The analysis of the variance was made according to the Griffing Method (1956).

RESULTS AND DISCUSSION

In order to get acquainted with the genetic stability of the selected varieties and their F1 hybrids, we made measurements in 2016 and 2017 and on the basis of the results obtained we analyzed the inheritance of the number of leaves per plant and the dimensions (length and width) of the middle-belt leaves.

It can be seen from Table 1 that with the highest number of leaves among parental genotypes, in both years of investigations, is characterized P-23 (48.35 – 2016; 45.60 –2017), and with the lowest YK 7-4/2 (28.70 – 2016; 28.20 – 2017). Existence significantly differ between parents, which means that the genes are different. The highest number of leaves among diallel F1 hybrids has P-23 x P-84 (46.35 – 2016; 45.60 –2017), and the lowest P10-3/2 x YK 7-4/2 (31.05 – 2016; 30.15 –2017). The overall genotype set in 2017 has lower number of leaves in comparison with 2016, which is due to extremely drought conditions in the vegetation period of 2017, in spite of the three necessary watering. It is interesting to note that the biggest difference is in P-23 (approximately three leaves less in 2017, compared to 2016), which means that this variety is not resistant to drought. The other parents showed high resistance to dry conditions because the difference in the number of leaves between the two years is less than one leaf. Here, in the first place, it is P-84 (difference of 0.25), then YK 7-4/2 (difference of 0.50), then P 10-3/2 (difference of 0.60). Between F1 hybrids the slightest difference in the traits has in P 10-3/2 x P-23 (0.1) and P-23 x YK 7-4/2 (0.25). This data is important for the selection directed towards to stress drought resistance. From the visual inspection of the experiment, absence of the economically important diseases blue mould (Peronospora tabacina Adam) and black shank (Phytophthora parasitica var. nicotianae) was ascertained, which is important for further selection programs, obtaining resistant varieties, or improving resistance in the existing commercially important tobacco varieties. In parents and F1 hybrids the error of the mean value (S) is small and moves from 0.19 (P-23 x YK 7-4/2 and P-84 x YK 7-4/2) to 0.78 (P-23 x P-84) in 2016 and from 0.18 (P-84 x YK 7-4/2) to 0.63 (P-23 x P-84) in 2017. The standard deviation (σ) ranges from 0.87 to 3.48 in 2016 and from 0.80 to 2.82 in 2017 for the same combinations. The coefficient of variability (CV) ranges from 2.02 % (P-23 x YK 7-4/2) to 7.94 % (P 10-3/2) in 2016 and from 2.20 (P-84 x YK 7-4/2) to 6.29 % (P 10-3/2) in 2017. Low variability values are an indication of the high genetic homogeneity of the studied traits, i.e., stable homozygous varieties are selected and uniform heterozygous diallel F1 hybrids are obtained.

Table 1. Number of leaves per stalk in parents and F_1 hybrids.

Parents and F_1 hybrids	n	2016			2017		
		± S	σ	CV (%)	± S	σ	CV (%)
P 10-3/2	20	33.40 ± 0.59	2.65	7.94	32.80 ± 0.46	2.06	6.29
P 10-3/2 x P-23	20	40.30 ± 0.35	1.58	3.93	40.20 ± 0.34	1.54	3.82
P 10-3/2 x P-84	20	35.30 ± 0.26	1.14	3.24	34.35 ± 0.20	0.91	2.65
P10-3/2 x YK7-4/2	20	31.05 ± 0.28	1.24	4.01	30.15 ± 0.23	1.01	3.36
P-23	20	48.35 ± 0.44	1.96	4.05	43.55 ± 0.44	1.99	4.56
P-23 x P-84	20	46.35 ± 0.78	3.48	7.51	45.60 ± 0.63	2.82	6.18
P-23 x YK 7-4/2	20	43.20 ± 0.19	0.87	2.02	42.95 ± 0.28	1.24	2.90
P-84	20	42.45 ± 0.29	1.28	3.02	42.20 ± 0.31	1.37	3.26
P-84 x YK 7-4/2	20	37.50 ± 0.19	0.87	2.31	36.40 ± 0.18	0.80	2.20
YK 7-4/2	20	28.70 ± 0.28	1.27	4.42	28.20 ± 0.25	1.12	3.98
		$LSD_{0.05}$ = 1.52 $_{0.01}$ = 2.06			$LSD_{0.05}$ = 1.48 $_{0.01}$ = 1.99		

It can be seen From Table 2 that with the highest average value for the length of the middle-belt leaves among parental genotypes, in both years of research, is characterized P 10-3/2 (22.00 – 2016; 21.80 – 2017), and with the lowest number YK 7-4/2 (18 – 2016; 17.9 – 2017). There are significant differences between parents, which is a sign of genetic differentiation (with the exception of P-23 and P-84, among which there is no significant difference). Among diallel F1 hybrids the longest leaves have P10-3/2 x P-84 (21.90 – 2016; 21.70 – 2017), and the shortest P-84 x YK 7-4/2 (19.10 – 2016; 18.72 – 2017). In all investigated genotypes, the length of the leaves is lower in 2017 compared with that measured in 2016 as a result of the dry conditions during vegetation in 2017.

In parents and F1 hybrids the error of the mean value (S) is small and moves from 0.29 cm (P 10-3/2 x P-84) to 0.49 cm (P 10-3/2) in 2016 and from 0.27 cm (P-23 x P-84 and P-84 x YK 7-4/2) to 0.42 cm (P 10-3/2) in 2017. The standard deviation (σ) ranges from 1.32 cm (P10-3/2 x P-84) to 2.18 cm (P 10-3/2) in 2016 and from 0.27 cm (P-23 x P-84 and P-84 x YK 7-4/2) to 0.42 cm (P 10-3/2) in 2017. The coefficient of variability (CV) varies from 6.02 % (P10 3/2 x P-84) to 9.93 % (P 10-3/2) in 2016 and from 5.88 (P-23 x P-84) to 8.72 % (P 10-3/2) in 2017. Low values for variability in these traits are an indicator for existence of high genetic homogeneity.

Table 2. Length of the leaves from the middle belt in parents and F_1 hybrids (cm).

Parents and F_1 hybrids	n	2016			2017		
		± S	σ	CV (%)	± S	σ	CV (%)
P 10-3/2	20	22.00 ± 0.49	2.18	9.93	21.80 ± 0.42	1.90	8.72
P 10-3/2 x P-23	20	22.50 ± 0.39	1.73	7.70	22.04 ± 0.34	1.54	6.99
P 10-3/2 x P-84	20	21.90 ± 0.29	1.32	6.02	21.70 ± 0.29	1.28	5.89
P10-3/2 x YK7-4/2	20	20.04 ± 0.34	1.51	7.54	19.91 ± 0.34	1.52	7.64
P-23	20	20.50 ± 0.32	1.43	6.98	19.70 ± 0.33	1.46	7.42
P-23 x P-84	20	20.50 ± 0.31	1.40	6.81	20.20 ± 0.27	1.19	5.88
P-23 x YK 7-4/2	20	19.30 ± 0.31	1.37	7.11	19.20 ± 0.33	1.48	7.70
P-84	20	20.60 ± 0.35	1.56	7.58	20.50 ± 0.39	1.73	8.45
P-84 x YK 7-4/2	20	19.10 ± 0.32	1.44	7.52	18.72 ± 0.27	1.20	6.39
YK 7-4/2	20	18.00 ± 0.32	1.45	8.05	17.90 ± 0.32	1.45	8.11
		$LSD_{0.05}$ = 1.17 $_{0.01}$ = 1.57			$LSD_{0.05}$ = 0.96 $_{0.01}$ = 1.30		

The data on the width of the middle belt leaves shown in Table 3 shows that with the highest average values between parental genotypes, in both years of investigation has P-23 (10.60 – 2016; 10.50 – 2017), and with the lowest YK 7-4/2 (8.7 – 2016; 8.5 – 2017). The significance of differences between parental genotypes by 1% exists only in relation to YK 7-4/2. Among diallel F1 hybrids the widest leaves have P-23 x P-84 (10.30 – 2016; 10 – 2017), and the narrowest P 10-3/2 x YK 7-4/2 (9 – 2016; 8.8 – 2017).

In the parents and F1 hybrids standard deviation (σ) ranges from 0.42 cm (P 10-3/2 x P-84) to 0.93 cm (P-23 x YK 7-4/2) in 2016 and from 0.17 cm (YK 7 -4/2) to 0.87 cm (P 10-3/2 x P-84) in 2017. The coefficient of variability (CV) ranges from 4.18% (P 10-3/2 x P-84) to 9.85% (P-23 x YK 7-4/2) at 2016 and from 5.70 (P-23 x P-84) to 9.30% (P-84 x YK 7-4/2) in 2017. Coefficient of variability (CV) ranges from 4.18% (P 10-3/2 x P-84) to 9.85% (P-23 x YK 7-4/2) at 2016, and from 5.70 (P-23 x P-84) to 9.30% (P-84 x YK 7-4/2) in 2017. The low values for variability in this traits are indicative of the existence of high genetic homogeneity.

Table 3. Width of the leaves from the middle belt in parents and F_1 hybrids (cm).

Parents and F_1 hybrids	n	2016			2017		
		± S	σ	CV (%)	± S	σ	CV (%)
P 10-3/2	20	10.10 ± 0.13	0.60	5.98	10.00 ± 0.14	0.63	6.32
P 10-3/2 x P-23	20	10.20 ± 0.13	0.58	5.67	10.00 ± 0.17	0.74	7.42
P 10-3/2 x P-84	20	10.00 ± 0.09	0.42	4.18	9.70 ± 0.19	0.87	8.99
P10-3/2 x YK7-4/2	20	9.00 ± 0.18	0.79	8.78	8.80 ± 0.26	0.80	9.05
P-23	20	10.60 ± 0.17	0.78	7.40	10.50 ± 0.19	0.85	8.11
P-23 x P-84	20	10.30 ± 0.13	0.60	5.82	10.00 ± 0.13	0.57	5.70
P-23 x YK 7-4/2	20	9.50 ± 0.21	0.93	9.85	9.00 ± 0.16	0.71	7.86
P-84	20	10.00 ± 0.12	0.52	5.24	9.50 ± 0.14	0.63	6.66
P-84 x YK 7-4/2	20	9.80 ± 0.12	0.56	5.68	9.00 ± 0.19	0.84	9.30
YK 7-4/2	20	8.70 ± 0.17	0.78	8.98	8.50 ± 0.20	0.17	8.72
		LSD $_{0.05}$ = 0.51 $_{0.01}$ = 0.69			LSD $_{0.05}$ = 0.68 $_{0.01}$ = 0.92		

In order to give genetic knowledge for the number of leaves and dimensions of leaves from the middle belt in F2 – generation at the beginning of the selection activity, and BC1(P1) – generation obtained by backcross of F1 with the first parent, and BC1 (P2) – generation obtained by backcross of F1 with the second parent, we made measurements in 2017 and based on the obtained results, we made analysis of inheritance for traits. The aim of this investigation was to determine the selection material needed for the future selection programs in order to improve some traits in commercial varieties, as well as for obtaining resistance to drought stress and resistance to diseases of crucial nature.

The analysis of the number of leaves per plant in the offspring of F2 generation and those from backcross, points to a series of laws (Table 4). Thus, the number of leaves is greater in F2 offspring relative to F1 (with the exception of P-23 x P-84 where the F1 offspring has more leaves than both parents and the F2 generation, while in P-23 x YK 7-4/2, the F1 offspring has more leaves than the F2 generation, but the difference between the values is minimal). Values for the F2 property range from 31cm in P 10-3/2 x YK 7-4/2 to 43.2 cm in P-23 x P-84. The heterotic effect of P-23 x P-84 for this trait could not be confirmed with certainty because it is not in line with the 2016 results. It is necessary to repeat the experiment in 2018.

With the highest number of leaves per plant in offspring of the BC1 (P1) generation is characterized (P-23 x P-84) x P-23 (42.50) and with the lowest (P 10-3/2 x YK 7-4/2) x P 10-3/2 (32.20). The inheritance of the trait in this generation depends from the leaves number of parent that backcrossed F1 population. In combinations where backcrossed with a parent with a lower number of leaves, BC1 (P1) offspring is with smaller size than F2, while in the examples where backcrossed with the parent with a higher number of leaves, BC1 (P1) offspring is with larger size than F2 generation. With the highest number of leaves per plant in offspring of the BC1 (P2) generation is characterized (P 10-3/2 x P-23) x P-23 (43), and with the lowest (P-84 x YK 7-4/2) x YK 7-4/2 (37). In BC1 (P2) generation, all crosses of BC1 (P2) where they are backcrossed with the better parent, better offspring are obtained in relation to BC1 (P1) and vice versa.

Table 4. Number of leaves per stalk in the parents, F_1, F_2, BC_1 (P_1) and BC_1 (P_2) offspring (2017).

Parents and hybrids	Number of leaves per stalk			
	P & F_1	P & F_2	P & BC_1 (P_1)	P & BC_1 (P_2)
P 10-3/2	32.80	32.80	32.80	32.80
P 10-3/2 x P-23	40.20	41.50	36.00	43.00
P 10-3/2 x P-84	34.35	38.00	35.00	41.00
P 10-3/2 x YK 7-4/2	30.15	31.00	32.20	30.20
P-23	43.55	43.52	43.52	43.52
P-23 x P-84	45.60	43.20	42.50	42.03
P-23 x YK 7-4/2	42.95	42.80	32.50	40.50
P-84	42.20	42.00	42.00	42.00
P-84 x YK 7-4/2	36.40	38.00	41.00	37.00
YK 7-4/2	28.20	28.20	28.20	28.20
	$LSD_{0.05}$ = 1.48 $_{0.01}$ = 1.99	$LSD_{0.05}$ = 2.01 $_{0.01}$ = 2.72	$LSD_{0.05}$ = 2.18 $_{0.01}$ = 2.94	$LSD_{0.05}$ = 1.90 $_{0.01}$ = 2.57

The length of the middle-belt leaves is greater in F2 offspring relative to that of F1 (with the exception of P 10-3/2 x P-23 where the difference between the values is minimal). Values for the traits in F2 range from 18.9 cm to P-84 x YK 7-4/2 to 21.75 cm in P 10-3/2 x P-84 (Table 5).

The largest length of the leaves in the BC1 (P1) generation is characterized in the cross (P 10-3/2 x P-84) x P 10-3/2 (21.75 cm), and the shortest in (P-23 x YK 7-4/2) x P-23 (19 cm). In this case the inheritance of the trait depends on the length of the parent's leaves that backcrossed the F1 population. In BC1 (P2) generation with the longest leaves is the cross (P 10-3/2 x P-23) x P-23 (21.24 cm), and with the smallest (P 10-3/2 x YK 7-4/2) x YK 7-4/2 (18.03 cm). In all BC1 (P2) crossings where backcrossed with the better parent, better offspring are obtained in relation to BC1 (P1) and vice versa.

Table 5. Length of the leaves from the middle belt in the parents, F_1, F_2, BC_1 (P_1) and BC_1 (P_2) offspring (2017).

Parents and hybrids	Length of the leaves from the middle belt (cm)			
	P & F_1	P & F_2	P & BC_1 (P_1)	P & BC_1 (P_2)
P 10-3/2	21.80	21.80	21.80	21.80
P 10-3/2 x P-23	22.04	21.30	21.73	19.85
P 10-3/2 x P-84	21.70	21.75	21.75	21.24
P 10-3/2 x YK 7-4/2	19.91	20.50	20.50	18.03
P-23	19.70	19.70	19.70	19.70
P-23 x P-84	20.20	20.40	20.50	19.90
P-23 x YK 7-4/2	19.20	19.50	19.00	18.50
P-84	20.50	20.50	20.50	20.50
P-84 x YK 7-4/2	18.72	18.90	19.50	18.25
YK 7-4/2	17.90	17.90	17.90	17.90
	$LSD_{0.05}$ = 0.96 $_{0.01}$ = 1.30	$LSD_{0.05}$ = 1.37 $_{0.01}$ = 1.84	$LSD_{0.05}$ = 1.35 $_{0.01}$ = 1.82	$LSD_{0.05}$ = 1.28 $_{0.01}$ = 1.73

The width of the middle belt leaves is a property whose values do not have an overall significance in the differences between the parents and, therefore, between the crosses. Therefore, lawfulness in the inheritance of the generations studied is not fully expressed. Values for the F2 traits are ranged from 8.8 cm in P 10-3/2 x YK 7-4/2 to 10.3 cm in P-23 x P-84 (Table 6). The highest width of the leaves in the BC1 (P1) generation is characterized by the cross (P-23 x P-84) x P-23 (10.5 cm) and the smallest (P-84 x YK 7-4/2) x P-84 (9.3 cm). The broadest middle belt leaves in the BC1 (P2) generation has the cross (P 10-3/2 x P-23) x P-23 (10.5 cm), and the narrowest (P-84 x YK 7-4/2) x YK 7-4/2 (8.7 cm).

Table 6. Width of the leaves from the middle belt in the parents, F_1, F_2, BC_1 (P_1) and BC_1 (P_2) offspring (2017)

Parents and hybrids	Width of the leaves from the middle belt (cm)			
	P & F_1	P & F_2	P & BC_1 (P_1)	P & BC_1 (P_2)
P 10-3/2	10.00	10	10	10
P 10-3/2 x P-23	10.00	10.2	10.1	10.5
P 10-3/2 x P-84	9.70	9.7	9.8	9.4
P 10-3/2 x YK 7-4/2	8.80	8.8	9.8	8.8
P-23	10.50	10.5	10.5	10.5
P-23 x P-84	10.00	10.3	10.5	9.3
P-23 x YK 7-4/2	9.00	9.5	10.4	9
P-84	9.50	9.5	9.5	9.5
P-84 x YK 7-4/2	9.00	9.4	9.3	8.7
YK 7-4/2	8.50	8.5	8.5	8.5
	$LSD_{0.05}$ = 0.68 $_{0.01}$ = 0.92	$LSD_{0.05}$ = 0.66 $_{0.01}$ = 0.89	$LSD_{0.05}$ = 0.78 $_{0.01}$ = 1.05	$LSD_{0.05}$ = 0.61 $_{0.01}$ = 0.82

CONCLUDING REMARKS

The greatest number of leaves among parental genotypes in both years of investigation gave P-23 (48.35 – 2016; 45.60 – 2017), and the smallest YK 7-4/2 (28.7 – 2016; 28.2 – 2017). The largest length of the middle-belt leaves was in P 10-3/2 (22 cm – 2016; 21.8 cm – 2017), and the smallest in YK 7-4 / 2 (18 cm – 2016; 17.9 cm – 2017). With the greatest width of the middle belt leaves is characterized P-23 (10.6 cm – 2016; 10.5 cm – 2017), and with the smallest width YK 7-4/2 (8.7 cm – 2017; 8.5 cm – 2017). Differences in values between the two years in the varieties are minimal, which is a sign of their ecological stability. An exception is made by P-23, which in 2017 (extremely drought, with three irrigations trough the season) gave about 3 leaves less than 2016, and thus it is characterized by poor resistance to drought stress.

In F1 hybrids P-23 x P-84 (46.35 – 2016) with the highest number of leaves is characterized, and with the smallest P 10-3/2 x YK 7-4/2 (31.05 – 2016). The longest leaves had P 10-3/2 x P-84 (21.9 cm – 2016), and the shortest P-84 x YK 7-4/2 (18.72 cm – 2017). The widest leaves had P-23 x P-84 (10.3 cm – 2016), and the narrowest P 10-3/2 x YK 7-4/2 (8.8 cm – 2017). The low differences between the years of research are another confirmation that these are high-heritable traits on which the influence of environmental factors is weak and limited.

Two years of investigations on the variability of the traits of parental genotypes and their diallel F1 crosses showed low values. The coefficient of variability (CV) for the number of leaves per stalk ranges from 2.02% (P-23 x YK 7-4/2 – 2016) to 7.94% (P 10-3/2 – 2016), for the length of the leaves of the middle belt from 5.88% (P-23 x P-84 – 2017) to 9.93% (P 10-3/2 – 2016), and for the width by 4.18% (P 10-3/2 x P -84 – 2016) to 9.85% (P-23 x YK 7-4/2 – 2016). The results indicate high genetic homogeneity, i.e. stability of homozygous parents and uniformity of heterozygous hybrids.

With the highest number of leaves in the F2 generation is characterized P-23 x P-84 (43.2), and with smallest P 10-3/2 x YK 7-4/2 (31). The longest leaves had P 10-3/2 x P-84 (21.75 cm), and the shortest P-84 x YK 7-4/2 (18.9 cm). The widest are the leaves of P-23 x P-84 (10.3 cm), and the narrowest are of P 10-3/2 x YK 7-4/2 (8.8 cm). The values obtained from F2 offspring are higher than those of the F1 generation.

In the offspring of the BC1 (P1) generation with the highest number of leaves per stalk is characterized (P-23 x P-84) x P-23 (42.5), and with the lowest (P10-3/2 x YK 7-4/2) x P10-3/2 (32.2). With the largest length of the leaves is (P10-3/2 x P-84) x P10-3/2 (21.75 cm), and with the smallest (P-23 x YK 7-4/2) x P-23 (19 cm). The highest width of the leaves has (P-23 x P-84) x P-23 (10.5 cm), and the smallest (P-84 x YK 7-4/2) x P-84 (9.3 cm). The inheritance of the traits in this backcross generation depends on the parent back-crossed with the F1 offspring.

The highest number of leaves in the offspring of the BC1 (P2) generation is characterized by (P-10-3/2 x P-23) x P-23 (43), and the lowest by (P-84 x YK 7-4/2) x YK 7-4/2 (37). The largest length has the leaves of (P-10-3/2 x P-23) x P-23 (21.24 cm) and the smallest of (P10-3/2 x JK 7-4/2) x JK 7-4/2 (18.03 cm). With the highest width of the leaves is (P-10-3/2 x P-23) x P-23 (10.5 cm), and with the smallest width is (P-84 x YK 7-4/2) x YK 7-4/2 (8.7 cm). And here the inheritance of the traits depends on the parent back-crossed with the F1 offspring.

From the results shown in the paper, we can see, among other things, the effects of the backcrossing are obtaining resistance to stress from drought – an increasing world problem. In the breeding directed to this aim, the varieties P 10-3/2, P-23 and P-84 are distinguished, and they can be successfully integrated in selection programmes. From the crosses most suitable for the given purpose is P-23 x P-84.

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ЕФЕКТ ОД ПОВРАТНОТО ВКРСТУВАЊЕ ВО ОБЛАГОРОДУВАЊЕТО НА ТУТУНОТ

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Резиме

Трудот опфаќа испитувања на четири сорти од ориенталски тип (П10-3/2, П-23, П-84 и ЈК 7-4/2, и нивните дијалелни F1, F2, BC1(P1) и BC1 (P2) крстоски, во текот на 2016 и 2017 година за бројот на листови по страк и димензиите на листовите од средниот појас. Истражувањата беа направени на опитното поле при Научниот институт за тутун – Прилеп во опит поставен по случаен блок-систем во четири повторувања. Мерењата беа направени во периодот на буен пораст (фаза на бутонизација), а добиените вредности беа варијационо статистички обработени. Херитабилноста (h2) на својствата беше пресметувана по метод на Mather и Jinks.

Целта на испитувањата е да се проучи ефектот од повратното вкрстување во подобрувањето на квантитативните својства кај тутунот, да се даде визија за можноста на избор на единки кај максималниот број крстоски кои ги овозможува дијалелот на родителските генотипови и да се понудат насоки за понатамошна селекција.

Добиените резултати покажаа различен начин на наследување во сите анализирани генерации. Херитабилноста кај сите крстоски е повисока од 95%, што е знак за висока наследност на проучуваните својства. Понудената шема за понатамошна сукцесивна селекција може да се користи и кај други растителни видови за подобрување на голем број особини, меѓу кои и добивање на отпорност кон болести.

Клучни зборови: *тутун* (*Nicotiana tabacum* L.), *повратно вкрстување* (backcross), *дијалел, херитабилност*