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PHENOTYPIC DIVERGENCE OF BURLEY TOBACCO VARIETIES

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Seven traits (duration of growing season, height, leaf number, length and width of mid plant leaf and yield) in 20 burley tobacco varieties were observed. Significant differences of their values, i.e. great variability of traits among observed genotypes were determined. The degree of their divergence was esteemed by hierarchical cluster analysis. One of two produced dendrograms was based on varietal divergence by more important traits of development and morphology, i.e. yield components, while the second dendrogram was also based on this complex. Three (I-1, II-1, III-1), i.e. two clusters (I-2, II-2), are observable on the first, i.e. the second dendrogram, respectively. Genotypes of similar productivity were found within each cluster, indicating that selected yield components were the basis for breeding of barely tobacco for yield. When planning hybridisation, parents should be selected from different clusters or subclusters in order to recombine genotypes as divergent as possible over their quantitative properties.

Key words: burley tobacco, divergence, germplasm, yield, yield components

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INTRODUCTION

Tobacco varieties can, more or less, differ from one another in relation to their morphological, productive and other traits under certain growing conditions (DRAŽIĆ, 1995; 1996; 1997a). In the pre-breeding period, breeders attempt to determine phenotypic divergence among genotype germplasm in genetic collections they work with (ASHRI, 1973; DUVICK, 1984, PRODANOVIĆ, 1995, DRAŽIĆ, 1997b). Breeders' special interest is to determine material diversity over estimates of quantitative traits (JOVANOVIĆ *et al.*, 1992; 1993; 1994; 1994a). Yield and yield components are the most fundamental traits for selection and production.

The method of hierarchical cluster analysis (WARD, 1963) is often applied to determine a form and degree of genotypic similarity for several variables. Groups (or clusters) obtained by this method, diverge phenotypically different varieties, while similar varieties are linked within groups.

Grouping genotypes of a certain germplasm collection into clusters, makes selection of the parental pairs, most favourable for hybridisation, easier to breeders (BHATT, 1970; ZAHARY, 1991). In relation to a greater number of traits, crosses of the most divergent genotypes, from the most distant groups, can in progenies result into transgressive recombinations.

The aim of the present study was to determine, by the hierarchical cluster analysis, phenotypic divergence of the working germplasm collection of 20 burley tobacco genotypes, originating from various geographic regions and selection periods, under agroecological conditions of eastern Serbia, where the breeding process has been conducting. This study is a continuation of studies on phenotypic divergence within the species *Nicotiana tabacum* L. that were initiated under identical conditions with the collection of flue-cured Virginian tobacco varieties (DRAŽIĆ and PRODANOVIĆ, 1999).

MATERIAL AND METHODS

Twenty burley tobacco varieties originating from four countries were studied. Varieties Spartak, Poseidon, Bols III, Bols 334 and Bols 335 (1-5) were from Austria (BOLSUNOV, 1961). The local varieties Burley DKH 28 and Burley DKH 33 (6-7) (DRAŽIĆ and KOJIČIĆ, 1987; DRAŽIĆ, 1995; 1997a) were derived on the basis of initial material originating from Austria. These two varieties represent hybrid variations. The variety Burley T (8) has been grown over 25 years in Yugoslavia on the basis of the introduced material (DRAŽIĆ, 1997a). Varieties Burley 49, Burley 21, Burley 37, Burley 64, Va 590, TN 86, TN 90, SA 130, Ti 1499, L8, N88 and N 777 (9-20) originate from the USA. The last seven USA varieties have been recently developed (MILLER, 1987; PALMER *et al.*, 1991).

Varieties were grown during two years (1993 and 1996) in the location of Veliko Gradište in microtrials set up according to the 4-replicate randomised complete block design. The elementary plot size amounted to 20 m^2. Planting distance was 80 x 50 cm, while planting density amounted to 25,000 plants ha^{-1}. The trial was conducted on yellow sandy soil. The mean air temperature of the growing season (April - September) was about 19°C, while the precipitation sum amounted to over 400 mm.

Ten plants per each replication were sampled for the analysis. The following yield components of each genotype were esteemed: duration of the growing season (in days), height (cm), leaf number on stalk, length and width of mid-plant leaf (cm), leaf area (after formula of TSO, 1979). Yield as the most complex trait was also observed and measured (kg ha^{-1}).

Means for all traits (M) for each genotype and each variety in the trial were determined. Variability of traits among genotypes within germplasm collection is presented by variance (S^2) and coefficient of correlation (Cv). Significance of differences among genotypes was evaluated by the analysis of variance and F-test.

Table 1. Trait means of analysed genotypes

Genotype	Growing season	Height (cm)	Leaf number	Leaf length (cm)	Leaf width (cm)	Leaf area (cm^2)	Yield (kg ha^{-1})
Spartak	82	178	26	55	30	1048	2003
Poseidon	67	167	23	60	33	1258	1994
Bols III	65	151	20	50	30	951	1270
Bols 334	64	170	22	62	38	1103	1990
Bols 335	64	172	22	62	37	1064	1950
Berlej DKH 28	70	153	23	50	31	985	2154
Berlej DKH 33	72	175	25	56	30	1067	2028
Berlej T	65	162	20	58	25	921	1650
Ti 1449	80	138	19	47	24	717	1509
Burley 49	62	137	28	48	25	762	1261
Burley 21	74	47	14	26	14	231	730
Burley 37	73	36	12	21	10	133	517
Burley 64	74	50	13	23	12	175	562
Va 590	80	40	11	22	10	140	535
TN 86	95	124	26	50	25	794	1675
TN 90	107	149	25	48	23	701	1874
SA 130	106	145	27	47	22	657	1904
L8	109	103	21	41	18	469	435
N88	111	95	23	33	15	315	990
N 777	106	87	15	31	16	316	780

The Cluster programme of SAS software (1992) was applied to the hierarchical cluster analysis (WARD, 1963) in order to esteem the degree of divergence among genotypes. The matrix of Euclidean distances $d_2(e_i, e_j)$ among group means is calculated by this method:

$$d_2(e_i,e_j)=\left[\sum_{k=1}^{p}\frac{(x_{ik}-x_{jk})^2}{\sigma_k^2}\right]^{\frac{1}{2}}$$

The method of single linkage was used, whereby a dendrogram, showing successive fusions of genotypes, culminating at the stage where all groups belonged to the same cluster, was produced to display phenotypic differences among studied varieties.

RESULTS AND DISCUSSION

The estimates of quantitative traits of 20 studied burley tobacco varieties are presented in Table 1.

Table 2 presents basic biometric parameters for the entire germplasm collection. Maximum and minimum estimates of traits are especially pointed out, indicating significant differences among varieties. Coefficients of variation regarding traits of observed material ranged from 21% (duration of the growing season) to 52% (leaf area). F-test expresses statistically very significant differences among genotypes for all traits.

Table 2. Variability parameters of traits of studied genotypes

Trait	Mean	Min	Max	Variance	Coefficient of variation	F
Growing season	81	62	111	290.1	21	13.81**
Height	124	36	178	2254.3	38	103.03**
Leaf number	21	11	28	26	24	26.18**
Leaf area	690	133	1258	127449	52	98.3**
Yield	1391	435	2154	503233.2	51	31.51**

Due to pronounced variability, the hierarchical cluster analysis showed a great divergence of the material. Two cases of analysis of divergence were considered: the first, when only yield components were encompassed and the second, when a complex trait - yield was added to them. Two dendrograms of divergence with linkage distances for 20 studied burley tobacco varieties, designated by ordinal numerals from the Table 1, are presented by the Figures 1 and 2.

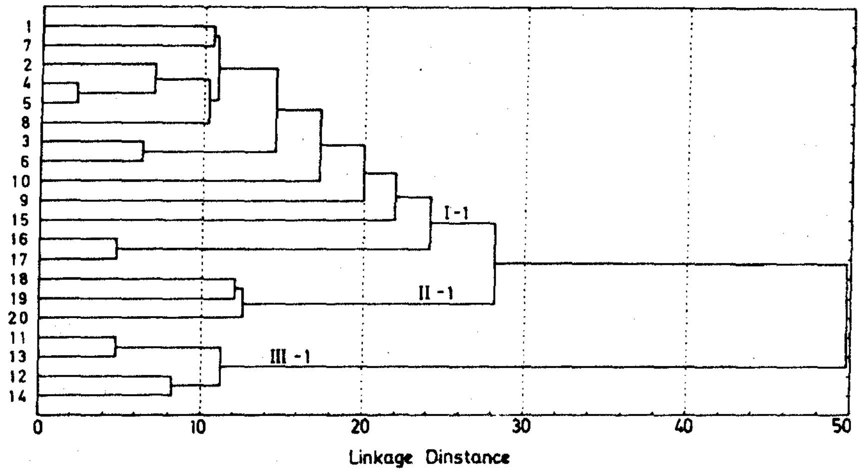

Fig.1. Dendrogram of linkage distances among 20 varietes (yield components)

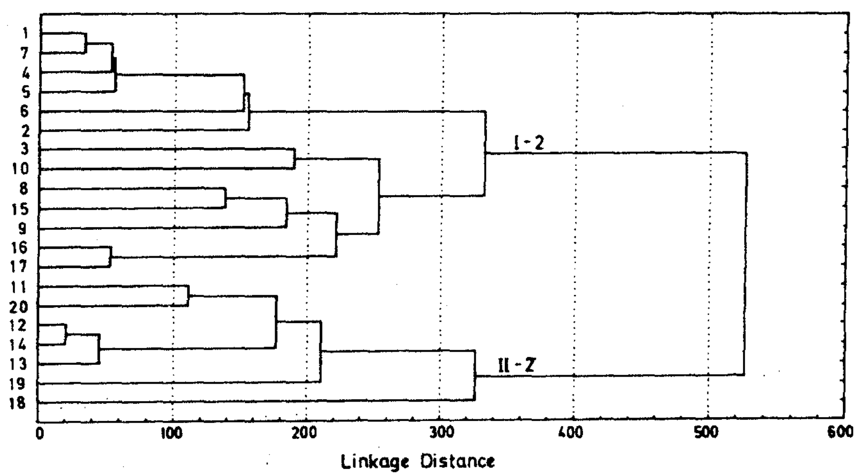

Fig.2. Dendrogram of linkage distances among 20 varietes (yield components and yield)

Three genotypic groups of a different complex of phenotypic properties are noticeable in the Figure 1. There are similar varieties with relatively close estimates of traits within each of these three groups. There are 13, seven and four varieties in the first (I-1), the second (II-1) and the third (III-1) group, respectively.

Two genotypic groups are observable in the Figure 2. There are 13, i.e. seven varieties in the first (I-2), i.e. the second (II-2), respectively. The latter group consists of varieties of the cluster II-1 and III-1.

The comparison of the varietal distribution across the dendrogram (Figure 2) with their estimates in Table 1 shows that linking into groups was done, first of all, according to yield. The group I-2 (Spartak, Burley DKH 33, Bols 334, Bols 335, Burley DKH 28, Poseidon, Bols III, Burley 49, Burley T, TN 86, PI 1449, TN 90 and SA 130) encompasses varieties with relatively high yield, ranging from 1261 to 2154 kg ha^{-1}, while the group II-2 (Burley 21, Burley 37, Burley 64, Va 590, L8, N88 and N 777) is characterized by a lower yield (ranging from 435 to 990 kg ha^{-1}). Although the hierarchical cluster analysis was based on a greater number of elementary quantitative traits (yield components) and only one complex trait (yield) it seems that yield effects on grouping was the most important. However, since yield is a result of development of many elementary quantitative traits and depends on their values, elementary and complex traits should not be observed as conflicted sides. It should be noticed that the elementary traits enabling grouping of varieties by their yield were chosen for this study.

With regard to the fact that the stated traits are of the crucial importance for the yield level, the special attention should be paid to them in selection of burley tobacco.

Linkage of yield components and yield is also confirmed by congruity of grouping of varieties into cluster (Figures 1 and 2). However, there are certain differences especially in the position of the cluster II-1 with varieties L8, N 88 and N 777. This cluster is expressly detached in the Figure 1 and at a higher level associated with high yielding genotypes, while in the Figure 2 it belongs to low yielding genotypes. This statement points out to the fact that these three recently derived US varieties have a potential to form good yield according to their morphological traits, but they do not achieve such yield under our conditions.

Moreover, it should be mentioned that the form of grouping was not changed when the trait leaf area was omitted if leaf length and width were analysed and vice versa. This means that the addition of positively highly interrelated and derived traits in the hierarchical cluster analysis does not affect the form of divergence and therefore the number of observed traits should not be increased. From the practical point of selection it means that greater efficiency can be achieved by monitoring a lower number of more important traits in more abundant material.

The dendrograms show linkage of genotypes in relation to the centre and time of their selection. For instance, all varieties of Austrian origin (1-5) (BOLSUNOV, 1961; 1967) and local varieties (6-7, derived from the initial material of Austrian origin, DRAŽIĆ, 1997a; 1997b) belong to the same cluster. The US varieties were also linked, whereby grouping into sublusters was mainly related to the period of their development (HEGGERSTAD *et al.*, 1960). Some authors (JOVANOVIĆ *et al.*, 1994a) suggested that varietal linkage into clusters could be, to a great extent, caused by a location of their development, explaining it by the model of a variety development applied in a particular institute and by the use of relatively smaller amount of tested germlasm with regard to combining abilities for parental components in each of the breeding centres.

The produced dendrogram can be used to plan hybridisation. Crosses should be performed among genotypes as divergent as possible from different groups and subgroups, but of satisfactory traits. In such a way, a great number of unnecessary crosses of similar to similar varieties is eliminated, because they cannot result in progenies with the most pronounced gene recombinations for several traits. The mode of grouping of studied varieties point out to potentially good parental combinations.

CONCLUSION

Studies on 20 burley tobacco varieties, among which 18 were introduced, under conditions of eastern Serbia, point to the following:

There are significant differences among genotypes of this germplasm collection based on estimates of variances, coefficients of variations and F-test.

Groups of genotypes primarily linked by estimates of yield were singled out by the hierarchical cluster analysis based on both, yield components and yield. The obtained form of divergence did not alter more essentially even when yield was omitted, pointing out that selected quantitative traits were exactly those directly affecting yield estimates, and therefore a special attention should be paid to them in burley tobacco selection.

The location and time of selection of observed varieties also significantly affected their divergence.

Phenotypic divergence established among genotypes can be used in selection of parental pairs in the further breeding programme.

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FENOTIPSKA DIVERGENTNOST SORTI BERLEJ DUVANA

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Izvod

Ispitivano je sedam svojstava (dužina vegetacionog perioda, visina, broj listova, dužina i širina srednjeg lista, površina lista i prinos) kod dvadeset sorti berlej duvana. Utvrđene su značajne razlike u njihovim vrednostima, odnosno velika varijabilnost svojstava između proučavanih genotipova. Za procenu stepena njihove divergencije korišćena je hijerarhijska klaster analiza. Dobijena su dva dendrograma od kojih je prvi zasnovan na divergenciji sorata po važnijim svojstvima razvoja i morfologije odnosno komponentama rodnosti, bez uključivanja prinosa, a drugi je zasnovan i na ovom kompleksnom svojstvu. Na prvom dendrogramu se izdvajaju tri (I-1, II-1, III-1), a na drugom dva (I-2, II-2) klastera, odnosno grupe sorti. Klaster II-2 se sastoji od sorti iz klastera II-1 i III-1. Unutar svakog klastera našli su se genotipovi približne produktivnosti, što ukazuje da su izabrana elementarna svojstva osnov za oplemenjivanje na prinos berlej duvana. Pri planiranju hibridizacija roditelje treba odabirati iz različitih klastera ili subklastera kako bi se rekombinovali što divergentniji genotipovi po ispitivanim kvantitativnim svojstvima.

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