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OBSAH

SOMACLONAL VARIATION OF CALLUS-DERIVED POTATO REGENERANTS

P. Kostřica, Z. Opatrný, E. Fričová, S. Hausvaterová

KOSTŘICA, P. — OPATRNÝ, Z. — FRIČOVÁ, E. — HAUSVATEROVÁ, S. (OSEVA — Research and Breeding Institute of Potato Growing, Havlíčkův Brod; Institute of Experimental Botany, Czechoslovak Academy of Sciences, Praha): *Somaclonal Variation of Callus-derived Potato Regenerants.* Genet. a Šlecht., *24,* 1988 (4) : 245-256.

The basic morphological, cytological and agricultural properties of plants regenerated *in vitro* from stem-, leaf- and tuber-derived calli were studied. The eight compared cultivars showed a frequency of variant somaclones ranging from 0 to 7 %. Cv. Apta was the only one to show 100 % of morphologically deviated clones in the group obtained from stem-derived calli. Some mutant regenerants exhibited changes in the ploidy level, associated as a rule with the overall modification of the plant's habit. Variant tetraploid genotypes demonstrated changes in colour involving the tuber skin and flowers, and changes in leaf morphology. Some of the observed deviations were of chimerical nature.

potatoes; plant tissue culture; somaclonal variation; mutagenesis *in vitro*

Somaclonal variation defined by Larkin and Scowcroft (1981) as a genetic variation seen in plants regenerated *in vitro* underlies notable genotype deviations also in potatoes. It is both the manifestation of spontaneuos mutations accumulating in the genotype during vegetative propagation *in vivo* and genetic deviation arising during cultivation *in vitro.* The range and frequency of regenerant variation depends therefore on the properties of the initial material (genotype origin, ploidy level, type of explant etc.) and also on the technique and duration of cultivation.

The relationship of the inductive and selective effects of *in vitro* culture is high indistinguishable. Accumulation of deviations in regenerants obtained from long-term tissue cultures is usually interpreted as the result of the inductive effect of *in vitro* acting factors. In contrast, somaclonal variation of regenerants from short-term cultures (primary callus or protoplasts isolated directly from tissues of an intact plant) should be relatively low and/or commensurate with genetic variation of cellular population of the primary explant with a minor number of deviations developed during the process of regeneration.

Yet on the other hand the single cell origin of protoclones permits of a maximum expression of traits that would be obscured in chimerical regenerants. This is apparently why protoplast-derived clones exhibit after regeneration a wider range of variations than clones orginating from explants (Bright et al., 1982; Jones et al., 1983; Karp et al., 1987). In addition, the nature of mutations in protoclones is usually pronounced, and responsible for extensive changes in the initial more or less balanced genotype. In contrast, point mutations, interesting for breeders, are often reported in explant-derived somaclones. This, together with the less sophisticated and time-consuming method of obtaining regenerants, accounts for the growing interest in this technique of cultivation.

This paper therefore evaluates the range of variation of somaclones derived from adventive shoots of primary callus of explant origin in eight important cultivars.

MATERIAL AND METHODS

For the experiments we used the following cultivars: Apta, Désirée, Lada, Nora, Première, Resy, Xenia and Zvíkov stored in a collection *in vitro*. Stem internodia, leaf blades, petioles and tubers obtained *in vitro* served as primary explants. Their cultivation was two-phase on an induction and regeneration medium, using the methods after Kostřica et al. (1985) for cvs. Apta — series 1984, Désirée, Lada, Nora, Première, Resy and Zvíkov, and after Opatrný, Müllerová (1986) for cvs. Apta — series 1986, Première and Xenia. All regenerants were obtained from shoots isolated from the primary callus developing on explants over a period of several weeks of cultivation, except for cv. Zvíkov, where we used also shoots differentiated after 1—5 callus passages.

Regenerated shoots were registered as independent clones and after rooting they were planted in greenhouse. The following year the harvested tubers were planted in the field. Phenological and morphological observations of clones were performed during vegetation; tubers were analyzed after harvest. For morphological description of regenerants we used the nomenclature in the descriptor list by Vidner et al. (1987). The results obtained in cvs. Apta — series 1984 and Resy were summarized after three-year field trials and those obtained in cv. Apta — series 1986 and other cultivars were summarized after one-year controlled field cultivation.

For assessing the ploidy level in the regenerants of cv. Apta, we determined chloroplast number in the guard cells of stomata (Zadina, Horáčková, 1977) and chromosome number in squashed root tips, using the modified method after La Cour (1941). Regenerants propagated in field conditions were tested for viruses *S*, *X*, *M*, *Y*, *A* and leafrolling at the eye test by the ELISA technique (Kameníková, Pohořelá, 1987). Extreme leafrolling intolerance was determined by tuber grafting (Zadina, Novák, 1983). Potato nematode resistance (*Globodera rostochiensis*, pathotype Ro 1) was tested with the aid of the greenhouse test (Zadina, Jermoljev, 1976); tuber starch content was estimated on the Polikeit weighing machine (Zadina, Jermoljev, 1976).

RESULTS

Properties of somaclones of cv. Apta — series 1984

In experiments extending over three years we compared 12 and 15 regenerants obtained from leaves and stems, respectively. Most of the clones showed marked deviations in tuft habits according to which we could divide the regenerants into several characteristic groups (Tab. I).

Morphological properties of the tuft

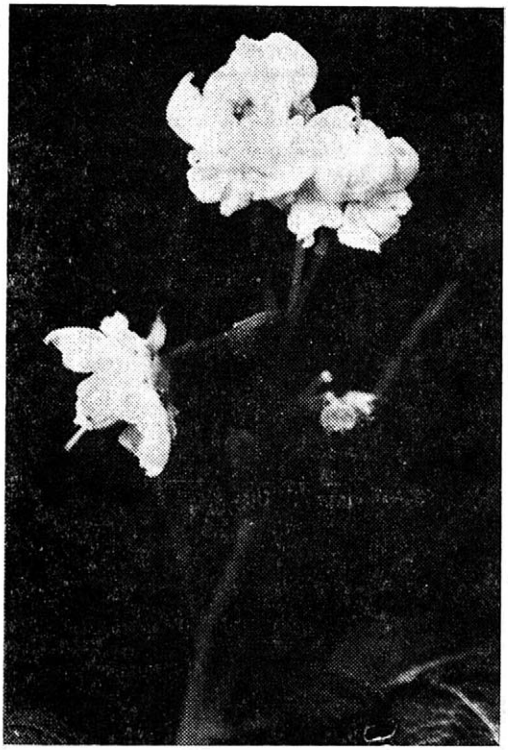
Regenerants obtained from leaf blades exhibited no morphological deviations compared with control (morphological type I — Fig. 1)

I. Properties of regenerants of cv. Apta (series 1984) stable throughout three-years of field trials

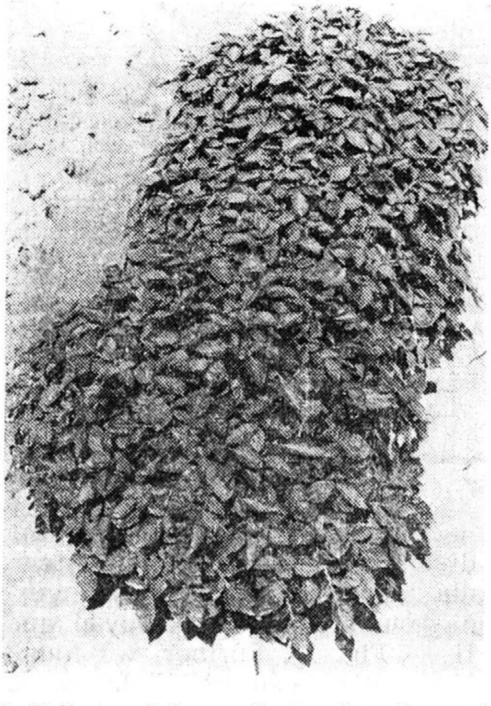
Morphological type of plant	Control	I	II	III	IV
Type & No. of regenerating explants	—	blade 4	stem 3	stem 1	stem 2
No. of regenerated sprouts (clones)	—	12	8	2	5
Ploidy level of regenerants	4x; 4x—1	4x; 4x—1,2,3	4x; 4x—1,2,3 or 3x	4x; 4x—1	2n = 70—85
Haulm height of plants (cm)	60—80	60—80	40—50	10—15	15—20
No. of stems	6—8	6—8	23—36	5—7	17—26
Morphology of leaves	dissected, undulate	dissected, undulate	dissected, smooth - undulate	non-dissected, smooth - undulate	non-dissected, undulate
Flower	intensive, blue-violet	intensive, blue-violet; mutation: white corolla	weak and delayed, irregular, blue-violet	absent	absent
Tubers size and shape	large + intermediate, round-oval	large + intermediate, round-oval	intermediate + small, oval	small, round-oval, oval	small, round-oval, oval
Eye depth	intermediate	intermediate	shallow	shallow	shallow
Skin colour	yellow-brown	yellow-brown, mutation: violet apex	yellow-brown	yellow-brown	yellow-brown
Mean starch content	13.6 %	13.3 %	11.5 %	—	—

with the exception of one clone having one stem in the plant bearing white flowers with a distinct outer diparacola (Fig. 2). Eight stem-derived regenerants were of intermediate growth, combined with extensive stem branching just above the ground, and with delayed and weak flowering (morphological type II — Fig. 3). Further, we found dwarf non-flowering tufts with weak, normal or extensively branched stems and little dissected (pinnatilobed) leaves (morphological types III and IV — Figs. 4, 5).

1. Overall plant appearance of a standard clone of cv. Apta — morphological type I

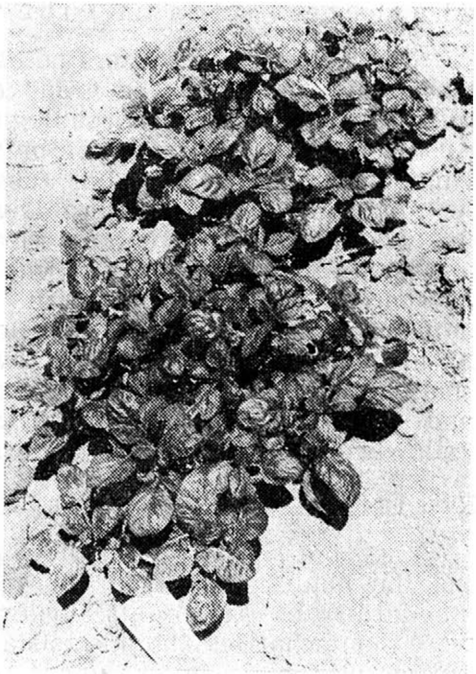


2. White corolla with outer diparacola in one of the clones of cv. Apta

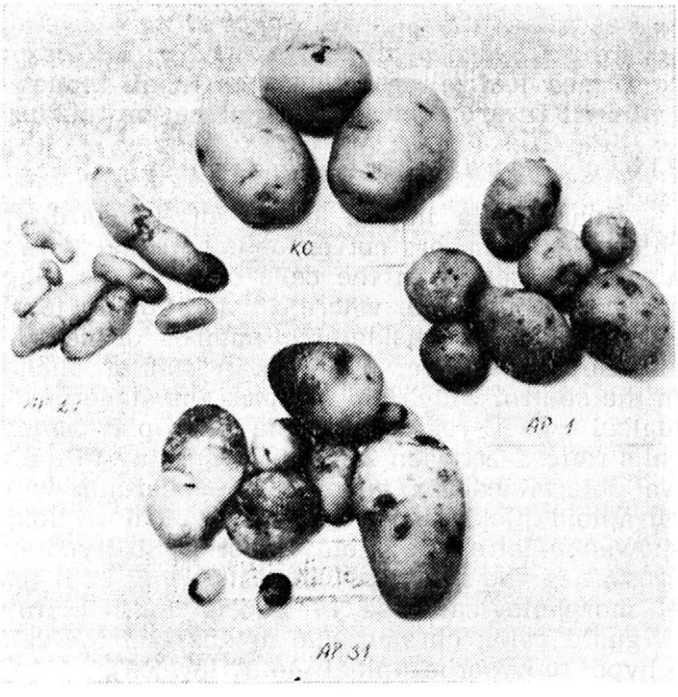


3. Foliage of three plants of a clone of cv. Apta — morphological type II

4. Overall plant appearance of a clone of cv. Apta — morphological type III



5. Two plants of a clone of cv. Apta — morphological type IV



6. Tuber morphology of some clones of cv. Apta compared with control (KO)

Characteristics of tubers

The properties of tubers coincided with the markedly differentiated morphology of tufts. The group of regenerants with standard type of tuft produced tubers morphologically similar to controls (Fig. 6 — AP 1). This was not true of only one clone which displayed marked violet spots at the apex of tubers and around the eyes (Fig. 6 — AP 31). The yield of regenerants with abundantly branched tufts was on the whole lower and characterized by a high amount of intermediate and small long oval tubers with shallow eyes (Fig. 6 — AP 21). Compared with controls and standard-type regenerants, we demonstrated statistically a significantly lower starch content in tubers in all clones of this group. Dwarf regenerants produced only very small tubers varying in shape and showing deformities such as knobs and cracks. The tubers of all the 27 studied clones had the same yellowish colour of flesh as controls.

Resistance to some pathogens

Cv. Apta shows intermediate resistance to potato late blight, affecting the haulm. The same degree of field resistance persisted also in standard-type regenerants. Regenerants of other morphological types were somewhat less blight-resistant, which manifested itself, inter alia, by necrotic spots in the upper segments of the stem and by soft rot of long-oval tubers extending from the stolon end.

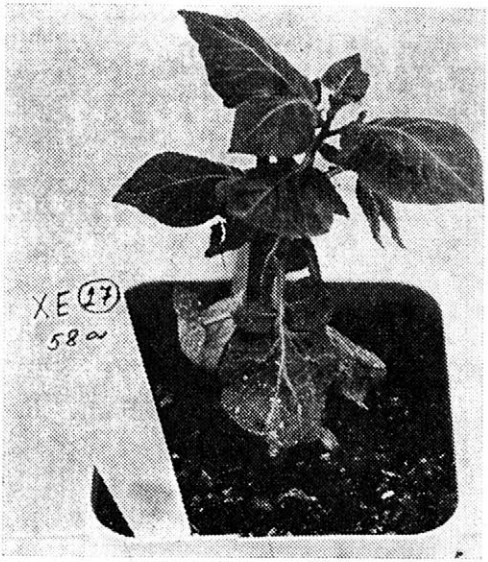
Tests for viroses confirmed an increasing incidence of viral infections in the collection of regenerants during the three-year period of field propagation. The fastest rate was recorded in virus-*S* reinfection, amounting to 100 % in the second year; other viruses spread in the following order: *M, X, Y, A.* None of the clones did exhibit a markedly altered relative resistance to any of the above viruses. Field provocation tests for extreme potato leaf-roll virus intolerance in the grafted tubers confirmed leafrolling intolerance in all clones of morphological types I and II. Dwarf clones could not be grafted for lack of tuber material.

Ploidy level of regenerants

Guard cells in the leaves of standard-type regenerants showed chloroplast numbers corresponding to the tetraploid level. Chromosome numbers assessed in the cells of root tips suggested a mixoploid character of the tissue, where, in addition to tetraploidy level ($4x = 48$), we detected a considerable number of cells with a hypotetraploid chromosome number (Tab. I). A similar phenomenon was noted also in the control which did not pass the stage of tissue culture. In morphological type II regenerants the chloroplast numbers in the paired guard cells ranged between 21 — 26. According to the number of chromosomes we determined six mixoploid regenerants with tetraploid and hypotetraploid ploidy level and two typical triploids. Type III regenerants showed a tetraploid ploidy level (with hypotetraploid cells repeatedly present in the root tips) in tests using both testing techniques. Clones of morphological type IV had a high chloroplast number (35 — 45) in guard cells; chromosome numbers in the cells of root tips indicated a hypo- to hyperhexaploid ploidy levels.

Properties of regenerants of other cultivars

Dwarf clones recurred in five cultivars with a higher number of regenerants at a frequency ranging from 0.4 to 4.1 % (Tab. II). These plants were 10 to 20 cm high, had deformed, slightly dissected or non-dessected leaves (Figs. 7, 8), did not flower, and yielded only a negligible amount of very small tubers. Owing to the low number of the observed regenerants, we failed to detect morphological deviations in clones of cvs. Lada and Resy. In contrast with the series of the studied cultivars, cv. Apta again displayed pronounced morphological deviations in all regenerated clones among which the highest number comprised abundantly branched tufts of medium growth (morphological type II).



7. Dwarf growth and leaf deformation in one of the clones of cv. Xenia

8. Dwarf growth and leaf deformation in one of the clones of cv. Apta

Changes in the morphology of leaves occured also in regenerants with a standard habit, i. e. in cvs. Première (undulate blades) and Xenia (somewhat broader light green leaflet, blade "blistering"). Two somaclones of the latter cultivar showed also changes in the colour of tuber skin from pink to yellow. In one potato clone the change involved all tubers, in the other about 50 % of all the harvested tubers, which in addition had pink spots around the eyes. Cv. Désirée showed an even higher tendency to change from red- to yellow-coloured skin. However, change in colour involving all tubers of a potato plant occured only in one of the four variant clones, while in the remaining ones a complete change in colour affected only a few tubers just under the tuft.

II. Morphological deviations of somatic clones of some potato cultivars (Figures in brackets express % of variant regenerants)

Cultivar	Type of explant	No. of regenerants	Properties of variant regenerants				
			dwarf growth, leaf deformation	intermediate growth, extensive branching	chlorophyll chimera	change in leaf morphology	change in colour of tuber skin
Zvíkov	petiole	252	–	–	3 (1,2)	–	–
	tuber	795	10 (1,3)	–	4 (0,5)	–	–
	stem	46	–	–	–	–	–
Nora	petiole	182	–	–	1 (0,5)	–	–
	leaf blade	262	1 (0,4)	–	1 (0,4)	–	–
Désirée	petiole	74	1 (1,4)	–	–	–	2 (2,7)
	leaf blade	29	–	–	–	–	–
	stem	74	1 (1,4)	–	–	–	2 (2,7)
Première	petiole	10	–	–	–	–	–
	leaf blade	4	–	–	–	–	–
	stem	244	10 (4,1)	–	–	4 (1,6)	–
Xenia	stem	114	3 (2,6)	–	1 (0,9)	2 (1,8)	2 (1,8)
Lada	petiole	23	–	–	–	–	–
	tuber	10	–	–	–	–	–
	stem	2	–	–	–	–	–
Resy	petiole	11	–	–	–	–	–
	leaf blade	13	–	–	–	–	–
	stem	7	–	–	–	–	–
Apta	stem	39	3 (7,7)	36 (92,3)	–	–	–

Isolated chlorophyll mutations were seen in the clones of cvs. Nora, Xenia and Zvíkov and were as a rule confined only to some leaves of young plants. These chlorophyll deficiencies gradually disappeared with further growth.

Tests for potato nematode resistance of somaclones fully confirmed a weak resistance of Apta and Resy and a high resistance of Xenia. Among the 129 tested clones of the resistant cv. Première, we detected one clone showing loss of the initial resistance in tests repeated after three years.

DISCUSSION

Cv. Apta was bred in the Federal Republic of Germany in 1951 and has since been used for cross-breeding mainly as a source of high relative resistance and extreme intolerance to the leaf-roll virus. The wide range and high frequency of mutations found in the somaclones of this cultivar distinguish it distinctly from other cultivars, where the frequency of variation clones agrees with the data reported by other autors (Jones et al., 1983; Wheeler et al., 1985; Karp, 1986) for regenerants from primary calli.

The extraordinary variability of the somaclones of cv. Apta does not seem to have been directly influenced by conditions of explant cultivation (we evaluated regenerants obtained by three methods of cultivation), but it did show some relationship to explants of stem origin (Tabs. I, II). However, an unequivocal confirmation of such a relationship would obviously need a much larger amount of initial material. Yet the high variability of cv. Apta appears to be due mainly to its origin, as this cultivar was obtained by crossing of an inter-species hybrid based on *Solanum demissum* with cv. Hindenburg (Rothacker, 1961). Thus, unlike other cultivars, its chromosome set is not fully autotetraploid. Vegetative propagation of this cultivar extending over more than 30 years is apparently responsible for the detected mixoploid character of tissues which was identified already in the initial material. This phenomenon was described also in other potato cultivars (Alicchio, Antonioli, 1984). The triploid character of some extensively branched clones of cv. Apta indicated that it might be possible to eliminate one set of 12 "alien" chromosomes and double the remaining genome to a hypo- or even hyperhexaploidy level in dwarf regenerants.

Marked morphological deviations associated with dwarf growth and leaf deformities in cvs. Apta, Première and Zvíkov were as rule combined with an elevated ploidy level. Such grossly aberrant plants often occur also in protoclone series, where regenerants occasionally attain even an octoploid level (Karp et al., 1982; Sree — Ramulu et al., 1983, 1986). However, from the point of view of breeding, such a profound reconstruction of balanced genotypes is of doubtful value even through the thus obtained mutants may preserve some of the propitious properties of the initial cultivar.

Change in colour of tuber skin from red to yellow (recessive mutation) ranks among the often described deviations in cv. Désirée following irridiation of tubers *in vivo* (Harten, 1969), of plants *in vitro,* and their micropropagation by means of nodal cuttings (Sonnino et al., 1986) and regeneration of adventitious sprouts in tissue culture (Harten et al., 1981; Wheeler et al., 1985). Colour of the tuber skin is also known to be a highly mutable trait in cv. Xenia, where Tiemann et al. (1984) found completely discoloured tubers in 17.5 % of protoclones. Yellow skin changing to red is less common. Violet splashing of skin encountered in one of the clones of cv. Apta was thought to be a non-chimerical permanent mutation as we failed to eliminate it by vegetative techniques in conditions of field propagation, nor by meristem culture *in vitro.* The skin splashing was in part transmitted to offsprings when we crossed the clone with the yellow skinned cv. Svatava.

For breeding purposes the quarantine potato nematode resistance is a valuable property in any cultivar. Somaclone tests show this property to stabilize at the level of the initial cultivars, be they resistant such as Xenia (Tiemann et al., 1984), Feltwel (Thomson et al., 1986) and Stina (Umaerus, Ireholm, 1987) or sensitive to this pathogen, such as cv. Desirée (Evans et al., 1986), Bintje (Umaerus, Ireholm, 1987). So far exceptions have been cvs. Première and Matilda. In our experiments one clone of the former lost its initial resistance, in the latter Umaerus and Ireholm (1987) detected one protoclone which developed resistance *in vitro.*

The results hitherto obtained and presented in this paper have confirmed the occurence of somaclones with desirable properties even following regeneration of adventitious sprouts directly from primary explant calli. They are in agreement with the following hypothesis: a) conditions of explant culture exert a selective rather than inductive influence for variation; b) the high level of somaclonal variation of cv. Apta regenerants is due to the effect of an a priori unstable genotype. Tests of the somaclone series dealt with in this paper will continue. Their purpose will to be investigate other properties of the regenerants and verify the stability of the already identified deviations of which some are apparently of chimerical origin.

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Byly sledovány základní morfologické, cytologické a hospodářské vlastnosti rostlin regenerovaných *in vitro* z kalusů stonkového, listového a hlízového původu. U osmi srovnávaných odrůd činila frekvence variantních somaklonů 0—7 %, pouze odrůda 'Apta' vykázala 100 % morfologicky odchylných klonů v souboru regenerantů z kalusů stonkového původu. U některých mutantních regenerantů byly zjištěny změny v úrovni ploidie, které byly zpravidla provázeny celkovou přestavbou habitu rostliny. Variantní tetraploidní genotypy prokázaly změny v barvě slupky hlíz, barvě květu a morfologii listů. Některé ze zaznamenaných odchylek byly chimérické povahy.

brambory; explantátové kultury; somaklonální variabilita; mutageneze *in vitro*

КОСТРЖИЦА, П. — ОПАТРНЫ, З. — ФРИЧЕРОВА, Э. — ГАУСВАТЕРОВА, С. (ОСЕВА — Научно-исследовательский и селекционный институт картофелеводства, Г. Брод; Институт экспериментальной ботаники ЧСАН, Прага): **Сомаклональная изменчивость каллюсных регенерантов картофеля.** Genet. a Šlecht., *24,* 1988 (4) : 245-256.

Определяли основные морфологические, цитологические и хозяйственные свойства растений, регенерированных *in vitro* из каллюса стеблей листьев и клубеньков. У 8 сравниваемых сортов частота вариантных сомаклонов составила 0—7 %, лишь сорт 'Апта' показал 100 % морфоотклоненных клонов в стеблевых каллюсах. У этих мутантов регенерантов отмечены изменения в уровне плоидии, сопровождающейся, как правило, общей перестройкой габитуса растения. У вариантных тетраплоидных генов установлены изменения в окраске кожуры клубней и цветков, в морфологии листа. Некоторые отклонения носили химерический характер.

картофель; эксплантатные культуры; сомаклональная изменчивость; мутагенез *in vitro*

KOSTŘICA, P. — OPATRNÝ, Z. — FRIČOVÁ, E. — HAUSVATEROVÁ, S. (OSEVA — Forschungs- und Züchtungsinstitut für Kartoffelanbau, Havlíčkův Brod; Institut für experimentelle Botanik der ČSAV, Praha): *Somaklonale Variabilität der Kallusregenerate der Kartoffeln.* Genet. a Šlecht., *24,* 1988 (4) : 245-256.

Wir untersuchten die grundlegenden morphologischen, zytologischen und ökonomischen Eigenschaften der *in vitro* aus Stengel-, Blatt- und Knollenkallus regenerierten Pflanzen. Bei acht verglichenen Sorten betrug die Frequenz der varianten Somaklonale 0—7 %, nur die Sorte Apta wies 100 % morphologisch abweichender Klone in einer Gruppe von Regeneraten aus Stengelkallus auf. Bei einigen Mutantregeneraten konnten Veränderungen auf dem Niveau der Ploidie beobachtet werden, die von einem Gesamtumbau des Habitus der Pflanze begleitet worden waren. Die varianten tetraploiden Genotypen wiesen Veränderungen in der Farbe der Knollenschale, der Blüte und in der Morphologie der Blätter auf. Einige der beobachteten Abweichungen waren chimärischen Charakters.

Kartoffeln; Explantatkulturen; somaklonale Variabilität; Mutagenese *in vitro*

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EVALUATION OF SOMACLONAL VARIATION AND INDUCED MUTAGENESIS IN SPRING WHEAT

L. Ohnoutková, Z. Ohnoutka

OHNOUTKOVÁ, L. — OHNOUTKA, Z. (OSEVA — Research and Breeding Institute of Cereal Crops Kroměříž, Plant Breeding Station Hrubčice): *Evaluation of Somaclonal Variation and Induced Mutagenesis in Spring Wheat.* Genet. a Šlecht., *24,* 1988 (4) : 257-262.

In spring wheat somatic embryoids were derived from scutellar parts of zygotic embryos. The percentages of somatic embryos formation and regenerants were ranging between 7 and 28 %, and 5 and 17 %, respectively. The increased amount of somatic embryoids was observed in the culture of zygotic embryos removed from M_1 plants being treated with low doses of the mutagen (^{60}Co). In SC_3 generation, tests were made of a total of 102 progenies and 1 247 plants to examine agronomic and quality characters (plant height, 1 000-grain weight, grain weight per plant, grain number per spike etc.). As compared to the control variant, the progenies exhibited deviations in the characters both with single and complex genetic constitution. The embryo culture derived from M_1 plants and subsequent formation of somaclones had a positive effect on an increase in the frequency of mutations.

Triticum aestivum L.; spring wheat; regeneration; somaclonal variation; mutagenesis; agronomic characters

The phenomenon of somaclonal variation in the *in vitro* cultures of some crops can exercise a favourable effect upon obtaining novel morphotypes (Larkin, Scowcroft, 1981). In wheat (*Triticum aestivum* L., $2n = 6x = 42$) induction of suitable callus is most often achieved in the culture of scutellar parts in immature zygotic embryos (Shimada, Yamada, 1979; Ozias — Akins, Vasil, 1982). Regeneration of individual cells can result in morphological abnormalities due to undefined effects, the regenerated plants thus showing phenotypical changes (Larkin, Scowcroft, 1981). The occurrence of somaclonal variation in regenerants has been studied and documented in detail. Chromosomal aberrations, ranging from changes in ploidy level and whole chromosome loss to translocations, have been widely reported (e.g. Karp, Maddock, 1984; Davies et al., 1986). A vast study has been in progress of variation in individual characters, such as height (Larkin et al., 1984), seed colour (Greorge, Rao, 1983), herbicide resistance (Chalef, Ray, 1984) and gliadine patterns of grains (Maddock et al., 1985) although none has yet, to our knowledge, been deployed in achieving plant breeding goals. Genes with less recognizable effects on yield and/or quality are presumably just as subject to somaclonal variation. However, there is no simple method of isolating these variants (Ryan et al., 1987).

It seems desirable to identify the causes of such changes in respective regeneration procedures with the aim of subsequent application to crop improvement.

The importance of the techniques under consideration and their exploitation in cereals have been widely discussed by numerous authors (e. g. Bright, Jones, 1985; Bajaj, Gosal, 1986).

MATERIALS AND METHODS

Plant regenerants have been obtained in the culture of immature embryos (0.5 mm in size) of spring wheat (*Triticum aestivum* L. cv. 'Rena'). Parallelly the embryos for *in vitro* culture were also removed from the same breeding material in M_1-generation irradiated with gamma-rays (^{60}Co) at the doses of 100, 150, and 200 Gy. The embryos excised under sterile conditions were placed in Petri dishes on the culture medium of Murashige-Skoog (1962) containing double concentrations of macro- and microelements, and supplemented with 10 μm 2,4-D (2,4-dichlorophenoxyacetic acid). After 4-week-culture in the dark at 20 °C white embryogenic formations began developing on the surface of the compact callus tissue (Fig. 1). Being transferred onto the regeneration medium containing 1 μm NAA (α-naphthaleneacetic acid) and 2.5 μm 2-iP (N^6-dimethylallyladenine) they were cultured in light (1 200 Lx) under 16-hour-photoperiod at 20 °C.

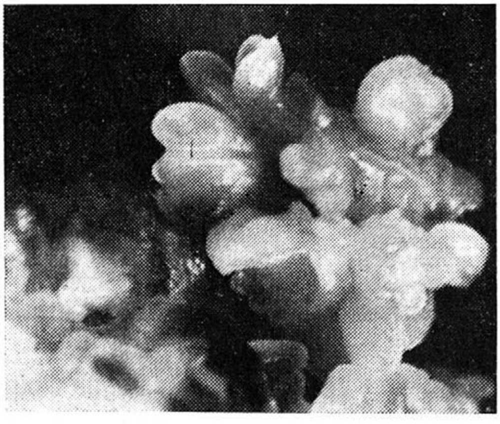
The regenerants were transplanted into garden soil and grown in a glasshouse to reach maturity. The progenies SC_1, SC_2, and SC_3 were cultivated in the field, in a parallel trial the seed of the cv. 'Rena' M_1-generation irradiated with ^{60}Co at 100 Gy were sown.

The experiment comprised the following variants:

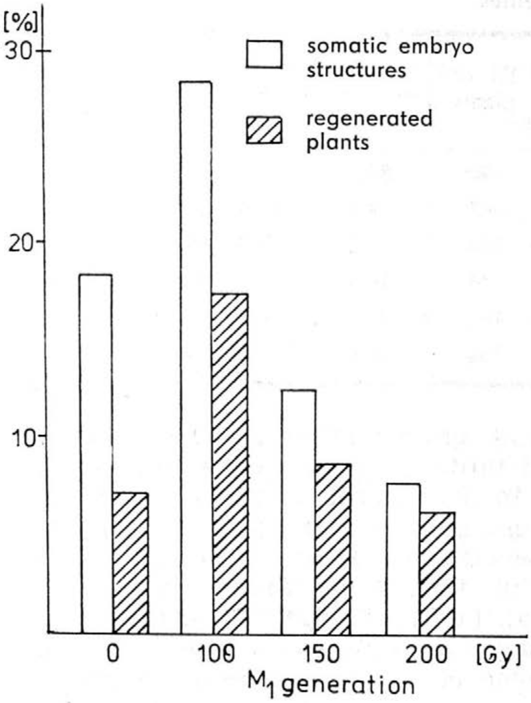
Control (without irradiation);
Variant A (without irradiation, evaluation of somaclonal variation in SC_3);
Variant B, C, D (seeds irradiated with ^{60}Co — 100, 150, 200 Gy, immature embryos removed from M_1 — plants, evaluation of combined somaclonal and induced variation in SC_3);
Variant E (seeds irradiated with ^{60}Co — 100 Gy, evaluation of M_3 — progeny).

RESULTS

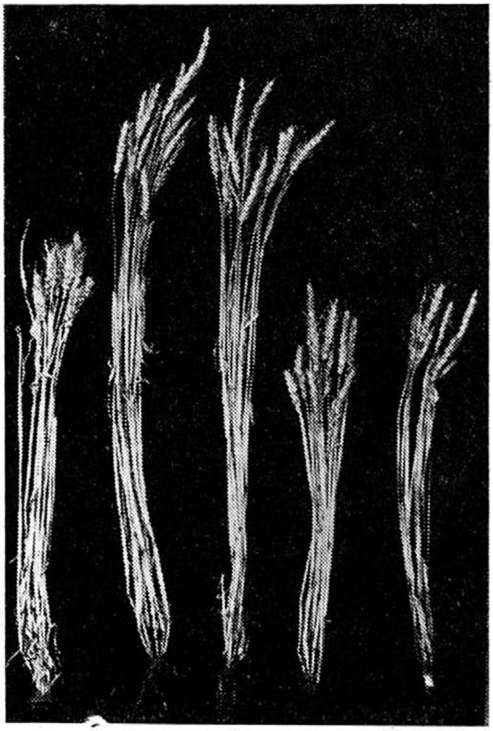
There was a remarkable increase in the amount of somatic embryo structures (7 to 28 %) and regenerants (5 to 17 %) in the culture of embryos removed from M_1 plants treated with low doses (100 Gy) of the mutagen ^{60}Co (Fig. 2).



1. Somatic embryo structures arising from scutellar callus



2. Effect of ^{60}Co dose on induction of somatic embryo structures and plant regeneration in spring wheat cv. 'Rena'



3. Height variants in SC_3 generation. Left: cv. 'Rena'; other: deviations in height

In the experimental variants of the respective generations we observed differences in the characters under study as compared to the control (Tab. I). There was a significant reduction in plant height of the somaclones in the variant A (Fig. 3), as well as in other variants due to gamma-ray irradiation resulting in final height of 72.2 cm (variant D), 74.8 cm (variant C) in contrast to the mean plant height of 80.1 cm (control).

It may be alleged that the percentage of aberrant types in respective variants was increasing with the rising dose of gamma-irradiation, the maximum being 7.1 % in the variant D (Tab. I). The impact of gamma--irradiation also resulted in a significant decrease in the values of agronomic characters, the most remarkable reduction being observed in grain number per spike (9 to 14 % decrease as compared to control), followed by grain weight per plant and 1 000-grain weight (Tab. I).

DISCUSSION

More intensive formation of somatic embryo structures derived from zygotic embryos of M_1 plants and increased plantlet regeneration have demonstrated a positive effect of low mutagen doses (i. e. 100 Gy of ^{60}Co). Induction of point mutations led to an increase in genetic heterogeneity of originally homozygous material. A study on plant height and some other agronomic characters in respective generations (i. e. 1 000-

I. Variation in SC_3 and other wheat progenies

Variant	Progenies	No. of plants	Height (cm)		No. of spikes per plant
			mean	range	
Rena C	15	290	80.1	75.0 – 90.0	6.1
A Rena SC_3	22	405	79.5	62.1 – 85.2	6.5
B Rena 100Gy SC_3	43	398	77.4	63.0 – 95.1	6.8
C Rena 150Gy SC_3	25	263	74.8	41.2 – 98.0	7.4
D Rena 200Gy SC_3	12	181	72.2	42.1 – 100.0	9.1
E Rena 100Gy M_3	15	185	76.4	49.3 – 89.1	6.6

-grain weight, grain weight per plant, grain number per spike] of the plants and their progenies obtained through callus regeneration shows genetic abnormalities as compared to the control. Significant variation was also observed in the characters both with simple and complex genetic background, such as presence/absence of awns, colour of spikelet glumes and grains, period of tilleting etc. Similar conclusions have been drawn by Larkin et al. [1984]. In contrast to the results of Ahloowalia and Sherington [1985] we have found no sterile plants in SC_3 generation; some of these have been detected in SC_1 only.

Regeneration of plants via somatic embryogenesis from callus derived from zygotic embryos of M_1 plants had a positive effect on increasing the frequency of mutations in respective experimental variants. As compared to traditional procedures of mutation breeding, it was possible to use rather small sets of plants in SC_2 and SC_3 generations after mutagen treatment.

The present results have proven practical and potential application of *in vitro* cultures in spring wheat after mutagen treatment with the aim of obtaining a higher percentage of mutations with agronomically important characters, using smaller sets of the plant material in successive generations as compared to traditional methods of mutation breeding.

Acknowledgements

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Grain weight per plant (g)		Grain number per spike		1000-grain weight		% mutations
mean	range	mean	range	mean	range	
10.4	6.6–13.1	46.5	39.2–48.4	39.4	29.0–35.2	0.0
10.1	8.5–13.9	46.7	39.6–51.4	31.5	25.0–36.3	1.1
9.5	5.2–16.8	43.7	37.0–53.1	30.7	24.2–34.7	2.4
10.1	2.3–17.8	41.2	30.3–47.1	30.7	25.1–36.1	3.0
9.8	2.1–17.9	40.0	29.1–49.1	30.1	23.1–34.1	7.1
9.8	7.9–11.4	44.3	36.0–49.3	31.1	28.1–33.2	1.3

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OHNOUTKOVÁ, L. — OHNOUTKA, Z. (OSEVA — Výzkumný a šlechtitelský ústav obilnářský, Kroměříž, Šlechtitelská stanice Hrubčice): *Hodnocení somaklonální variability a indukované mutageneze u pšenice jarní.* Genet. a Šlecht., *24*, 1988 (4) : 257-262.

Byly odvozeny somatické embryoidy u pšenice jarní ze scutelární části zygotického embrya. Procento embryoidních struktur se pohybovalo od 7 do 28, procento regenerovaných rostlin od 5 do 17. Zvýšená tvorba somatických embryoidů byla prokázána u kalusu odvozeného ze zygotických embryí M_1 generace rostlin ovlivněných nízkými dávkami mutagenu ^{60}Co. V generaci SC_3 bylo hodnoceno 102 potomstev a 1247 rostlin; výška rostlin a některé výnosové prvky (HTZ, hmotnost zrna na rostlině, počet zrn v klasu). Potomstvo vykazovalo odchylky ve srovnání s kontrolní variantou jak pro znaky jednoduše založené, tak se složitějším genetickým založením. Kultivace embryí z rostlin M_1 a následné získání somaklonů mělo kladný vliv na zvýšení frekvence mutací.

Triticum aestivum L.; pšenice jarní; regenerace; somaklonální variabilita; mutageneze; agronomické charakteristiky

ОГНОУТКОВА, Л. — ОГНОУТКА, З. (ОСЕВА — Научно-исследовательский и селекционный институт зерновых культур, Кромержиж; Селекционная станция Грубчице): **Оценка сомаклональной изменчивости и индуцированного мутагенеза у яровой пшеницы.** Genet. a Šlecht., *24,* 1988 (4) : 257-262.

Соматоэмбрисиды выведены у яровой пшеницы из скутелярных партий зиготного эмбриона. Процент ембриоидных структур 7—28, а регенерированных растений 5—17. Повышенное образование соматических эмбриоидов установлено у каллуса, выведенного из зиготных эмбрионов M_1 поколения растений, обработанных низкими дозами мутагена ^{60}Co. В поколении СЦ$_3$ оценивали 102 потомства и 1247 растений по высоте растений и некоторые элементы урожая (ВТЗ, вес зерна на растении, количество зерен в колосе). Потомство показывало отклонения от контроля как по упрощенной закладке признаков, так и по сложной. Культивация эмбрионов из M_1 и последующее получение сомаклонов стимулировали частоту мутаций.

Triticum aestivum L.; пшеница яровая; регенерация; сомаклональная изменчивость; мутагенез; агрономические характеристики

OHNOUTKOVÁ, L. — OHNOUTKA, Z. (OSEVA — Forschungs- und Züchtungsinstitut für Getreidebau, Kroměříž, Züchtungsstation Hrubčice): *Bewertung der somaklonalen Variabilität und der induzierten Mutagenese bei Sommerweizen.* Genet. a Šlecht., *24,* 1988 (4) : 257-262.

Es wurden somatische Embryoide bei Sommerweizen aus dem scutellaren Teil des zygotischen Embryos abgeleitet. Der Prozentsatz der embryoiden Struktur schwankte von 7 bis 28 %, derjenige der regenerierten Pflanzen von 5 bis 17 %. Eine höhere Bildung von somatischen Embryoiden konnte bei einem aus zygotischen Embryonen der M_1-Generation der mit niedrigen Gaben des Mutagens ^{60}Co beeinflussten Pflanzen abgeleiteten Kallus nachgewiesen werden. In der SC$_3$-Generation wurden 102 Nachkommenschaften und 1247 Pflanzen, die Pflanzenhöhe und einige ertragsbildende Faktoren (Tausendkorngewicht, Korngewicht je Pflanze, Kornzahl je Ähre) bewertet. Die Nachkommenschaft wies Abweichungen im Vergleich zur Kontrollvariante sowohl für einfach angelegte, als auch für genetisch kompliziert angelegte Merkmale auf. Die Kultivierung der Embryonen aus den M_1-Pflanzen und die nachfolgende Gewinnung der Somaklone wirkten sich positiv auf die Steigerung der Mutationsfrequenz aus.

Triticum aestivum L. & Sommerweizen; Regenerierung; somaklonale Variabilität; Mutagenese; agronomische Charakteristiken

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VARIABILITY OF PHYSIOLOGICAL TRAITS IN LUCERNE REGENERATED FROM TISSUE CULTURES

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Some characteristics of water regime and chlorophyll content were tested in seven groups of plants regenerated from calluses derived from one lucerne plant. It was statistically proved that some groups of plants significantly differed in traits characterizing drought resistance (high water-holding capacity, decrease of transpiration in full bloom) and in the content of chlorophyll. The results indicate that plant regeneration from callus cultures by means of somatic embryogenesis can be used in order to develop new plant materials combining the required physiological traits.

lucerne; callus cultures; somatic embryogenesis; chlorophyll; transpiration; water-holding capacity

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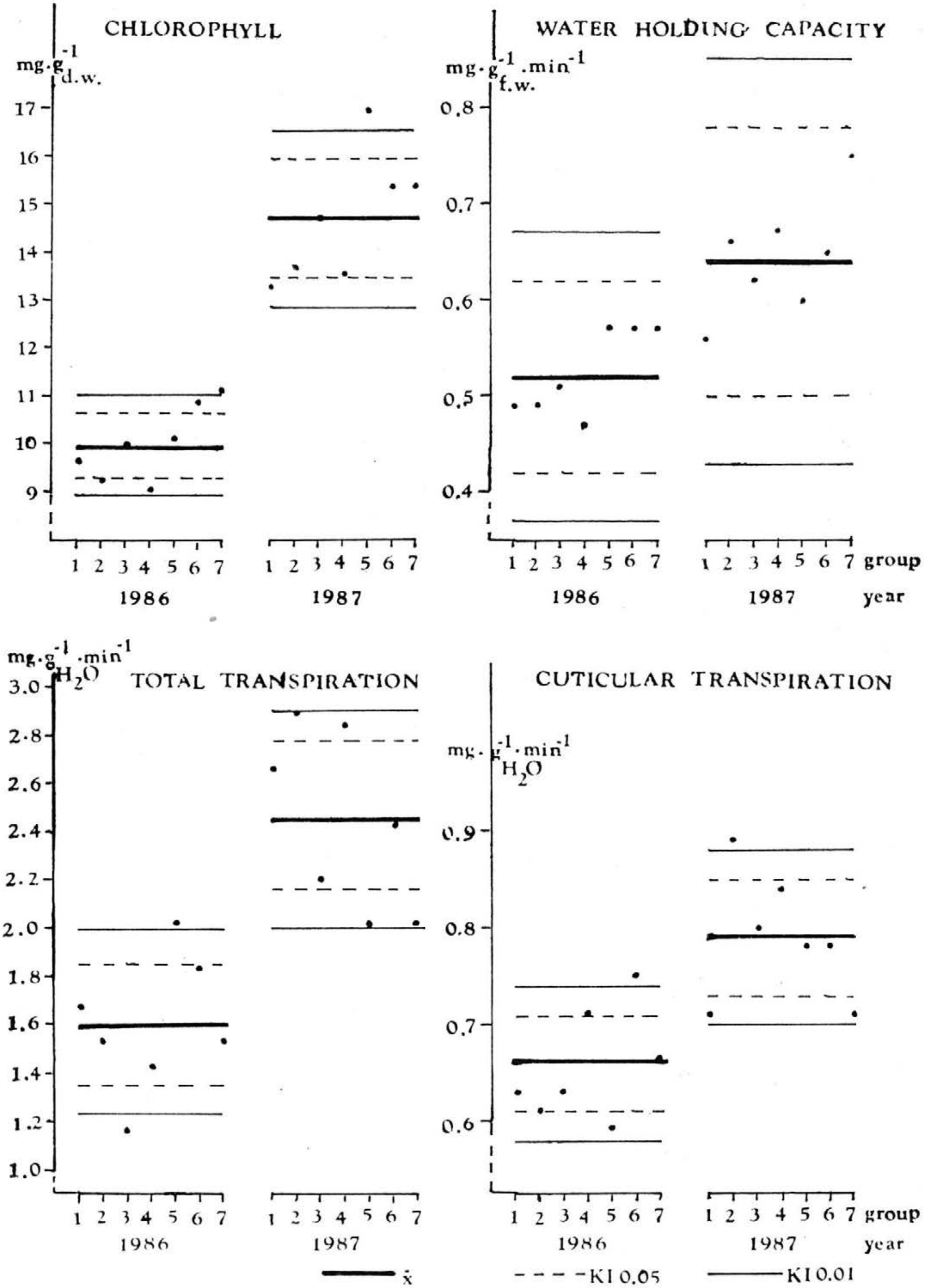
Plant tissue cultures have been successfully used in recent years as an unconventional propagation and breeding method. In the sphere of breeding this concerns, in particular, the exploitation of genetical variability manifested on the level of the regenerated plants and of its progeny. This so called somaclonal variability includes not only the genetical constitutions of the primary explant, but also the probability of obtaining new genotypes during *in vitro* cultivation. We can then obtain a group of regenerated plants in which variability on chromosomal, morphological, biochemical, physiological and other levels is manifested. It was on the basis of these facts that the goal of this study was formulated, consisting in estimating the variability of selected physiological characteristics in lucerne plants regenerated by means of somatic embryogenesis and in the possibility of further selection of the best individuals. The traits tested were chosen according to correlations with seed and fodder yields, determined in our preliminary experiments.

MATERIALS AND METHODS

Seven plants regenerated by somatic embryogenesis (Novák, Konečná, 1982) from callus cultures derived from plant G22 were cloned, resulting in an experimental population (7 groups) with a total of 40 individuals. We estimated the physiological traits as follows: chlorophyll content (Erdelský, Frič, 1979),



1. Comparison of plant groups with the population mean — confidence interval estimation (KI)

I. Evaluation of differences between groups by means of variance analysis and Tukey's test

Year			1986			1987				
Characteristics	source of variability	f	MS	D_t 0.05	contrasts	MS	D_t		contrasts	
							0.05	0.01	0.05	0.01
Chlorophyll	groups	6	3.29^{+}	0.98	7–3,1,2,4 6–1,2,4	10.47^{++}	2.11	2.53	5–3	5–2,4,1
	technical error	35	1.34		5–4	1.60				
Water holding capacity	groups	6	0.01			0.02				
	technical error	35	0.01	–	–	0.01	–	–	–	–
Total transpiration	groups	6	0.47			0.76				
	technical error	35	0.57	–	–	0.34	–	–	–	–
Cuticular transpiration	groups	6	0.02			0.03				
	technical error	35	0.02	–	–	0.02	–	–	–	–

$^{+}$ $P \leqq 0.05$
$^{++}$ $P \leqq 0.01$

transpiration rate (total and cuticular), and water holding capacity using the method of transpiration curves (Slavík, 1965).

The measurements were carried out in the lay out year (first year, 1986) and in the first harvest year (second year, 1987) in the full bloom stage of the second regrowth. Analysis of variance, confidence interval and coefficient of variation were used for the statistical evaluation of the results obtained.

RESULTS

Values of the characteristics studied in the individual groups are given in Fig. 1, as well as the mean for the whole population (all groups) and the range of the confidence interval on the levels of $P = 0.05$ and 0.01. In Tab. I the statistical evaluation of differences between groups is shown, based on the analysis of variance. Coefficients of variation of the characteristics within groups and between groups are given in Tab. II.

It has been stated in evaluating chlorophyll content by the analysis of variance (Tab. I) that groups 7, 6 and 5 with the maximum chlorophyll content differed significantly from groups 4 and 2 with the minimum one in the first year. Similar results were found by evaluating the confidence interval (the means of groups were compared with the mean of the whole population, Fig. 1). In this case significantly higher values than the population mean were found in groups 7 and 6 and lower values in groups 4, 2 and 1. In the second year, group 5

II. Coefficient of variation v [%] in physiologic characteristics within groups and between groups of plants regenerated from callus cultures

Group	Chlorophyll		Water holding capacity		Total transpiration		Cuticular transpiration	
	1986	1987	1986	1987	1986	1987	1986	1987
1	9.8	9.4	20.4	17.9	37.7	23.5	15.9	14.1
2	8.0	9.0	20.4	23.9	47.1	14.2	16.4	24.7
3	10.8	2.3	10.8	5.2	39.7	22.3	22.2	12.5
4	16.0	15.6	11.7	5.6	39.4	29.6	19.7	12.5
5	14.2	7.8	24.6	16.7	39.6	35.1	7.6	18.0
6	12.0	7.4	35.1	15.4	35.9	21.8	29.3	18.0
7	10.3	5.5	24.6	13.7	26.1	9.7	14.9	35.2
$\bar{x}$	11.6	8.1	21.1	14.1	37.9	22.3	18.0	16.1
Among groups	7.4	9.0	8.6	7.0	17.5	14.6	8.7	8.3

had the highest chlorophyll content and groups 1, 4 and 2 the lowest, according to analysis of variance (Tab. I). Evaluation by means of confidence interval (Fig. 1) showed nearly identical results. Significant differences from the population mean were found in groups 5 and 1 with the highest and lowest values, respectively.

Water regime characteristics did not differ significantly in any year, using analysis of variance (Tab. I), whereas the confidence interval (Fig 1) showed significant deviations of groups from the population mean in the case of total and cuticular transpiration. A desirable low total transpiration in the full bloom period was found in group 3 in the first year and in groups 5 and 7 in the second. Significantly lower values of cuticular transpiration in comparison to the population mean were found in groups 2 and 5 in the first year and groups 1 and 7 in the second. The water holding capacity, characterized by a low water loss during the linear phase of transpiration curve (which starts between the 1st and 2nd hour of fading), was very satisfactory for all groups in both years. No differences between groups were found by the two methods of statistical evaluation.

Confidence intervals used for testing individual plants within the groups showed also a number of significant deviations from the group means. Thus in the 1st and 2nd years, four and six plants with high chlorophyll content were found, five and eight plants showed the favourable low transpiration (total or cuticular), and four and two plants manifested an excellent water holding capacity, respectively.

The coefficient of variation (Tab. III) within the groups was relatively low (about 20 % on the average) in all characteristics with the exception of total transpiration for the first year (about 40 %). The lowest values were found in chlorophyll content (about 10 %). In the second year the values of the coefficient of variation decreased, especially in the case of total transpiration. The variability between the groups was smaller than within the groups, with values from 7.4 % in chlorophyll to 17.5 % in transpiration, and it remained almost on the same level in the second year.

DISCUSSION

Our previous trials in lucerne (Ptáčková, 1981; Bystřická, Ptáčková, 1985, 1987) demonstrated close correlations between many of the physiological characteristics and seed yield. Reduced total transpiration, low cuticular transpiration and a high water holding capacity in full bloom resulted in high seed production. All these characteristics denote in a certain way drought resistance. This important trait as a genetical potential feature develops in plants gradually due to the effect of drought in summer months. During this time lucerne usually grows in a dry soil because of its very high water consumption (Ptáčková, 1987). From the point of view of seed production drought resistance is more important during the full bloom period, which is why we chose this stage for our tests.

The role chlorophyll in photosynthesis is generally known. It was stated that the lucerne plants dark green in colour are more productive than plants with light green leaves (Koter et al., 1976). In our previous papers cited above a correlation between the amount of chlorophyll or its components (C_a, C_b) and the growth characteristics (leaf area per plant, relative leaf weight), and also seed yield, appeared in some phenophases.

In the study presented with plants derived from tissue cultures the significant differences in chlorophyll amount was found by means of analysis of variance. Characteristics of drought resistance did not differ, and the whole material tested from this point of view was good. It had a high water holding capacity and a low transpiration, especially in a dry first year.

When estimating by means of the confidence interval, significant deviations of groups from the population mean were demonstrated in all characteristics except for water holding capacity. This enabled in both years to detect groups of plants with the highest chlorophyll content and the highest resistance (i. e. those with the lowest total or cuticular transpiration). In some groups the characteristics changed in the second wet year. Group 2 no longer manifested its resistance — its transpiration increased significantly. On the other hand group 5 was classified unambigiously as material with a desirable low transpiration, though its absolute values did not change. Group 3 did not remain according to the statistical evaluation among the superior ones, nevertheless in all traits characterising drought resistance it ranged above the average (in comparison with the population mean).

Considering all results and with respect to a certain replaceability of water regime characteristics, groups 5 and 7 appeared the best from the viewpoint of both traits studied (i. e. resistance and chlorophyll content).

It can be stated that according to the values of the coefficient of variation the variability of most physiological characters is low (in a number of cases under 10 %) and the traits studied can be considered stable. The considerable decrease in variation coefficient values in the second year suggests a lowering of variability within groups. The stabilization of some characteristics could be caused by the ontogenetical development of plants, as well as by change of environmental conditions, when there was no out standing differentiation in drought resistance in a humid year, compared with the first year with dry conditions.

In both years, the evaluation of plants within the groups by means of the confidence interval showed, deviations from the mean of a given group (either in positive or negative sense), in about a half to two-thirds of the cases. The experimental results show that in plants regenerated from calluses by somatic embryogenesis variability in the physiological traits studied exists. From the 40 tested plants eleven exceeded the mean in the characteristics of production, water regime, and chlorophyll content, and four of these plants kept their good traits during both experimental years. These individuals appear to be promising for further use in breeding.

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PTÁČKOVÁ, M. — BYSTŘICKÁ, A. — NEDBÁLKOVÁ, B. — BINAROVÁ, P. (OSEVA — Výzkumný a šlechtitelský ústav pícninářský, Troubsko; Ústav experimentální botaniky ČSAV, Olomouc): *Proměnlivost fyziologických ukazatelů u vojtěšky regenerované z tkáňových kultur.* Genet. a Šlecht., *24*, 1988 (4) : 263-269.

U sedmi skupin rostlin regenerovaných cestou somatické embryogeneze z kalusů odvozených z jedné rostliny vojtěšky byly testovány některé charakteristiky vodního provozu a obsah chlorofylu. Statisticky se prokázalo, že jednotlivé skupiny rostlin se významně odlišují v ukazatelích charakterizujících odolnost vůči suchu (vysoká schopnost udržet vodu, pokles transpirace v plném květu) i v množství

chlorofylu. Výsledky naznačují, že regeneraci rostlin z kalusových kultur cestou somatické embryogeneze lze použít pro tvorbu nových rostlinných materiálů s kombinací žádaných fyziologických vlastností.

vojtěška; kalusové kultury; somatická embryogeneze; chlorofyl; transpirace; schopnost udržovat vodu

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ПТАЧКОВА, М. — БЫСТРЖИЦКА, А. — НЕДБАЛКОВА, Б. — БИНАРОВА, П. (ОСЕВА — Научно-исследовательский и селекционный институт кормоводства, Троубско; Институт экспериментальной ботаники ЧСАН, Оломоуц): **Изменчивость физиологических показателей у люцерны, регенерированной из тканевых культур.** Genet. a Šlecht., *24*, 1988 (4) : 263-269.

У 7 групп растений, регенерированных путем соматического эмбриогенеза из каллюсов одного растения люцерны, аттестировали характеристики водного режима и содержание хлорофилла. Отдельные эти группы заметно отличаются по показателям засухоустойчивости (высокая вододерживающая способность, понижений транспирации в полном цветении) и по количеству хлорофилла. Как показывают результаты, регенерация растений из каллюсных культур путем соматического эмбриогенеза может служить для создания новых растительных материалов с комбинацией требуемых физиологических свойств.

люцерна; каллюсные культуры; соматический эмбриогенез; хлорофилл; транспирация; вододерживающая способность

PTÁČKOVÁ, M. — BYSTŘICKÁ, A. — NEDBÁLKOVÁ, B. — BINAROVÁ, P. (OSEVA — Forschungs- und Züchtungsinstitut für Futterpflanzen, Troubsko; Institut für experimentelle Botanik der ČSAV, Olomouc): *Veränderlichkeit physiologischer Merkmale bei der aus Gewebekulturen regenerierten Luzerne*. Genet. a Šlecht., *24*, 1988 (4) : 263-269.

Bei sieben Gruppen von Pflanzen, regenerierten mittels somatischer Embryogenesis aus Kalluskulturen, die von einer einzigen Pflanze abgeleitet worden waren, sind einige Charakteristiken des Wasserbetriebes und der Chlorophyllgehalt getestet worden. Es konnte statistisch nachgewiesen worden, dass sich die einigen Pflanzengruppen bedeutend in Trockenheitsresistenz charakterisierenden Merkmalen (ein hohes Gewebe-Wasserhaltendsvermögen, Transpirationssenkung bei voller Blüte), sowie in der Chlorophyllmenge unterscheiden. Die Ergebnisse lassen erwarten, dass die aus Kalluskulturen mittels somatischer Embryogenesis erzielte Regeneration von Pflanzen auch für die Schaffung neues Pflanzenmaterials und dessen Kombination mit erforderlichen physiologischen Eigenschaften zu nutzen sei.

Luzerne; Kalluskulturen; somatische Embryogenesis; Chlorophyll; Transpiration; Wasserhaltendsvermögen

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SCIENTIFIC JOURNALS

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COMPARATIVE STUDY OF EMBRYOGENESIS IN SUNFLOWER (*HELIANTHUS ANNUUS* L.)

A. Kováčik, V. Vlčková

KOVÁČIK, A. — VLČKOVÁ, V. (Research Institute for Crop Production, Praha-Ruzyně): *Comparative Study of Embryogenesis in Sunflower (Helianthus annuus L.)*. Genet. a Šlecht., *24*, 1988 (4) : 271-280.

Embryogenesis during the first 12 days after pollination was studied on the longitudinal sections of a sunflower ovary. The size of a developing embryo, embryo sac and achene were evaluated in five kinds of the crosses: intraline, intravarietal, interline, line-varietal and intervarietal. The lines possessing male pollen sterility were also used in the crosses. Out of the used genotypes, a trend to the elongation of achene was shown by a fertility restorer line as father and the variety VNIIMK 6540 as mother. The CMS line CG displayed a trend to an achene width increase. The line-varietal hybrids have a tendency to the greater width of embryo sac.

Helianthus annuus L.; pollination; embryogenesis

Nowadays, interspecific hybridization became an integral part of sunflower breeding. This type of hybridization is materialized primarily with the aim to develop new sources of CMS and fertility restoration, sources of disease resistance, as well as new progressive morphological and physiological traits that enrich the germplasm of cultivated sunflower (Leclerq, 1969; Whelan, 1981; Vranceanu, Stoenescu, 1971).

In distant hybridization some complications often occur that make this procedure partly or completely impossible (incrossability, decreased viability of hybrid embryos, etc.).

Advancement of tissue cultures helps to overcome these obstacles and enables a broader utilization of wild sunflower species as resistance sources (Bohorova et al., 1985; Chandler, Beard, 1983; Power, 1987).

Continuous selection with the aim to improve economically important traits can affect the anatomical structure of flowers (Samataro et al., 1985), as well as fertilization processes in dependence on parental lines used in crosses. With regard to the broad utilization of CMS lines in sunflower hybrids grown at present, their effect on the fertilization level has to be also considered. Development of the sunflower embryo sac before — and after fertilization (Newcomb, 1973a, b), as well as problems of embryo nutrition (Newcomb, Steeves, 1971) have been described.

I. A survey of the studied hybrid combinations

Variant	Mother		Father	Type of cross
A	VNIIMK 6540	×	VNIIMK 6540	intravarietal
B	VNIIMK 6540	×	Felix	intervarietal
C	CMS CG	×	Felix	line - varietal
D	CMS 3508	×	VNIIMK 6540	line - varietal
E	CMS 1607	×	RF 121	hybrid
F	GMS AST 117	×	RF 121	hybrid
G	CMS CG	×	CG	intraline

The objective of this study was to investigate possible differences in the speed of development of the fertilized egg cell, embryo sac and achene in sunflower in dependence on genotypes used in crosses.

MATERIALS AND METHODS

In the study of embryogenesis in the course of the first days after pollination, the following sunflower genotypes were used:

VNIIMK 6540 — varietal population
Felix — hybrid
CMS CG, CMS 1607 and CMS 3508 lines with cytoplasmic male sterility
GMS AST 117 line with genetic male sterility
CG — sterility maintainer
RF 121 fertility restorer

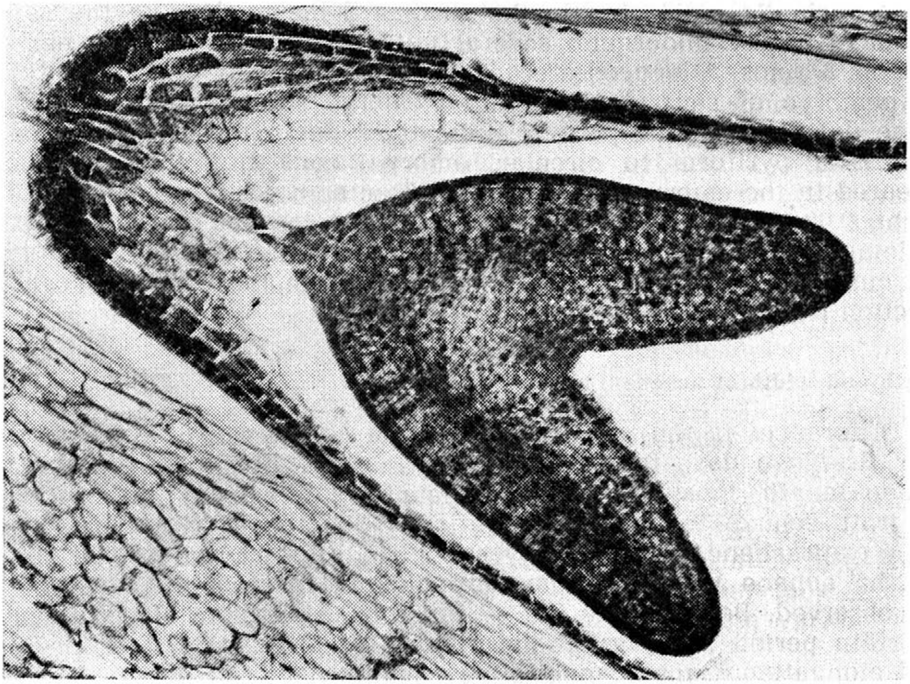
Tab. I presents a survey of the studied hybrid combinations. Fertile mother plants were emasculated by hand. CMS and GMS mother plants displayed complete sterility. After pollination the tubular flowers were separated in the following intervals; 2, 3, 4, 5, 6, 11, 12 days and fixed in Navashin fixative. Then they were dehydrated in gradually increased concentrations of alcohol and transferred into paraffin according to classical methods (Němec, 1962). On a microtome, longitudinal sections 10—15 μm thin were cut and stained with a stain mixture safranine--light green. After differentiation and clearing preparations were imbedded in Canada balsam.

Developmental stages of sunflower embryo-proembryo, globular embryo (Fig. 1), heart stage (Fig. 2), torpedo and developing cotyledons were defined after Newcomb (1973). On longitudinal sections of the ovary the development of the pollinated mother cell, embryo, embryo sac and developing achenes was investigated. Their width and height was measured in a light-microscope by an ocular micrometer.

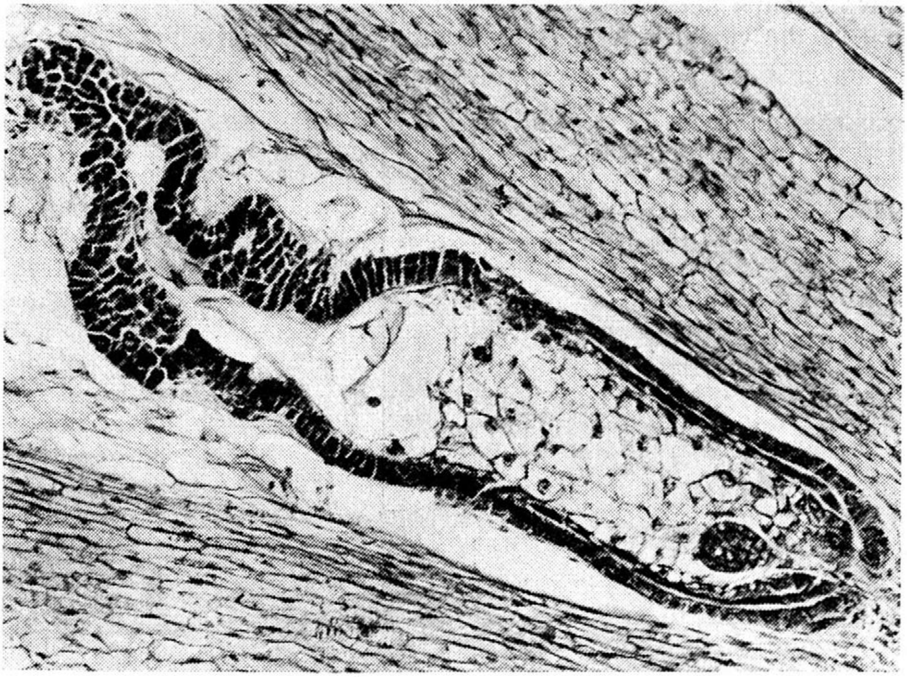
In each trait, single variants were compared by *t*-test for pair values. Relation between trait pairs in single variants was evaluated by testing the similarity of regression coefficients in regression of two traits.

RESULTS AND DISCUSSION

Evaluation of an egg cell development in the embryo already on the second day after pollination in single variants differed. In variant A, B, G the fertilized egg cell containing the spermatic nucleus in its nucleus was still present. One of the synergids was in the beginning of its degeneration. Width of the egg cell in the variants A, B was 0.04 mm,



1. Variant C. Embryo sac containing a globular embryo and growing endosperm. Endosperm cells fill the embryo sac towards chalaza (125-fold magnification)



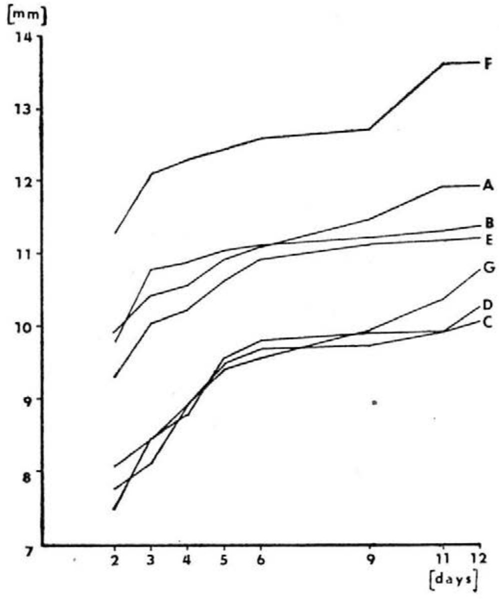
2. Variant E. Late heart — stage embryo which is separated by a zone from the endosperm (120-fold magnification)

in the variant G 0.03 mm. In the variant E the nucleus of the central cell has already undergone several mitotic divisions without egg cell division. Upmost advanced were the variants C, D, F that already had a proembryo of several cells in the embryo sac, surrounded by cells of the developing endosperm. On the third day after pollination in all variants a pyriform to circular embryo consisting of more cells appeared in the embryo sac. Width of these embryos was 0.05—0.07 mm, height 0.08—0.09 mm. The most advanced was the variant D (line-varietal cross) having embryo in the beginning of the heart stage, 0.11 mm high. The cellular endosperm grows in the embryo sac in the direction from micropyle to chalaza.

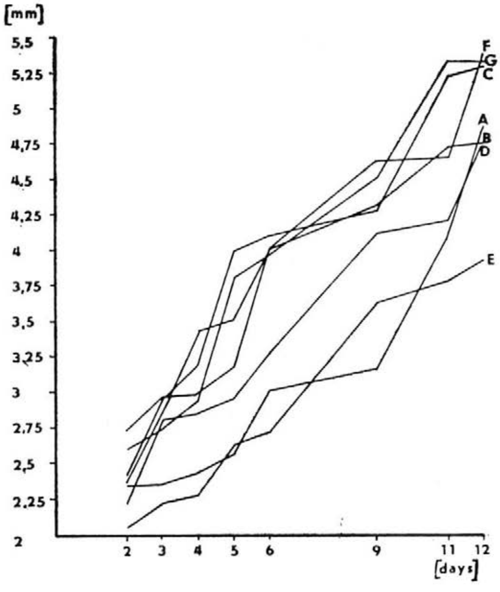
Length and width of achene

Differences in the length and width of achenes also appear already after first two days following the pollination (Fig. 3, 4). In the trait achene length, most variants significantly differ from each other. In the trait achene width, less significant differences were found than in the trait achene length; however, 2/3 of all differences are significant. For the achene length, a relatively distinct increase till the 5th day was observed. Between the 5th — 9th day the growth slows down for a certain period (lasting till the 11th day in the variants B, C, D, E). Then elongation of the achene follows again.

The longest achenes were in the variant F — cross of a GMS line and a fertility restorer. This variant possesses extremely long achenes within the framework of the studied set. The set can be further divided into two groups according to the height of achenes. The first group is formed by the variants A, B (i. e. crosses between varieties and hybrids)



3. Dependence of achene height on the time of fertilization



4. Dependence of achene width on the time of fertilization

and the variant E (i. e. cross of a CMS line and a fertility restorer) that have medium long achenes.

On the other hand, variants C, D (crosses of CMS lines and varieties) and the variant G (intraline hybrid) have shorter achenes. Fertility restorer as father and variety VNIIMK 6540 as mother show a trend towards the elongation of achenes in hybrids. Relatively most continuous increase of achene length can be observed in close crosses — intravarietal (variant A) and intraline (variant G), that have no distinct period of stagnation of achene elongation.

Width of achene have continuous growth in the course of observation. Three groups can be again formed, into the first one variants with broader achenes belong (C, F, G), medium broad achenes are in the variants A, B, D and relatively narrow ones in the variant E. A trend towards a broader achene is induced by the CMS line CG. The increase of achene width has two culmination periods. Variants C, D, F, G, i. e. most line crosses culminate between the 4th and 6th day. In the second period between the 9th and 12th day, variants C, G, F, A, B culminate, hence line-, as well as varietal crosses. In general, till 12 days after pollination the variant F has long, broad achenes, variants G, C broad, short achenes, variants A, B — medium broad and medium long achenes, the variant D — short, medium short achenes and the variant F — narrow, medium long achenes.

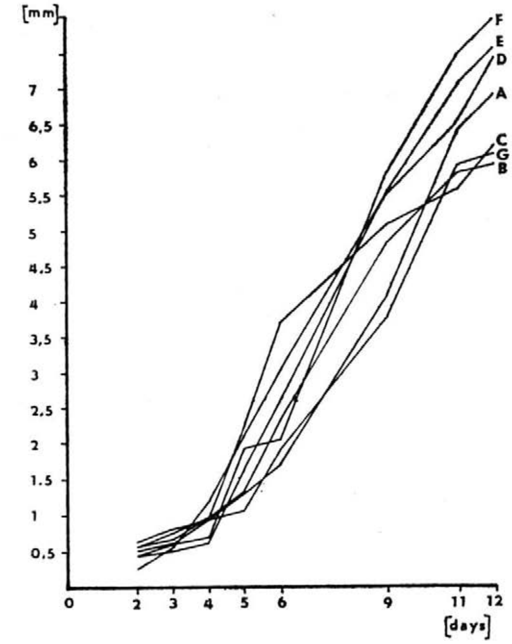
It can be summarized that all types of interhybrids first show an accelerated elongation of achenes, later on a short stagnation followed again by an intensive growth. Intravarietal and intraline crosses display a slower but uninterrupted growth of achenes.

Length and width of the embryo sac

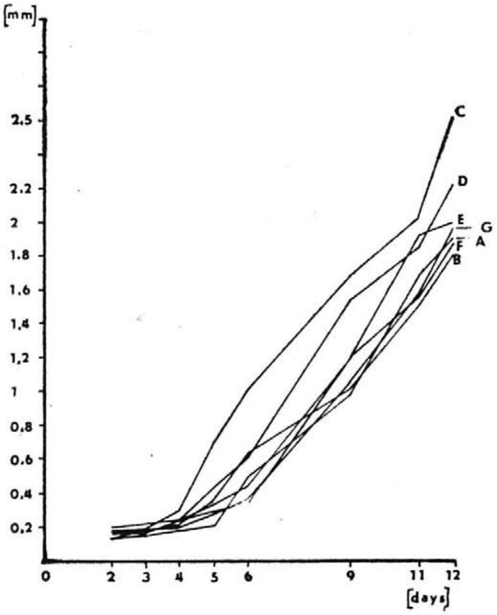
In single variants, length of the embryo sac can be well distinguished already from the first two days after pollination. In the trait length of the embryo sac no differences can be noted. In principles, the set of variants is homogeneous, in the trait width of the embryo sac more significant differences appear, particularly between the 4th and 5th day (Fig. 5, 6).

The variant F (with the longest achenes) has also the longest embryo sac but not in the whole course of the growth. E. g., on the 6th day when the achene is the longest one of all variants, the embryo sac is relatively short. On the other hand, the variant C, possessing a short achene, as well as a short embryo sac on the end of the studied period, has the relatively longest embryo sac on the 6th day. Of single variants, D and E have a relatively longer embryo sac than it would correspond with the length of achene, on the contrary, variants B and G have a shorter embryo sac than it corresponds with the length of achene.

In general, the width of the embryo sac is uniform till the 4th day. Variants C and D, i. e. line varietal hybrids show broader embryo sacs. Hybrid C has the broadest both the embyo sac and achene, on the contrary, the height of the embryo sac and achene belongs to the lowest ones. Hybrid D has a broad embryo sac but the achene only



5. Dependence of embryo sac height on the time of fertilization



6. Dependence of embryo sac width on the time of fertilization

medium broad, the height of the embryo sac medium and the achene height low.

The length and width of the embryo sac increases considerably in relation with the achene size. Nevertheless, some exceptions appear that cannot be mostly correlated with the type of the hybridization.

Length and width of the embryo

In single variants the length of the embryo can be well distinguished as late as from the 5th day. In the trait length of embryo also few significant differences appear. The trait width of embryo is again more differentiated than the length of embryo. The maximum embryo length is achieved in the variants D, E, F what is approximately in relation with the length of the embryo sac. Only the variant D has a relatively longer embryo than all other ones which contrasts in comparison with the length of the embryo sac that is ranked as far on the third place. Variants C, D, E have a relatively longer embryo than it corresponds with the length of their achene. In comparison with the length of the achene and embryo sac, the shortest embryo appears in the variant A, i. e. in the intravarietal hybrid within the population VNIIMK 6540.

In single variants, the embryo width can be distinguished starting the 4th day. Maximum values are achieved again in the variant C with a broad achene and broad embryo sac. Also the variant D has the width of the embryo approximately in relation, although between the 9th and 11th day the embryo growth into the width decreases, whereas the embryo sac continues to grow.

Embryo in the variant E (CMS × fertility restorer) grows relatively faster into the width than it corresponds with the growth of the embryo sac and especially with the achene growth into the width. Other variants C, D, G, A, F, B have a wellbalanced relation between the width of the embryo sac and embryo. Hence, disproportions between the embryo width and achene width are similar as between the embryo sac width and achene width (i. e. in the variants C and D and in addition in E). The variant C represents the type with a broad embryo, the variant F represents the type with a long embryo which corresponds with the relation of the embryo sac.

The embryo develops differently from the growth of achene and embryo sac. Variants of line-varietal and interline crosses possess a relatively longer embryo than it corresponds to the length of their achene.

The embryo width corresponds with the relations of achene and embryo sac width except the interline cross CMS 1607 × RF 121. This variant of interline crosses differs from all other variants in that its embryo uses more intensively the space of the embryo sac as to the width. Whereas in other variants embryo grows equally with the embryo sac, i. e. the size of the embryo sac exceeds the embryo size, in the above mentioned variant the embryo grows relatively faster so that it fills the width of the embryo sac better up. This phenomenon can be connected with the fact that the both used lines of the above mentioned variant have a good combining ability, whereas in other inter-hybrid combinations it is possessed by utmost one of the parents.

Evaluation of differences between variants in the study of two traits dependence

In the evaluation of differences between variants in the dependence of trait pairs, it appeared that the relation between the achene length, embryo sac and embryo length was approximately equal in all variants (Tab. II).

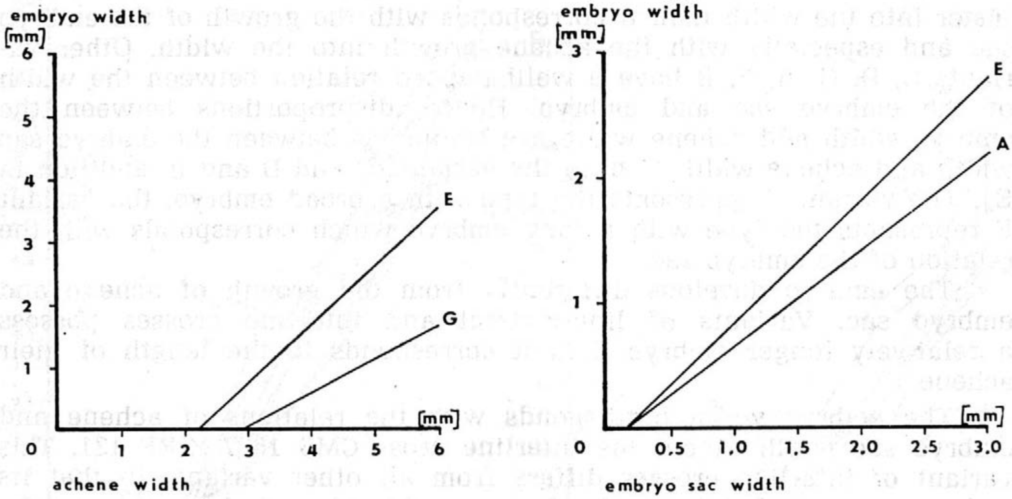
In the values for the width, some significant differences were found in the relation achene width to embryo sac width and in the relation embryo width to achene width (Tab. III). In the third combination of traits achene width — embryo sac width no differences between the variants have been found. The dependence of embryo width on

II. Regression coefficient between length characters with

Achene — embryo sac	2.235 up to 3.695	C — F
Achene — embryo	1.743 up to 2.982	C — F
Embryo sac — embryo	0.683 up to 0.943	A — D

III. Regression coefficient between width characters with

Achene — embryo sac	0.599 up to 0.976	G — E
Achene — embryo	0.548 up to 0.943	G — E
Embryo sac — embryo	0.755 up to 0.962	A — E



7. Expression of the extreme linear regressions of embryo width on achene width and embryo sac width

achene width and that one of embryo width on embryo sac width differs significantly in the variant E (i. e. combination CMS line × fertility restorer line). In the first case (dependence on the achene width) the variant E differs from A, B, F, G. In the second case (dependence on the embryo sac width) the variant E differs from A, D, F.

In both cases the value of regression coefficient b for the E variant achieves the highest level of all variants and approaches at most the value $b = 1$. This means that in the variant E the embryo growth into the width is in close harmony with the growth of the embryo sac, as well as the achene.

The course of the dependence in extreme variants in the second and third relation is illustrated on Fig. 5.

CONCLUSIONS

Evaluation of the achene length and width in the period of observation did not show any distinct trends with respect to the type of hybridization, i. e. neither the effect of heterosis nor the effect of inbreeding in CMS lines in comparison with varietal populations. Of the used genotypes, a trend towards the elongation of achene was shown by a fertility restorer line as father and variety VNIIMK 6540 as mother. The CMS line CG displayed a trend towards the achene width increase.

The length and width of the embryo sac grows in relation with the achene size to a considerable degree. Line-varietal hybrids have a trend towards an increased width of the embryo sac. The embryo width corresponds with the relations of achene — as well as the embryo sac width except the interline cross CMS 1607 × fertility restorer. In this case the embryo grows relatively faster which can be in connection with a good combining ability of both used lines.

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KOVÁČIK, A. — VLČKOVÁ, V. (Výzkumný ústav rostlinné výroby, Praha-Ruzyně): *Srovnávací studium embryogeneze u slunečnice (Helianthus annuus L.).* Genet. a Šlecht., *24,* 1988 (4) : 271-280.

Na podélných řezech semeníkem slunečnice byla sledována embryogeneze v průběhu prvních 12 dnů po opylení. Byly hodnoceny rozměry vyvíjejícího se embrya, zárodečného vaku a nažky u pěti druhů křížení: vnitroliniového, vnitroodrůdového, meziliniového, odrůdovoliniového a meziodrůdového. Ke křížení byly použity i linie se samčí pylovou sterilitou. Hodnocení výšky a šířky nažky ve sledovaném období neukázalo žádné zřetelné tendence ve vztahu k typu hybridizace. Sklon k prodlužování nažky má z použitých genotypů linie obnovitel fertility jako otec a odrůda 'VNIIMK 6540' jako matky. Sklon k větší šířce zárodečného vaku mají odrůdovoliniová hybridi.

Helianthus annuus L.; opylení; embryogeneze

КОВАЧИК, А. — ВЛЧКОВА, В. (Научно-исследовательский институт растениеводства, Прага-Рузыне): **Сравнительное исследование эмбриогенеза у подсолнечника** (*Helianthus annuus* L.). Genet a Šlecht., *24*, 1988 (4) : 271-280.

На продольных срезах семенника подсолнечника определяли эмбриогенез в первые 12 дней после опыления. Определяли размеры развивающегося эмбриона, зародышевого мешочка и семянки в 5 видах скрещивания: внутрилинейного, внутрисортового, межлинейного, сортолинейного и межсортового. Для скрещивания служили и линии с мужской пылц. стерильностью. Оценка высоты и ширины семянки не показала никаких явных тенденций к типу гибридизации. Склон к удлинению семянки показали возобновитель фертильности в роли отца и сорт ВНИИМК 6540 в роли матери. Склон к расширению зарод. мешочка показывают сортолинейные гибриды.

подсолнечник; опыление; эмбриогенез

KOVÁČIK, A. — VLČKOVÁ, V. (Forschungsinstitut für Pflanzenproduktion, Praha-Ruzyně): *Vergleichsstudium der Embryogenese bei Sonnenblumen (Helianthus annuus L.).* Genet. a Šlecht., *24,* 1988 (4) : 271-280.

An Längsschnitten durch den Samenbeutel der Sonnenblumen verfolgten wir die Embryogenese in den ersten 12 Tagen nach der Bestäubung. Wir bewerteten die Abmessungen der sich entwickelnden Embryonen, des Embryosackes und der Schliessfrucht bei fünf Kreuzungstypen: Innerlinien-, Innersorten-, Zwischenlinien-, Sortenlinien-, Zwischensortenkreuzung. Zur Kreuzung wurden auch Linien mit männlicher Pollensterilität herangezogen. Die Bewertung der ermittelten Schliessfruchthöhe und -breite wies in der verfolgten Zeitperiode keine Tendenz in Beziehung zum Hybridisationstyp auf. Eine Tendenz zur Schliessfruchtverlängerung weisen von den benutzten Genotypen der Linie der Fertilitätsrestorer als Vater und die Sorte VNIIMK 6540 als Mutter auf. Eine Tendenz zu einer grösseren Embryosackbreite weisen die Sortenlinienhybriden auf.

Helianthus annuus L.; Bestäubung; Embryogenese

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EVALUATION OF TOMATO (*LYCOPERSICON ESCULENTUM* MILL) PLANTS TRANSFORMED BY MEANS OF T-DNA

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PEKÁRKOVÁ-TRONÍČKOVÁ, E. — DUSBÁBKOVÁ, J. — NEČÁSEK, J. (Institute of Crop Production, Praha-Ruzyně; Institute of Experimental Botany, Czechoslovak Academy of Sciences, České Budějovice): *Evaluation of Tomato (Lycopersicon esculentum Mill) Plants Transformed by means of T-DNA.* Genet. a Šlecht., *24*, 1988 (4) : 281-291.

Tomato plants transformed with T-DNA of the pTiT37 plasmid from *Agrobacterium tumefaciens* were tested concerning their sterility and possible value for hybrid seed production. Experiments comprised plants of two cultivars in which the pollen viability *in vitro* was ascertained to 23.3—82.9 %. Varietal differences were stated in degrees of female sterility and negative side-effects in transformed plants: In the cv. Linia XXIV, generative as well as clonal offsprings of transformed plants with the lowest pollen viability *in vitro* (23.3—52.0 %) manifested a high male and female sterility. Spontaneous setting fluctuated between 0—3.7 fruits per plant, artificial selfpollination resulted in only 0.5—2.1 and fertile pollination as few as 0.1—0.07 fruits per pollination. Anthers contained only very small pollen amounts and underdeveloped stigmas occured. Decreased seed setting was followed by decreased seed emergence (31.0 %) and plant survival (26.0 %). F1 resulted always in genogenetic seeds. Bilateral sterility was accompanied by negative side-effects as growth depression, compact growth and necroses. Unlike this, in the cv. Ostravské rané some offsprings were gained in which a definite male sterility was accompanied with only a slight disturbation of female fertility and no growth depressions took place.

Tomato; transformation; pTiT37 plasmid; *Agrobacterium tumefaciens*; evaluation of sterility

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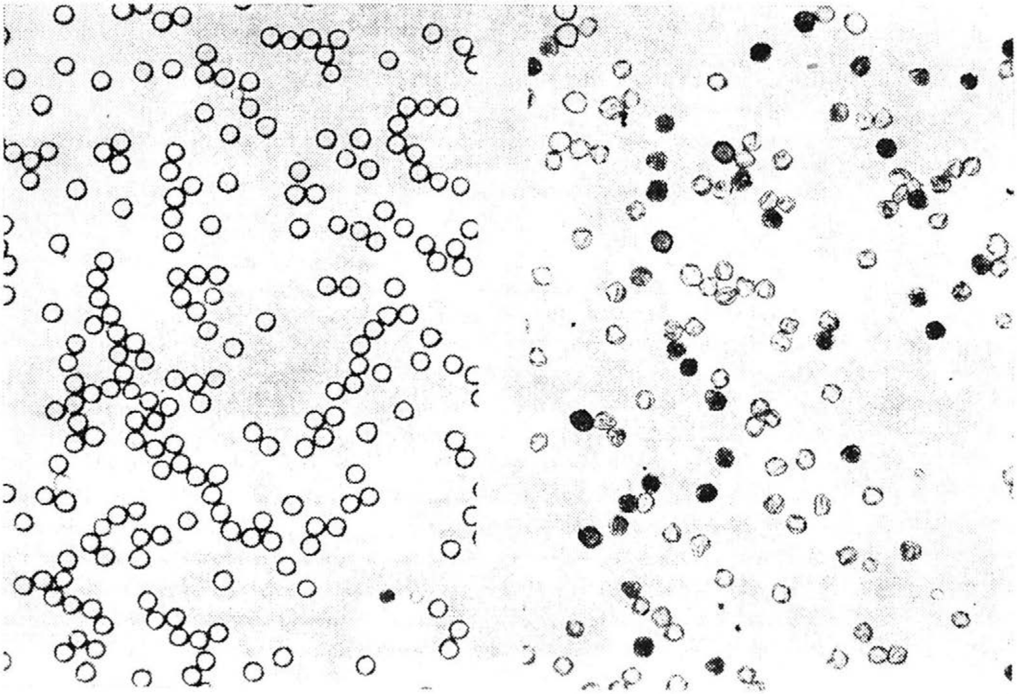
T-DNA of the Ti plasmid from *Agrobacterium tumefaciens* can be integrated into plant genome. T-DNA is considered as one of the most promising vectors of foreign DNA in genetic ingeneering. In many plant species, however, crown galls induced by *Agrobacterium tumefaciens* are able to regenerate shoots but never form roots. Buchmann et al. (1985) and Thomashow et al. (1986) stated that root formation in plants transformed with T-DNA is blocked through the presence of loci *tms* and *tmr* controlling biosynthesis of auxins and cytokinins. Regeneration of whole transformed tomato plants from crown galls was described in the previous paper of us (Nečásek et al., 1988). In tobacco plants transformed with unchanged nopaline T-DNA, male sterility as well as longistyly was observed by Wullems et al. (1981) and Memelink et al. (1983). Male sterility and also longistyly are desirable characters for breeding F1 hybrids of several crops including vegetables (Troníčková, 1973). Suitable genetic resources of sterility and longistyly have been searched among natural mutants and forms originated of former distant hybridization; they are also induced artificially. In tomato likely as in some other species even several selfsterility sources exist the fitness of which 'for breeding F_1 hybrids may be unequal due to different expression and genetic condition. Also genetic background of the source in question is of importance. In contrast to many crops in which male sterility is cytoplasmically conditioned, all sterile forms described in tomato (namely *ms, sl, pi, ps* and *ex*) are monogene recessive. This is, of course, a cause of a relatively difficult propagation. Functional sterility (*ps*) is the only one exception among them (Troníčková, Špirytová, 1981).

The aim of our studies was to reveal whether male sterility occurs in transformed plants and, if there is any, to compare it with the known sterility sources and to estimate its possible value for breeding F_1 hybrid seed.

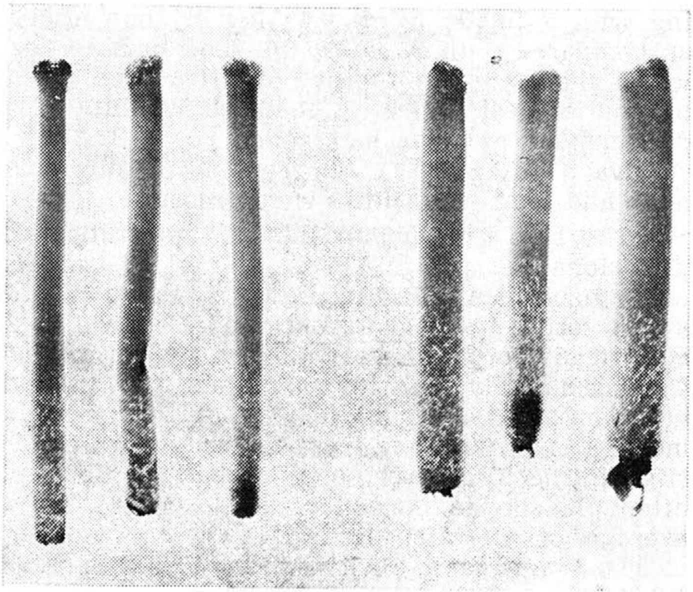
MATERIALS AND METHODS

Lycopersicon esculentum Mill cv. Linia XXIV (from Bulgaria) and cv. Ostravské rané (Czechoslovak cv.) were used as recipients of T-DNA. Both experimental cultivars proved a high combining ability in many-year experiments in the Research Institute of Crop Production (RICP) in Prague-Ruzyně. They are genetically divergent and were exploited as parental components for the Czechoslovak hybrid Start F_1 (registred since 1975). Methods of regeneration of whole transformed plants with T-DNA of plasmid pTiT37 and data on their pollen viability *in vitro*



1. Pollen viability *in vitro* in the cv. Linia XXIV. Normal control plant (98.2 %) — on the left; transformed plant No. 20 (32.6 %) — on the right

2. Normal "pestle-shaped" stigmas of the control plant of the cv. Linia XXIV (left) and "pile-shaped" stigmas of the transformed plant No. 8/2 (right)



were described in the paper by Nečásek et al. (1988). *In vitro* pollen viability in 13 whole plants regenerated from five tumors was relatively high (23.3—77.0 %) indicating only a little chance of finding sterility (Fig. 1). Therefore our studies started with five plants (all cv. Linia XXIV) which manifested the lowest pollen viability degree all over the plant set: plant No 8 (viability 23.6 %), plant No 20 (32.6 %), plant No 22 (40.0 %), plant No 23 (52.0 %) and plant No 27 (23.3 %). Later experiments included plants (of Linia XXIV) exhibiting high values of pollen viability as follows: plant 32xK1 (viability 78.6 %), plant No 32xK2 (54.0 %), plant No 32xK3 (88.9 %), plant No 32xK8 (66.8 %) and plant No 32xK9 (47.5 %). With the second experimental cultivar Ostravské rané the data on transformed plants were as follows: plant No 17 (viability 75.6 %), plant No 18 (62.0 %), plant No 29 (69.0 %) and plant No 30 (77.0 %).

Experiments were established in the Research Institute of Crop Production, Prague-Ruzyně. Young plants were planted in the soil in unheated glasshouse and cultivated intensively on strings. Evaluation was made in three groups of plant offsprings: *in vitro* cloned, artificially selfed, and F_1's from crossing with the fertile tester. Sterility degree was tested by counting spontaneously set fruits, and by percentage of fruit set after artificial self- and crosspollination.

RESULTS

In the first experimental year (1985), all R_0 clonal offsprings of five R_0 transformed plants of the Linia XXIV were uniform maintaining all characters typical for the original cultivar. The growth of plants was, however, lower and spontaneous fruit setting was very poor as documented by only 2.2 spontaneous fruit set per plant and a very small seed amount in them (1.64 seed per fruit). Artificial pollination, which was made by technicians experienced in hybrid seed production, confirmed a high sterility of the material. After selfpollination, which was difficult to make due to a lack of pollen in the anthers, fruit setting was 36.1 %. Most fruits (78.9 %) were, however, seedless and the seed number in seeded fruits was very low (in average 6.9 seed per fruit and 2.1 seed per pollination). Although fruit setting after crossing with a fertile tester was higher than after selfpollination (72.3 % as compared with 36.1 %), the seed number per fruit was surprisingly lower than after selfpollination (0.8 seed per fruit and 0.1 seed per pollination, respectively). Reduced viability of produced seed may be documented by poor emergence (only 32.2 %) and even lower plant survival (only 26.0 %). Experimental results thus indicate that both the male and female sterilities were present.

The 1986 experiments included generative offsprings (47 R_1 plants) and clonal offsprings (16 R_0 plants) of transformed plants that were under experiments in the previous year, and three F_1's from pollination by the fertile tester Ostravské rané. Observation at the vegetation period confirmed morphological stability of transformed plants, slow development, relatively low compact plant growth and high sterility. Evaluation of stigmas of all opened flowers twice a vegetation period by means of a magnifying glass showed a high incidence of underdeveloped stigmas that did form neither lobes nor secret (Fig. 2). Stigmas were often pile-shaped instead of pestle-shaped, sometimes even hooked. In average of all offsprings 51.6 % plants developed abnormal stigmas, 45.0 % plants were intermediate with both types of stigmas and only 3.3 % plants developed only normal stigmas. No definite connection was found between incidence of abnormal stigmas and plant sterility degree.

An important statement was made concerning the plant habitus in F_1 offsprings of transformed plants pollinated with the fertile tester Ostravské rané. All plants exhibited characters typical for the mother cv. Linia XXIV transformants: a low compact growth and high sterility. This may testify that no hybridization but gynogenesis took place.

Sterility of the material was again very high (Tab. I): no spontaneous fruit setting was observed; after selfpollination set only 12.1 % seeded fruits containing in average 4.2 seed per fruit and 0.5 seed per pollination only. Crossing with a fertile tester lead to even lower values: 4.5 % fruit setting, 1.2 seed per fruit and 0.07 seed per pollination. Control spontaneously set fruits developed in average 53.03 seed per fruit. No considerable differences were observed between R_1 generative and R_0 clonal offsprings.

In 1987, 263 seeds were sown of 62 offsprings; 34 of them from selfpollination (24 R_2 and 10 R_1) and 23 backcrossing (13 B_2 and 10 B_1).

It was interesting that the worse seed setting after crosspolination (as compared with selfpollination), which was observed in both the previous years, was connected with after - effects of somewhat decreased seed emergence and survival of plants from crosspollination: after backcrossing the average seed emergence was 29.8 and plant survival 25.5 %, while after selfpollination the respective values were 45.8 and 38.4 % (Tab. II).

Again, practically all transformed plants grew more slowly, were lower and more compact than control plants. The height of selfpollinated offsprings was in average 70.2 cm and that of backcrossed offsprings 64.3 cm, whereas control plants were 117.7 cm high. Transformed plants were thus by about 40 % shorter.

At the end of June, necroses occurred on transformed plants from the 12th leaf up to plant top and inflorescences. Symptoms of necroses

I. Fertility of R_1 transformed plants after selfpollination and fertile crosspollination. Cv. Linia XXIV

R_1 offspring	Selfpollination						Crosspollination					
	number of pollinations	% of fruit setting			number of developed seeds		number of pollinations	% of fruit setting			number of developed seeds	
		non set	seedless	seeded	per fruit	per pollination		non set	seedless	seeded	per fruit	per pollination
8/2a	97	76.3	6.1	17.5	4.1	0.7	143	32.1	60.1	6.9	5.4	0.37
8/2b	30	76.6	16.6	6.6	3.5	0.4	72	34.7	61.1	4.1	1.6	0.06
20/1	33	84.8	9.0	11.0	6.0	0.4	47	48.9	48.9	2.1	1.0	0.02
20/2	75	73.3	6.6	20.0	3.1	0.7	93	39.8	52.7	7.5	1.4	0.11
20/3	16	100.0	0	0	0	0	35	54.3	45.7	0	0	0.00
22/1a	7	100.0	0	0	0	0	11	18.1	81.1	0	0	0.00
22/1b	6	100.0	0	0	0	0	31	38.7	54.8	6.4	1.0	0.06
22/2	22	68.2	22.7	9.0	2.0	0.2	24	12.5	87.5	0	0	0.00
23/1[illegible]	70	82.8	8.6	8.6	5.8	0.5	85	30.6	68.2	1.2	1.0	0.01
23/2a	8	75.0	12.5	12.5	4.0	0.5	4	0	100.0	0	0	0.00
23/2b	8	87.5	12.5	0	0	0	30	30.0	63.3	6.6	2.0	0.13
Total, Average	372	79.3	8.6	12.1	4.2	0.5	575	35.1	60.3	4.5	1.2	0.07
Control	20	10.0	5.0	85.0	35.2	29.9	20	5.0	5.0	90.0	38.5	34.6

II. Seed emergence and plant survival after selfpollination and backpollination of transformed plants of the cv. Linia XXIV

Pollination	Mother generation	Parental plant No.	Number of offsprings	Seed number sown	Emerged seed number	Number of survived plants	Average seed emergence %		Average plant survival %	
Self	R$_2$	20	7	50	21	15	46.5	45.8	36.9	38.4
		21	2	7	2	2				
		22	2	11	4	4				
		23	6	42	18	13				
		28	1	1	0	0				
		30	5	42	26	22				
		31	1	4	2	2				
		Total	24	157	73	58				
	R$_1$	8	5	23	11	11	44.1		42.4	
		22	8	21	9	8				
		23	2	15	6	6				
		Total	15	59	26	25				
Back	B$_2$	21	3	4	1	1	28.5	29.8	28.5	25.5
		22	1	1	0	0				
		23	5	10	1	1				
		26	1	2	1	1				
		30	2	2	1	1				
		32	1	2	2	2				
		Total	13	21	6	6				
	B$_1$	8	4	12	3	3	30.7		23.6	
		20	1	2	0	0				
		22	3	9	2	2				
		23	2	3	3	1				
		Total	10	26	8	6				
Total			62	263	113	95	42.9		36.1	

were similar to those of *Botrytis*. Repeated microscopic and cultivation diagnoses did confirm, however, neither presence of *Botrytis* nor of another pathogen. After the second wave of necrotization plants recovered and continued growth and blossoming. For no necroses occurred on fertile control plants, they seem to be connected with transformation. Dependence between necrosis and sterility degree as well as growth depression degree in transformed plants was indistinct.

Sterility of plants was again very high: spontaneous fruit setting

III. Spontaneous fruit setting in R_1 offsprings of plants with higher pollen viability values. Cv. Iinia XXIV

R_1 generation	Pollen viability %	Number of fruits per plant				
		0	1	2	3	Total
Linia XXIV - C	99.0	4.3	6.7	3.0	18.7	32.6
32 × K1-A	78.6	1.3	3.7	7.1	19.8	32.0
32 × K2-B	54.7	3.5	4.4	3.4	17.1	28.5
32 × K3-C	82.9	3.9	4.8	5.8	24.4	38.0
32 × K8-D	66.8	2.4	2.9	4.1	17.1	26.5
32 × K/9-E	47.5	5.7	5.7	4.0	15.1	30.5

Fruits: 0 — seedless, 1 — containing several seeds, 2 — containing reduced seed amount, 3 — fully seeded

did not exceed 3.74 fruits per plant and only 0.15 of them were fully seeded. Fruit setting after backcrossing was characterized by 8.1 % setting normal fruits, by setting 6.9 seed per fruit and 0.56 seed per pollination.

All plants of 11 backcrosses had typical transformation features: high sterility expressed by zero fruit setting, compact (by 40.3 % shorter) growth and presence of necroses.

Both the F_1 offsprings from test pollination with the fertile Ostravské rané were highly sterile setting 0.0 and 0.1 normal fruits per plant. Plant habitus was again close to that of transformed mother plants. F_1 offsprings thus seemed to testify gynogenetic origin.

All plant material under our experiments up till that time thus manifested a high, both male and female sterility accompanied by some unfavourable side-characters. Therefore our further attention was concerned to plants manifesting in R_0 higher pollen viability *in vitro* (47.0 to 82.9 % — Tab. III) than the previous experimental material. All five offsprings under test proved full fertility which practically did not differ from that of control plants. In glasshouse, plants developed 26.5 — 36.0 fruits per plant from which 15.1 — 24.4 were fully seeded. The respective control values were 32.6 fruit per plant (18.7 of them fully seeded). In field conditions, all offsprings were also fertile and seem thus not to be transformed.

Four R_1 offsprings of transformed plants of the cv. Ostravské rané were the last experimental set. Pollen viability *in vitro* of transformed R_0 plants fluctuated between 6.1 and 81.8 % (Tab. IV). Mentioned great differences in pollen viability percentage proved to be not correlated with fertility of respective plants. All four offsprings were highly sterile (spontaneous fruit setting 28.6 — 32.0 fruits per plant, only 0.0 — 0.8 of them, however, fully seeded). The fertile control plants set 78.0 fruits per plant (63.0 of them fully seeded). A similar picture was found concerning fruit setting after self- and crosspollination. Morphology of transformed plants responded to this of original cultivar. In opposite to the cv. Linia XXIV, where transformed offsprings were either bilaterally sterile with unfavourable side-characters (trans-

IV. Fertility of transformed R1 offsprings of the cv. Ostravské rané

R1 generation		Spontaneous setting			Selfpollination			Backcrossing			Plant height cm
Designation	pollen viability %	average fruit number			fruit setting %	seed number		fruit setting %	seed number		
		1 + 2 + + 3*	3*	total		per fruit	per pollination		per fruit	per pollination	
Control	98.7	77.3	63.0	78.0	—	—	—	—	—	—	269.0
29/4	25.6	14.0	0.1	32.0	63.6	12.0	7.6	55.5	0.3	0.20	277.8
29/15	20.9	15.4	0.8	28.6	63.0	9.5	4.9	5.8	1.0	0.06	286.1
17/1	6.1	19.0	0.0	32.0	62.5	12.2	7.6	71.4	3.0	2.14	282.0
17/7	81.8	11.6	0.0	29.0	75.0	11.0	8.3	38.4	1.2	0.46	291.0

* 1 — fruits containing only several seeds, 2 — fruits containing reduced seed amounts, 3 — fully seeded fruits

formed) or normally fertile (likely untransformed), in the cv. Ostravské rané we got sterile plants manifesting neither depressions (plant height 103 — 108 % to control) nor necroses. Also fruit setting after self- and crosspollination was somewhat more favourable. Selfpollination resulted in 9.5 — 12.2 seeds per fruit and 4.9 — 8.3 seeds per pollination; in backcrosses the respective values were 0.3 — 3.0 seeds per fruit and 0.46 — 2.14 seeds per pollination. Female sterility in transformed plants of the cv. Ostravské rané thus seems to be disturbed less distinctly. The plants need therefore further studies.

DISCUSSION

In two tomato cultivars we succeeded in getting normal rooted plants transformed by means of *Agrobacterium tumefaciens* T 37 (pTiT37) with unchanged T-DNA (Nečásek et al., 1988). Wullems et al. (1981) and Memelink et al. (1983) described sterility and longistyly in tobacco plants transformed with unchanged T-DNA. High degree of sterility was also observed in transformed *Arabidopsis thaliana* plants (Pavingerová et al., 1983). Transformed tomato plants manifested in a various degree depressed pollen viability *in vitro* (Nečásek et al., 1988). Sterility of grown-up plants was very high. It was documented by very poor spontaneous fruit set and also very low fruit set after artificial selfpollination. In all transformed plants male sterility was accompanied with disturbances in female fertility. This is apparent from a very low fruit set after pollinating with the fertile tester, and also low setting of normal seeds and depressed viability of them. Incidence of underdeveloped flower stigmas may explain some causes of female sterility. A consistent conclusion may be derived from the fact that all offsprings from pollination with the fertile tester indicate no hybrid but gynogenetic origin of plants. Sterility induced in transformed tomato plants thus differs considerably from sterile mutants (*ms, sl, pi, ps* and *ex*) as described in the literature

(Tronîčková, 1973). Strong disturbance of oogenesis in transformed cv. Linia XXIV plants gives thus no hope of possible exploiting them as mother components in hybrid seed production.

T-DNA changes the cytokinin/auxin ratio in transformed plants (Schell et al., 1984). Transformed tomato plants of the cv. Linia XXIV and Ostravské rané developed roots and the increased IAA level in plants was ascertained (Nečásek et al., 1988). The increased IAA content may cause not only reduced seed setting, development on unviable seed and parthenocarpy, but also considerably shortened compact plant growth. The cause of necroses as well as their relation to growth depressions maintained unexplained. Application of growth regulating substances to tomato strongly affects not only flower morphology but also fertilization process. So longistyly may be induced by means of GA application (Honma, Bukovac, 1966; Tronîčková, 1979) and viable pollen development may be restored in various *ms* (male sterile) mutants (Schmidt, 1976). The same was shown for *sl*^{2} (stamenless) mutant in which a lower level of endogenous GA was documented (Sawhney, 1974). Reversely, morphoregulators of auxin type (e. g. beta indolyl-acetic acid) may induce production of parthenocarpic seedless fruits (George et al., 1984) and pseudoembrya in seeds (Lin et al., 1986). At present, interest for parthenocarpy has been involved also in breeding programs for tomato. It is supposed, that tomato genotypes tending to developing parthenocarpic normally-sized fruits contain greater auxin amounts in pistills which are partially responsible for female sterility. Tendency to parthenocarpic fruit setting observed in our transformed plants, similarly as incidence of underdeveloped stigmas, are in consent with ascertained effects of increased level of auxin-type morphoregulators.

Being transformed by Ti plasmid, various tomato genotypes do not behave quite equally: In the cv. Linia XXIV, offsprings were gained in which high bilateral sterility was accompanied with deeply changed function of morphoregulators (in plants with lower pollen viability *in vitro*) or quite fertile offsprings (in plants with higher pollen viability values). In opposite to it, in the cv. Ostravské rané the transformed offsprings were derived with a very different pollen viability which manifested various degree of sterility, always without unfavourable accompanying effects of changed ratio of morphoregulators on plant growth.

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PEKÁRKOVÁ-TRONÍČKOVÁ, E. — DUSBÁBKOVÁ, J. — NEČÁSEK, J. (Výzkumný ústav rostlinné výroby, Praha-Ruzyně; Ústav experimentální botaniky ČSAV, České Budějovice): *Zhodnocení rostlin rajčete (Lycopersicon esculentum Mill) transformovaných pomocí T-DNA.* Genet. a Šlecht., *24,* 1988 (4) : 281-291.

U rostlin rajčat transformovaných pomocí T-DNA plasmidu pTiT37 z *Agrobacterium tumefaciens* byla studována sterilita a její případné využití při výrobě hybridního osiva. Životnost pylu *in vitro* u pokusných transformovaných rostlin dvou odrůd se pohybovala od 23,3 do 82,9 %. Byly zjištěny odrůdové rozdíly ve stupni samičí sterility a negativních vedlejších projevech transformovaných rostlin: U Linie XXIV projevovala generativní i klonová potomstva transformovaných rostlin s nejnižší životností pylu (23,3—52,0 %) vysokou samičí i samčí sterilitu. Spontánní zakládání činilo 0—3,7 plodů na rostlinu, umělé samoopylení vedlo k založení 0,5—2,1 plodů a křížení k založení pouze 0,1—0,07 plodů na jedno opylení. Prašníky obsahovaly jen málo pylu a často se vyskytovaly nedovyvinuté blizny. Nízké zakládání plodů doznívalo v nízké vzcházivosti semen (31,0 %) a přežívání rostlin (26,0 %). F_1 potomstva byla vesměs gynogenetická. Oboustranná sterilita byla doprovázena negativními vedlejšími projevy jako je růstová represe, kompaktní vzrůst a nekrózy. Naproti tomu u odrůdy 'Ostravské rané' byla získána některá potomstva, u nichž byla samčí sterilita provázena jen slabším poškozením samičí fertility a růstové deprese se neprojevily.

rajče; transformace; pTiT37 plasmid; *Agrobacterium tumefaciens*; zhodnocení sterility

ПЕКАРКОВА-ТРОНИЧКОВА, Э. — ДУСБАБКОВА, Я. — НЕЧАСЕК, Я. (Научно-исследовательский институт растениеводства, Прага-Рузыне; Институт экспериментальной ботаники ЧСАН, Ч. Будейовице): **Оценка томатных растений** (*Lycopersicon esculentum* Mill) **трансформированных с помощью Т-ДНК.** Genet. a Šlecht., *24,* 1988 (4) : : 281-291.

У томатных растений, трансформированных с помощью Т-ДНК плазмида пТиТ37 из *Agrobacterium tumefaciens* определяли стерильность и возможности ее использования в производстве гибридных семян. Жизнестойкость пыльцы *in vitro* у 2 сортов этих растений была 23,3—82,9 %. Сортовые различия установлены в степени женской стерильности и негативных побочных проявлениях трансф. растений. У линии XXIV генеративные и клоновые потомства растений с самой низкой жизнестойкостью пыльцы (23,3—52,0) обладали высокой стерильностью. Спонтанное завязывание 0—3,7 плода на растение, искусственное самоопыление вело к завязыванию 0,5—2,1 плода, а скрещивание — лишь к 0,1—0,07 плода на опыление. Пыльники содержали мало пыльцы, и часто встречались недоразвитые рыльца. Низкое завязывание плодов отразилось на слабой всхожести семян (31,0 %) и выживании растений (26,0 %). Потомства Ф_1 были гиногенетические. Двусторонняя стерильность сопровождалась негативными побочными проявлениями как депрессия роста, компактный рост и некрозы. У сорта же 'Остравске ране' некоторые потомства с мужской стерильностью сопровождались лишь слабым повреждением женской фертильности, депрессии роста себя не проявили.

томаты; трансформировка; плазмид пТиТ37; *Agrobacterium tumefaciens*; оценка стерильности

PEKÁRKOVÁ-TRONÍČKOVÁ, E. — DUSBÁBKOVÁ, J. — NEČÁSEK, J. (Forschungsinstitut für Pflanzenproduktion, Praha-Ruzyně; Institut für experimentelle Botanik der ČSAV, České Budějovice): *Bewertung der mit Hilfe von T-DNA transformierten Tomatenpflanzen (Lycopersicon esculentum Mill).* Genet. a Šlecht., *24,* 1988 (4) : 281-291.

Bei mit T-DNA von Plasmid pTiT37 aus *Agrobacterium tumefaciens* transformierten Tomatenpflanzen untersuchten wir die Sterilität und ihre eventuelle Ausnutzung für die Produktion von Hybridsaatgut. Die Lebensfähigkeit des Pollens *in vitro* schwankte bei den transformierten Versuchspflanzen zweier Sorten von 23,3 bis 82,9 %. Wir stellten sortenbedingte Unterschiede in der Stufe der weiblichen Sterilität und in negativen sekundären Symptomen der transformierten Pflanzen fest: bei der Linie XXIV wiesen sowohl die generativen als auch klonalen Nachkommenschaften der transformierten Pflanzen mit der niedrigsten Lebensfähigkeit des Pollens (23,3—52,0 %) eine hohe weibliche und männliche Sterilität auf. Der spontane Ansatz betrug 0—3,7 Früchte je Pflanze, die künstliche Selbstbestäubung führte zum Ansatz von 0,5—2,1 Früchten und die Kreuzung zum Ansatz von 0,1 bis 0,07 Früchten je Bestäubung. Die Staubbeutel beinhalteten nur wenig Pollen und sehr oft konnten wir nicht vollentwickelte Narben feststellen. Ein zu niedriger Ansatz von Früchten hatte ein zu niedriges Aufgehen der Samen (31,0 %) und ein niedrigeres Überleben (26,0 %) zur Folge. Die F_1 Nachkommenschaften waren insgesamt gynogenetisch. Die beiderseitige Sterilität wurde von negativen Nebensymptomen (Wachstumsdepression, Kompaktwachstum, Nekrosen) begleitet. Bei der Sorte Ostravské rané wurden hingegen eine Nachkommenschaften erhalten, bei denen die männliche Sterilität von einer nur schwachen Beschädigung der weiblichen Fertilität begleitet wurde, wobei keine Wachstumsdepressionen auftraten.

Tomaten; Transformation; Plasmid pTiT37; *Agrobacterium tumefaciens*; Bewertung der Sterilität

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We call the attention of our readers to Number 1/1989 of the periodical

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which will bring the below-mentioned papers. These papers well be published in Czech language with Russian, English and German summaries.

Dusbábková J., Nečásek J., Hrouda M.: Transformation of Oilseed Rape with T-DNA of *Agrobacterium* Plasmids

Košner J., Foltýn J.: Chromosomal Relations in the Common Wheat (*Triticum aestivum* L.) with Branched Spike

Křivský K., Borovec V.: Formation of a Clone-Line F_1 Hybrid of White Cabbage with the Use of Explant Cultures

Vožda J., Kubecová B.: Evaluation of the Combining Ability of Maize Genotypes by the System of Diallel Crossing in Macro-Environment

Pešina K.: Two Tetrasomic Cultivars of Tomato

Dreiseitl A.: The Resistance of Czechoslovak Spring Barley Varieties to Powdery Mildew (*Erysiphe graminis* f. sp. ***hordei***)

Foltýn J.: Economic Characteristics of Duospiculum Mutants and Hybrids of Winter Wheat (*Triticum aestivum* L.)

Hofírek P.: Results of Measurements of Stem Firmness in Pea

SUPPLEMENT

Ondřej M., Vlasák J.: Contemporary Targets of Gene Transfer in Cultural Dicotyledonous Plants and an Experimental Procedure for Optimization of the Disk Method of Transformation by the *Agrobacterium* Bacteria

EVALUATION OF COMBINING ABILITIES OF MAIZE GENOTYPES WITHIN A SYSTEM OF TRIALLEL CROSSING

J. Vožda

VOŽDA, J. (Mendeleum, Lednice na Moravě): *Evaluation of Combining Abilities of Maize Genotypes within a System of Triallel Crossing.* Genet. a Šlecht., *24,* 1988 (4) : 293-308.

Applying the results of a three-year evaluation of the set of 360 hybrid combinations TWC, obtained within a triallel crossing system of 10 parental genotypes of maize, the analysis of combining abilities was carried out using a model (Vožda, 1980, 1985; Wolf, 1985) involving the decomposition of genetic effects and their interactions with experimental years for the evaluation of combining abilities in four quantitative traits. As far as the trait "grain yield per plant" is concerned, it was demonstrated that it was conditioned by contributions of genotypes in TWC combinations expressed by GCA effects ($\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$), and by mutual interactions of genotypes expressed by SCA effects [$\hat{t}_{i(jk)}$] and their interactions of GCA and SCA with experimental years. Estimated effects of GCA of genotypes represented a substantial proportion of contributions to the phenotypic value of the trait; the contribution of $\hat{g}_i$ was the most significant for this value. This fact was manifested both in a set of hybrid combinations with the maximum value (positive contributions) and in combinations with the minimum value (negative contributions). The contribution of $\hat{h}_j$ and $\hat{h}_k$ effects was variable, similarly like that of $\hat{t}_{i(jk)}$ but with an obvious tendency. From the viewpoint of the phenotypic value of the trait it is possible to say that estimations of GCA and SCA effects and their interactions with the environment represent the most complete information for individual TWC combinations, which can be used for further breeding.

system of triallel crossing; effects of GCA ($\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$); effects of SCA [$\hat{t}_{i(jk)}$]; interactions of GCA and SCA effects with environment

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The evaluation of combining abilities of genotypes is one of the basic preconditions for the selection of prospective hybrid combinations when using the phenomenon of heterosis within the system of plant breeding. To obtain information about combining abilities of genotypes, above all biparental systems are used (diallel crossing — Griffing, 1956; factorial paired crossing — Vožda, 1980b, 1981) in which the paternal genotypes function as testers against the maternal genotypes within the framework of the same set or of different sets. These biparental systems of crossing enable the selection of hybrid combinations on the level of single hybrids in which the maternal and the paternal genotype show mutually high effects of both the general combining ability (GCA) and the specific combining ability (SCA).

Regarding the fact that besides simple hybrids, also three-way hybrids represent the final products of plant breeding, we have constructed a model for the evaluation of combining abilities within the framework of the triparental system of crossing (Vožda, 1980b, 1985; Wolf, 1985). The model is derived from the system of triallel crossing (Rawlings, Cockerham, 1962) which, however, was not used in a greater extent due to its complexity and was focussed on the analysis of variance components in terms of general and specific genetic effects and effects of the arrangement of genotypes in hybrid combinations. In our model, the system of triallel crossing was used to estimate the effects of combining abilities on the base of testing the material in several environments.

The aim of this study is to document the possibilities of this model when evaluating a concrete breeding material.

MATERIAL AND METHODS

In this study a set of 10 parental, inbred lines of maize was used (i. e. LD29, LC3, EP1, LC4, CO114, LE6, LC49, LC40, LC140, LC72) from which altogether $c = p/p—1/p—2/2 = 360$ combinations of three-way hybrids were obtained consisting of three different genotypes. The reciprocal hybrid combinations were not taken into account in this crossing.

The experimental material was evaluated in field experiments in 1981—1983. The experimental scheme involved 4 randomized blocks with single-row plots, 25 plants each, with spacings 70 × 25 cm (i. e. 57,143 plants per hectar). To evaluate the phenotypic manifestation of four representative traits (height of plant in cm, ear height in cm, length of ear in mm, grain yield per plant in gr.), 20 plants from each plot were used with the exception of marginal plants. The estimation of effects of combining abilities are presented only for the trait "yield of grain per plant".

The analysis of combining abilities was based on the model relationship

$$y_{i(jk)lm} = u + c_{i(jk)} + a_l + b_{lm} + (ac)_{i(jk)l} + e_{i(jk)lm} \qquad [1]$$

where: $i, j, k = 1, \ldots p$; $l = 1, \ldots a$; $m = 1, \ldots b$

$y_{i(jk)lm}$ — phenotypic value of the trait of the $i(jk)$-th combination in the m-block of the I-th environment

u — total trait average within the population

$c_{i(jk)}$ — genetic effect of the $i(jk)$-th combination

a_l — effect of the l-th environment

b_{lm} — effect of the m-th block in the l-th environment

$(ac)_{i(jk)l}$ — effect of the interaction of the $i(jk)$-th combination in the l-th environment

$e_{i(jk)lm}$ — experimental error [interaction of the $i(jk)$-th combination] of the m-th block in the l-th environment

The genetic effect $c_{i(jk)}$ and its interaction with the environment $(ac)_{i(jk)l}$ can be then divided into effects of combining abilities according to the following equations:

$$c_{i(jk)} = \hat{g}_i + \hat{h}_j + \hat{h}_k + \hat{t}_{i(jk)} \qquad [2]$$

and

$$\widehat{(ac)}_{i(jk)l} = \widehat{(ag)}_{il} + \widehat{(ah)}_{jl} + \widehat{(ah)}_{kl} + \widehat{(at)}_{i(jk)l} \qquad [3]$$

where: $\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$ — effects of general combining ability (GCA) of the i-th, j-th, k-th genotype

$\hat{t}_{i(jk)}$ — effect of specific combining ability (SCA) expressing the interaction of two and three genotypes in the structure of triallel hybrid combination

$\widehat{(ag)}_{il}$, $\widehat{(ah)}_{jl}$, $\widehat{(ah)}_{kl}$ — effect of interaction of GCA of the i, j, k-th genotype with the l-th environment

$\widehat{(at)}_{i(jk)l}$ — effect of interaction SCA of genotypes in the structure of triallel hybrid combination with the l-th environment

The presented distribution of genetic effects thus involves de facto three types of effects of combining abilities:

- effect of genotype i as the parent $(\hat{g})$ — GCA$_i$
- effect of genotypes j and k as grandparents $(\hat{h})$ — GCA$_i$, GCA$_k$
- effect of interaction of genotypes i, j, k within the structure of the triallel hybrid combination $(\hat{t})$ — SCA$_{i(jk)}$ which are important from the practical point of view.

I. Characteristics of climatic conditions and indices of deviations in the growing seasons of the experimental years 1981—1983

Characteristics	1981		1982		1983		$\bar{x}$
	x	I_a	x	I_a	x	I_a	
Mean temperature [°C]	15.53	−0.55	16.24	−0.14	17.07	+0.69	16.38
Sum of temperatures	2 972.4	−25.5	2 898.1	−99.8	3 123.2	+125.3	2 997.9
Intensity of solar radiation [gcal/cm^2]	36 422.6	−1843.3	38 863.7	+598.0	39 511.0	+1245.3	38 265.7
Sum of precipitation [mm]	309.8	+24.8	282.0	−3.2	263.4	−21.6	285.0

II. Mean values of four quantitative traits and indices of deviations within the set of triallel hybrids evaluated in 1981—1983

Trait	1981		1982		1983		$\bar{x}$
	x	I_a	x	I_a	x	I_a	
Height of plant [cm]	197.53	−17.81	218.59	+3.25	229.90	+14.56	215.34
Height of ear setting [cm]	66.34	−8.53	75.93	+1.06	82.34	+7.48	74.87
Length of ear [mm]	162.02	+0.08	175.30	+13.36	148.00	−13.44	161.94
Grain yield per plant [g]	113.30	−5.33	156.51	+37.88	86.90	−32.54	118.63

RESULTS

In each experimental year, a genetically identical material was evaluated (i. e. 360 TWC combinations); for that reason the differences in the phenotypic manifestation of quantitative traits under study were affected above all by the conditions existing in individual experimental years. The main meteorological characteristics of experimental years are presented in Tab. I for the whole growing season (April — — September).

Conditions of individual experimental years were markedly manifested in average values of quantitative traits evaluated in our experiments (Tab. II). This is documented also by the environmental indices (I_a). Marked deviations of environmental indices can be observed, above all, in years 1981 and 1983.

Results of a general analysis of variance carried out in the set of triallel crossing according to four traits under study are presented in Tab. III. All the sources of variance were seen to participate significantly in the total variability of traits under study. The proportion of variability (expressed as components of variance), conditioned by experimental years, is very important for all the traits evaluated. The proportion of hybrid combinations in the total variability fluctuates, in spite of its significance, at the level of the proportion of experimental error. Interactions of hybrid combinations show, similarly as those of

III. Analysis of variance of 360 triallel hybrid combinations of maize evaluated according to four quantitative traits and the component of phenotypic variability in 1981—1983

Source	df	MS			
		Height of plant	Ear of height setting	Length of ear	Grain yield per plant
Years	2	388 483.98	9 3474.23	258 707.35	1815 966.55
Blocks in years	9	6 046.75	1 140.23	717.80	1 360.31
Hybrid combinations	359	1 010.31	731.09	1 150.08	1 918.80
GCA$_{g_i}$	18	16 854.69	11 296.26	16 685.62	31 421.02
GCA$_{h_j}$	9	18 973.83	10 226.81	22 301.17	44 681.82
GCA$_{h_k}$	9	8 656.32	8 224.09	5 251.21	7 992.55
SCA$_{i(jk)}$	341	173.95	173.40	330.02	361.50
Hybrids × years	718	133.47	123.37	202.40	295.32
GCA$_{g_i}$ × years	36	664.49	316.89	2 031.16	2 568.15
GCA$_{h_j}$ × years	18	857.24	283.46	2 437.31	3 305.98
GCA$_{h_k}$ × years	18	323.22	248.81	882.35	994.98
SCA$_{i(jk)}$ × × years	682	105.44	113.16	105.87	175.35
Experimental error	3231	90.17	101.72	71.19	155.38
		Components of phenotypic variability			
σ^2_A		265.56 (58.2)	64.11 (28.5)	179.07 (49.2)	1260.05 (79.3)
σ^2_{B-R}		16.55 (3.6)	2.88 (1.3)	1.80 (0.5)	3.35 (0.2)
σ^2_C		73.07 (16.0)	50.64 (22.5)	78.97 (21.7)	135.29 (8.5)
σ^2_{AC}		10.89 (2.4)	5.41 (2.4)	32.81 (9.0)	34.99 (2.2)
σ^2_E		90.17 (19.8)	101.72 (45.3)	71.18 (19.6)	155.38 (9.8)

blocks in individual years, a lower proportion than the variance component of experimental error.

Basing on results obtained, an analysis of genetic effects $c_{i(jk)}$ and their interaction with experimental years $(ac)_{i(jk)l}$ was performed with regard to effects of combining abilities of inbred lines according to the trait "grain yield per plant".

Estimates of GCA effects for individual lines are presented in Tab. IV; these lines are represented in TWC combinations in the same way as their parents $(\hat{g}_i)$ and grandparents $(\hat{h}_j$ and $\hat{h}_k)$. High and positive values of these effects contribute positively to the phenotypic value of a trait if they are represented in the same way as the parents or the grandparents. In all other lines of this set the values of effects are negative; this means that their contribution to the trait value is manifested as a decrease in its value.

In Tab. V and VI, characteristics of estimates of effects of combin-

IV. Estimates of the effect of combining abilities of inbred lines of maize based on an analysis of the triallel system of crossing

Genotype	$\hat{g}_i$	$\hat{h}_i = \hat{h}_j$
LD29	−15.1	−7.5
LC3	− 9.2	−4.0
EP1	−10.8	−3.0
LC4	− 5.4	0.1
LE6	16.3	7.1
CO114	− 9.3	−4.9
LC49	12.9	6.3
LC40	3.6	0.1
LC140	10.3	3.6
LC72	6.7	2.2

$\mathrm{var}(\hat{g}_i) = \mathrm{var}(\hat{h}_j) = \mathrm{var}(\hat{h}_k) = 0.33$

ing abilities and of effects of interactions of combining abilities with experimental years are presented for 25 TWC combinations showing the highest values of the trait "grain yield per plant" (Tab. V) and the lowest values of this trait (Tab. VI).

The total average (u) of the trait "grain yield per plant", analyzed within three years in 360 hybrid TWC combinations, was 118.6 g per plant, i. e. 6.77 t/ha at the given plant density. The estimated effects of GCA and SCA as well as their interactions with experimental years for individual genotypes and their combinations express the contributions to the value of this trait; this results from the model relationships [2] and [3]. From the viewpoint of analysis of genetic effects and their interactions with experimental years according to the combining abilities of genotypes and, thus, their contribution to the phenotypic value of the trait it is possible to say that these data provide the best information for breeding purposes.

As mentioned above, the high value of this trait is conditioned in this set above all by a high effect of CGA of the i-th genotype involved in the hybrid composition as the parent ($\hat{g}_i$ effect), i. e. by additive genetic effects. This observation was corroborated by data obtained from nearly all the 25 best TWC combinations in which the highest and positive value of the $\hat{g}_i$ effect was observed. As compared with $\hat{g}_i$, values of $\hat{h}_j$ and $\hat{h}_k$ effects were variable, similarly as those of SCA effects expressing the contribution conditioned by the interaction of all three genotypes in the composition of three-way hybrid. A relatively high degree of variability was found also for effects of interactions of GCA and SCA with experimental years which can serve for the evaluation of stability of these effects under concrete environmental conditions for each hybrid combination.

The proportion of estimates of the effect of combining abilities and their interactions with the environment (Tab. VI) in 25 TWC combinations showing the lowest values of this trait is characterized by high

V. Characteristics of combining abilities of genotypes and their interactions with experimental years in 25 triallel hybrids of maize showing the highest grain yield per plant in 1981—1983 (u = 118.6 g)

Hybrid	Experimental year	Effects of combining ability				Interaction with environment				Grain yield per plant [g]
		$\hat{g}_i$	$\hat{h}_j$	$\hat{h}_k$	$\hat{t}_{i(jk)}$	$\widehat{(ag)}_{il}$	$\widehat{(ah)}_{jl}$	$\widehat{(ah)}_{kl}$	$\widehat{(at)}_{i(jk)l}$	
LC49 × (LE6 × LC140)	I	12.9	7.1	3.6	10.3	1.4	−3.8	1.9	−2.1	149.90
	II	(38.1)	(20.9)	(10.6)	(30.4)	1.9	6.3	−0.6	−2.6	157.50
	III					−3.3	−2.5	−1.3	4.7	150.10
LE6 × (LC49 × LC72)	I	16.3	6.3	2.2	5.6	−6.9	−0.1	0.2	−2.9	139.30
	II	(53.6)	(18.4)	(7.3)	(18.4)	12.6	0.8	−0.4	−2.2	159.80
	III					−5.7	−0.7	0.2	5.1	147.90
LC140 × (LE6 × LC49)	I	10.3	7.1	6.3	5.3	2.7	−3.8	−0.1	−6.1	140.30
	II	(35.5)	(24.5)	(21.7)	(18.3)	−0.7	6.8	0.8	−1.6	152.90
	III					−2.0	−2.5	−0.7	7.7	150.10
LC49 × (EP1 × LE6)	I	12.9	− 3.0	7.1	11.0	1.4	−0.5	−3.8	−0.5	143.10
	II	(37.9)	−(8.8)	(20.9	(32.4)	1.9	0.0	6.3	10.7	165.50
	III					−3.3	0.5	−2.5	−10.2	131.10
LE6 × (LC4 × LC40)	I	16.3	0.1	0.1	10.7	−6.9	−1.8	0.8	6.7	144.60
	II	(59.9)	(0.4)	(0.4)	(39.3)	12.6	1.0	0.5	8.0	167.90
	III					−5.7	0.8	−1.3	−14.7	124.90
LC140 × (EP1 × LC49)	I	10.3	− 3.0	6.3	13.0	2.7	−0.5	−0.1	−3.8	148.50
	II	(31.6)	−(9.2)	(19.3)	(39.9)	−0.7	0.0	0.8	2.2	152.50
	III					−2.0	0.5	−0.7	1.6	149.60
LE6 × (LC49 × LC140)	I	16.3	6.3	3.6	− 0.8	−6.9	−0.1	2.0	0.8	139.80
	II	(60.4)	(23.3)	(13.3)	−(3.0)	12.6	0.8	−0.6	−9.0	147.80
	III					−5.7	−0.7	−1.4	8.2	144.40
LE6 × (EP1 × LC49)	I	16.3	− 3.0	6.3	4.9	−6.9	−0.5	−0.1	5.2	140.80
	II	(53.4)	−(9.8)	(20.7)	(16.1)	12.6	0.0	0.8	2.8	159.30
	III					−5.7	0.5	−0.7	−8.0	129.20

LE6 × (LC4 × LC49)	I	16.3	0.1	6.3	1.6	−6.9	−1.8	−0.1	−3.8	130.40
	II	(67.1)	(0.4)	(25.9)	(6.6)	12.6	1.0	0.8	11.5	168.80
	III					−5.7	0.8	−0.7	−7.7	129.60
LC140 × (LC49 × LC72)	I	10.3	6.3	2.2	5.2	2.7	−0.1	0.2	0.8	146.20
	II	(42.9)	(26.3)	(9.1)	(21.7)	−0.7	0.8	−0.4	−3.3	139.00
	III					−2.0	−0.7	0.2	2.5	142.60
LC49 × (LC4 × LC140)	I	12.9	0.1	3.6	7.2	1.4	−1.8	2.0	−3.5	140.50
	II	(54.2)	(0.4)	(15.1)	(30.3)	1.9	1.0	−0.6	4.5	149.20
	III					3.3	0.8	−1.4	−1.0	144.10
LE6 × (LC4 × LC140)	I	16.3	0.1	3.6	3.2	−6.9	−1.8	2.0	−9.3	125.80
	II	(70.3)	(0.4)	(15.5)	(13.8)	12.6	1.0	−0.6	7.3	162.10
	III					−5.7	0.8	−1.4	2.0	137.50
LC49 × (LE6 × LC72)	I	12.9	7.1	2.2	0.7	1.4	−3.8	0.2	−5.9	133.40
	II	(56.3)	(31.0)	(9.6)	(3.1)	1.9	6.3	−0.4	2.2	151.50
	III					−3.3	−2.5	0.2	3.7	139.60
LC49 × (LC40 × LC72)	I	12.9	0.1	2.2	7.2	1.4	0.8	0.2	−2.6	140.80
	II	(57.6)	(0.4)	(9.8)	(32.2)	1.9	0.5	−0.4	−3.7	139.30
	III					−3.3	−1.3	0.2	6.3	142.90
LC49 × (LC40 × LC140)	I	12.9	0.1	3.6	5.7	1.4	0.8	1.9	6.0	151.00
	II	(57.8)	(0.5)	(16.2)	(25.5)	1.9	0.5	−0.6	−7.8	134.90
	III					−3.3	−1.3	−1.3	1.8	136.80
LC49 × (EP1 × LC72)	I	12.9	− 3.0	2.2	9.6	1.4	−0.5	0.2	−8.2	133.20
	II	(46.6)	−(10.8)	(7.9)	(34.7)	1.9	0.0	−0.4	3.5	145.30
	III					−3.3	0.5	0.2	4.7	142.40
LC49 × (LC140 × LC72)	I	12.9	3.6	2.2	2.7	1.4	1.9	0.2	1.8	145.30
	II	(60.3)	(16.8)	(10.3)	(12.6)	1.9	−0.6	−0.4	−12.2	128.70
	III					−3.3	−1.3	0.2	10.4	146.00

Tab. V is continued

Hybrid	Experimental year	Effects of combining ability				Interaction with environment				Grain yield per plant [g]
		$\hat{g}_i$	$\hat{h}_j$	$\hat{h}_k$	$\hat{t}_{i(jk)}$	$\widehat{(ag)}_{il}$	$\widehat{(ah)}_{jl}$	$\widehat{(ah)}_{kl}$	$\widehat{(at)}_{i(jk)l}$	
LC72 × (LE6 × LC140)	I	6.7	7.1	3.6	3.8	1.9	−3.8	1.9	−3.8	136.00
	II	(31.6)	(33.5)	(17.0)	(17.9)	1.2	6.3	−0.6	−1.0	145.70
	III					−3.1	−2.5	−1.3	4.8	137.70
LE6 × (LC × LC72)	I	16.3	0.1	2.2	2.3	−6.9	−1.8	0.2	7.1	138.10
	II	(78.0)	(0.5)	(10.5)	(11.0)	12.6	1.0	−0.4	3.4	149.30
	III					−5.7	0.8	0.2	−10.5	124.30
LC72 × (LE6 × LC49)	I	6.7	7.1	6.3	0.5	1.9	−3.8	−0.1	−5.9	131.30
	II	(32.5)	(34.5)	(30.6)	(2.4)	1.2	6.3	0.8	14.4	161.90
	III					−3.1	−2.5	−0.7	8.5	141.40
LE6 × (CO114 × LC49)	I	16.3	− 4.9	6.3	2.8	−6.9	0.2	0.0	−5.5	126.90
	II	(53.8)	−(16.2)	(20.8)	(9.2)	12.6	−3.3	0.8	−3.4	145.80
	III					−5.7	3.1	−0.8	8.9	144.60
LC140 × (LC4 × LC49)	I	10.3	0.1	6.3	3.6	2.7	−1.8	0.0	5.0	144.80
	II	(50.8)	(0.5)	(31.0)	(17.7)	−0.6	1.0	0.8	−3.9	136.20
	III					−2.1	0.8	−0.8	−1.1	135.70
LE6 × (LC4 × CO114)	I	16.3	0.1	− 4.9	8.7	−6.9	−1.8	0.2	−4.0	126.30
	II	(54.3)	(0.3)	−(16.3)	(29.1)	12.6	1.0	−3.3	−4.2	144.90
	III					−5.7	0.8	3.1	8.2	145.20
LE6 × (LD × LC140)	I	16.3	− 7.5	3.6	6.9	−6.9	0.7	1.9	−8.6	125.00
	II	(47.5)	−(21.9)	(10.5)	(20.1)	12.6	0.4	−0.6	2.8	153.10
	III					−5.7	−1.1	−1.3	5.8	135.60
LC49 × (LC4 × LE6)	I	12.9	0.1	7.1	− 0.9	1.4	−1.8	−3.8	−2.6	131.00
	II	(61.4)	(0.5)	(33.8)	−(4.3)	1.9	1.0	6.3	−0.9	146.10
	III					−3.3	0.8	−2.5	3.5	136.30

and negative values of $\hat{g}_i$ effects and, predominantly, also of $\hat{h}_j$ and $\hat{h}_k$ effects including effects of SCA $(\hat{t}_{i(jk)})$; this characterizes the low combining ability of parental genotypes in TWC combinations.

Comparisons of both groups of hybrid combinations show that the degree of heterosis effects is conditioned above all by the genetic principle of parental genotypes which is manifested partly through the contribution of individual lines into the hybrid combination and partly through the mutual interaction of these genetic principles in the composition of hybrid combination and partly through the mutual interaction of these genetic principles in the composition of hybrid combination.

From this viewpoint, it is of interest to compare the contributions of individual genotypes to the phenotypic value of the trait in hybrid combinations, expressed by means of relative proportions of GCA (effects $\hat{g}_i$, $\hat{h}_i$, $\hat{h}_k$) and SCA (effects $\hat{t}_{i(jk)}$). It is possible to say that, in principle, these are the contributions of genotypes and their interactions to the composition of hybrid which are conditioned by additive and non-additive gene effects. From this viewpoint it is possible to say that the additive gene effects play a decisive role both in terms of the increase in the trait value and of its decrease (only in combinations LC4 × (EP1 × LC72) and LC4 × (EP1 × LC140) the non-additive effects predominate which decrease the value of this trait in a more significant manner).

The combining ability existing within the set of parental lines is indicated also by data about their proportion in compositions of three-way hybrids showing a different level of phenotypic manifestation of this trait (Tab. VII).

In 25 TWC combinations with the highest values of the trait "grain yield per plant", four lines (LE6, LC49, LC140, LC72) are represented as parents (A..) but with different frequencies. As grandparents (.B. or ..C), 8 and 6 inbred lines, respectively, are represented. Of the best performing combinations the line LC3 is not represented and the lines LD29, CO114 and LC140 occur with the minimum frequency. In 25 TWC combinations with the lowest values of this trait all inbred lines are represented excepting the line LE6; the most frequent are the lines showing the lowest values of GCA effects (i. e. LD29, EP1, CO114, LC4 and LC3). In the remaining 310 TWC combinations the representation of all lines of the experimental set shows the expected frequency.

As far as the combining abilities of genotypes are concerned the obtained results document that the analysis of the system of triallel crossing provides information which is very important and useful for breeding purposes.

DISCUSSION

The evaluation of combining abilities of genotypes represents one of the principal procedures in maize breeding enabling a purposeful selection of initial material for the production of high performing hybrid combinations. The evaluation of combining abilities may be carried out only when applying certain systems of crossing genotypes and testing the hybrid progenies. Different systems of biparental cross-

VI. Characteristics of combining abilities of genotypes and their interactions with experimental years in 25 triallel hybrids of maize showing the lowest grain yield per plant in years 1981—1983 (u = 118.6 g)

Hybrid	Experimental year	Effects of combining ability				Interaction with environment				Grain yield per plant [g]
		$\hat{g}_i$	$\hat{h}_j$	$\hat{h}_k$	$\hat{t}_{i(jk)}$	$\widehat{(ag)}_{il}$	$\widehat{(ah)}_{jl}$	$\widehat{(ah)}_{kl}$	$\widehat{(at)}_{ij(k)l}$	
EP1 × (LD29 × LC4)	I	10.8	- 7.5	0.1	-14.6	-1.6	0.7	-1.8	3.1	86.2
	II	-(32.7)	-(22.7)	(0.3)	-(44.3)	-2.0	0.4	1.0	-8.3	76.9
	III					3.6	-1.1	0.8	5.2	94.3
LD29 × (EP1 × CO114)	I	-15.1	- 3.0	- 4.9	- 8.3	-0.4	-0.4	0.2	4.5	91.2
	II	-(48.2)	-(9.6)	-(15.6)	-(26.5)	-0.1	0.0	-3.3	0.6	84.5
	III					0.5	0.4	3.1	-5.1	86.2
EP1 × (LC4 × CO114)	I	-10.8	- 4.0	- 4.9	-13.3	-1.6	-1.8	0.2	-1.3	81.1
	II	-(32.8)	-(12.1)	-(14.8)	-(40.3)	-2.0	1.0	-3.3	-5.2	76.1
	III					3.6	0.8	3.1	6.5	99.6
LD29 × (LC3 × CO114)	I	-15.1	- 4.0	- 4.9	- 4.1	-0.4	2.2	0.2	-2.2	90.3
	II	-(53.7)	-(14.2)	-(17.5)	-(14.6)	-0.1	-4.6	-3.3	-3.6	78.9
	III					0.5	2.4	3.1	5.8	102.3
CO114 × (LD29 × LC3)	I	- 9.3	- 7.5	- 4.0	- 6.0	0.8	0.7	2.2	-3.2	92.3
	II	-(34.7)	-(28.0)	-(14.9)	-(22.4)	-7.5	0.4	-4.6	4.2	84.3
	III					6.7	-1.1	2.4	-1.0	98.8
LC4 × (LD29 × EP1)	I	- 5.4	- 7.5	- 3.0	- 9.9	-1.2	0.7	-0.4	-1.1	90.8
	II	-(20.9)	-(29.1)	-(11.6)	-(38.4)	-0.3	0.4	0.0	-8.6	84.3
	III					1.5	-1.1	0.4	9.7	103.3
CO114 × (LD29 × EP1)	I	- 9.3	- 7.5	- 3.0	- 6.0	0.8	0.7	-0.4	-3.3	90.6
	II	-(36.0)	-(29.1)	-(11.6)	-(23.3)	-7.5	0.4	0.0	0.7	86.5
	III					6.7	-1.1	0.4	2.6	101.4
EP1 × (LC3 × LC4)	I	-10.8	- 4.0	0.1	- 9.2	-1.6	2.2	-1.8	6.0	99.5
	II	-(44.8)	-(16.6)	(0. 4)	-(38.2)	-2.0	-4.6	1.0	-6.7	82.4
	III					3.6	2.4	0.8	0.7	102.2

LC4 × (LC3 × EP1)	I	− 5.4	− 4.0	− 3.0	−11.0	−1.2	2.2	−0.4	2.1	97.9
	II	−(23.1)	−(17.1)	−(12.8)	−(47.0)	−0.3	−4.6	0.0	−5.7	84.6
	III					1.5	2.4	0.4	3.6	103.1
LC3 × (LD29 × CO114)	I	− 9.2	− 7.5	− 4.9	− 1.2	0.5	0.7	0.2	2.0	99.2
	II	−(40.4)	−(32.9)	−(21.5)	− (5.2)	−6.6	0.4	−3.3	7.2	93.5
	III					6.1	−1.1	3.1	−9.2	94.7
EP1 × (LC4 × LC72)	I	−10.8	− 4.0	2.2	−13.5	−1.6	−1.8	0.2	−1.2	88.1
	II	−(35.4)	−(13.1)	(7.2)	−(44.3)	−2.0	1.0	−0.4	−2.6	89.3
	III					3.6	0.8	0.2	3.8	100.9
LC4 × (EP1 × CO114)	I	− 5.4	− 3.0	− 4.9	− 8.5	−1.2	−0.4	0.2	−3.8	91.6
	II	−(24.8)	−(13.9)	−(22.5)	−(38.9)	−0.3	−0.1	−3.3	−1.6	91.5
	III					1.5	0.5	3.1	5.4	107.3
EP1 × (LD29 × CO114)	I	−10.8	− 7.5	− 4.9	1.4	−1.6	0.7	0.2	1.5	97.6
	II	−(43.9)	−(30.5)	−(19.9)	(5.7)	−2.0	0.4	−3.3	1.2	93.1
	III					3.6	−1.1	3.1	−2.7	99.7
LD29 × (CO114 × LC140)	I	−15.1	− 4.9	3.6	− 4.9	−0.4	0.2	2.0	−0.8	98.3
	II	−(53.0)	−(17.2)	−(12.6)	−(17.2)	−0.1	−3.3	−0.6	4.4	97.7
	III					0.5	3.1	−1.4	−3.6	95.9
LD29 × (CO114 × LC49)	I	−15.1	− 4.9	6.3	− 7.6	−0.4	0.2	−0.1	−2.3	94.7
	II	−(44.5)	−(14.5)	(18.6)	−(22.4)	−0.1	−3.3	0.8	−5.8	88.9
	III					0.5	3.1	−0.7	8.1	108.3
LD29 × (CO114 × LC40)	I	−15.1	− 4.9	0.1	− 1.3	−0.4	0.2	0.8	−2.7	95.3
	II	−(70.6)	−(22.9)	(0.5)	−(6.0)	−0.1	−3.3	0.5	−1.6	92.9
	III					0.5	3.1	−1.3	4.3	104.0
LD29 × (LC4 × CO114)	I	−15.1	0.1	− 4.9	− 1.2	−0.4	−1.8	0.2	−0.3	95.2
	II	−(70.9)	(0.5)	−(23.0)	−(5.6)	−0.1	1.0	−3.3	0.5	95.6
	III					0.5	0.8	3.1	−0.2	101.7

Tab. VI is continued

Hybrid	Experimental year	Effects of combining ability				Interaction with environment				Grain yield per plant [g]
		$\hat{g}_i$	$\hat{h}_i$	$\hat{h}_k$	$\hat{t}_{i(jk)}$	$\widehat{(ag)}_{il}$	$\widehat{(ah)}_{jl}$	$\widehat{(ah)}_{kl}$	$\widehat{(at)}_{i(jk)l}$	
LD29 × (LC3 × EP1)	I	−15.1	−4.0	−3.0	1.7	−0.4	2.2	−0.4	−3.5	96.1
	II	−(63.4)	−(16.8)	−(12.6)	(7.2)	−0.1	−4.6	0.0	7.6	101.1
	III					0.5	2.4	0.4	−4.1	97.4
LD29 × (EP1 × LC4)	I	−15.1	−3.0	0.1	−2.2	−0.4	−0.4	−1.8	−5.4	90.4
	II	−(74.0)	−(14.7)	(0.5)	−(10.8)	−0.1	0.0	1.0	4.4	103.7
	III					0.5	0.4	0.8	1.0	101.1
LD29 × (LC3 × LC40)	I	−15.1	−4.0	0.1	−0.9	−0.4	2.2	0.8	−4.6	96.7
	II	−(75.1)	−(19.9)	(0.5)	−(4.5)	−0.1	−4.6	0.5	4.5	99.0
	III					0.5	2.4	−1.3	0.1	100.4
LC4 × (EP1 × LC72)	I	−5.4	−3.0	2.2	−13.8	−1.2	−0.4	0.2	−5.1	92.1
	II	−(22.1)	−(12.3)	(9.0)	−(56.6)	−0.3	0.0	−0.4	−3.9	94.0
	III					1.5	0.4	0.2	9.0	109.7
EP1 × (LD29 × LC40)	I	−10.8	−7.5	0.1	−1.6	−1.6	0.7	0.8	−0.4	98.3
	II	−(54.0)	−(37.5)	(0.5)	−(8.0)	−2.0	0.4	0.5	2.5	100.2
	III					3.6	−1.1	−1.3	−2.1	97.9
CO114 × (LC3 × LC40)	I	−9.3	−4.0	0.1	−6.1	0.8	2.2	0.8	−7.4	95.7
	II	−(47.7)	−(20.5)	(0.5)	−(31.3)	−7.5	−4.6	0.5	7.7	95.4
	III					6.7	2.4	−1.3	−0.3	106.8
LC4 × (EP1 × LC140)	I	−5.4	−3.0	3.6	−14.3	−1.2	−0.4	2.0	−1.3	98.6
	II	−(20.5)	−(11.4)	(13.7)	−(54.4)	−0.3	0.0	−0.6	−9.2	89.4
	III					1.5	0.4	−1.4	10.5	110.5
LD29 × (LC3 × LC72)	I	−15.1	−3.0	2.2	−3.0	−0.4	−0.4	0.2	−3.5	95.6
	II	−(64.8)	−(12.9)	(9.4)	−(12.9)	−0.1	0.0	−0.4	−2.9	96.3
	III					0.5	0.4	0.2	6.4	107.2

VII. Representation of parental hybrids in 360 hybrid combinations of triallel hybrids of maize evaluated according to the trait "grain yield per plant"

Genotype	Actual representation of genotypes					Representation of genotypes in the best combinations					Representation of genotypes in the worst combinatoins					Representation of genotypes in the mean combinations				
	i..	*.j.*	*..k*		[%]	*i..*	*.j.*	*..k*		[%]	*i..*	*.j*	*..k*		[%]	*i..*	*.j.*	*..k*		[%]
LD29	36	72	—	108	100.0	—	1	—	1	0.9	10	7	—	17	15.7	26	64	—	90	83.4
LC3	36	64	8	108	100.0	—	—	—	—	0.0	1	6	1	8	7.4	35	58	7	100	92.6
EP1	36	56	16	108	100.0	—	4	—	4	3.7	6	6	4	16	14.8	30	46	12	88	81.5
LC4	36	48	24	108	100.0	—	8	—	8	7.4	5	3	3	11	10.2	31	37	21	89	82.4
LE6	36	40	32	108	100.0	10	5	2	17	15.7	—	—	—	—	0.0	26	35	30	91	84.3
CO114	36	32	40	108	100.0	—	1	1	2	1.9	3	3	7	13	12.0	33	28	32	93	86.1
LC49	36	24	48	108	100.0	9	3	7	19	17.6	—	—	1	1	0.9	27	21	40	88	81.5
LC40	36	16	56	108	100.0	—	2	1	3	2.8	—	—	4	4	3.7	36	14	51	101	93.5
LC140	36	8	64	108	100.0	4	1	7	12	11.1	—	—	2	2	1.9	32	7	55	94	87.0
LC72	36	—	72	108	100.0	2	—	7	9	8.3	—	—	3	3	2.8	34	—	62	96	88.9

ing are the most frequent and, of them, that of diallel crossing (Griffing, 1956; Turbin et al., 1974; Vožda, 1980a, b) which is based on the crossing within the set of selected genotypes is the most important. Within the framework of biparental crossing, we have elaborated a factorial system of paired crossing (Vožda, 1980, 1981, 1985) which is based on the hybridization of two non-relative sets of genotypes. Both systems are based on estimates of effects of combining abilities using the analysis of hybrid combinations on the level of single hybrids.

Rawlings and Cockerham (1962) and, later on, also Hinkelmann (1964) elaborated a system of crossing genotypes on the level of three-way hybrids which is designated as triallel crossing performed within the framework of a set of genotypes. However, this system was not used in greater extent due to its experimental complexity and low informative value. It was used in our laboratory (Vožda, 1985) and its application was extended to the analysis of combining abilities of genotypes on the level of triparental crossing (Vožda, 1980, 1985; Wolf, 1985). Although the triallel system of crossing requires a considerable number of hybrid combinations $\left(c = \frac{P\,(p\text{-}1)\;(p\text{-}2)}{2}\right)$ for the analysis it is possible to hold its application for substantiated because it provides very valuable information suitable for breeding purposes; this was documented by the results obtained.

In the same way as biparental systems of crossing (Vožda, 1988) require an evaluation in different environments for reliable estimates of effects of combining abilities (of years, localities) it is necessary to improve the informative value of triallel systems of crossing by means of its testing in different environments. Results presented in this study showed significant differences in estimates of the effects of combining abilities in the individual years; this reduced their reliability and informative value.

The objectivized estimates of effects of GCA and SCA in triparental hybrid combinations show that the phenotypic value of the trait "grain yield per plant" is conditioned above all by additive effects the most important of which in hybrid combinations with the highest and the lowest performance is the contribution of the first genotype in the TWC combination ($\hat{g}_i$ effects) as the parent. Effects $\hat{h}_j$ and $\hat{h}_k$ as grandparents show to be variable in TWC combinations. The contributions of the effect of SCA, expressing the interaction of genotypes resulting from non-additive genetic effects, preserve a distinct tendency in TWC combinations in spite of their specifity; this is documented above all in Tabs V and VI.

The application of triparental systems of crossing in breeding practice may be markedly supported by our system of trifactorial crossing (i. e. crossing of three unrelated sets of genotypes) which enables to use a higher number of parental genotypes with the same number of hybrid combinations as in the triallel system of crossing. In the triallel system it is necessary to obtain 360 hybrid combinations from 10 genotypes while in the trifactorial system 343 combinations are obtained from 21 genotypes.

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VOŽDA, J. (Mendeleum, Lednice na Moravě): *Hodnocení kombinačních schopností genotypů kukuřice v systému trialelního křížení.* Genet. a Šlecht., *24*, 1988 (4) : 293-308.

Na základě tříletého hodnocení souboru 360 hybridních kombinací TWC, získaných trialelním systémem křížení 10 parentálních genotypů kukuřice, byla provedena analýza kombinačních schopností s využitím modelu (Vožda, 1980, 1985; Wolf, 1984), zahrnujícího rozklad genetického účinku a jejich interakcí s pokusnými ročníky pro hodnocení efektů kombinačních schopností u čtyř kvantitativních znaků. Pro znak výnos zrna na rostlinu bylo v hodnoceném souboru prokázáno, že je podmíněn přínosy genotypů ve skladbách TWC, vyjádřených efekty GCA ($\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$), vzájemnou interakcí genotypů, vyjádřených efekty SCA ($\hat{t}_{i(jk)}$) a jejich interakcemi GCA a SCA s pokusnými ročníky. Odhadnuté efekty GCA genotypů tvoří podstatnou část přínosů k fenotypové hodnotě znaku, přičemž přínos $\hat{g}_i$ je pro tuto hodnotu nejvýznamnější. Tato skutečnost se projevila v souboru hybridních kombinací s nejvyšší hodnotou (pozitivní přínosy), tak i v kombinacích s nejnižší hodnotou znaku (negativní přínosy). Variabilní je přínos efektů $\hat{h}_j$ a $\hat{h}_k$, podobně jako $\hat{t}_{i(jk)}$, avšak se zřejmou tendencí. Z hlediska přínosů k fenotypové hodnotě znaku tvoří odhady efektů GCA a SCA spolu s jejich interakcemi s prostředím nejúplnější a šlechtitelsky použitelnou informaci pro jednotlivé kombinace TWC.

trialelní systém křížení; efekty GCA ($\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$); efekty SCA ($\hat{t}_{i(jk)}$); interakce efektů GCA a SCA s prostředím

ВОЖДА, Я. (Менделеум, Леднице на Мораве): **Оценка комбинационных способностей генотипов кукурузы в системе триаллельного скрещивания.** Genet. a Šlecht., *24*, 1988 (4) : 293-308.

На основании трехлетнего испытания 360 трехлинейных гибридных комбинаций, полученных системой триаллельного скрещивания 10 родительских генотипов кукурузы, был проведен анализ комбинационных способностей с использованием модели (Вожда, 1980; Вольф, 1985), включающей разложение генетического эффекта и его взаимодействия с годами испытаний для оценки эффектов комбинационных способностей четырех количественных признаков. Анализ показал, что признак «урожайность зерна на растении» обусловлен вносами генотипов в трехлинейные гибриды, выражающимися эффектами ОКС ($\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$), взаимодействием генотипов, представленных эффектами СКС ($\hat{t}_{i(jk)}$) и также взаимодействием ОКС и СКС по годам испытаний. Эффекты ОКС генотипов составляют существенную долю фенотипического проявления признака, причем эффекты $\hat{g}_i$ являются наиболее значительными. Это обстоятельство проявилось как в гибридных комбинациях с наиболее высокими значениями признака (положительные эффекты), так и комбинациях с наиболее низкими значениями признака (отрицательные эффекты). Доля эффектов $\hat{h}_j$ и $\hat{h}_k$, также как и $\hat{t}_{i(jk)}$ значительно вариабильна, хотя и у них проявляется явная тенденция. С точки зрения вкладов генотипов к фенотипическому проявлению признака представляют оценки эффектов ОКС и СКС, совместно с их взаимодействием по годам испытаний, наиболее полную и селекционно используемую информацию для каждой конкретной комбинации трехлинейных гибридов.

триаллельная система скрещивания; эффекты ОКС ($\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$); эффекты СКС ($\hat{t}_{i(jk)}$); взаимодействие эффектов ОКС и СКС с средом

VOŽDA, J. (Mendeleum, Lednice na Moravě): *Bewertung der Kombinationseignung der Maisgenotypen im System der Dreiallelkreuzung.* Genet. a Šlecht., *24*, 1988 (4) : 293-308.

Aufgrund einer dreijährigen Bewertung einer Kollektion von 360 Hybridkombinationen von TWC, die im Rahmen des Dreiallelkreuzungssystems erzüchtet wurden, in dem 10 parentale Maisgenotypen gekreuzt worden waren, analysierten wir die Kombinationseignung unter Anwendung eines Modells (Vožda, 1980, 1985; Wolf, 1984), das die Zerlegung der genetischen Wirkung darstellt, ferner ihre Wechselwirkungen mit Versuchsjahrgängen zwecks Bewertung der Effekte der Kombinationseignung bei vier Quantitätsmerkmalen. Für das Merkmal Körnerertrag pro Pflanze konnten wir in der bewerteten Kollektion nachweisen, dass es von Beiträgen der Genotypen in der Zusammensetzung von TWC, die durch die Effekte GCA ($\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$), durch eine gegenseitige Wechselwirkung der Genotypen die durch die Effekte SCA ($\hat{t}_{i(jk)}$) ausgedrückt sind und durch ihre Wechselwirkungen GCA und SCA mit Versuchsjahrgängen bedingt ist. Die geschätzten Effekte GCA der Genotypen bilden den wesentlichen Teil der Beiträge zum phenotypischen Wert des Merkmals, der Beitrag g_i ist dabei für diesen Wert der bedeutendste. Diese Tatsache fand in einer Gruppe von Hybridkombinationen mit höchstem (positive Beiträge), als auch mit niedrigstem Wert des Merkmals (negative Beiträge) ihren Niederschlag. Variabel ist der Beitrag der Effekte $\hat{h}_j$ und $\hat{h}_k$ als auch des Effektes $\hat{t}_{i(jk)}$, aber mit einer offenbaren Tendenz. Aus der Sicht der Beiträge zum phenotypischen Wert des Merkmals bilden die Schätzungen der Effekte GCA und SCA mit ihren Wechselwirkungen mit der Umwelt die beste und züchterisch ausnutzbare Information für einzelne TWC-Kombinationen.

Dreiallelkreuzungssystem; Effekte GCA ($\hat{g}_i$, $\hat{h}_j$, $\hat{h}_k$); Effekte SCA ($\hat{t}_{i(jk)}$); Wechselwirkung der Effekte GCA und SCA mit der Umwelt

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ACCELERATION OF BREEDING PROCESS OF WINTER CEREALS BY GROWING THE 3rd GENERATION IN A PLASTIC HOUSE WITH WASTE-HEAT SYSTEM

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ŠPUNAR, J. (OSEVA — Research and Breeding Institute of Cereal Growing, Kroměříž): *Acceleration of Breeding Process of Winter Cereals by Growing the 3rd Generation in a Plastic House with Waste-Heat System.* Genet. a Šlecht., *24*, 1988 (4) : 309-314.

The three-year results are summarized of growing spring and winter cereals in a plastic house with waste-heat system in the period of January — June. The complete vernalization took place in winter cereals and there was no winter killing in spring cereals. Cereal growing in this period is practised to maintain the continuity of breeding process by means of growing the 3rd generation of winter cereals immediately after the two generation of cereals had been grown in the previous year.

cereals; energy; breeding; shortening of breeding process

Growing 2 — generations a year is one of the most efficient measures for acceleration of the breeding process. Breeders of West European countries have their 2nd barley generation multiplied on the South Hemisphere, mainly in Chile and New Zealand (Persson et al., 1975; Mc Evan, 1983 — written report). In the CMEA countries, extensive glasshouse and phytotron complexes were constructed: Hungary — Martonvásár (Rajki, 1982), Soviet Union — Odessa (Sozinov, 1978) etc. In Czechoslovakia practically all breeding stations dealing with cereals have built glasshouses for cultivating 2 — 3 generations within a year. Cultivation in glasshouses and in phytotrons in autumn and particularly in winter consumes a great amount of energy. Electric energy consumption for artificial illumination in spring barley alone grown in glasshouse, is as high as 850—1500 kWh/m^2 (Špunar, 1979), and in a phytotron 3600 — 5200 kWh/m^2 (Birjukov et al., 1982). Špunar and Malovaná (1984) elaborated a system of two winter barley generations with minimum material and energy costs. This system can also be applied in wheat breeding. Having harvested the 2nd generation during autumn the problem arises of maintaining the continuity of the breeding process in cultivating the 3rd generation. The purpose of the presented publication is to characterize the cultivation of the 3rd winter cereals generation in the period of January — June in a plastic house, warmed with the waste-heat produced by the gas compressor station at Hrušky near Břeclav, Czechoslovakia.

MATERIALS AND METHODS

Upon agreement with the managers of the Joint Agricultural Enterprise at Tvrdonice, South Moravia, which uses the glass- and plastic-house complex for vegetable production, one plastic-house was selected for the experiment. The plastic-houses (all built from unified ready-made parts) have dimensions as follows: 50 m length, 8 m width, 3 m height to the top. The soil was prepared by rotavating. The sowing dates were as follows: 1985 — January 1; 1986 — January 15; 1987 — January 25.

The following cultivars were chosen in each of the years:

Cereal	1985	1986 and 1987
winter wheat	Mironovskaya	Mironovskaya, BR-55, Selekta, Mara, Hana, Viginta, Solaris
rye	Daňkovské nové	Daňkovské nové
winter barley	Erfa	Erfa
spring barley	Zenit	Zenit
oats	Pan	Pan

Seeding was performed by hand. The spacing was 12.5 cm × 3.5 cm, each cultivar in one row, i. e. 30 seeds. Plant height, ear (panicle) length and yield components were determined from ten main tillers of random sampled plants.

RESULTS

Tab. I, II, III illustrate the course of vegetative phases in individual years. From the results it follows that the intentionally delayed sowing date did not influence negatively the plant growth and development. Although both winter and spring cereals were grown together, it was proved, that even winter rye, which is most sensitive to good vernalization was vernalized sufficiently and showed no delay in the onset of developmental phases, especially that of heading. There were great differences between the species and varieties, particularly in winter wheat, as for onset of individual phases of development in comparison with cultivation in the field.

Tab. IV, V and VI contain an evaluation of the basic characteristics essential from the economic and yield points of view. Assuming grain production from the main ear as being only 20 — 60 grains, then regardless of grain production from the remaining tillers it is possible to consider the coefficient of multiplication of 20 — 60 as being satisfactory. 1000-grain weight varied from year to year and the highest one was recorded in the earliest seeding date (1985).

I. Course of cereal growing in the heated plastic house in 1985

Cultivar	Emergence	Earing	Milk ripeness	Harvest ripeness
Mironovskaya	28. 1.	6. 5.	30. 5.	15. 6.
Erfa	26. 1.	27. 4.	20. 5.	8. 6.
Daňkovské nové	6. 2.	29. 4.	24. 5.	10. 6.
Zenit	25. 1.	26. 4.	30. 5.	9. 6.
Pan	27. 1.	29. 4.	23. 5.	13. 6.

II. Course of cereal growing in the heated plastic house in 1986

Cultivar	Emergence	Earing	Milk ripeness	Harvest ripeness
Mironovskaya	1. 2.	28. 4.	20. 5.	1. 6.
BR 55	1. 2.	24. 4.	19. 5.	1. 6.
Selekta	2. 2.	25. 4.	20. 5.	2. 6.
Mara	2. 2.	25. 4.	20. 5.	2. 6.
Hana	2. 2.	25. 4.	20. 5.	2. 6.
Viginta	2. 2.	25. 4.	21. 5.	3. 6.
Solaris	1. 2.	27. 4.	24. 5.	4. 6.
Erfa	1. 2.	24. 4.	19. 5.	30. 5.
Daňkovské nové	1. 2.	23. 4.	19. 5.	30. 5.
Zenit	1. 2.	24. 4.	20. 5.	1. 6.
Pan	1. 2.	29. 4.	27. 5.	6. 6.

III. Course of cereal growing in the heated plastic house in 1987

Cultivar	Emergence	Earing	Milk ripeness	Harvest ripeness
Mironovskaya	13. 2.	10. 5.	10. 7.	31. 7.
BR 55	13. 2.	10. 5.	12. 7.	31. 7.
Selekta	9. 2.	5. 5.	5. 7.	25. 7.
Mara	9. 2.	26. 4.	5. 7.	28. 7.
Hana	9. 2.	30. 4.	8. 7.	26. 7.
Viginta	9. 2.	30. 4.	8. 7.	28. 7.
Solaris	9. 2.	30. 4.	4. 7.	24. 7.
Erfa	4. 2.	26. 4.	30. 6.	22. 7.
Daňkovské nové	5. 2.	26. 4.	4. 7.	26. 7.
Zenit	5. 2.	26. 4.	30. 6.	23. 7.
Pan	9. 2.	5. 5.	1. 7.	26. 7.

IV. Results of cereal growing in heated plastic house in 1985

Cultivar	Plant height [cm]	No. of tillers	Ear-panicle length [cm]	Grains/ ear	Grain weight/ ear [g]	1000 grain weight [g]
Mironovskaya	120	2.5	10.5	45.0	2.16	48.9
Erfa	110	5.0	8.0	55.5	2.88	52.0
Daňkovské nové	160	2.0	12.0	52.0	2.41	46.5
Zenit	95	6.5	11.0	28.8	1.62	56.5
Pan	110	4.2	28.0	49.5	1.91	38.5

V. Results of cereal growing in heated plastic house in 1986

Cultivar	Plant height [cm]	No. of tillers	Ear-panicle length [cm]	Grains/ ear	Grain weight/ ear [g]	1000 grain weight [g]
Mironovskaya	100	2.8	10.25	41.0	1.92	46.8
BR 55	80	3.5	8.95	37.6	1.11	29.5
Selekta	65	4.6	7.65	32.2	1.21	37.6
Mara	70	2.8	6.95	28.1	1.29	45.9
Hana	90	3.3	7.70	37.8	1.71	45.2
Viginta	80	3.8	7.35	31.4	1.16	36.9
Solaris	80	2.5	7.35	26.3	1.16	44.1
Erfa	110	4.5	6.85	47.0	2.24	47.7
Daňkovské nové	140	1.8	10.70	48.9	2.09	42.7
Zenit	80	5.6	9.70	28.4	1.64	57.7
Pan	120	4.5	29.30	55.1	1.90	34.4

VI. Results of cereal growing in heated plastic house in 1987

Cultivar	Plant height [cm]	No. of tillers	Ear-panicle length [cm]	Grains/ ear	Grain weight/ ear [g]	1000 grain weight [g]
Mironovskaya	110	2.5	9.9	28.3	0.78	27.4
BR 55	85	1.5	7.9	28.8	0.58	20.8
Selekta	70	2.5	7.8	25.4	0.79	31.1
Mara	85	2.0	8.5	26.0	0.99	32.4
Hana	80	1.5	7.8	24.2	0.53	21.9
Viginta	75	2.0	7.6	18.2	0.38	20.9
Solaris	75	3.0	7.5	45.0	2.10	46.7
Erfa	105	3.2	8.5	59.9	2.79	46.6
Daňkovské nové	130	1.8	11.5	34.0	1.10	32.4
Zenit	95	4.5	7.5	13.2	0.60	45.6
Pan	110	3.0	25.0	53.2	1.94	36.5

DISCUSSION

Krekule (1982) holds the perfect course of vernalization as a fundamental condition for harmonic transition to the generative phase.

If the normal course of vernalization in natural conditions was held as the major aim of the above experiments, with no negative influence on subsequent growth and development and with no frost-killing of the spring cereals, it is possible to say that this aim was fulfilled.

Abakumenko (1980) shows that cereals sown in a glasshouse or a plastic-house artificially heated to let the cereals emerge and to maintain the temperature of 5 °C are the same in development as the cereals sown in autumn in field conditions.

With cereals cultivated in this way, reliable selection for productivity can be performed. On the other hand, Fedak and Fejer (1975) confirmed that if vernalization is performed in artificial environment, productivity cannot be evaluated. In the given case if the plastic film is removed after vernalization the cereals will grow in natural conditions, the plants being exposed to stress factors (lodging, disease infections, high temperature) etc. This means that selection for productivity and other characters can be done. It is a point of discussion from the point of view of the plant breeder's practical concern whether it is more advantageous either to multiply the 3rd generation at a comparatively remote place in plastic houses using waste-heat or to build such a plastic-house at the breeding station itself. System of growing 2 generations of winter cereals is described in details by Špunar and Malovaná (1984). The described system of growing is in its complex cheaper than growing in the controlled-environment rooms (Biryukov et al., 1982).

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ŠPUNAR, J. (OSEVA — Výzkumný a šlechtitelský ústav obilnářský, Kroměříž): *Urychlení šlechtitelského procesu ozimých obilnin pěstováním třetí generace ve fóliovníku vytápěném odpadním teplem.* Genet. a Šlecht., *24,* 1988 (4) : 309-314.

V práci jsou shrnuty tříleté výsledky pěstování jarních a ozimých obilnin ve fóliovníku vytápěném odpadním teplem v období leden až červen. Plná jarovizace proběhla u ozimých obilnin a nedošlo k poškození jarních obilnin chladem. Pěstování obilnin v tomto období má význam pro udržení kontinuity šlechtitelského procesu, poněvadž třetí generace je pěstována ihned po sklizni druhé generace.

obilniny; energie; zkrácení šlechtitelského procesu; pěstování ve fóliovníku

ШПУНАР, Я. (ОСЕВА — Научно-исследовательский и селекционный институт зерновых культур, Кромержиж): **Ускорение селекционного процесса озимых зерновых культур выращиванием третей генерации под пленкой с отоплением отработанным теплом.** Genet. a Šlecht., *24,* 1988 (4) : 309-314.

Приводится анализ трехлетних результатов, полученных при выращивании яровых и озимых зерновых культур под пленкой с отоплением отработанным теплом в период январь—июнь. У озимых прошла только яровизация и у яровых не отмечалось повреждения зимой. Выращивание зерновых культур в этот период предусматривается для сохранения непрерывности селекционного процесса выращиванием третьей генерации озимых зерновых после создания двух генераций в предыдущем году.

зерновые культуры; энергия; селекция; сокращение селекционного процесса

ŠPUNAR, J. (OSEVA — Forschungs- und Züchtungsinstitut für Getreidebau, Kroměříž): *Die Beschleunigung des Züchtungsprozesses von Wintergetreidearten durch Züchtung der 3. Generation im Folienhaus bei Abfallwärmeheizung.* Genet. a Šlecht., *24,* 1988 (4) : 309-314.

Im Beitrag sind die dreijährigen Resultate des Anzucht von Sommer- und Wintergetreidearten im Folienhaus mit Abfallwärmeheizung in der Periode Januar—Juni zusammengefasst. Bei Wintergetreidearten ist die Jarowisation verlaufen und die Sommergetreidearten sind nicht beschädigt worden. Der Anbau in dieser Periode solte für die Erhaltung der Kontinuität des züchterischen Prozesses dienen, das der Anbau der dritten Generation der Wintergetreidearten unmittelbar nach der Ernte von zwei vorhergehenden Generationen erfolgt.

Getreidearten; Energie; Züchtung; Verkürzung der Züchtung

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PERFORMANCE AND GENETIC PARAMETERS OF THE SYNTHETIC POPULATIONS OF RED CLOVER

M. Užík

UŽÍK, M. (Research Institute for Crop Production, Piešťany): *Performance and Genetic Parameters of Synthetic Populations of Red Clover.* Genet. a Šlecht., *24,* 1988 (4) : 315-324.

From a set of 40 families we chose the first two, or five with the highest values of green matter yield (H), seed yield (S), persistence (T) and also those with all three above — average characters (I). The performance of the families was expressed in % of the trial average (S_p) and in % of the average of systematically included control variety (S_b). We also made negative selection for the characters H, S, T. For the production of genotypic synthetic populations (Syn G) we used the seed from the reserve of mother plants from which the families were grown. For phenotypic synthetic populations (Syn P) the seed from the test of families was used. We tested the populations at three localities using the seed originating from its multiplication in the sowing year. The number of components influenced neither the average nor the variability of the characters of populations. Genotypic selection was more effective than phenotypic one. Among populations of Syn G there were some differences according to the kind of selection, however, among Syn P ones there were not differences even between plus and minus selection. The marked genetic shift expressed in smaller genotypic variance among the phenotypic populations than among the genotypic ones appeared to be caused by natural selection pressure.

selection of mother plants; selection of families; green matter yield; seed yield; persistence; natural selection; red clover

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In breeding cross-pollinated crops there is an efort for increasing gene frequency of favourable alleles and maintaining a high heterozygosity (Falconer, 1970). This goal can be achieved with genotypic or phenotypic selection (Bogaret, 1984; Twamley, 1971) both of which can be applied in the programme of recurrent selection.

In connection with the previous work (Užík, 1986), we have utilized the selected families for the creation of synthetic populations.

MATERIALS AND METHODS

We have started with the set of 40 families divided into ten blocks with the systematically arranged check variety (Užík, 1986). For each family yield of green matter (H), yield of seed (S), and persistence (T) were expressed in the percentages of the check variety in the block (S_b), and in the percentage of the trial average (S_p). For each character were determined first two and five families with the highest value irrespective of the value of further characters. Simultaneously, according to the selection method of independent culling levels were chosen the families possessing above values of all these characters. The average values of chosen families grouped according to the selection criteria can be found in Tab. I and Fig. 1.

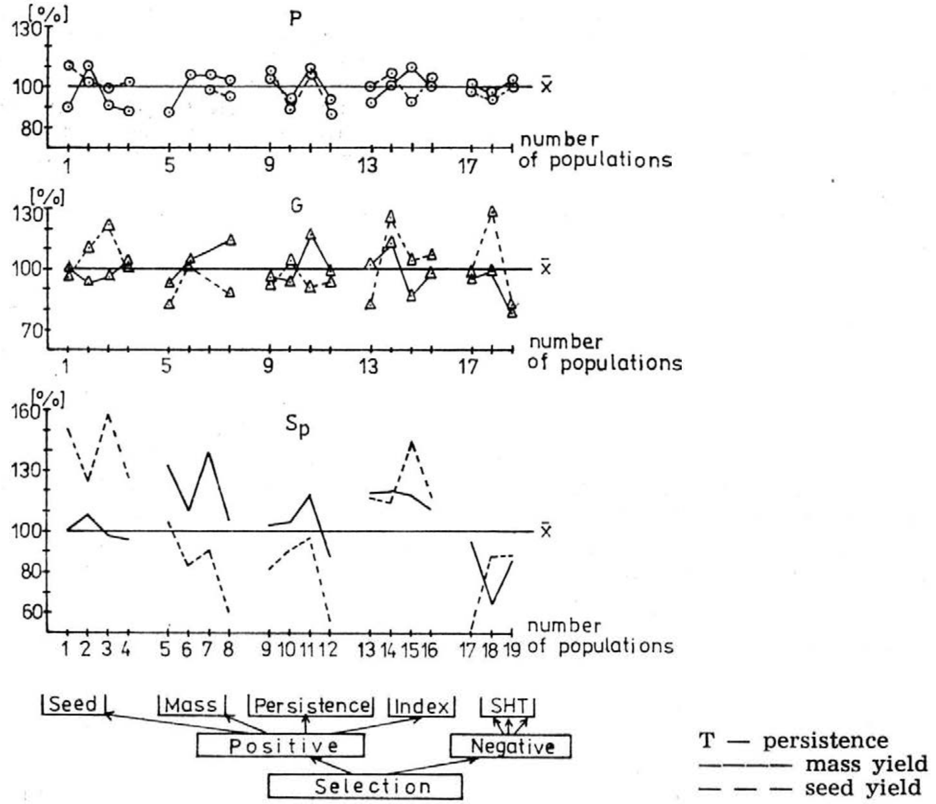
For the creation of genotypic synthetic populations seed of the mother plants was utilized, from which the chosen families originated, and for the creation of the phenotypic populations seed from family test was utilized.

Genotypic populations were propagated in spacing planting of 0.4 × 0.4 m and in space isolation. Check population Syn G_K originated from the aliquot rate of seeds (plants) of all 40 mothers plants. Phenotypic populations were propagated in drill sowings and without strict isolation. Populations were sown on the plot 8 × 8 m side by side. For performance test seed from central part of the plot was utilized. Check populations Syn P_K originated from the aliquote seed rate of all plants of the family test.

Performance tests were laid out on the three localities — Piešťany, M. Šariš, Vígľaš — in 1985. For the shortage of seed some populations were not included in all localities. In the performance tests were included synthetic populations, check populations (Syn K_G a Syn K_P), as well as control varieties Kvarta and Javorina. The trials had four replications for green matter and four for seed, whith randomised variants (harvest plot area 2 m^2, row width for green matter 12.5 cm, for seed 25 cm, seeding rate of 75 germinating seeds per 1 meter). Evaluated were: yield of green matter, seed yield, and at Piešťany also persistence.

RESULTS AND DISCUSSION

Average values of the characters of the groups of families (Tab. I) indicated that more marked differentiation among populations can be

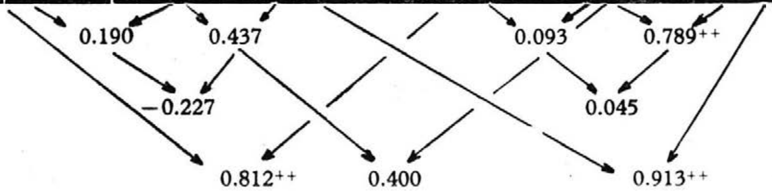


1. Comparison of mass yield (H) and seed yield (S) of genotypic (G) and phenotypic (P) populations with selection difference (S_p) on their components

I. Average values of the characters of families (components) grouped according to the selection criteria

Population No.	Selection		Number of components (families)	Average values expressed					
				in % of mean value of the whole trial (S_p)			in % of mean value of control variety in block (S_p)		
	for a character	according to ($\bar{x}_b$) ($\bar{x}_p$)		seed	gr. matt.	persistence	seed	gr. matt.	persistence
1	seed	$\bar{x}_p$	5	150.54	101.04	95.06	168.80	106.60	201.80
2		$\bar{x}_{kb}$	4	125.58	108.93	109.11	219.00	132.00	228.50
3		$\bar{x}_p$	2	157.98	98.57	78.09	189.00	106.50	181.00
4		$\bar{x}_{kb}$	2	127.33	96.63	106.86	205.35	118.00	222.50
5	green matter	$\bar{x}_p$	5	105.45	133.13	100.84	170.84	126.20	198.60
6		$\bar{x}_{kb}$	4	83.51	110.42	123.72	156.42	154.00	253.00
7		$\bar{x}_p$	2	90.56	138.53	102.63	156.20	125.00	194.00
8		$\bar{x}_{kb}$	2	60.60	106.32	126.34	107.85	160.00	269.00
9	persistence	$\bar{x}_p$	5	81.91	103.34	135.87	124.36	135.60	243.40
10		$\bar{x}_{kb}$	5	91.05	104.86	127.66	126.22	126.80	284.60
11		$\bar{x}_p$	2	97.96	118.17	138.58	145.60	130.50	229.00
12		$\bar{x}_{kb}$	2	56.32	87.96	129.84	82.50	146.00	296.00
13	index	$\bar{x}_p$	5	117.32	119.55	125.04	160.94	127.80	246.60
14		$\bar{x}_{kb}$	4	114.06	120.08	118.14	192.88	139.00	245.25
15		$\bar{x}_p$	2	144.16	118.82	109.21	174.00	130.00	248.00
16		$\bar{x}_{kb}$	2	117.12	101.50	111.32	203.65	152.50	235.50
	Negative selection:								
17	seed		2	52.64	95.42	99.98	81.26	115.60	210.40
18	green matter		5	88.11	65.56	68.40	114.20	92.40	142.60
19	persistence		5	89.07	86.27	45.43	100.00	98.60	93.80

correlations



expected only due to independent selection for characters, and also due to positive and negative selection. In the foregoing work we have shown (Užík, 1986) that no family did combine the mentioned characters for above-average levels. By means of selection method of independent culling level we have created groups of the families having above—average values of above mentioned characters (Fig. 1 and Tab. I).

There was only positive correlation between green matter yield and persistence of the grouped families. There were significant correlations for the character between their average values expressed in percentages of trial average value (S_p) and in percentages of values of control variety in block (S_b) (for persistence 0,913^{++}, for seed yield 0,812^{++} and for green matter yield 0,400) (Tab. I). Correlations indicated that family selections for green matter yield according to control variety and according to trial average are not consistent.

Characteristics of synthetic populations

Because there were no significant differences between two and five component populations, the results are stated in Tab. II only as average values according to the characters and the kind of selection. The obtained data for all populations are included in Fig. 1.

Green matter — In case of genotypic populations and positive selection the highest average green matter yield (84,43 t/ha) expressed (showed) populations of direct selection for green matter. The lowest, however, green matter yield possessed populations from the negative selection for persistence (72,68 t/ha) and not these from the negative selection for green matter (80,5 t/ha). On the contrary, in case of phenotypic populations no tendencies were found, but even populations from the negative selection have given the same yield as those from positive selection (Tab. II).

Seed yield — In evaluating the average data from above three localities no marked tendencies according to the investigated factors were found (Tab. II). At Piešťany, where this selection and creation were performed, certain tendencies in case of the genotypic populations existed, but no ones in case of the phenotypic populations (Tab. II). However, the highest seed yield in general gave population from the negative selection for green matter (419,82 kg/ha), as well as the lowest one a population from the negative selection for the persistence.

Persistence (Tab. II) — In case of genotypic populations selection response was in expected direction. The highest persistence was found in populations from selection for persistence (81,55 %) while a lower one after selection for other traits (72 — 79 %). The lowest persistence at all was found in population from negative selection for persistence (49,15 %). Among phenotypic populations derived, from positive selection, the highest persistence was appeared no doubt in populations from selection for persistence (72,53 %), however, the average persistence of all populations from negative selection was higher (83,02 %). Average persistence of all populations from the positive selection for all selected characters was lower (68,44 %) than the average persistence of all populations from the negative selection (83,02) — Tab. II.

II. Characteristics of synthetic populations

Selection for a trait	Mass yield [t.ha^{-1}]		Seed yield [kg.ha^{-1}]		Persistence [%]
	Piešťany	mean*	Piešťany	mean*	Piešťany
Positive genotypic selection					
Mass yield	95.76	84.43	296.58	490.67	79.58
Seed yield	90.98	83.33	350.29	508.01	73.54
Persistence	94.36	81.42	311.98	486.84	81.55
Index	92.92	80.58	341.35	489.62	72.80
Mean	93.51	82.44	325.05	493.79	76.87
Negative genotypic selection					
Mass yield	94.35	80.15	419.82	511.61	63.80
Seed yield	89.70	80.65	371.15	526.13	85.48
Persistence	73.31	72.68	269.59	438.61	49.15
Mean	85.12	77.83	335.52	492.12	66.14
Syn G_K	101.39	81.12	264.24	518.91	85.63
Positive phenotypic selection					
Mass yield	94.26	83.90	314.31	507.27	70.56
Seed yield	88.75	81.26	333.70	494.26	62.13
Persistence	93.98	84.49	315.67	477.93	72.53
Index	95.13	84.15	325.78	497.87	68.46
Mean	93.03	83.45	322.37	494.33	68.44
Negative phenotypic selection					
Mass yield	90.53	83.09	303.86	502.54	85.69
Seed yield	94.86	84.52	315.95	524.90	79.90
Persistence	96.69	84.79	322.46	555.82	83.47
Mean	94.03	84.13	314.09	527.75	83.02
Syn P_K	95.71	85.15	311.60	539.70	73.20
Kvarta	89.70	80.52	290.00	423.75	80.09
Javorina	94.25	82.86	308.38	433.21	79.10
D_T (0.05)	9.56	7.71	40.32	n	7.39

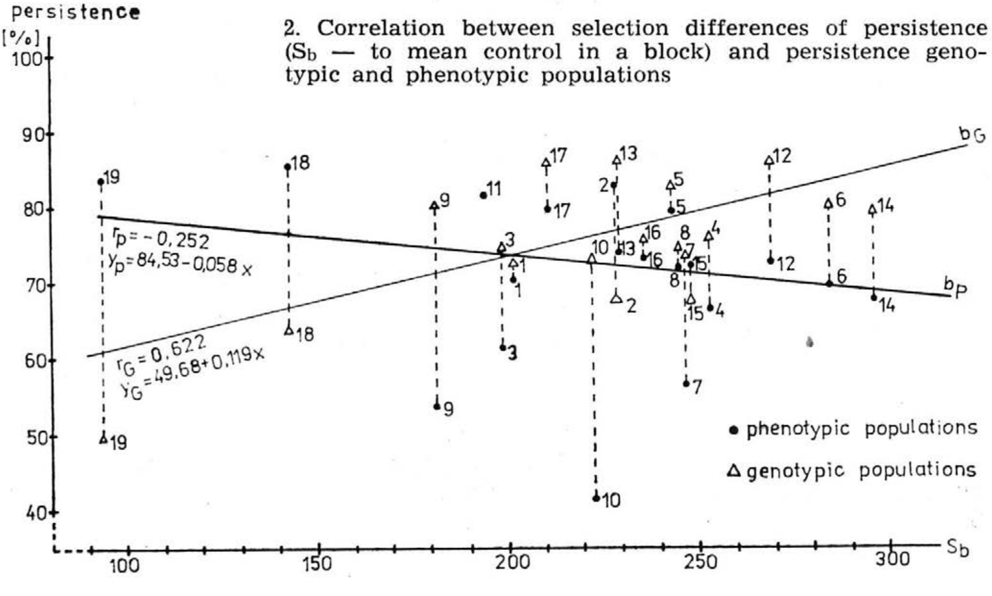
* mean of three sites

Obviously, due to the natural selection to which phenotypic populations during the family trial were exposed seed for growing next generations was obtained exclusively from the persistent plants and therefore there were no differences between the positive and negative selections.

Correlations between family (component) group and their synthetic populations

Correlations between these generations were generally weak (Tab. III), however, certain tendencies can be seen. We have found that the genotypic populations showed stronger correlations with groups of families than phenotypic ones. At Piešťany these correlations were stronger than on the other two localities. Stronger correlations existed between green-matter yield of the synthetic populations and yield of their components (i. e. families), when the yield of families was expressed in the percentages of check variety in block (S_b) (at Piešťany $r = 0{,}428$) than by its expressing in percentages of the trial average (S_p) (at Piešťany $r = 0{,}190$). Similar correlations but weaker ones can be found in seed yield (Tab. III).

At Piešťany, in case of genotypic populations, there was positive significant correlation between persistance of the synthetic populations and persistence of their components (families) ($0{,}557^{+}$ and $0{,}485^{+}$) however, in case of phenotypic populations these correlations were weak, but negative ($r = 0{,}156$, and $r = -0{,}252$) (Tab. III). Persistence of individual populations was clearly changed in consequence of leaving the phenotypic populations for seed production in the sowing year. In the populations increased the share of early flowering types, which were able to give seed yield in sowing year. However, these types had lower persistence. Similar but less marked genetic shift was also observed by other authors (Valle, 1953; Taylor et al., 1966). A different kind of multiplication of genotypic and phenotypic populations contributed to their differentiation. In spaced sowing and harversting in the sowing year, all plants had better chance to survive than in the drilled ones (Bula et al., 1965). Multiplication of the phenotypic populations without a strict isolation caused some changes, which were manifested in the lower genotypic variance. This was confirmed on all three localities (Tab. IV). Due to the natural selection pressure the populations, originating from the same components, distinquished



2. Correlation between selection differences of persistence (S_b — to mean control in a block) and persistence genotypic and phenotypic populations

III. Correlations between family (component) groups and their synthetic populations

Combinations	Average values of family (component) groups expressed					
	in % of trial average (S_p)			in % of check variety (S_b)		
	Py	Vi	MŠ	Py	Vi	MŠ
			Genotypic populations			
Green matter of synthetics						
× (S_p, S_b) green matter	0.190	−0.203	0.311	0.428	0.334	0.241
× (S_p, S_b) seed yield	−0.136	−0.088	0.257	0.080	0.144	0.514^{+}
× (S_p, S_b) persistence	0.569	0.016	0.254	0.432	0.127	0.217
Seed yield of synthetics						
× (S_p, S_b) seed yield	0.036	0.391	−0.167	0.169	0.164	0.155
× (S_p, S_b) green matter	−0.112	−0.036	0.360	0.246	-0.500^{+}	0.304
× (S_p, S_b) persistence	0.152	−0.302	0.450	0.324	−0.230	0.229
Persistence of synthetics						
× (S_p, S_b) persistence	0.557^{+}			0.485^{+}		
× (S_p, S_b) green matter	0.044			0.355		
× (S_p, S_b) seed yield of synthetics	0.121			0.001		
			Phenotypic populations			
Green matter of synthetics						
× (S_p, S_b) green matter	0.195	−0.283	0.382	0.220	0.128	0.306
× (S_p, S_b) seed yield	−0.078	−0.214	−0.078	0.076	−0.256	0.224
× (S_p, S_b) persistence	0.076	−0.110	0.257	−0.069	0.000	0.135
Seed yield of synthetics						
× (S_p, S_b) seed yield	0.319	0.013	−0.281	0.440	−0.219	−0.174
× (S_p, S_b) green matter	0.271	−0.284	0.104	0.115	-0.499^{++}	−0.209
× (S_p, S_b) persistence	0.159	-0.708^{++}	−0.209	−0.066	-0.629^{++}	−0.436
Persistence						
× (S_p, S_b) persistence	−0.156			−0.252		
× (S_p, S_b) green matter	−0.019			−0.005		
× (S_p, S_b) seed yield	−0.474			−0.410		

reciprocally. The marked genetic shift can be seen in the persistence in comparing the genotypic and phenotypic populations created by negative selection. The genotypic population had persistence only 49,15 %, however, its phenotypic analogue possessed higher persistence (83,02 %) even than another one from positive selection (72,53 %) (Tab. II). The development of individual populations tended to overall population average (Fig. 2). Average values in spite of the mentioned changes in individual populations were equal in both populations (Tab. II). These results sustained our modification of synthetic population

IV. Variance analysis of green matter of genotypic and phenotypic populations (1986)

Variability source	Degrees of freedom	Mean squares		
		Piešťany	Malý Šariš	Vígľaš
		Genotypic populations		
Populations	18	302.41^{++}	76.30^{+}	133.06
Replications	3	162.23	2438.83	669.56
Error	54	53.79	38.27	78.02
$\bar{x}$ [t.ha^{-1}]		92.49	82.61	68.92
$\sqrt{MSe}$ % $\bar{x}$		7.92	7.48	12.81
σ^2G		62.15	9.50	13.76
σ^2P		75.59	19.06	33.26
h^2		0.822	0.262	0.413
		Phenotypic populations		
Populations	19	173.62^{++}	52.30	73.80
Replications	3	507.50	2383.88	2450.73
Error	57	77.45	94.26	55.17
$\bar{x}$ [t.ha^{-1}]		93.28	81.50	75.90
$\sqrt{MSe}$ % $\bar{x}$		9.43	11.88	9.78
σ^2G		24.04	0.00	4.65
σ^2P		43.40	23.56	18.44
h^2		0.553	0.00	0.252

creation. From the family polycross only the best plants of each family were chosen. Their progeny performance was compared with the progeny performance of mother plants of preceding generation. The family polycross served as the progeny test of individual plants and in the same time as the selection nursery for the further generation (Užík, 1986). A similar modification for building synthetic varieties was used in breeding of root-creeping lucerne, where one and the same nursery served for several functions (Rod, 1967). By this manner we wanted to achieve a more rapid cumulation of desirable alleles in population.

The mathematical index was not used. In selection for more characters, however, from the Fig. 1 it follows that natural selection combined equally the green-matter and seed yield without respect to the original ratio in all populations. It seems that the plant in certain extent combines the green matter and seed yield in better way than the breeder could it do alone (Lawrence, 1981).

Genotype X environment interaction which is usually a cause of selection failure (Busbice, 1974) decreased the efficiency of selection also in our experiments. From the results of plus- and minus-selection, even at genotypic populations, it follows that excepting the persistence, the reliability of identification of well-performing progenies in green matter and seed yield is very small. This is considered to be one of the causes of a low progress in forage crop breeding (Guy, 1981). We were not able to improve it substantially even by measuring the performance of families and progenies by means of systematically arranged control variety and by the performance of the family of preceding generation.

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UŽÍK, M. (Výskumný ústav rastlinnej výroby, Piešťany): *Výkonnosť a genetické parametre syntetických populácií ďateliny lúčnej.* Genet. a Šlecht., *24*, 1988 (4) : 315-324.

Zo súboru 40 rodín sme vybrali prvé dve, prípadne päť s najvyššou hodnotou v úrode hmoty (H), v úrode semena (S), trvácnosti (T) a s nadpriemernou hodnotou všetkých troch znakov (I). Výkonnosť vybraných rodín bola vyjadrená v percentách priemeru pokusu (S_p) a v percentách priemeru systematicky zaradenej kontrolnej odrody (S_b). Na znaky H, S, T sme vykonali tiež negatívnu selekciu. Pre tvorbu syntetických populácií genotypických (Syn G) sme použili osivo z rezervy matiek, z ktorých rodiny pochádzali a pre fenotypické (Syn P) osivo zo skúšok rodín. Po jednoročnom rozmnožení sme populácie skúšali na troch miestach. Počet komponentov neovplyvnil ani priemer, ani variabilitu znakov populácií. Selekcia genotypická bola efektívnejšia než fenotypická. Medzi populáciami Syn G boli rozdiely podľa druhu selekcie, avšak medzi populáciami Syn P neboli diferencie ani medzi plus, ani medzi mínus selekciou. Zreteľný genetický posun pre-

javený v menšej genetickej variancii medzi fenotypickými populáciami než medzi genotypickými sa zda byť spôsobený tlakom prirodzenej selekcie.

selekcia materských rastlín; selekcia rodín; úroda hmoty; úroda semena; trvácnosť; prirodzená selekcia; datelina lúčna

УЖИК, М. (Научно-исследовательский институт растениеводства, Пиештяны): **Продуктивность и генетические параметры синтетических популяций клевера лугового.** Genet. a Šlecht., *24*, 1988 (4) : 315-324.

Из совокупности 40 семейств мы отобрали первые 2 или 5 с макс. продукцией вещества (Б), семян (С), устойчивостью (У) и с повышенными значениями всех трех признаков (И). Продуктивность избранных семейств обозначалась в % средних показателей опыта и % средних показателей систематически включаемого контрольного сорта. По признакам Б, О, У проводили негативную селекцию. Для образования синтетических генотипических популяций (Син Г) брали семена из того запаса маток, из которого семейства происходили, а для фенотипических (Син П) — семена из испытаний семейств. В результате годового размножения мы испытывали популяции на 3 местах. Количество компонентов не повлияло ни на средний уровень, ни на изменчивость признаков популяций. Генотипическая селекция эффективнее фенотипической. Между популяциями Син Г отмечены различия по виду селекции, но в Син П их нет ни между плюс, ни между минус селекциями. Явное смещение в сторону уменьшения геновариантности в большей мере у фенотипических популяций вызван давлением естественной селекции.

селекция материнских растений; селекция семейств; продукция массы; продукция семян; устойчивость; естественная селекция; клевер луговой

UŽÍK, M. (Forschungsinstitut für Pflanzenproduktion, Piešťany): *Leistung und genetische Parameter der synthetischen Wiesenkleepopulationen.* Genet. a Šlecht., *24*, 1988 (4) : 315-324.

Aus einer Kollektion von 40 Familien wählten wir die ersten zwei bzw. fünf Familien mit dem höchsten Wert im Massenertrag (H), im Samenertrag (S), in der Perennität (T) und mit einem überdurchschnittlichen Wert aller drei Merkmale (I) aus. Die Leistung der ausgewählten Familien wurde in % des Versuchsdurchschnitts (S_p) und in % des Durchschnitts einer systematisch klassifizierten Kontrollsorte (S_b) ausgedrückt. Auf die Merkmale H, S, T wurde eine negative Selektion durchgeführt. Zur Bildung der genotypischen synthetischen Populationen (Syn G) zogen wir ein Saatgut aus der Reserve der Mütter aus denen die Familien stammten und für die phänotypischen (Syn P) Populationen ein Saatgut aus den durchgeführten Familienprüfungen heran. Nach einjähriger Vermehrung untersuchten und testeten wir die Populationen auf drei Standorten. Die Zahl der Komponenten beeinflusste weder den Durchschnitt noch die Variabilität der Merkmale der Populationen. Die genotypische Selektion war effektiver als die phänotypische Selektion. Zwischen der Syn G-Populationen bestanden Unterschiede entsprechend der Selektionsart, zwischen den Syn P-Populationen waren keine Unterschiede zwischen der Plus- oder Minus-Selektion zu verzeichnen. Die markante genetische Verschiebung, die in einer niedrigeren genetischen Varianz zwischen den phänotypischen Populationen als zwischen den genotypischen Populationen ihren Niederschlag findet, scheint auf den Druck einer natürlichen Selektion zurückzuführen zu sein.

Selektion der Mutterpflanzen; Selektion der Familien; Massenertrag; Samenertrag; Perennität; natürliche Selektion; Wiesenklee

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HEREDITY OF SEEDLESSNESS IN GRAPES

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POSPÍŠILOVÁ, D. — PÁLENÍK, V. (Research Institute of Viticulture and Enology, Bratislava): *Heredity of Seedlessness in Grapes.* Genet. a Šlecht., *24,* 1988 (4) : 325-332.

The heredity of seedlessness has been studied in 10 crossing combinations. The influence of parental varieties was analyzed with respect to the heredity of seedlessness by the analysis of qualitative characters by means of χ^2-test. The segregation ratios of seedlessness and their significance were calculated. The significant segregation ratio was 3 : 1 for all crossing combinations as unit. Ceaus roz, Katta kurgan and Muscat Susanna are recommended as suitable maternal varieties conferring seedlessness. Suitable paternal varieties are Delight, Perletta and Chibrid bezsemen V-6. Seedlessness of grape is a lethal recessive character. It is linked up to several alleles connected by interaction. There is a direct correlation between the size of seed rudiments and the berry size. The elites of agricultural importance are mentioned, especially from the crossing with varieties Katta kurgan (large-berry), Muscat Susanna, Delight and Ceaus roz (small-berry).

Vitis vinifera L.; seedlessness; heredity

Raisin table grapes are the basis for raisin production — the viticulture branch, which is important especially in Greece, Turkey and in the countries of the Middle East, where the great deal of raisin grapes come from. Seedlessness is one of the breeding purposes especially in the case of table grapes in our country, because it improves testing and dietetic value of table grapes.

The seedless berry is qualified by the various size of seed rudiments from parthenocarpy to stenospermocarpy and to so-called solf seeds. Different authors (Smirnov, 1962; Chačatrjan et al., 1978; Božinova-Boneva, 1978) divide raisin grapes to 3—4 categories of seedlessness, while the 4th category has been cited only by some of them (Ivanov, Vlčev, 1968; Pogosjan et al., 1974). The seeds in this category are of normal size, sclerenchyma is incompletely developed, without embryos and endosperm. In our crossing all the types of seedlessness are represented.

To find out the heredity of seedlessness by the influence of parental gametophyt upon the frequency of seedlessness in hybrid population was the aim of our work. The influence of parental varieties upon the heredity of seedlessness was quantified, too.

MATERIALS AND METHODS

The breeding of raisin table grapes was one of the research aims in our institute. Varieties with the natural tendency to form parthenocarpic berries have been chosen as the maternal in our composition of crossing combinations according to conclusions of Smirnov (1962); Ivanov and Valčev (1968).

The gynoid varieties (Ički mar, Ceaus roz, Katta kurgan) and the hermaphroditic varieties (Dunavski misket, Muscat Susanna, Muscat Hambourg) were used as maternal plants in 10 crossing combinations. The variety of different stage of seedlessness has been used in all combinations as paternal plants (Beauty seedless, Delight, Perletta, Chibrid bezsemen V-6, Vardagujn Jerevani). After the seedlings started to be fertile the percentage of seedlessness in individual crossing combinations and their agricultural qualities were evaluated. The best ones were reproduced to clones, which were investigated according to their agricultural use. The hybrid combinations were evaluated according to the character of heredity of seedlessness by the mathematical-statistical method of qualitative character analysis. The different fission ratios have been tested by χ^2-test. Significant fission ratios are given in the tables.

RESULTS

Evaluating of hermaphroditic or gynoid maternal variety in crossing with the seedless variety is included in Tab. I. It is obvious that the frequency of seedlessness varies in progeny from combination to combination and the mean in all crossing combinations is 25,5 %; it corresponds to the only fission ratio 3 : 1. In the case of hermaphroditic maternal variety frequency is the least in the crossing Dunavski misket × Beauty seedless; in the case of gynoid maternal variety the frequency of seedlessness is the least in the combination Ički mar × × Beauty seedless. Very high percentage of seedlessness in hybrid progeny Ceaus roz × Perletta was explained by few individuals in population.

When comparing the frequency of seedlessness in all crossing combinations of both groups, it is obvious that in the case of gynoid maternal variety the fission of seedless forms was only by 4.2 % higher. The most probable fission ratio in both groups of crossing is 3 : 1. When comparing significant fission ratio range the crossing group with hermaphroditic maternal variety is less suitable for frequency of seedlessness in progeny (from 3 : 1 to 5 : 1), than the group with gynoid maternal variety (from 2 : 1 to 3 : 1).

Tab. II lists crossing combinations to determine the influence of the maternal variety genotype upon the frequency of seedlessness of seedlings in progeny. The most seedless individuals were obtained in case when Katta kurgan, Ceaus roz, Muscat Susanna and Muscat Hambourg were used, as maternal varieties in spite of the small number of individuals in hybrid populations of the latter two varieties. Crossing with the maternal variety Ički mar brought the least number of seedless types. Their frequency was low, too, when the maternal variety was Dunavski misket.

Crossing with varieties Ceaus roz, Katta kurgan and Muscat Susanna gave the highest number of elite individuals, i. e. of economical importance.

The crossing group with variety Katta kurgan is undoubtedly the most suitable by range of fission ratios (from 2 : 1 to 3 : 1). The crossing group with variety Ceaus roz is nearly the same as this result, while the crossing with variety Dunavski misket has much worse fission ratio range (from 3 : 1 to 7 : 1). The rest of maternal varieties were used only in one combination, therefore this fission ratio range is wider according to statistical data.

The influence of the used paternal seedless variety upon a number of seedless individuals in progeny was investigated (Tab. III), too. The

I. Influence of hermaphrodite or gynoide maternal variety upon the seedlessness frequency in the progeny

Crossing combination	Number of seedlings		% seedless individuals	Most probable fisson ratio	χ^2	Interval of significant fission ratios
	fruitfuls	seedless				
Hermaphrodite × seedless						
Dunavski Misket × Beauty Seedless	27	4	14.8	6 : 1	0.01	(3 : 1) – (16 : 1)
Dunavski Misket × Vardagujn Jerevani	41	9	21.9	4 : 1	0.10	(2 : 1) – (7 : 1)
Muskat Susanna × Delight	21	7	33.3	2 : 1	0.00	(1 : 1) – (4 : 1)
Muscat Hambourg × Perletta	11	3	27.3	3 : 1	0.03	(1 : 1) – (9 : 1)
Sum and arithmetical mean	100	23	23.0	3 : 1	0.21	(3 : 1) – (5 : 1)
Gynoide × seedless						
Ičkimar × Beauty Seedless	22	3	13.6	6 : 1	0.01	(2 : 1) – (20 : 1)
Ceaus Roz × Delight	39	9	23.0	3 : 1	0.08	(2 : 1) – (6 : 1)
Ceaus Roz × Perletta	5	4	80.0	1 : 4	0.00	(1 : 26) – (1 : 1)
Katta – Kurgan × Perletta	32	8	25.0	3 : 1	0.00	(2 : 1) – (6 : 1)
Ceaus Roz × Chibrid Bezsemen V-6	6	2	33.3	2 : 1	0.00	(1 : 2) – (9 : 1)
Katta – Kurgan × Chibrid Bezsemen V-6	43	14	32.6	2 : 1	0.01	(2 : 1) – (3 : 1)
Sum and arithmetical mean	147	40	27.2	3 : 1	0.38	(2 : 1) – (3 : 1)
Total sum	247	63	25.5	3 : 1	0.03	(3 : 1)

II. Influence of the maternal variety upon the seedlessness frequency in the progeny

Crossing combination	Number of seedlings		% seedless individuals	Most probable fisson ratio	χ^2	Interval of significant fission ratios	Number of elites	% of elites	Seedlings number of elites
	fruitfuls	seedless							
Dunavski Misket × Beauty Seedless	27	4	14.8				1	3.7	23/7
Dunavski Misket × Vardagujn Jerevani	41	9	21.9				—	—	—
Sum and arithmetical mean	68	13	19.1	4 : 1	0.03	(3 : 1) – (7 : 1)	1	1.5	
Ceaus Roz × Delight	39	9	23.0				4	10.2	5/1, 5/9, 8/10, 19/34
Ceaus Roz × Perletta	5	4	80.0				1	20.0	17/40
Ceaus Roz × Chibrid Bezsemen V-6	6	2	33.3				1	16.6	21/8
Sum and arithmetical mean	50	15	30.0	2 : 1	0.25	(2 : 1) – (4 : 1)	6	12.0	
Katta – Kurgan × Perletta	32	8	25.0				3	9.3	14/38, 14/44, 15/42
Katta – Kurgan × Chibrid Bezsemen V-6	43	14	32.6				5	11.6	23/34, 25/6, 25/7, 25/19, 25/34
Sum and arithmetical mean	75	22	29.3	2 : 1	0.54	(2 : 1) – (3 : 1)	8	10.7	
Muscat Hambourg × Perletta	11	3	27.3	3 : 1	0.03	(1 : 1) – (9 : 1)	—	—	—
Ikčimar × Beauty Seedless	22	3	13.6	6 : 1	0.01	(2 : 1) – (20 : 1)	1	4.5	32/1
Muskat Susanna × Delight	21	7	33.3	2 : 1	0.00	(1 : 1) – (4 : 1)	4	19.0	11/8, 11/33, 12/25
Total sum	247	63	25.5	3 : 1	0.03	(3 : 1)	20	8.1	

high percentage of seedless types gave the combinations with varieties Chibrid bezsemen V-6, Perletta and Delight, while the highest elite number was in combinations with varieties Delight, Perletta and Chibrid bezsemen V-6 again. The interval of significant fission ratios is the best in the crossing group with Chibrid bezsemen V-6 (from 2 : 1 to 3 : 1). It is a little bit worse in crossing combinations with varieties Delight and Perletta (from 2 : 1 to 4 : 1). Much worse fission ratio interval was in crossing with variety Beauty seedless (from 3 : 1 to 13 : 1) which means that the probability of frequency of seedless types is much reduced in these crossings. The amount of seedless individuals was sufficient in crossing with variety Vardagujn Jerevani, but the interval of this combination was wider (from 2 : 1 to 7 : 1).

DISCUSSION

Seedlessness is probably the result of the small mutations with the effect of recessive inherited trait of lethal character (Božinova — — Boneva, 1978). According to our results, the heredity of seedlessness is probably linked up to several alleles, connected by interaction. But the influence of a plasmatic heredity upon the demonstration of this character is not to eliminate too. On the basis of our experience that the stage of seedlessness of some individuals was changed in the ontogenese in some hybrid populations (for example Katta kurgan × Chibrid bezsemen V-6), we can assume the result of external influence upon the plasma. According to Ivanov and Valčev (1968), 30 % of seedless individuals varies by years in categories of seedlessness. Moliver (1985) regards seedlessness as polyfactorial character linked up to small berry. There is a direct correlation between the pericarp size and the seed size. Pogosjan et al. (1974) advises upon a physiological influence of seeds in the process of berry growth. The fertilization and seed development is controlled by gene series linked up among themselves. The manifestation of recessive mutations in these or those alleles in the different stages of this process lead to seed anomaly at different stage of their development. These theoretical suppositions were confirmed by our results, too. Large berry elites (especially in crossings with variety Katta kurgan) contained more larger seed rudiments than the typical parthenocarpic small berry elites from crossing with variety Delight. Chačatrjan et al. (1978) came to the same conclusion — large berry seedless varieties have greater number of larger seed rudiments than small berry varieties. This character was inherited in progeny, too. The frequency of seedless varieties in *V. vinifera* is the result of the selection breeding process, which fixed there varieties by the vegetative reproduction. The seedless forms do not exist in wild forms of *V. silvestris* Gmel. (Smirnov, 1976).

The number of natural mutants of seedless varieties was increased by breeding process. Obtaining of these form is a difficult breeding aim, there are relatively little seedless individuals in progeny and this is the reason for investigating larger families. Moliver (1985) pointed out the method of repeated crossing of the F_1 hybrids with seedless variety giving the higher fission ratio of seedlessness. This observation can be confirmed by our crossing with seedless varieties Delight, Perletta and

III. Influence of the paternal variety upon the seedlessness frequency in the progeny

Crossing combination	Number of seedlings		% seedless inviduals	Most probable fission ratio	χ^2	Interval of significant fission ratios	Number of elites	% of elites	Seedlings number of elites
	fruitfuls	seedless							
Ičkimar × Beauty Seedless	22	3	13.6				1	4.5	32/1
Dunavski Misket × Beauty Seedless	27	4	14.8				1	3.7	23/7
Sum and arithmetical mean	49	7	14.3	6 : 1	0.00	(3 : 1) – (13 : 1)	2	4.1	
Ceaus Roz × Delight	39	9	23.0				4	10.2	5/1, 5/9, 8/10, 19/43
Muskat Susanna × Delight	21	7	33.3				4	19.0	11/8, 11/33, 12/17, 12/25
Sum and arithmetical mean	60	16	26.6	3 : 1	0.09	(2 : 1) – (4 : 1)	8	13.3	
Ceaus Roz × Perletta	5	4	80.0				1	20.0	17/40
Katta – Kurgan × Perletta	32	8	25.0				3	9.3	14/38, 14/44, 15/42
Muscat Hambourg × Perletta	11	3	27.2				—	—	—
Sum and arithmetical mean	48	15	31.3	2 : 1	0.09	(2 : 1) – (4 : 1)	4	8.3	
Ceaus Roz × Chibrid Bezsemen V-6	6	2	33.3				1	16.6	21/8
Katta – Kurgan × Chibrid Bezsemen V-6	43	14	32.6				5	11.6	25/19, 25/7, 23/34, 25/34, 25/6
Sum and arithmetical mean	49	16	32.7	2 : 1	0.01	(2 : 1) – (3 : 1)	6	12.2	
Dunavski Misket × Vardagujn Jerevani	41	9	21.9	4 : 1	0.10	(2 : 1) – (7 : 1)	—	—	—
Total sum	247	63	25.5	3 : 1	0.03	(3 : 1)	20	8.1	

Chibrid bezsemen V-6. The former two came from crossing Muscat Alexandria × Sultanina, and Chibrid bezsemen V-6 is the result of crossing Italia × Sultanina. Our crossing with these hybrids were the repeated crossings directed to seedlessness and this fact appears in the fission ratio of seedlessness of their progeny.

The influence of parental genotypes on the manifestation of seedlessness is high. Arranging of our hybrid partners was based on the hypothesis that by using the gynoid maternal variety, which has morphological and physiological inhibions of the normal berry development during autogamy, the frequency of seedless forms will be increased and this fact was confirmed. The gene influence of the gynoid gametophyt on the manifestation of seedlessness and the result of the physiological reaction is not known.

The genotype of the paternal variety influences the heredity of seedlessness decisively. All the seedless varieties, which are paternal in crossings, do not give seedlessness in progeny in the same ratios. For example, Beauty seedless, compulsory parthenocarpic, gives fission ratio of seedling and seedless individuals in our crossings 6 : 1, while Perletta, Delight and Chibrid bezsemen V-6 give most frequently fission ratios 2 : 1 and 3 : 1. Beauty seedless is not regarded as ideal paternal genotype. Its significant fission ratio is 1 : 13.

Pogosjan et al. (1974) regards as suitable maternal varieties for obtaining seedlessness apart from other Katta kurgan, Perletta and Delight; these are the genotypes giving the most seedless forms in our crossings, too. Muscat Susanna, Ceaus roz, Katta kurgan and Muscat Hambourg gave a good account of crossings as the maternal varieties; it corresponds with the results of Pogosjan et al. (1974).

From the cultural point of view, the agricultural usage of seedless varieties is important. Our crossings produced elites especially of Katta kurgan × Perletta, Katta kurgan × Chibrid bezsemen V-6, which are large-berried with later terms of ripening, suitable for growing in green-houses without heating. Another group of elites are small berry types, from crossings of Muscat Susanna × Delight and Ceaus roz × Delight, parthenocarpic, suitable for using especially in candy industry.

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POSPÍŠILOVÁ, D. — PÁLENÍK, V. (Komplexný výskumný ústav vinohradnícky a vinársky, Bratislava): *Dedičnosť bezsemennosti u viniča.* Genet. a Šlecht., *24,* 1988 (4) : 325-332.

V 10 kombináciách kríženia, zameraných na bezsemennosť sa študoval charakter dedičnosti tohto znaku. Analyzoval sa vplyv rodičovských odrôd na dedičnosť bezsemennosti metódou analýzy kvalitatívnych znakov testovaním χ^2. Vypočítali sa štepné pomery bezsemennosti a ich preukaznosť. Štepný pomer za všetky kombinácie krížení bol preukazne 3 : 1. Za vhodné materské odrody pre získanie bezsemennosti sa odporúčajú: Ceaus roz, Katta kurgan, Muskat Susanna. Vhodné otcovské odrody sú: Delight, Perletta a Chibrid bezsemen V-6. Bezsemennosť viniča je recesívny znak letálneho charakteru. Je viazaný na viac alel, medzi ktorými platia vzťahy interakcie. Medzi veľkosťou rudimentov semien a veľkosťou bobúl existuje priama korelácia. Poukazuje sa na hospodársky využiteľné elity, najmä z krížení s odrodami: Katta kurgan (veľkoplodé), Muskat Susanna, Delight a Ceaus roz (maloplodé).

Vitis vinifera L.; bezsemennosť; dedičnosť

ПОСПИШИЛОВА, Д. — ПАЛЕНИК, В. (Комплексный научно-исследовательский институт виноградарства и виноделия, Братислава): **Наследуемость бессемянности у винограда.** Genet. a Šlecht., *24,* 1988 (4) : 325-332.

В 10 комбинациях скрещивания, направленных на бессемянность, определяли характер наследственности этого признака. Анализировали влияние родительских сортов на эту наследственность по методу анализа признаков качества посредством тестирования χ^2. Выведены соотношение дробления бессемянности и их достоверность. Соотношение дробления по всем комбинациям достоверно 3 : 1. Пригодными для бессемянности можно считать материнские сорта: Цауш роз, Катта курган, Мускат Сузанна. И отцовские: Дилайт, Перлетта и Хибрид безсемен V-6. Бессемянность винограда — рецессивный признак летального характера, связанный с несколькими аллелями, к которым относятся и взаимодействия. Между размерами рудиментов семян и ягод существует прямая корреляция. Указаны важны в хозяйственном отношении элитные сорта, главные, из скрещивания с сортами Катта курган (крупноягодные), Мускат Сузанна, Дилайт и Цауш роз (мелкоягодные).

Vitis vinifera L.; бессемянность; наследуемасть

POSPÍŠILOVÁ, D. — PÁLENÍK, V. (Forschungsinstitut für Weinbau und Kellrwirtschaft, Bratislava): *Erblichkeit der Somenlosigkeit von Weinreben.* Genet. a Šlecht., *24,* 1988 (4) : 325-332.

In 10 Kreuzungskombinationen, die auf die Samenlosigkeit von Weinreben abgezielt worden waren, untersuchten wir die Vererbung dieses Merkmals. Wir analysierten den Einfluss der Elternsorten auf die Vererbung der Samenlosigkeit mittels der Analyse der Qualitätsmerkmale durch das χ^2-Testen. Wir berechneten die Spaltungsverhältnisse der Samenlosigkeit und ihre Signifikanz. Das Spaltungsverhältnis betrug in allen Kreuzungskombinationen einen signifikanten Wert von 3 : 1. Als geeignete Muttersorten können in dieser Hinsicht Ceaus roz, Katta kurgan, Muskat Susanna empfohlen werden. Als geeignete Vatersorten können Delight, Perletta und Chibrid bezsemen V-6 empfohlen werden. Die Samenlosigkeit der Weinrebe ist ein rezessives Merkmal letalen Charakters. Es ist an mehrere Allelen gebunden, zwischen denen die Wechselwirkungsbeziehungen gelten. Zwischen der Grösse der Samenrudimente und der Beerengrösse besteht eine Direktkorrelation. Es wird auf die ökonomisch ausnutzbaren Eliten, insbesondere aufgrund der Kreuzung mit den Sorten Katta kurgan (Grossfruchtsorten), Muskat Susanna, Delight und Ceaus roz (Kleinfruchtsorten) hingewiesen.

Vitis vinifera L.; Samenlosigkeit; Vererbung

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