GENETICS OF MONOGERMITY TRAIT IN SUGAR BEET

(New genetical resource of monogermity)

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INTRODUCTION

The monogermity of beet is a complex trait and in the case the only shoot appears from single fruit seedling. There isn't necessity to remind of its importance and all modern varieties and hybrids must be monogerms.

In my report I'll use the next abbreviation: C L-"clusters" for multigerm phenotype designation and M F-"monoflorets" for monogerm phenotype designation. Sorry, if it will unusual for you.

MULTIPLE SERIES OF RECESSIVE ALLELES IN M-m LOCUS

In 1950-1954 Victor SAVITSKY obtained the line SLC-101 and reported about M-m locus. His genetical materials were distributed to breeders in the USA and then elsewere. There isn't any reports about new alleles or new genetical resources after this. For example, Dr. N.O.BOSEMARK wrote in last book "The Sugar Beet Crop. Science into practice"(eds. Cooke D.A. and Scott R.K.) about only one investigation by E.KNAPP, 1967 in which "monogermity in Russian material is not due to gene m but is polygenic in nature (Bosemark, 1993).

More over than 30 years after V.SAVITSKY we could report about 3 new recessive alleles in M-m locus (Maletsky et al, 1988). Unfortunately this information was published only in Russian and therefore it didn' accept by Scientific Community. Now I'll shortly talk about this because it isn't main purpose of my report.

The peculiarity of these alleles is an identity in phenotypes and these recessive alleles can be identified only in genetical analysis. The first step to this consisted in the crossings between 4 lines by reciprocal scheme. These data are disposed on the Table 1.

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Table 1. Results of reciprocal crossings between 4 MF-lines in F_1 generation.

♀ \ ♂	SLC-91	SOAN-31	SOAN-243	SOAN-22
SLC-91	70-0	0-24	0-31	18-29
SOAN-31	0-50	230-14	3-34	92-0
SOAN-243	2-53	0-47	45-5	50-0
SOAN-22	6-65	70-0	35-0	250-0

In the table the first position are the number of MF-plants, the second one - the number of CL-plants; In red squares at diagonale are the data about MF-CL trait in each lines.

Look at the first 3 lines in the top of the table. We believe that they are homozygotes in 3 MF-alleles (m^1, m^2 and m^3). All or almost all their progenies had c l u s t e r s-phenotypes in F_1 generation. Thus it occures the restruction of "wide" CL-phenotype. This phenomenon is known to be named as "interallelic complimentation". The compound is a heterozygote in two different alleles and has c l u s t e r s-phenotype. Similar phenomena were observed by many scientists especially in crossings between American and Russian or East-European breeding materials. The heterozygote is segregated in genotypes in ratio 1:2:1 and in phenotypes in ratio 1 MF- : 1 CL-plants in F_2 generation. That means that m o n o f l o r e t s and c l u s t e r s-plants should be about 50% each in F_2 and F_1B generations. This mind is illustrated in Table 2 (Shavrukov, 1990).

Table 2. Analysis of progenies in F_1, F_2 and F_1B generation of MF-CL trait after crossings between MF-lines SOAN-31 and SOAN-243

Combination	F_1 MF	F_1 CL		MF	CL	χ^2 (1:1)
SOAN-31 x SOAN-243	3	34	F_2	64	62	0,03
F_1 x SOAN-243			F_1B	30	33	0,14
SOAN-243 x SOAN-31	-	47	F_2	71	75	0,11
F_1 x SOAN-31			F_1B	23	28	0,49

SELF-POLLINATION OF MF-lines

The lines used in our investigation had not only stable, but unstable MF -phenotype also (see Table.1, at diagonal, in red squares). The similar results were obtained after self-pollination of some MF-lines. There are 3 possible results in this case. They are represent in Fig.1.

126 MF-lines
self-pollination

CL-plants	CL + MF-plants	only MF-plants
11,9%	54,8%	33,3%

Fig. 1. Results of self-pollination of 126 MF-lines

After investigation of self-pollinated progenies of 126 MF-lines we obtained next results. 11,9% lines lost the monogerm character absolutely. About half of MF-lines gave both phenotypes - MF and CL. And only 33,3% of investigated lines took the MF-phenotype without changes.

In this last group we found one line SOAN-22 with very stable MF-phenotype and with unusual properties. It is concerned with dominant effect of SOAN-22 in crossings with some CL-materials. I would like to put out the discovery of SOAN-22 beside with SLC-101 by V.SAVITSKY and I belive that SOAN-22 is a new genetical resource of monogermity (Maletsky et al., 1988, 1991).

CROSSINGS BETWEEN SOAN-22 AND MF-LINES

At the Table 3 the results of analysis of F_1 and F_2 hybrids between SOAN-22 and two lines of different origins with unstable MF-character and plants from Russian monogerm variety L'govskaya odnosemyannaya 52 (L052) are presented. We can see all these hybrids had only MF-phenotype. Thus we can believe SOAN-22 has a very stable MF-progeny in crossings with different MF-materials (Shavrukov, Khanov, 1992).

Table 3. Analysis of the progenies in F_1 and F_2 generations of MF-CL trait in combanations SOAN-22 x MF-materials.

Combination	F_1 MF	F_1 CL	F_2 MF	F_2 CL
SOAN-22 x SOAN-31	162	-	315	-
SOAN-22 x SOAN-243	85	-	220	-
SOAN-22 x variety L052	323	-	535	-

CROSSINGS BETWEEN SOAN-22 AND 1-2-f l o r e t s LINES

In next experiment we used 3 ms-forms from East-Germany with 1-2-f l o r e t s-clusters. After pollinated by pollen of SOAN-22 the hybrids F_1 were analysed and used again as female component in F_1B generation. These data are presented in Table 4. You can see all progenies also were m o n o f l o r e t s.

Table 4. Analysis of progenies in generations F_1 and F_1B of M F-trait in combinations ms-DDR x SOAN-22

Combination	F_1 MF	F_1 CL	F_1B MF	F_1B CL
ms-DDR 6119 x SOAN-22	205	-	185	-
ms-DDR 1605 x SOAN-22	118	-	214	-
ms-DDR 1611 x SOAN-22	124	-	170	-

CROSSINGS BETWEEN SOAN-22 AND MATERIALS WITH 2-f l o r e t s CLUSTERS

There weren't any principle changes if you use as parents with complitely 2-f l o r e t s clusters. The results of crossings with SOAN-22 were always similar. Now they are presented in Table 5.

Table 5. Analysis of progenies F_1 and F_2 generations of M F-C L trait in combinations SOAN-22 x C L-lines with 2-f l o r e t s clusters

Combination	F_1 MF	F_1 CL	F_2 MF	F_2 CL
SOAN-22 x SOAN-28	18	-	217	-
(SOAN-28 x SOAN-23) x SOAN-22	42	-	405	-
SOAN-22 x SOAN-92	19	-	303	6

Thus almost all hybrids with SOAN-22 had the stable M F-phenotype independently from origin and methods of parent breedins. We can convinced that 2-f l o r e t s phenotype dissappers or "dissolves". But this is in a contradiction not only with our knowledges about nature of M F-trait but with the lows of genetics. The dominant trait cann't dissappear. Now we don't know exactly about biology of this phenomenon and we can only suppose some possible mechanisms of occurence and heredity of M F-C L trait.

The simplest possible explanation is in revision of the row of dominance in M-m locus. To my mind it will be next (Fig. 2):

$$M^{z} > M^{+} > M^{Br} \sim m^{4} > [M^{?}] > M^{1} = [M^{?}] > m^{1} > m^{2} = m^{3}$$

Variety KWS-ZZ	Usual multigerm varieties, red and food beet	GW4821	SOAN -22	Russian CL-lines with 2-fl. clusters	SLC-100	E-German ms-forms with 1-2-fl. clusters	SLC-101	SOAN -31	SOAN -243

Fig. 2. Row of dominance in M-m locus.

CROSSINGS BETWEEN SOAN-22 AND MATERIALS WITH multiflorets CLUSTERS

For this experiment firstly we chose one CL-line from Russian multigerm variety Pervomaiskaya 028 (P028) and special CL-form with red-coloured leaves Rot Blatt (R.B.) from East Germany. Data of analysis of hybrids F_1 and F_2 are shown at the Table 6. You can see the segregarion in F_2 were different. First combination had the MF-plants more than expected but in second one had a monogenic segregation. These two variants were taken to demonstrate the different resultats of crossings between SOAN-22 and multigerm materials.

Table 6. Analysis of progenies in F_1 and F_2 generations of MF-CL trait in combinations SOAN-22 x materials with multiflorets clusters

Combination	F_1 MF	F_1 CL	F_2 MF	F_2 CL	χ^2 (1:3)
SOAN-22 x SOAN-14	4	5	122	287	5,08*
SOAN-22 x R.B.	5	9	68	193	0,16

* $P > P_{05}$

CROSSINGS BETWEEN SOAN-22 AND POLISH NATERIALS WITH multiflorets clusters

The next step was given when we took for investagation old Polish multigerm variety Janasz 3 and one of it modern multigerm component (FA 29/87). Genetical results of crossings with SOAN-22 in F_1 and F_1B generations are presented in Table 7. In both combinations we obtained too many M F-plants as we could expect. This fact are also very interesting because V.SAVITSKY had the only result in F_1B generation i.e. 50% / 50% of M F and C L-plants.

Table 7. Analysis of F_1 and F_1B hybrids of M F - C L trait in combinations SOAN-22 x Janasz 3 and FA 29/87

Combination	F_1 MF	F_1 CL	F_1B MF	F_1B CL	χ^2 (1:1)
msSOAN-22 x Janacz 3	-	35			
F_1 x SOAN-22			121	89	4.88*
FA 29/87 x SOAN-22	-	21			
F_1 x SOAN-22			66	28	10.90**

* $P > P_{05}$; ** $P > P_{01}$.

CROSSINGS BETWEEN SOAN-22 AND m u l t i c l u s t e r s LINES OBTAINED FROM RUSSIAN VARIETY P028

Table 8. Analysis of F_1 and F_1B hybrids of M F - C L trait in combinations SOAN-22 x 8 C L-lines from Russian variety P028

Combination	F_1 MF	F_1 CL	F_1B MF	F_1B CL	χ^2 (1:1)
A)					
msSOAN-22 x P028	1	31			
F_1 x SOAN-22			55	57	0,04
B)					
msSOAN-22 x P028	2	65			
F_1 x SOAN-22			206	11	175,20***

*** $P > P_{001}$

Our third step in investigation of SOAN-22 were crossings between SOAN-22 and group of C L-lines obtained from Russian multigerm variety Pervomaiskaya 028 (P028). The plants from C L-lines had a very m u l t i f l o r e t s clusters (before 8 florets at cluster). These results are presented in Table 8. All progenies F_1 had C L-phenotype but the quantity of florets at cluster were not so many as parent.

After analysis of F_1B progenies we divided Table 8 on two parts: A and B. Part A consists of 3 combinations with equal ratio of M F- and C L-progenies in F_1B generation. In part B there are 5 combinations in which the quantity of M F-plants was sufficiently more than those with C L-phenotype. The per-cent of M F-plants in the last case is 94,9%.

So, after two steps in crossings with SOAN-22 we can obtain two different variants of results: 1) The material with 50% of M F-progeny; 2) Almost all progenies had M F-phenotype. In this experiment was an absolutelly unimportant haw many florets were in clusters of parents and it didn't influence on groups division.

COMPARISON BETWEEN KNOWN RESOURCES OF MONOGERMITY

We will compare 3 known resources of monogermity in next scheme.
A. American M F-resource - line SLC-101;
B. Russian M F-resources - some lines and varieties together;
C. New Russian M F-resource - line SOAN-22.

1. ORIGIN. A) V.SAVITSKY found 5 monogerm plants from Michigan Hybrid-18, but only one became extensively used. This line was designated SLC-101; B) Russian monogerm resource is the group from 109 plants with different per-cent of monogermity. They were found from different Russian varieties; C) New resource of monogerm trait is the inbred line designated SOAN-22. It was obtained by us from Russian monogerm variety Ramonskaya odnosemyannaya 09.

2. METHOD OF OBTAINING. A) By natural inbreeding; B) By strong selection and only recently with using inbreeding; C) By artificial inbreeding.

3. STABILITY AT THE REPRODUCTION. A) Stable; B) Not stable; C) Stable.

4. SEGREGATION IN CROSSING WITH MULTIGERM MATERIALS. A) Practically always there are next segregations: in F_2 - 25% of M F-plants and in F_1B - 50% of M F-plants. Sometimes this segregations can be modyfied a little but this does not present any difficulties; B) It is possible different ratio in F_2 and F_1B generations including complete absence of M F-progenies in segregations; C) There are some variants. In crossings with unstable monogerm, 1-2-germ and bigerm materials we have either only monogerm progenies or 1,9% of C L-plants in F_2 generation. In crossings with multigerm materials we have 26,0-29,8% M F-plants in F_2 generation and from 49,1% before 94,9% M F-progenies in F_1B generation.

5. RELATIONS WITH OTHER MONOGERM MATERIALS. A) There is always MF-progeny in crossings with materials the same origin. On the other hand, crossings with MF-materials from Russia and East-Europe give usually CL-progeny. B) In crossings with materials from same origin are possible diametrically opposite results from MF- to CL-progenies. If the crosing was making with material of American origin, all progeny F_1 will have a CL-phenotype. B) New genetical resource (SOAN-22) always gives only MF-progeny in crossing with any material from Russia or East-Europe. In crossing with American line SLC-91 the progenies were presented either 8.5% or 38.3% of MF-plants in reciprocal directions.

CONCLUSION

In conclusion I would like to say that inbred line SOAN-22 is a new genetical resource of monogerm trait. This resource has sufficient differences as from American as from Russian resources in spite of his Russian origin. Preliminaryly we designated his allele as m^4 and the genotype of line SOAN-22 as m^4m^4. But not all above results we can explain so simple. Moreother there are many contradictions with simple monogene scheme of monogerm trait heredity. To my mind the investigation of new genetical resource (SOAN-22) can give for us many new unusual information about this character.

Information about SOAN-22 was published in Russian (Maletsky et al., 1988, 1991; Shavrukov, 1990) and was introduced shortly by Dr. Michel DESPREZ at Meeting of the Study Group "Genetics and Breeding" of IIRB, Brussels (Chavroukov, 1994). We have the Author's certificate of invention about SOAN-22 utilization (Maletsky et al., 1990).

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