Contamination and ploidy degradation in sugar-beet (*Beta vulgaris* L.)

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ABSTRACT

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It is presented a study of contamination in sugar-beet by pollen coming from plants of a different ploidy level.

Very low competitivity of the diploid pollen, in relation with haploid pollen, is observed.

In the case of diploid populations contaminated by pollen coming from tetraploid plants, the original populations are able to eliminate these contaminations in a very short period of time.

In the reverse case the ability for contamination of the haploid pollen appears heavily proved, because the original tetraploid population is degradated to diploid in a short number of generations.

It is concluded the need of severe cytological control, at the time of any tetraploid multiplication.

INTRODUCTION

Near the totallity of the sugar-beet triploid monogerm varieties, are produced from a diploid monogerm male-sterile and a tetraploid pollinator. With this system, and due to the longer duration of the

flowering period in the diploid parental, appears the risk of contamination by foreign pollen, with the result of hybrids with the so called wild beets.

The use of tetraploid monogerm male-sterile, being pollinated by diploids, would highly decrease that risk, due to the longer duration of the flowering in the pollinator than in the female. Also with this system, it is easier to get a practical hundred per cent of male-sterility in tetraploid materials than it was in the diploids, and in addition, some results (FITZGERALD, 1975) seems to indicate a superiority between six and seven per cent, in terms of sugar per Ha, of these crossed against the reverse ones. These reasons, have motivated the initiation of different studies, to look the possibility of substitution in the normal system of triploid hybrids production.

A first appearing problem is aneuploidy, always present in tetraploid material without a real answer to selection, with figures of around twenty per cent (ROMMEL, 1963, 1965; BOSEMARK, 1966, 1967), it means loss of the production, that in spite of being aminorated through competition effects, stretch as far as the surroundings of the five per cent. These losses don't affect practically the classical system of production of triploids, due to the very low transmission of aneuploidy through the male gametes, but when using tetraploids as females, the problem appears in all its extent.

Another problem, is the easiness of tetraploid materials to be contaminated by plants of a different ploidy level. Some consequences of this contamination have been studied in the present work.

MATERIAL AND METHODS

In figure 1 is shown the scheme of work used for the study of the chromosome number degradations as a result of contamination by foreing pollen. In the first instance there is the contamination plot, where the diplid and tetraploid plants are alternated, leaving them into open pollination. Seed was harvested separately on the tetraploid mother plants, and on the diploid ones, being called $G_1$4x and G_1 2x respectively. Two more generations were produced, out in isolated plots, as G_2 and G_3.

The work was made with three different diploid and tetrapolid groups of populations from U.S.D.A., called

A69-25 (2x) × A69-26 (4x)

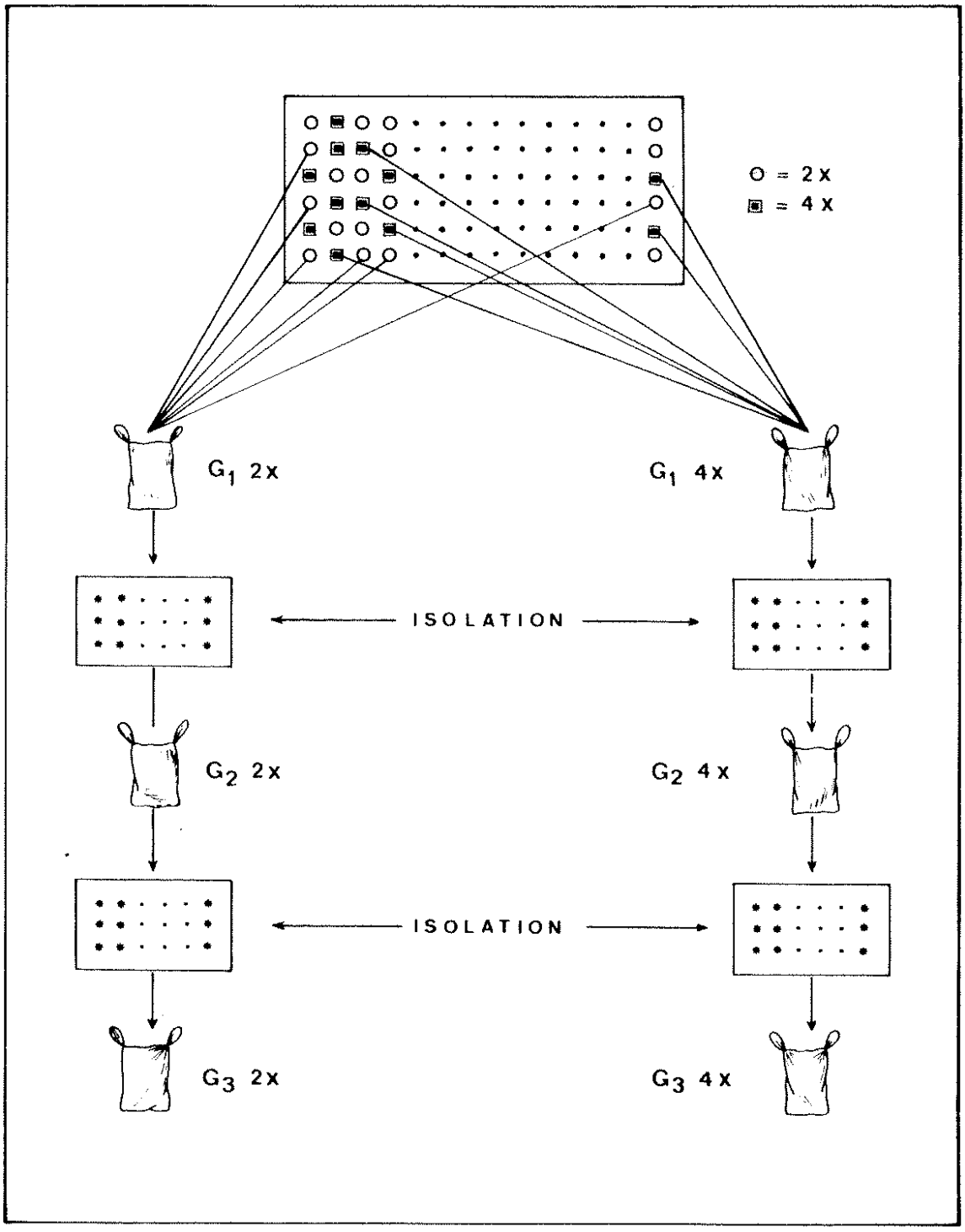

Fig. 1

TABLE 1. — *A69-26 (4x) × A69-25 (2x).*

		Ger. %	Tot	CHROMOSOME NUMBER 9	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Av.
	Pl.	—	43	—	—	—	—	—	—	—	—	—	—	41	—	—	—	—	—	—	—	—	2	27.4
	G1 Seeds	50	149	—	—	—	—	—	—	—	—	—	—	146	—	—	—	—	—	—	—	—	3	27.2
4x	Tot	—	192	—	—	—	—	—	—	—	—	—	—	187	—	—	—	—	—	—	—	—	5	27.2
	G2 Seeds	4	56	—	6	18	14	2	2	3	1	2	5	3	—	—	—	—	—	—	—	—	—	20.9
	G3 Seeds	77	96	—	94	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18.0
	Pl.	—	103	—	95	—	—	—	—	—	—	—	—	8	—	—	—	—	—	—	—	—	—	18.7
	G1 Seeds	83	114	—	102	—	—	—	—	—	—	—	—	12	—	—	—	—	—	—	—	—	—	18.9
2x	Tot	—	217	—	197	—	—	—	—	—	—	—	—	20	—	—	—	—	—	—	—	—	—	18.8
	G2 Seeds	81	253	—	252	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	18.0
	G3 Seeds	86	117	—	115	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18.0

TABLE 2. — *A69-21 (4x) × A69-22 (2x).*

		Ger. %	Tot	CHROMOSOME NUMBER 9	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Av.
	Pl.	—	49	—	1	—	—	—	—	—	—	—	—	44	—	—	—	—	—	—	—	—	4	27.6
	G1 Seeds	21	126	—	3	—	—	—	—	—	—	—	—	121	—	—	—	—	—	—	—	—	2	26.9
4x	Tot	—	175	—	4	—	—	—	—	—	—	—	—	165	—	—	—	—	—	—	—	—	6	27.1
	G2 Seeds	18	124	—	49	22	18	5	1	2	3	4	4	13	3	—	—	—	—	—	—	—	—	20.5
	G3 Seeds	77	132	—	126	5	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18.1
	Pl.	—	95	—	80	—	—	—	—	—	—	—	—	15	—	—	—	—	—	—	—	—	—	19.4
	G1 Seeds	55	123	—	110	—	—	—	—	—	—	—	—	13	—	—	—	—	—	—	—	—	—	19.0
2x	Tot	—	218	—	190	—	—	—	—	—	—	—	—	28	—	—	—	—	—	—	—	—	—	19.2
	G2 Seeds	84	307	—	296	5	2	—	—	—	—	1	—	2	1	—	—	—	—	—	—	—	—	18.1
	G3 Seeds	86	203	—	201	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	18.0

TABLE 3. — *A69-20 (4x) × A69-19 (2x).*

			Ger. %	Tot	CHROMOSOME NUMBER 9	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Av.
		Pl.	—	*44*	—	—	—	—	—	—	—	—	—		36	—	—	—	—	—	—	—	—	*8*	28.6
	G1	Seeds	36	177	—	2	—	—	—	—	—	—	—	—	170	—	—	—	—	—	—	—	—	5	27.2
4x		Tot	—	221	—	2	—	—	—	—	—	—	—	—	206	—	—	—	—	—	—	—	—	13	27.4
	G2	Seeds	17	123	—	4	18	10	3	1	1	4	5	8	58	1	4	—	1	—	1	1	2	1	24.9
	G3	Seeds	54	116	—	80	14	9	3	—	5	1	1	1	2	—	—	—	—	—	—	—	—	—	18.9
		Pl.	—	64	—	59	—	—	—	—	—	—	—	—	5	—	—	—	—	—	—	—	—	—	18.7
	G1	Seeds	63	139	—	123	—	—	—	—	—	—	—	—	16	—	—	—	—	—	—	—	—	—	19.0
2x		Tot	—	203	—	182	—	—	—	—	—	—	—	—	21	—	—	—	—	—	—	—	—	—	18.9
	G2	Seeds	87	332	1	319	3	—	1	—	—	—	—	—	8	—	—	—	—	—	—	—	—	—	18.2
	G3	Seeds	86	120	—	117	2	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	18.1

TABLE 4. — *Average of the three groups.*

			Ger. %	Tot	CHROMOSOME NUMBER 9	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	Av.
		Pl.	—	*136*	—	*0,7*	—	—	—	—	—	—	—	—	*89.0*	—	—	—	—	—	—	—	—	*10.4*	*27.9*
	G1	Seeds	36	452	—	1.2	—	—	—	—	—	—	—	—	96.7	—	—	—	—	—	—	—	—	2.1	27.1
4x		Tot	—	588	—	1.1	—	—	—	—	—	—	—	—	95.0	—	—	—	—	—	—	—	—	4.0	27.3
	G2	Seeds	13	303	—	17.8	21.5	14.5	3.3	1.7	2.6	2.5	3.6	6.2	21.0	1.1	1.1	—	0.3	—	0.3	0.3	0.5	0.3	22.3
	G3	Seeds	69	344	—	87.5	6.0	2.9	0.9	—	1.4	0.3	0.3	0,3	0.6	—	—	—	—	—	—	—	—	—	18.3
		Pl.	—	262	—	89.5	—	—	—	—	—	—	—	—	10.5	—	—	—	—	—	—	—	—	—	18.9
	G1	Seeds	67	376	—	89.1	—	—	—	—	—	—	—	—	10.9	—	—	—	—	—	—	—	—	—	19.0
2x		Tot	—	638	—	89.2	—	—	—	—	—	—	—	—	10.8	—	—	—	—	—	—	—	—	—	19.0
	G3	Seeds	84	892	0.1	97.4	0.8	0.3	—	—	—	—	0.1	—	1.2	—	—	—	—	—	—	—	—	—	18.1
	G3	Seeds	86	440	—	98.3	0.9	0.3	0.3	—	—	—	0.3	—	—	—	—	—	—	—	—	—	—	—	18.0

A69-22 (2x) × A69-21 (4x)
A69-19 (2x) × A69-20 (4x)

The cytological control was made on germinated seed from samples of the G_1, G_2 and G_3, in both sides, diploid and tetraploid, with the use of the lacto-propionic orcein technique of DYER (1963). On the G_1, the control was a routine one, taking only in acount diploids, triploids and tetraploids, without paying attention to the natural aneuploids. By the use of young leaves, plants from the G_1, were also controled. On the G_2 and G_3, the analysis was made carefully, with a control of the exact chromosome number in at least five unbroken cells of each root-tip.

RESULTS AND DISCUSSION

In Tables 1, 2 and 3, are presented the results obtained in the three groups of populations, in terms of chromosome numbers, and also is possible to denote the negative influence of aneuploidy on the germination of the seed.

In the G_1s is possible to compare the results from plants, with the ones from germinated seeds. The differences obtained, look to be caused by a bad sampling of the seed, because the G_1s from plants explain quite clearly the G_2s.

In Table 4, average results of the three groups of populations, are presented.

Looking the data from the diploid mother plants, it can be observed inmediatly, the higher percentage of fecundations with haploid pollen. This lack of competitivity of the diploid pollen, looks to be caused by its bigger size and subsequent worse movility, the smaller number of pollen grains produced in the tetrapolid plants in comparison with the diploids, and also the shorter duration of its anthesis. This carries the G_1 to values of only ten per cent of triploids, with a very similar answer in the three groups of populations.

The G_2 appears practically clean, with more than 97% diploids, and in the G_3 the average chromosome number is 18.0, then it is possible to consider than the effect of contamination through pollination of a 50% tetraploid plants, has been erased totally in two more generations, in relation to the chromosome number.

In the case of tetraploid mother plants, the lack of competitivity of the diploid pollen has been present again, although the answer has

been of different magnitude on the three groups, and could be considered as progressive. So, in the first, the G_1 on plants gives a 4.7% tetraploids and the rest triploid. The chromosome number in the G_2, are very similar to the data obtained by LEVAN (1942) in crosses 3x x 2x, only increased in the proportion of triploids. It seems to be that the viability of the aneuploid pollen grains produced by triploid plants, is practically zero, only working the haploid and diploid pollen from the triploids, being similar the proportion of aneuploid female gametes that are functional. The G_3 appears with a 97.9% diploids, that means a practical conversion to the diploid side.

The second group presents a tetraploid increase of 8.2% in the G_1, with the presence also of a 2.0% diploids, difficult to explain. The results in the G_2, are heavily affected by both extremes of the G_1, diploids and tetraploids, and in spite of a chromosome average of 20.5 similar to the Levan 3x x 2x crosses, the percentage of diploids and triploids are much increased. The G_3 gives a 95.5% of diploids, that offers the practical conversion to diploid, like in the case before.

In the third group, the presence of tetraploids, in the G_1, is the highest with an 18.2%. This gives origin to a G_2 with chromosome numbers between 18 and 36, with a clear pick in triploids, 47.2%, being the average chromosome number 24.9. The G_3 presents a 69.0% of diploids, that looking to the other two groups, allows to think in a clear diploid situation in a theoretical G_4.

CONCLUSIONS

Looking to the results on the tetraploid side, it may be concluded the great degradation power of the haploid pollen, due to its very high competitivity. The case in the present work has been extreme, in the contamination aspects, but anyhow, the original tetraploid plants have been degradated to a clear diploid situation in three or four generations. It looks possible to extrapolate the conclusion, that contaminations in a very small percentage, will destroy a tetraploid material in a very short amount of time. As an example, 1% triploids in a tetraploid material, will degradate the material very quickly.

In the diploid side, the opposite picture is present, and the population is able to eliminate the contamination inmediatly.

As a practical conclusion, the need of severe cytological control in any tetraploid multiplication, looks to be clear.

RESUMEN

Se presenta un estudio sobre contaminación con polen procedente de plantas de distinto nivel ploídico, en remolacha azucarera.

Se observa la baja competitividad del polen diploide en relación con el haploide.

En el caso de poblaciones diploides contaminadas por polen procedente de plantas tetraploides, las poblaciones originales son capaces de eliminar esta contaminación en un corto espacio de tiempo.

En el caso inverso, la capacidad de contaminación del polen haploide queda fuertemente demostrada, ya que en un escaso número de generaciones, es capaz de convertir la población original tetraploide, en diploide.

Se concluye la necesidad de controles citológicos estrictos, al realizar cualquier multiplicación de materiales tetraploides.

LITERATURE CITED

BOSEMARK, N. O.

1966 On the origin and consequences of aneuploidy in triploid and tetraploid sugar beet. *IIRB*, 2 (1): 9-34.

1967 The effect of aneuploidy on yield in anisoploid sugar beet varieties. *IIRB*, 2 (3): 145-161.

DYER, A. F.

1963 The use of lacto-propionic orcein in rapid squash methods for chromosome preparations. *Stain Technol.*, 38: 85-90.

FITZGERALD, P.

1975 Value of sugar beet triploids as affected by reciprocal crosses. *IIRB Genetics and Breeding*, Ireland, September.

LEVAN, A.

1942 The effect of chromosomal variation in sugar beets. *Hereditas*, 28: 345-399.

ROMMEL, M.

1963 Some cytogenetic properties of autotetraploid varieties of sugar beet *Nature*, 198: 1.327-1.328.

1965 **Investigations in autotetraploid sugar beet.** *Compte Rendu-27e Congrés d'hiver IIRB*: 383-390.