Colchicine-Induced Tetraploidy in Sugar Beets: Morphological Effects Shown in Progenies of a Number of Selections

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Colchicine has been used successfully for the production of polyploid sugar beets by a number of workers, but it is still too early to evaluate the ultimate benefits of polyploidy 1o the sugar-beet industry since comparative data on performance, expressed in higher root yield, higher sucrose percentage, or increased disease resistance, are as yet unavailable or at best inconclusive.[2]

From observations with other plants, it is known that polyploidy affects certain morphological characters. Some of these, namely, increase in size of stomata and of pollen, have been used for the detection of polyploid condition in the sugar beet. Although these morphological distinctions belween diploids and polyploids are not always clear cut, they arc valuable in the initial elimination of unaffected plants from those[1] whose chromosome number has been altered.

Sugar-beet seedlings grown from colchicinc-treated seed frequently showed hypertrophy, the usual reaction to tins chemical.[a] (See figure 3.) Transplanted in the field, many of these plants outgrew the effect of colchicine ; this was evidenced by a change in the outer appearance of the newly formed leaves and a reduction in size of their stomata. Continued checks by stoma measurements (figure 1, A, B) before the beginning of seedstalk formation permitted the elimination of nearly all of the plants that appeared to be diploids. With the advent of flowering, another character—pollen size (figure *2,* A. B)—was employed as an additional check, and doubtful individuals were eliminated before their pollen could mix with that of polyploid individuals. How much roguing had to be done is indicated by the fact that out of several thousand seedlings obtained from colchicine-treated seed, only about 100 were allowed to flower and produce seedballs. Chromosome counts were made on somatic tissue of the seedstalk and pollen mother cells. Only tetraploid individuals or plants with chromosome counts closely approximating 36 in somatic cells and 18 in dividing pollen mother cells were kept (figure 2, O).

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[2]Peto, F. H. and Boyes, J. W. Comparison of Diploid and Triploid Sugar Beets. Canadian Journal of Research 18: 273-282. 1940.

"Artschwager, Ernst. Indications of Polyploidy in Sugar Beets Induced by Colchicine. Proceedings of the American Society of Sugar Beet Technologists, 1940.

Some of these seedballs were sown in the fall of 1940 and eliminations were again made on the basis of stoma size and pollen size. The number of discards was relatively small, indicating that pollination must have been very largely with polyploid pollen. With certain conspicuous exceptions, the seed yields from individual plants were moderate or small, but the individual seedballs, in general, tended to be larger than those of the diploids. Some of the plants failed to set seed altogether.

Seedballs from certain of the checked mother plants which flowered in 1941 were planted in late summer of the same year. They grew very rapidly and, although the parents had been allowed to cross-pollinate, the selections as a whole looked remarkably uniform.

In the course of the routine stoma and pollen studies of the mother plants in 1941, one was struck by the great size variations in both the stomata and pollen .grains and the absence of relation between these attributes. In other words, plants with large stomata did not necessarily produce large pollen and the size of stoma or of pollen grain did not seem related to the weight of the seedballs produced by these plants. Data on pollen size, stoma size, pollen germination, and total seedball weight for a few of the selections are given in table 1.

That doubling of chromosomes would find expression in an increase of the size of the stomata and of the pollen grains was to be expected from studies with other plants. In sugar beets this increase is striking, as seen in the following table. However, there is much variation among individuals of any given selection. Furthermore, increase in stoma size or pollen size is not necessarily correlated with a corresponding increase in the other character, though as a rule plants with large stomata do produce pollen grains of exceptional size.

Pollen germination in 1941 was excellent among commercial beets and sufficiently good among tetraploids to insure an adequate supply of viable pollen for seed setting.

Relative seed weight varied greatly and showed no correlation with stoma size or pollen size. Only in selection *"2"* (parent 47-2) practically all plants produced heavy seed, a character which was also conspicuous in the parent generation. As a rule, however, seed weight of the parent gave no indication as to the behavior of the offspring in regard to this character. This fact needs to be substantiated by growing the various selections under strict isolation to prevent any possible chance of cross-pollination.

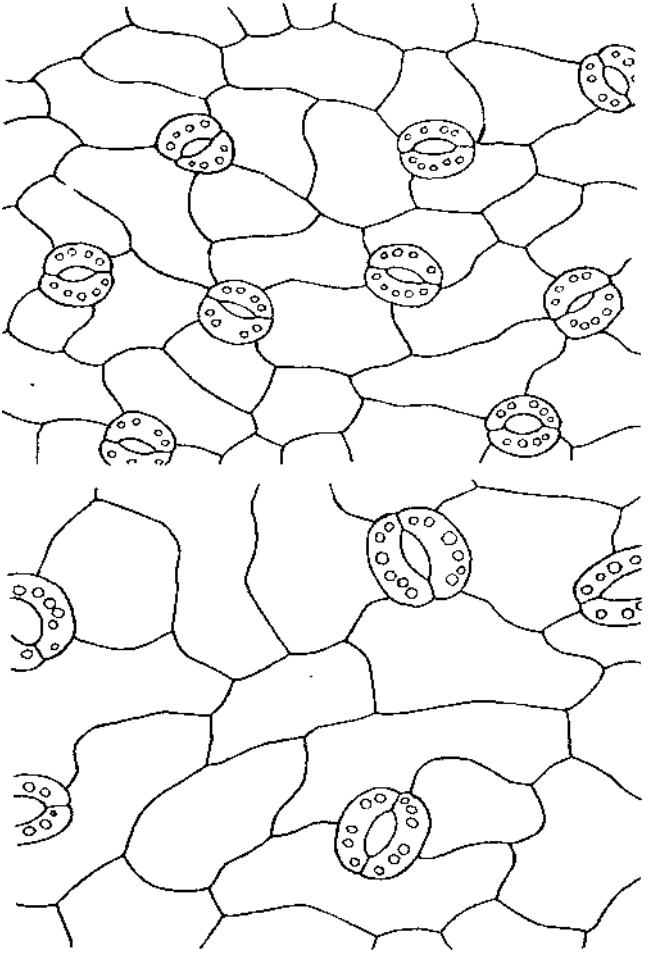

Figure 1.—Top—(A). Lower-leaf epidermis with stomata of diploic! plants. x 500. Bottom—(B). Lower-leaf epidermis with stomata of tetraploid plant, x 500.

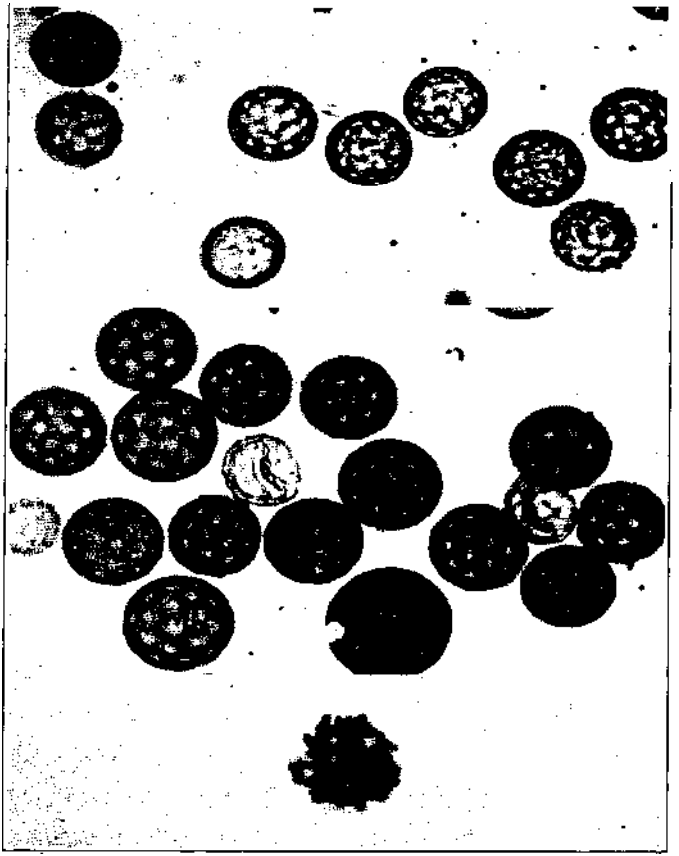

Figure 2.—Top—(A). Diploid pollen. x 500. Center—(B). Tetraploid pollen, x 500. Bottom—(C). Somatic plate of tetraploid plant.

Figure 3.—Appearance of beet seedlings developing from colchicine-treated seed

Table 1.—Stoma size, pollen size, pollen germination, and seed weight in the progeny of certain tetraploid sugar beets obtained from colchicine-treated seed.

Plants grown from colchicine-treated seed 1939-1940	1940-1941 progeny					
	Selection Row No.	Plant No.	Pollen	Stomata	Pollen germination	Weight of 100 seed-balls
			μ	μ	(rating*)	(grams)
Selection 7-8	26	1	25	36	5	—
Stomata 33 μ		2	27	36	4	2.72
Pollen 24 μ		3	28	70	4	1.60
Weight per 100		4	26	36	4	4.40
seed 2.12 grams		5	25	39	2	2.80
		6	25	39	—	—
		7	22	33	3	4.00
		8	28	44	3	2.16
		9	25	33	2	—
		10	22	36	3	4.70
		11	25	39	2	5.36
		12	20	36	1	2.72
		13	25	33	3	4.48
		14	28	36	2	2.24
		15	26	33	3	3.00
		16	28	36	1	2.40
		17	22	47	—	2.80
Average			25.4	38.5		3.28
Selection 18 8	27	1	25	36	4	2.92
Stomata 44 μ		2	25	33	2	3.32
Pollen 25 μ		3	28	44	4	3.65
Weight per 100		4	25	44	3	3.44
seed 2.56 grams		5	25	36	3	3.45
		6	30	36	—	4.82
		7	28	30	4	3.36
		8	22	36	3	—
		9	28	44	5	3.35
		10	28	33	3	4.92
		11	25	44	4	2.61
		12	28	39	—	4.71
		13	28	44	3	3.95
		14	25	39	2	3.10
		15	28	44	—	—
		16	25	33	2	3.08
		17	28	39	4	3.62
Average			26.53	38.82		3.62

*0, no germination; 1, very poor germination; 2, poor germination; 3, fair germination; 4, good germination; 5, excellent germination.

Selection 49-9	28	1	28	36	1	3.32
Stomata 44 μ		2	33	33	1	—
Pollen 25 μ		3	28	39	—	3.28
Weight per 100		4	28	36	3	3.66
seed 5.32 grams		5	28	33	—	—
		6	25	36	2	3.84
		7	25	33	1	2.84
		8	25	36	—	2.68
		9	25	39	—	3.60
		10	26	36	—	4.40
		11	28	33	—	3.20
		12	28	36	5	4.40
		13	26	33	—	3.56
		14	28	30	—	2.62
		15	26	39	4	4.76
		16	28	36	5	3.51
		17	26	36	3	3.70
		18	26	33	4	2.96
		19	28	36	—	2.88
		20	33	36	3	—
		21	20	39	1	3.18
		22	28	36	1	2.56
		23	26	36	—	—
		24	28	41	—	3.96
		25	28	36	1	3.80
		26	28	39	—	3.51
		27	26	44	5	4.00
		28	25	44	1	3.40
		29	28	39	4	3.55
		30	26	33	4	3.70
		31	28	37	4	2.88
		32	33	44	3	2.04
		33	33	39	4	4.19
Average			27.69	36.91		3.48
Selection 34-3	20	1	25	36	3	3.88
Stomata 33 μ		2	28	34	1	3.80
Pollen 28 μ		3	25	39	—	4.88
Weight per 100		4	28	36	1	4.72
seed 2.72 grams		5	25	34	—	2.16
		6	26	36	—	2.32
		7	28	39	—	2.16
		8	29	33	—	1.20
		9	25	36	—	—
		10	25	36	—	1.60
		11	26	36	—	3.08
		12	33	36	3	1.80
		13	33	44	—	2.47
		14	33	44	2	2.27
		15	26	38	3	2.68
		16	33	44	—	2.60
		17	26	36	2	1.60
		18	28	36	—	2.28
		19	24	44	—	—
		20	25	34	1	0
		21	25	33	2	2.27
		22	25	33	1	—
		23	28	39	1	—
Average			27.35	37.22		2.64

Selection 47-2	2	1	26	44	1	5.80
Stomata 36 μ		2	29	47	2	5.91
Pollen 25 μ		3	28	46	2	2.92
Weight per 100		4	26	39	2	5.30
seed 5.14 grams		5	29	41	1	5.92
		6	28	36	3	4.27
		7	26	38	4	2.80
		8	28	34	3	4.80
		9	28	32	—	4.48
		10	28	33	3	2.80
		11	29	32	4	5.24
		12	28	33	—	6.28
		13	26	33	1	—
		14	28	39	5	5.12
		15	28	32	1	3.32
		16	26	33	1	3.09
		17	25	33	3	3.88
		18	27	33	—	4.56
		19	27	33	—	4.40
		20	28	33	—	4.28
		21	28	32	—	3.48
		22	28	32	—	3.80
		23	28	31	—	3.75
		24	26	32	—	3.80
		25	28	31	—	—
		26	32	30	—	3.19
Average			27.4	35.4		4.29

Selection 49-6	25	1	23	30	—	2.50
Stomata 44 μ		2	23	33	3	2.90
Pollen 28 μ		3	28	36	3	—
Weight per 100		4	32	34	2	—
seed 3.76 grams		5	28	34	3	3.09
		6	26	33	1	—
		7	26	34	—	—
		8	27	33	—	—
		9	28	38	2	—
		10	26	34	3	3.60
		11	28	36	—	2.16
		12	25	33	—	2.85
		13	28	39	—	—
		14	25	34	3	3.60
		15	28	34	4	—
		16	28	35	4	2.60
		17	26	38	—	2.32
		18	26	33	3	5.16
		19	28	33	3	4.00
		20	29	33	2	3.80
		21	28	36	—	—
		22	28	33	1	3.52
		23	25	36	3	4.48
		24	29	36	2	—
		25	25	39	3	3.60
		26	28	39	3	2.80
		27	28	32	4	—
		28	32	33	4	—
Average			27.2	34.7		3.32