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The embryology of tetraploid F_1 and B_1 hybrids between the sugarbeet and *Beta patellaris* Moq.

MAREK JASSEM, BARBARA JASSEM

In 1967 and 1968 diploid and triploid sugarbeet × *Patellares*-species hybrids were embryologically studied (Jassem and Jassem 1969 a, b). In 1969 our investigations were focused on tetraploid hybrids, some of which yielded small numbers of viable seeds (Szota, unpl.). The ability of some tetraploid sugarbeet × *Beta patellaris* hybrids to produce viable seeds was reported earlier by Filutowicz and Kużdowicz (1959), Savitsky (1960), Bosemark (1969) and others.

MATERIAL AND METHOD

About 150 - 200 buds and flowers of different age were taken from each of the following types of hybrids:

1. F_1 (Monogerm sugarbeet × *B. patellaris*) — poor seed-setting
2. F_1 (Bigerm sugarbeet × *B. patellaris v. campanullata*) — poor seed-setting
3. F_1 (Monogerm sugarbeet × *B. patellaris*) — fair seed-setting
4. B_1 (Monogerm sugarbeet × *B. patellaris*) — poor seed-setting
5. B_1 (Monogerm sugarbeet × *B. patellaris*) — fair seed-setting

The method of preparing permanent paraffin slides was the same as that described earlier (Jassem and Jassem 1969 a).

RESULTS

The material under study was numerous enough for presenting the data obtained in terms of percentages (Table 1). The decreased fertility of the hybrids was caused by delayed and/or abnormal course of embryo sac and embryo development, resulting in degeneration of megaspores or embryo sacs or else of zygotes, proembryos and embryos, and consequently in the collapse of the whole ovule. The percentage of ovules showing regular development of embryo sac and embryo was higher in the F_1 than in B_1 hybrids and also higher in hybrids capable of relatively fair seed setting as compared with those setting seeds very poorly.

Plate I

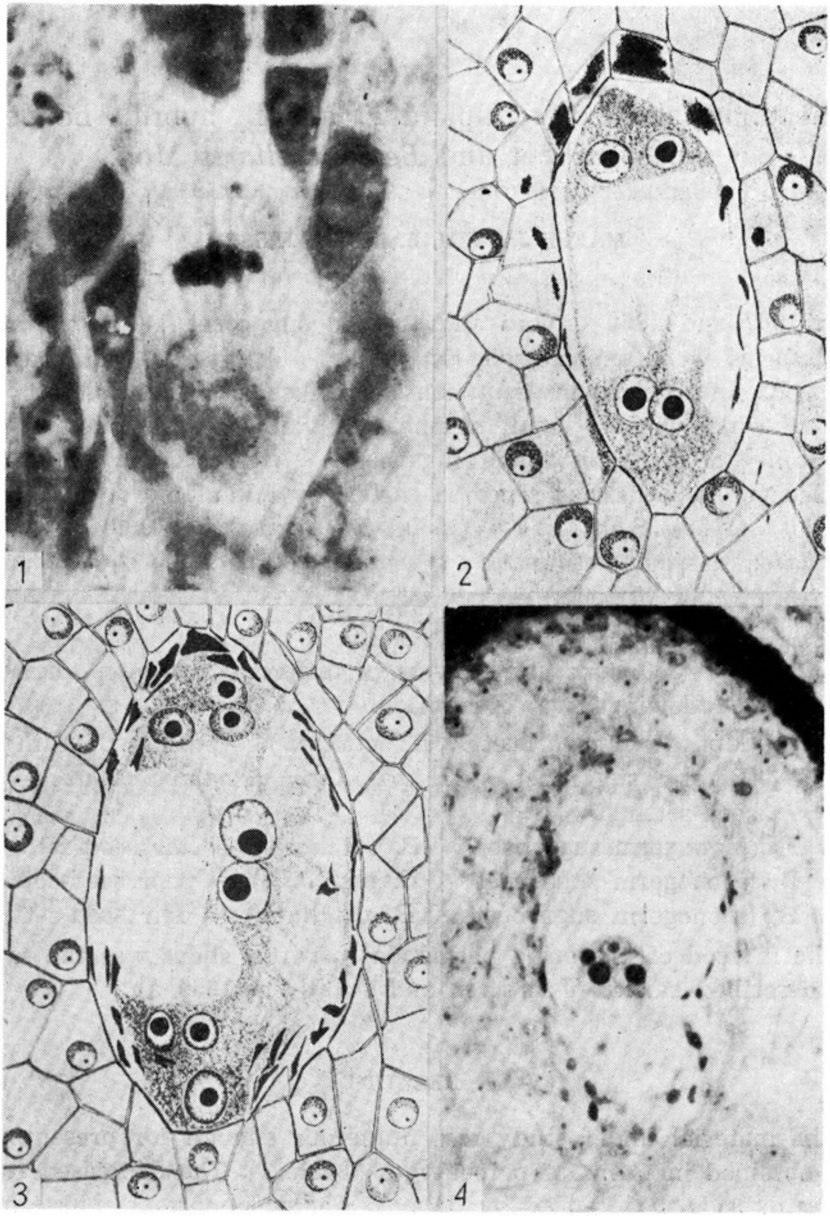

Fig. 1 — Megaspore mother cell — M_I
Fig. 2 — Regular four-nucleate embryo sac
Fig. 3 — Regular eight-nucleate embryo sac
Fig. 4 — An abnormal embryo sac with four clumped nuclei of different size

Plate II

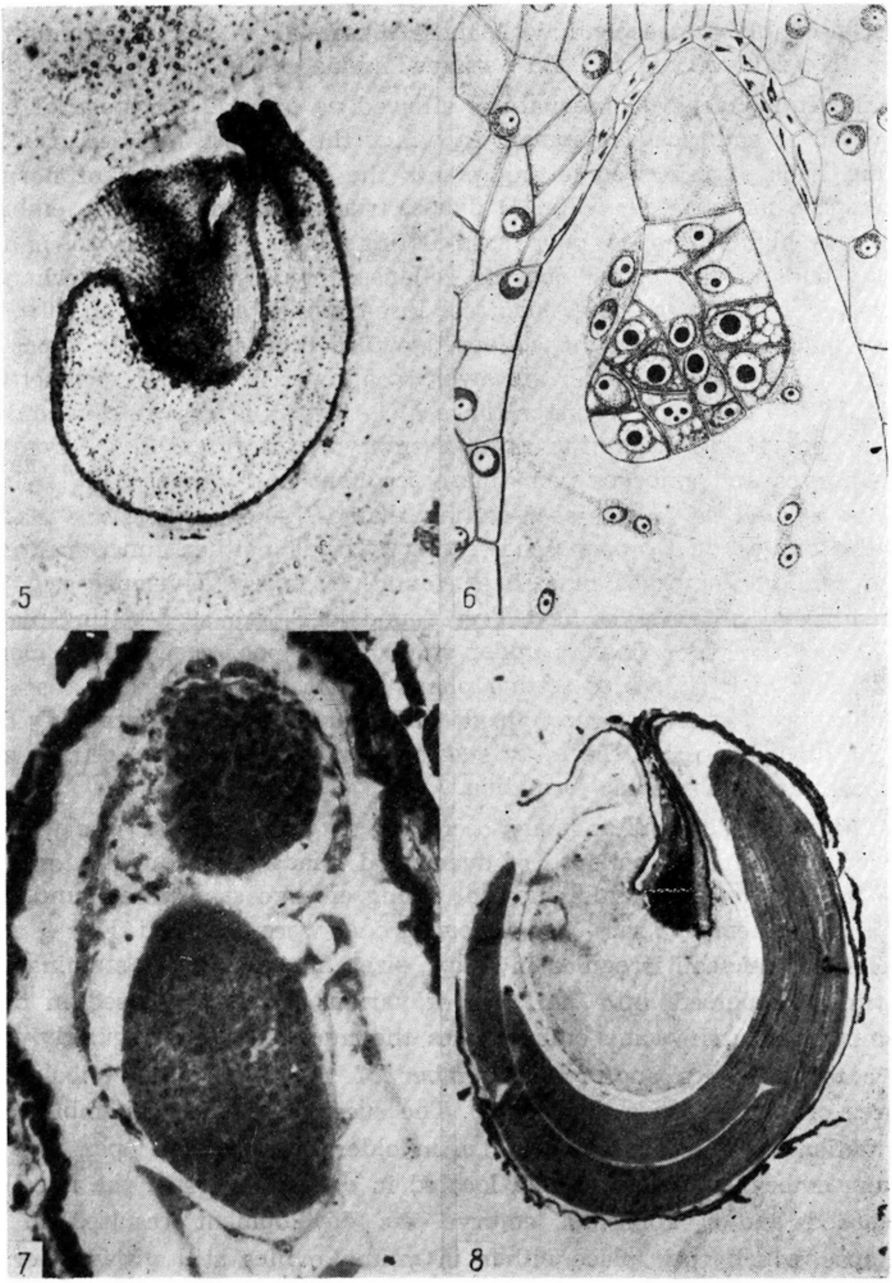

Fig. 5 — Collapsed ovule
Fig. 6 — An abnormal embryo of irregular shape
Fig. 7 — Twin embryos
Fig. 8 — A normal embryo over 20 days old

These differences can be ascribed to meiotic disturbances which we were not able to trace in detail in the megaspore mother cells but which most probably correspond with those observed in the pollen mother cells (Kużdowicz and Brzeskwińska 1969, and others).

The embryological observations allowed us to state the stage of embryo sac or embryo development in which the collapse had occurred. In young buds of fair seed-setting plants the relative number of normal megaspore mother cells, (Fig. 1) dyads, triads and one-nucleate embryo sacs was higher than in poor seed-setting plants. Furthermore, in the young buds of the former ones no collapsed ovules were found whereas in young buds of the later such collapsed ovules amounted to 30%. In older buds and flowers the collapsed ovules occurred in both types of hybrid plants, their number, however, was lower in the fair seed-setting ones. In the ovules of younger flowers (1 - 3 days after anthesis) and in older ones (4 - 10 days) the normal embryo sacs (Figs. 2, 3), zygotes, proembryos and embryos were more frequent in F_1 than in B_1 hybrid plants as well as in fair seed-setting than in poor seed-setting plants. In the ovules of B_1 poor seed-setting hybrids neither functional embryo sacs nor embryos have been found. Normally developed zygotes, proembryos and embryos have been found in F_1 fair seed-setting plants in 12% of the older flowers under study, in F_1 poor seed-setting plants in 2% and in B_1 fair seed-setting plants in 5%, which indicates that the handicapped fertility of the hybrids under investigation was mainly due to the disturbances in the early stages of embryogenesis i.e. during megaspores and embryo sac formation.

The most frequent anomaly occurring in young ovules was the retarded formation or collapse of dyads and triads. Consequently only in 10 - 35% of the older ovules normal young embryo sacs were found. Besides normal embryo sacs, also abnormal ones were observed (Fig. 4) with nuclei and nucleoli irregular in shape, size and intensity of staining, sometimes dispersed into particles of various sizes, immersed in deep staining plasm. In some embryo sacs the nuclei did not regularly pass over to the poles and/or the number of the nuclei was unbalanced (three or five or more than eight). The successive stages of embryo sac formation were often delayed i.e. in older buds and in open flowers young embryo sacs were found located in deeper layers of the nucellus. Retarded and/or abnormal embryo sac development resulted in its collapse which took place either in young ovules still growing or in older ones. In the first case the remnants were crushed and resorbed by growing nucellus tissue (Fig. 5). In such cases as well as in completely dead and shrunken ovules, the exact stage of the embryo sac abortion cannot be determined.

Table 1

Embryo sac and embryo development in tetraploid sugarbeet × *Beta patellaris*, F_1 and B_1 hybrids (data in terms of percentages)

Material	Young buds			Older Buds			Flowers 1—3 days after anthesis			Flowers 4—10 days after anthesis		
	MMC's, dyads triads, one-nucleate e.s.		collapsed ovules	one-, two-, four-or eight — nucleate e.s.		collapsed ovules	mature e.s., zygote or proembryo		collapsed ovules	proembryo or embryo		collapsed ovules
	normal	abnormal, delayed, atrophied		normal	abnormal, delayed, atrophied		normal	abnormal delayed, atrophied		normal	abnormal, delayed, atrophied	
F_1 — fair seed-setting	55	45	0	35	60	5	15	65	20	12	33	55
F_1 — poor seed-setting	30	40	30	25	35	40	5	35	60	2	8	90
F_1 — average	42,5	42,5	15	27,5	47,5	22,5	10	50	40	7	20,5	72,5
B_1 — fair seed-setting	40	60	0	25	50	25	10	40	50	5	10	85
B_1 — poor seed-setting	20	50	30	10	60	30	0	30	70	0	5	95
B_1 — average	30	55	15	17,5	55	27,5	5	35	60	2,5	7,5	90

If the collapse of the embryo sac occurred in an older ovule which did not grow any more, an empty cavern of different size could be found, sometimes with remnants of plasm and deteriorating nuclei.

Among few ovules in which the presence of proembryos or embryos were stated, the most frequent anomalies observed were disturbances in histogenesis resulting in irregular shape of the embryo (Fig. 6), and also poor endosperm development or sometimes its complete absence. In older ovules stunted, small embryos were occasionally seen.

In one embryo sac twin embryos were found (Fig. 7). Besides this exceptional case no evidence of apomictic embryo development has been noted.

DISCUSSION AND CONCLUSIONS

The tetraploid F_1 sugarbeet × *Beta patellaris* hybrids, as opposed to diploid and triploid hybrids (Jassem and Jassem 1969 a, b) yielded some viable seeds after backrossing to the sugarbeet. The backcross hybrids have shown clear wild parent traits (Szota, unpl.) and some of them yielded B_2 seeds in 1969. The embryo sac and embryo development, however, was more regular in F_1 than in B_1 plants which has to be ascribed to the differences in the sugarbeet : *Patellaris* genom ratio (2 : 2 and 3 : 1, respectively). Also individual differences in the degree of fertility were found among the tested plants. Distinctly decreased fertility was due to megaspore and embryo sac abortion rather than to the atrophy of the embryo. It is highly probable that when hybrid plants capable of producing embryos and viable seeds (Fig. 8) are selected, it will be possible to obtain introgressive hybrids of further backcross generations.

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Plant Breeding and Acclimatization Institute
Sugar Beets and Other Root Crops Department
Bydgoszcz, Poland, pl. Wayssenhoffa 11

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Badania embriologiczne nad tetraploidalnymi mieszańcami pokolenia F_1 i B_1 między burakiem cukrowym i *Beta patellaris* Moq.

Streszczenie

Mieszańce między tetraploidalną formą buraka cukrowego (2n = 36) i dzikim gatunkiem *Beta patellaris* Moq. (2n=36) są częściowo płodne, w odróżnieniu od podobnych mieszańców międzygatunkowych na poziomie diploidalnym i triploidalnym (Jassem i Jassem 1969 a, b). Przebadano przebieg embriogenezy u mieszańców tetraploidalnych pokolenia F_1 i B_1. W każdym pokoleniu wyróżniono formy o stosunkowo dobrym i o bardzo słabym zawiązywaniu nasion (Tabela 1). Przebieg embriogenezy był najbardziej prawidłowy w grupie F_1 — dobre zawiązywanie nasion. Ogólnie przebieg embriogenezy był bardziej prawidłowy w pokoleniu F_1 niż w B_1, co należy przypisać lepszemu zbalansowaniu genomów buraka cukrowego i buraka dzikiego (odpowiednio 2 : 2 i 3 : 1). Obumieranie zalążków było powodowane głównie przez zaburzenia we wczesnych etapach embriogenezy, na skutek których nie dochodziło do wytworzenia funkcjonalnych woreczków zalążkowych. Obumieranie zygot, prazarodków i zarodków było rzadziej obserwowane. Stwierdzono, że istnieją znaczne różnice indywidualne wśród badanych mieszańców w odniesieniu do ich płodności (przebiegu embriogenezy) i na drodze selekcji form zdolnych do tworzenia zarodków i żywotnych nasion można będzie otrzymać introgresywne mieszańce dalszych pokoleń, stanowiące materiał wyjściowy dla hodowli buraków cukrowych odpornych na mątwika korzeniowego.