Occurrence of Double Ovules in Sugar Beets

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With the development of monogerm sugar beet seed came the possibility of planting to a stand or of planting such low rates of seed per acre as to make hand thinning unnecessary. Two or more seed cavities per fruit, two or more ovules in single-cavity fruits, and two or more embryos per seed are characters which are common to many monogerm lines and which make the attaining of this objective very difficult.

Double ovules (Figure 1) and twin embryos (Figure 2) were reported in multigerm sugar beet varieties by Kohls and Nemazi[2]

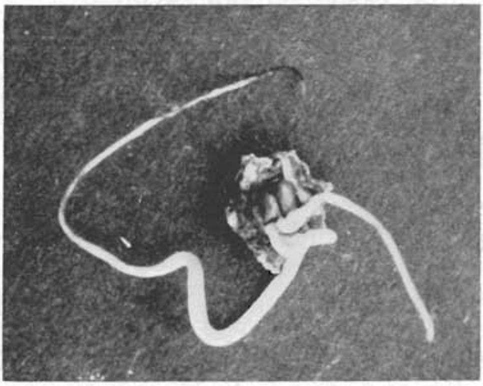

Figure 1.—Double ovules.
Two seeds within one seed cavity.

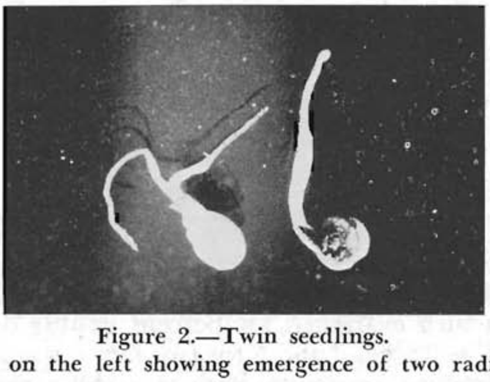

Figure 2.—Twin seedlings.
Seed on the left showing emergence of two radicals.

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[2] Kohls, H. L. and Joseph Nemazi, unpublished report.

in 1952. Hogaboam, (3)[3], using a radiographing technique, studied single-cavity fruits from plants of a monogerm variety and found 16 of 19 plants produced fruits with 2, 3 or 4 seeds per seed cavity. He also noted the presence of a few seeds with twin embryos. Twin embryos have been found in other crops such as onions, tobacco, (2) and corn (1) and are of interest to the plant breeder because of the possibility of obtaining haploid plants. Kruse (4), working with sugar beets, found 14 haploids out of 2,800 twins studied. However, eight of nine haploids reverted wholly or partially to diploids.

Inbred lines developed by the Utah-Idaho Sugar Company have from zero to 15% two-cavity fruits, zero to 73% double ovules, and zero to 3.5% twin embryos. Twin embryos occur rarely, are usually weak and would not appear to be of economic importance. This paper will deal primarily with double ovules.

Materials and Methods

Seeds in 200 fruits of each line and variety studied were germinated on blotting paper at 22° C. They were examined after three, four, five, and seven days. As seeds germinated the seed caps of the fruits were removed and the number of fruits having double ovules was determined.

Results and Discussion

Self-fertile monogerm lines, inbred for five or six generations were examined to determine percent double ovules. Ten of these inbreds (Table 1) varied from 2.6 to 36.5% double ovules. Sublines from these inbred lines were maintained separately.

Table 1.—Percent double ovules in ten monogerm inbred lines.

Inbred	Percent double ovules
12363	2.6
13263	4.6
12161	5.2
100363	5.2
13063	12.8
11563	12.9
10163	13.6
18263	18.4
1761	20.1
1861	36.5

In 1964, sublines were checked for percent double ovules and were again selfed by bagging. Progeny from each of these sublines were in turn examined for percent double ovules. Results are presented in Tables 2 and 3 for two families studies. Sublines tended to produce progenies with a wide range for percent

[3] Numbers in parentheses refer to literature cited.

double ovules. Sublines high in percent double ovules produced progenies which were relatively high for this character while sublines low in percent double ovules produced progenies which were relatively low.

Table 2.—Segregation of inbred lines for percent double ovules in 18263.

Parental lines	Percent double ovules	Percent double ovules in sublines									
		1	2	3	4	5	6	7	8	9	Avg.
18263-3	24.7	5.3	6.7	10.0	10.5	14.8	18.2	19.1	23.2		13.9
18263-24	9.2	2.9	4.4	9.5	10.2	12.2	14.6	17.1	20.0		11.4
18263-23	8.8	0.0	2.4	2.7	2.8	3.7	4.2	4.2	11.4	14.4	5.1
18263-28	7.6	0.0	2.9	4.2	4.6	7.6					3.9
18263-37	4.5	0.0	0.0	1.2	3.2	4.5	5.6	8.6			3.3
18263-36	2.4	0.0									0.0
18263-32	0.0	0.0									0.0

Table 3.—Segregation of inbred lines for percent double ovules in 12163.

Parental lines	Percent double ovules	Percent double ovules in sublines				
		1	2	3	4	Avg.
12163-99	7.3	2.1	6.5	7.1		5.2
12163-121	5.8	2.8	3.2	4.7	8.7	4.8
12163-98	5.7	2.5	3.6	8.2		4.8
12163-29	4.6	0.0	2.2			1.1
12163-111	4.2	0.0	1.2			.6
12163-118	3.8	1.4	5.4	6.4	12.4	6.4
12163-58	3.8	0.0				0.0
12163-120	3.2	0.0				0.0
12163-91	2.6	0.0	1.1			.6
12163-107	0.0	0.8				.8

Family 12163 was lower in percent double ovules than was family 18263. However, selecting against double ovules would be possible in both families, if selection were made from the best sublines.

Monogerm lines which had no double ovules, occasionally produced a small percentage of double ovules when subjected to further inbreeding (Table 4).

Table 4.—Segregation of inbred lines for percent double ovules in C3505.

Parental lines	Percent double ovules	Percent double ovules in sublines										
		1	2	3	4	5	6	7	8	9	10	11
C3505	0.0	0.0	0.0	0.0	0.0	0.6	1.3	1.3	1.4	1.8	1.8	2.3

Four monogerm inbred lines that contained 5.2 to 36.5% double ovules were crossed with self-fertile and self-sterile multigerm lines. Two hundred fruits of each of these multigerm

Table 5.—Percent double ovules in parental lines and in resulting F_3mm lines.

Generation								
P_1	1861 mm	1861 mm	1861 mm	1761 mm	1861 mm	1761 mm	1761 mm	1561 mm
	×	×	×	×	×	×	×	×
P_2	0261 MM	2361 MM	2461 MM	5502 MM	0661 MM	1161 MM	52-305 MM	2361 MM
P_3 mm	36.5	36.5	36.5	20.1	36.5	20.1	20.1	12.9
P_2 MM	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Range of F_3mm lines	17.2-34.3	3.0-42.6	1.2-13.8	0.7-9.4	0.0-10.1	1.2-3.7	0.8-7.3	0.0-3.5
Avg. of F_3mm lines	26.7	18.2	6.4	5.2	4.0	2.5	2.5	0.5

lines had been examined; none showed any double ovules (Tables 5 and 6). Selection for monogerm plants was made in the F_2 generation. These monogerm F_2mm selections were selfed and F_3 progenies produced. The F_2 and F_3 lines were examined for percent double ovules.

Table 6.—Percent double ovules in parental lines and in F_2mm and F_3mm lines.

Generation	P_1 / P_2	1761 mm × 0261 MM	133 mm × 0261 MM	1761 mm × 3861 MM	1761 mm × 0539 MM	1761 mm × 1061 MM
P_1 mm		20.1	5.2	20.1	20.1	20.1
F_2 mm		17.8	5.6	1.8	6.5	2.1
Range of F_3mm lines		0.0-23.4	0.0-27.0	2.2-13.0	2.4-12.6	0.0-13.5
Avg. of F_3mm lines		9.9	8.7	6.3	6.0	4.1
P_2 MM		0.0	0.0	0.0	0.0	0.0

The percentage of double ovules in F_3mm lines varied from below to above that found in the F_2mm populations (Table 6). All F_2mm lines examined had some double ovules (Table 6), but in five of the F_3 populations, lines could have been selected with no double ovules. Both monogerm and multigerm parents were important in determining the percent double ovules in F_2 and F_3 monogerm segregates. However, the MM gene suppresses expression of double ovules and estimates of this character in later generations can only be obtained from the monogerm parent. Multigerm line 0261 apparently carried many genes for double ovules while 2361 carried few genes for the same character (Tables 5 and 6).

Thirteen crosses between cytoplasmic male-sterile lines and type 0 monogerm pollinators were made and the F_1 produced was then crossed to other pollinators. Seed produced would be

Table 7.—Expected and observed results of F_1's from several inbred lines.

P_1	Percent double ovules	P_2	Percent double ovules	Percent double ovules in F_1	Geometric mean	Arithmetic mean
SL 129	28.2	SL 126	11.4	25.0	19.1	19.8
SL 129	28.2	12163	4.7	11.6	11.5	16.4
SL 129	28.2	CT5	13.8	14.1	19.7	21.0
SL 129	28.2	18263	18.5	24.1	22.8	23.4
SL 129	28.2	100363	5.2	11.6	12.1	16.7
SL 129	28.2	3061	12.8	19.7	19.0	20.5
SL 126	11.4	12163	4.7	1.6	7.3	8.0
CT5	13.8	12163	4.7	5.0	8.0	9.2
CT5	13.8	SL 128	20.1	12.9	21.9	17.0
12163	4.7	SL 128	20.1	3.3	9.7	12.4
SL 126	11.4	SL 128	20.1	8.9	15.1	15.8
100363	5.2	SL 128	20.1	5.8	10.2	12.6
11863	36.5	C 3505	1.0	13.5	6.1	18.8

equal to commercial hybrid seed. This seed was checked and tended to be between the two parents for percent double ovules. Percent double ovules of several F_1 crosses approached the geometric or the arithmetic mean of the parents (Table 7). However, other F_1 crosses were more nearly like either the high or the low parent. From the segregation observed in inbred lines and from segregation found in F_1, F_2 and F_3 populations, it is postulated that double ovules are controlled by multiple genes having several types of gene action.

To test the hypothesis that double ovules are the result of normal fertilization, several hundred seeds were planted each in a separate compartment. All seeds were from CMS plants with green hypocotyls which had obtained pollen from red hypocotyl plants. All plants produced had red hypocotyls, demonstrating that development of ovules by stimulation from pollen without fertilization did not occur.

Fruits of four monogerm CMS lines were screened to four sizes. Two hundred fruits of each line for each size were checked for percent double ovules (Table 8). The greater the fruit size the higher was the percentage of double ovules. Correlation between fruit size and percent double ovules was .933, which was highly significant.

Table 8.—Correlation between fruit size within lines and percent double ovules.

	Percent double ovules			
	Fruit size*			
Line	7	8½	10½	14
2161	0.0	0.0	0.0	4.0
1561	0.7	4.2	11.2	18.1
05.24	3.4	3.8	18.4	18.4
1861	5.4	14.6	33.6	36.5
Average	2.4	5.6	15.8	18.2

* In inches/64
Correlation between fruit size and percent double ovules = .933

Table 9.—Correlation between fruit size of different lines and percent double ovules.

Line	Weight of 100 fruits in grams	Percent double ovules
12363	1.00	2.6
11563	1.05	12.9
13063	1.27	12.8
10163	1.31	13.6
100363	1.31	5.2
18263	1.78	18.4
12163	2.08	5.2

Correlation between weight of fruit and percent double ovules = .12

Weight of fruits of each of seven inbred lines was obtained and the percent double ovules determined for each. The correlation coefficient between weight of fruits and percent double ovules was +.12, which was not significant, indicating the possibility of small fruited varieties having as many double ovules as large fruited varieties (Table 9). A correlation of –.01 for fruit weight with percent double ovules was obtained for 43 sublines of 12163. F_2 segregates of 0261 × 133 resulted in a correlation coefficient of –.07 for fruit weight versus percent double ovules. Within a line the larger fruits tend to have more double ovules, but selection against double ovules cannot be made by selection for fruit size.

Conclusions

Development of monogerm inbred lines are essential to the production of monogerm hybrids. As lines are inbred, double ovules can become a problem unless selection pressure is exerted against this character. Sublines can be selected which have no double ovules if selected from lines having a low frequency of genes for this character. F_3 segregates also can be obtained which have no double ovules.

Crosses between monogerm and multigerm lines produce double ovules in monogerm segregates. Number of double ovules produced depends upon both parents, but the MM gene suppresses the double-ovules genes in the multigerm parent and can only be evaluated by crossing with monogerm lines and observing F_2 and F_3 monogerm segregates.

Large fruits within a line are more likely to contain double ovules than are small fruits, but selection against double ovules is not possible simply by selection of small fruits.

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