Performance of Multigerm Triploid Sugarbeet Hybrids When Space Planted

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In recent years there has been much interest in polyploidy as a method of improving sugarbeet production. Polyploids are widely used in Europe, whereas in the United States most of the sugarbeet acreage is planted to diploid hybrid varieties. Results of comparative tests between equivalent diploid and triploid hybrids have been inconclusive but do show that the performance of a variety is not automatically improved by converting the pollinator from diploid to tetraploid (1,3,5)[2]. There is evidence that advantages associated with triploidy are most likely genotype specific (3) and that a program of combining ability testing will be required to identify high performing triploids. Our results and those of the West Coast Beet Seed Company[3] indicate that seed germination of triploid monogerm hybrids is often considerably lower than that of equivalent diploid monogerm hybrids. Frequently, germination is below 75% and is too low to permit commercial use of the seed. To overcome this problem, the breeder will need to give special emphasis to seed germination. In the meantime, multigerm triploid hybrids could possibly be used. This paper reports germination and field performance comparisons between diploid and triploid hybrids when space planted.

Experimental Methods

The multigerm, open-pollinated line 413 was converted to an autotetraploid through the use of colchicine by Dr. B. L. Hammond. Successive increases were made of seed originating from 67 tetraploid C_0 plants. Triploid hybrids were produced at Salinas, California, in a spatially isolated seed plot between four male-sterile seed-bearing diploid parents and tetraploid 413. The equivalent diploid hybrids were produced in a seed plot approximately 0.5 mile from the triploid plot.

Seed of each of the triploid and diploid hybrids was lightly decorticated with a small rice huller and then sized. Only that

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portion which passed through a 10/64 inch round-holed screen and retained by a 7/64 inch screen was used in the experiment. Lightweight seed was removed with an aspirator from each of the sized lots. The germination of each of the processed seed lots was determined on blotters.

The hybrids were grown in two replicated field tests at Salinas, California, in 1970. In the first test raw seed of each of the hybrids was thick sown in 53-foot single-row plots replicated 10 times. The test was planted February 10 and singled by hand March 18.

The second test was planted April 6 with a commercial seeder equipped to drop individual seedballs approximately 2 inches apart. Stand distribution determinations were made a few days after emergence. The two-row plots were 53 feet long and were replicated five times. The number of hills was counted in random 15 foot sections of each row of each plot. Counts were made of hills containing one, two, three, four and five seedlings.

Plants were removed with a long-handled hoe to produce a plant or hill spacing of 8 to 10 inches. No finger singling was done and no effort was made to remove plants that were separated from their neighbors by 1 inch or less. Stand determinations were again made, but this time complete plots were counted.

The two tests were harvested October 5 and 7 with the same commercial-type sugarbeet harvester. Root yield and sucrose percentages were determined from each plot. In addition, ppm of sodium (Na), potassium (K), and amino nitrogen (amino N) were measured in lead defecated sucrose filtrate. An impurity index was calculated as follows:

$$\text{Impurity index} = \frac{3.5\ \text{Na} + 2.5\ \text{K} + 10\ \text{Amino N}}{\%\ \text{sucrose}}.$$

Results

The seed germination for both the diploid and triploid hybrids produced in spatially isolated plots at Salinas, California, tended to be low (Table 1). This was especially true for the monogerm hybrid 813H8. Seed of the triploid hybrids germinated poorer than did that of the equivalent diploid hybrids. The proportion of the germinated seedballs producing a single sprout was higher for the triploid hybrids than for the diploid hybrids. With the three multigerm diploid hybrids, germinating seedballs producing a single sprout averaged 55.1%. Those producing two sprouts averaged 43.1% and those producing three sprouts averaged 2.4%. With the three equivalent triploid hybrids the corresponding averages were 73.2%, 26.1%, and 0.7%.

Table 1.—Seed germination of equivalent diploid and triploid sugarbeet hybrids.

Hybrid no.	Ploidy level	Parentage	Germination per 100 seedballs			
			Total	Sprouts per seedball 1	2	3
			No.	No.	No.	No.
Monogerm hybrid						
813H8	2n	546H3 × 413	58.2	51.2	7.0	—
	3n	546H3 × 413T	41.4	40.8	0.6	—
Multigerm hybrids						
813H32	2n	716H29 × 413	76.0	49.0	26.6	0.4
	3n	716H29 × 413T	63.8	48.0	15.6	0.2
813H41	2n	757H32 × 413	77.6	41.2	33.2	3.2
	3n	757H32 × 413T	75.6	55.0	19.6	1.0
813H49	2n	760H33 × 413	79.0	37.8	40.8	2.0
	3n	760H33 × 413T	63.4	45.4	17.8	0.2

The field emergence of the space planted multigerm triploid hybrids was lower than that of the equivalent diploid hybrids (Table 2). The number of hills per 100 feet of row averaged 210.4 for the three triploids compared with 320.2 for the diploids. In this test, seedling vigor was low for the monogerm hybrid 813H8 diploid and the triploid showed slightly better emergence. Triploid hybrids produced higher proportions of single plants. With the multigerm triploids 79.8% of the plants emerged as singles, 18.2% as doubles, and 2.0% as triples; whereas, with equivalent diploids 64.1% emerged as singles, 30.8% as doubles, 4.4% as triples, and 0.7% as quadruples. With the monogerm 813H8 triploid 93.2% of the plants emerged as singles, 6.5% as doubles, and 0.3% as triples compared with 88% singles and 12% doubles for the diploids.

Counts made after stand reductions with a long-handled hoe showed an average of 130.7 hills per 100 feet of row for the three multigerm triploids compared with 145.6 hills for the multigerm diploids (Table 3). Similar counts in the monogerm hybrid showed 123.4 hills per 100 feet of row for the triploid compared with 137.7 foı the diploid. Plants left in the multigerm triploids after stand reduction averaged 79.2% singles, 18.5% doubles, 2.1% triples, and 0.2% quadruples. Plants left in multigerm diploids averaged 61.4% singles, 31.7% doubles, 5.4% triples, 1.4% quadruples and 0.1% quintuplets. With the monogerm triploid, 92.1% of the plants were left as singles, 7.2% as doubles, and 0.7% as triples compared with 87.3% singles, 11.9% doubles, and 0.8% triples for the diploid hybrid.

Table 2.—Comparison of plant distributions at time of emergence for equivalent diploid and triploid sugarbeet hybrids.

Hybrid no.	Ploidy level	Total hills	Plant distribution per 100 ft. of row			
			Plants per hill			
			1	2	3	4
		No.	%	%	%	%
Monogerm hybrid						
813H8	2n	194.0	88.0	12.0	0	0
	3n	226.7	93.2	6.5	0.3	0
Multigerm hybrids						
813H32	2n	259.3	75.3	21.9	3.1	0
	3n	217.3	86.8	12.3	0.9	0
813H41	2n	349.3	61.1	32.1	5.7	1.1
	3n	229.3	77.1	20.6	2.3	0
813H49	2n	352.0	55.9	38.6	4.5	0.9
	3n	184.7	75.4	21.7	2.9	0

Table 3.—Comparison of plant distributions following stand reduction with long-handled hoe for equivalent diploid and triploid sugarbeet hybrids.

Hybrid no.	Ploidy level	Total hills	Plant distribution per 100 ft. of row				
			Plants per hill				
			1	2	3	4	5
		No.	%	%	%	%	%
Monogerm hybrid							
813H8	2n	137.7	87.3	11.9	0.8	0	0
	3n	123.4	92.1	7.2	0.7	0	0
Multigerm hybrids							
813H32	2n	139.8	74.9	22.2	2.4	0.4	0
	3n	126.6	85.2	13.7	0.9	0.2	0
813H41	2n	149.4	57.7	33.1	7.1	1.7	0.3
	3n	138.5	77.1	20.3	2.6	0	0
813H49	2n	147.5	51.4	39.9	6.6	1.9	0.1
	3n	127.0	75.2	21.6	2.8	0.5	0

Little difficulty was experienced with the mechanical harvest of the space-planted test. A few beets from multiple hills that measured less than 1 inch in diameter were lost through the cleaning Rienks. This occurred more frequently with the diploid than with the triploid hybrids. Significant differences did not occur among varieties in either beet or gross-sugar yields (Table 4). Sucrose percentages tended to be lower in the triploids, but significant differences did not occur between equivalent diploid and triploid hybrids. Only slight differences occurred among the varieties in the impurity components. None of the differences for either Na or amino N levels was significant. The K level was significantly higher in triploid 813H49 than in the equivalent diploid. Beet count at harvest was significantly higher for each of the diploid hybrids than for the equivalent triploids.

Table 4.—Performance of equivalent diploid and triploid sugarbeet hybrids when space planted followed by stand reduction with a long-handled hoe. The test was planted at Salinas, California, April 6 and harvested October 7, 1970.

Hybrid no.	Ploidy level	Acre yield Gross sugar	Acre yield Beets	Sucrose	N	Na	K	Impurity	Beet count
		Pounds	Tons	Percent	PPM	PPM	PPM	Index	No./ 100 ft.
Monogerm hybrid									
813H8	2n	9,130	26.72	17.1	1,198	192	2,282	1,070	(156)[1]
	3n	9,290	28.40	16.4	1,108	175	2,500	1,104	(134)
Multigerm hybrids									
813H32	2n	9,460	29.00	16.3	732	210	2,519	878	(179)
	3n	8,550	27.04	15.8	786	267	2,782	996	(147)
813H41	2n	9,220	28.56	16.2	796	233	2,526	938	(230)
	3n	9,140	28.74	15.9	721	236	2,767	940	(173)
813H49	2n	9,320	27.98	16.7	935	179	(2,145)	923	(237)
	3n	9,200	28.38	16.3	844	235	(2,738)	995	(163)
	LSD (5%)	NS	NS	0.6	NS	NS	250	NS	20

[1] Means enclosed in brackets were found significantly different at the 5% point by the t test.

The hand-singled test was planted about 2 months earlier than the space-planted test and the root yields were higher (Table 5). The general relationship between the performance of the triploid hybrids and the equivalent diploids was similar in the two tests. Root yield tended to be higher for the triploids and the sucrose percentages higher for the diploids. The differences between hybrids for either amino N or Na were not significant. The K level tended to be higher in the triploids, but differences between diploid and triploid hybrids were not significant.

Discussion

These tests indicate that multigerm triploid sugarbeet hybrids will give a satisfactory performance when decorticated seed of uniform shape and size is space planted. Low seed germination is a common occurrence in triploid hybrids compared with that of equivalent diploids. Germination tests showed that even though there was a lower total germination in many multigerm triploid hybrids, the actual percent of seedballs giving rise to a single sprout was higher than in the equivalent diploids. This occurs because a portion of the fruits in the triploid multigerm seedballs fail to produce viable seeds.

When space planted in the field, the emergence follows a pattern similar to that one would predict from the germination tests. The total hill count was higher for the multigerm diploids,

Table 5.—Performance of equivalent diploid and triploid sugarbeet hybrids when hand singled to a uniform plant spacing of about ten inches. The test was planted at Salinas, California, February 10 and harvested October 3, 1970.

Hybrid no.	Ploidy level	Acre yield: Gross sugar	Acre yield: Beets	Sucrose	N	Na	K	Impurity	Beet Count
		Pounds	Tons	Percent	PPM	PPM	PPM	Index	No./100 ft.
Monogerm hybrid									
813H8	2n	14,220	42.92	16.6	729	130	1,965	765	117
	3n	14,760	45.20	16.3	629	133	2,072	731	121
Multigerm hybrids									
813H32	2n	14,660	45.31	16.2	578	153	2,338	755	120
	3n	14,270	44.50	16.1	684	140	2,382	828	116
813H41	2n	13,900	42.63	16.3	684	159	2,359	816	117
	3n	14,290	45.24	15.8	630	143	2,458	820	115
813H49	2n	13,850	42.18	16.5	680	124	2,168	771	113
	3n	14,420	44.63	16.2	659	150	2,337	802	113
	LSD (5%)	543	1.74	0.4	NS	NS	139	NS	NS

[1] Means of paired comparisons between equivalent diploid and triploid hybrids are not significantly different at the 5% point.

but the percent of single plants was higher for the equivalent triploids. In this test the percent of hills with two or more plants was higher than expected from the germination tests. This was caused by the occasional entry of more than one seedball into some seedplate cells. This irregular cell fill occurred because the rice huller only partially decorticated the seed and the seed shape was still irregular. The shape of commercially decorticated seed would be more uniform and the seed would be sized to closer limits.

The results do not indicate any significant impairment in the performance of multigerm triploids when space planted followed by stand reduction with a long-handled hoe. When grown commercially, stand reduction could be done with a mechanical thinner. In this test 80% of the plants occurred as singles and the remainder were primarily doubles. Under favorable growing conditions the greater portion of the doubles would reach harvestable size and their presence would probably cause little, if any, reduction in yield (2,4). The germination of the multigerm seed produced at Salinas was about 10-15% lower than normally expected. Higher germination usually occurs in areas adapted to commercial seed production. A slightly higher percentage of the seedballs also might be expected to give rise to two or more seedlings. However, the proportion would be lower than with the diploid seedballs.

The ultimate aim of the breeder is the development of monogerm triploid hybrids with seed germination equal to that of our present diploid hybrids. European breeders with extensive polyploid breeding experience advise that high germinating triploid seed is being produced in Europe. This would indicate that, with additional effort, we can develop triploid hybrids with satisfactory germination. In the meantime, the results of this experiment demonstrated that high performing multigerm triploids can be utilized in a program of fully mechanized sugarbeet production.

In addition to overcoming a germination problem, multigerm triploids could provide a means of speeding up the incorporation of a desirable character into a commercial variety. Genetic diversity is greater in multigerm-breeding material than in our present monogerm populations. For this reason a new character, such as disease resistance, is usually obtained from a multigerm source. A common procedure is to develop high performing multigerm lines that possess the desired character and then convert the seed-bearing parents to monogerm. In some instances, more rapid progress could probably be made by converting the pollinator to tetraploid and utilizing a multigerm seed-bearing parent. The resulting multigerm triploid hybrid could then be used commercially until a monogerm hybrid was developed.

Summary

Tests with multigerm triploid sugarbeet hybrids showed that satisfactory performance can be obtained when they are space planted followed by stand reduction with a long-handled hoe. Germination is frequently lower in triploids than in the equivalent diploids and the number of seedlings produced per seedball is also lower. When decorticated seed of multigerm triploids was space planted, the field population after stand reduction with a long-handled hoe consisted of 79% single plants and the remaining hills were primarily doubles. Losses from undersized beets at harvest were minimal. High performing triploid hybrids with good seed germination is an aim of the breeder. These results indicate the multigerm triploids could be used pending the development of satisfactory monogerm triploids.

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