Divergent Selection in Tetraploid Pollinators for High and Low Germinating Triploid Hybrid Seed

R. E. STAFFORD AND R. E. FINKNER[1]

Received for publication April 25, 1966

The germination of beet seed is influenced by many factors. At the diploid level Smith (2)[2] has shown that sugar beet varieties differ in their ability to germinate at 43° F and that this ability is heritable. Snyder (3, 4) found that the speed of germination was largely controlled by the fruit (maternal tissues) surrounding the true seed. Chemical inhibitors in the seed appear to influence the speed of germination more than the physical nature of the fruit (3). A search of the literature revealed no attempts by investigators to study triploid germination.

Tetraploids which consistently produce high-germinating triploid progeny would be a desirable feature in a triploid-breeding program. The objective of this study was to determine if tetraploid male lines could be selected which would produce low and high germinating triploid hybrids.

Materials and Methods

An American Crystal tetraploid, 62-4T22, was selected for study. This tetraploid is a self-sterile, multigerm, nematode resistant selection. One-hundred-eighteen pairs of stecklings of 62-4T22 were planted in 1963. Two diploid male-sterile stecklings of 561H1, a slow bolting selection developed by McFarlane, USDA Geneticist, were planted in close proximity to each pair of tetraploid stecklings. The four stecklings were enclosed in a plastic cage at flowering time. Both males and/or male steriles were cut back when necessary to equalize bolting differences.

Triploid seed produced on the diploid male-sterile plants was harvested, cleaned, and polished with a small-sample polisher. Samples were germinated using the standard blotter technique. Sprout counts were made at the end of 10 days. Tetraploid parents of five extremely-low and five high-germinating triploid lines were selected for further study.

Stecklings were obtained from remnant tetraploid seed of the selected lines. In 1965, 10 pairs of stecklings from each high- and low-germinating line (100 pairs in total), were paired with diploid male-sterile stecklings of SLC #129, a curly-top selection

[1] Plant Breeder and former Director of Agricultural Research (now, Superintendent, Plains Branch Station, New Mexico State University, Clovis, New Mexico), respectively, American Crystal Sugar Company, Rocky Ford, Colorado.

[2] Numbers in parentheses refer to literature cited.

developed by Owen, USDA Geneticist. Pairs were caged at flowering time as in the previous year. Both males and/or male steriles were cut back when necessary to equalize bolting differences. Chromosome number in each tetraploid pollinator was checked microscopically. Both tetraploid and triploid seed was harvested, cleaned, and polished. Samples from 5 randomly selected cages of each line were germinated, using the blotter technique. Sprout counts were made at the end of 10 days.

Experimental Results

Germination results are given in Table 1. Low-germinating triploid hybrids ranged from 22 to 63% germination; high-germinating triploids ranged from 97 to 99% in 1963. Low- and high-germinating triploids ranged from 74-87 and 76-89%, respectively, in 1965. The intergeneration correlation between triploid-means was very low (.096).

Table 1.—Mean germination of triploid seed from low- and high-germinating lines grown in 1963 and 1965.

(Mean of 3 replications, Rocky Ford, Colorado)

Pedigree	Mean germination % (triploids—1963)	Mean germination % (triploids—1965)
Low-germinating lines		
63-93	22.0	80.0
63-61	34.0	77.2
63-141	51.3	87.2
63-79	58.3	74.7
63-77	63.0	77.4
Average	45.7	79.3
High-germinating lines		
63-87	97.0	77.3
63-86	97.7	89.3
63-98	98.0	81.4
63-137	99.3	76.1
63-172	99.3	78.9
Average	98.3	80.6

Inter-generation Correlation = .096

An analysis of variance for seed germination of triploid hybrid seed harvested in 1965 is given in Table 2. Variances for cages and sib pairs × cages were highly significant. The interaction variance (sib pairs × cages) was used to test the significance of the 3 variances immediately preceding it. These 3 variances: sib pairs, high vs. low, and within high and low were nonsignificant.

Table 2.—Analysis of variance for seed germination of low- and high-germinating triploid hybrids, grown in 1965 at Rocky Ford, Colorado.

Source of variation	d.f.	Mean squares triploid
Replications	2	2.0
Cages (subsibs)	4	330.8**
Error (a)	8	16.7
Sib pairs	9	367.4
High vs. low	(1)	152.0
Within high and low	(8)	394.3
Sib pair × cages	36	305.5**
Error (b)	90	28.3
Total	149	

** Significant at the 1% level.

Mean seed yield of the tetraploid lines and their triploid hybrids is given in Table 3. Low-germinating tetraploid lines averaged 36.5 grams per cage; high-germinating lines, 34.2 grams per cage. Low-germinating triploid hybrid selections averaged more than twice as much seed per cage (27.7 grams) as the high-germinating selections (11.7 grams).

Table 3.—Mean seed yield in grams of high- and low-germinating lines grown in 1965.

(Mean of 5 cages per line, Rocky Ford, Colorado)

Pedigree	Mean seed yield/gram per cage tetraploid	triploid
Low-germinating lines		
63-93	58.4	44.3
63-61	31.8	18.0
63-141	56.0	21.7
63-79	27.3	41.4
63-77	9.2	13.0
Average	36.5	27.7
High-germinating lines		
63-87	9.5	15.2
63-86	73.4	25.1
63-98	24.8	2.0
63-137	36.1	6.0
63-172	27.2	10.1
Average	34.2	11.7

An analysis of variance for seed yield of the low and high-germinating tetraploid sib pairs and their triploid hybrids is given in Table 4. All variances in the tetraploid analysis were nonsignificant. The variance for high vs. low in the triploid analysis was significant at the 5% level. Other variances were nonsignificant.

Table 4.—Analysis of variance for seed yield of low- and high-germinating tetraploid sib pairs and their triploid progeny grown in 1965.

Source of variation	d.f.	Mean squares tetraploid	triploid
Replications (cages)	4	955.3	216.6
Sib pairs	9	2232.3	982.7
Low sibs	(4)	2143.4	1011.2
High sibs	(4)	2862.2	400.7
High vs. low	(1)	68.4	3196.8*
Error	36	1354.3	462.0
Total	49		

* Significant at the 5% level.

Discussion

The extreme range in germination obtained in 1963 indicated there was a great deal of heterogeneity within the populations under study. Observations in the field regarding bolting-habit and overall plant appearance within the tetraploid lines in 1965, also indicated genetic variability existed. However, the extreme range in germination percent was not found in the populations grown in 1965, as in the previous year.

The male sterile, 561H1, paired with tetraploid lines in 1963 was a slow-bolting California selection. SLC #129, a curly-top resistant selection, was paired with the tetraploid lines in 1965, because stecklings of 561H1 were not available. Snyder (4) has pointed out that the speed of germination is largely controlled by the fruit (maternal tissue) which surrounds the true seed. The extent to which total germination or "germination *per se*" is controlled by maternal tissue might also be reflected in the germination results presented here.

Chromosome number in each tetraploid pollinator was checked microscopically. Several cages were found in which either one or both pollinators were triploid. When only one pollinator per cage was triploid, there appeared to be no adverse effect upon germination of the hybrid seed, as shown in the following table:

Pedigree	Number of cages having 1 triploid pollinator	Mean germination % (hybrids)
Low germinating lines	2	85.5
High germinating lines	15	81.0
Average	17	81.3

In those cages in which both pollinators were triploid, no hybrid seed was produced. This suggests that pollen from the triploid pollinators was nonfunctional.

Savitsky (1) has shown that sib-mating as a method of inbreeding in tetraploids is low in effectiveness. In tetraploids, 10 generations of sib-mating are needed to halve the proportion of heterozygotes and 31 generations are needed to reach 90% homozygosity. Tetraploids used in this study were sib-mated two generations. Unless a sizable tetraploid population is used in the second generation of sib-mating, the possibility of stabilizing the gains realized in the first sib-mating could be greatly diminished.

An analysis of variance for seed yield (Table 4) indicated no significant differences between the low- and high-germinating tetraploid lines. Greater variability was found in seed yield of the triploids. The mean seed yield of the low-germinating triploids was more than twice that of the high-germinating lines (Table 3). This is reflected in the significant variance for high- vs. low-germinating triploids in Table 4.

Summary

Tetraploid lines producing low- and high-germinating triploid hybrids were caged with male-sterile diploids in 1963 and 1965. Germination of triploid hybrid seed produced on the male-sterile plants was compared in the two years; seed yield of the tetraploids and triploids was compared in the latter year. The following conclusions were made:

1) Divergent selection in tetraploid pollinators for low- and high-germinating triploid hybrids was not effective in the material studied.

2) Limitations of the experiment were discussed. Because of the preliminary nature of the work, it would not be safe to conclude that selection for low- and high-germinating lines will not be effective with other material. More critical data are needed.

Literature Cited

(1) SAVITSKY, V. F. 1962. Sucrose and weight of root in tetraploid monogerm and multigerm sugar beet populations under different mating systems. J. Am. Soc. Sugar Beet Technol. 11 (8): 676-711.

(2) SMITH, C. H. 1952. Heritable differences in germination of sugar beet seed at low temperatures. Proc. Am. Soc. Sugar Beet Technol. 7: 411-414.

(3) SNYDER, F. W. 1959. Influence of the seed ball on speed of germination of sugar beet seeds. J. Am. Soc. Sugar Beet Technol. 10 (6): 513-520.

(4) SNYDER, F. W. 1963. Selections for speed of germination in sugar beet. J. Am. Soc. Sugar Beet Technol. 12 (7): 617-622.