Cane Breeding

THAILAND S. SPONTANEUM HYBRID PROGENY AS A NEW GERMPLASM SOURCE IN HAWAII

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ABSTRACT

Progeny derived from Thailand S. spontaneum hybridized with S. officinarum or commercial cultivars, have potential of becoming high tonnage commercial cultivars in the upper elevations of Hawaii.

INTRODUCTION

Crosses of sugarcane involving S. spontaneum with S. officinarum and/or commercial cultivars are an integral part of the cultivar development program in Hawaii (Heinz5). Since 1930, sugarcane breeders in Hawaii have hybridized over 40 different S. spontaneum clones with S. officinarum or commercial cultivars. In addition, clones of S. spontaneum hybridized with S. officinarum or commercial cultivars have been imported as vegetative cuttings (over 100) or have been germinated from seed (several hundred) imported from foreign countries.

These imported S. spontaneum clones or hybrids of S. spontaneum have been hybridized and used extensively in the Hawaiian cultivar development program.

Several sugarcane breeders have discussed the use of S. spontaneum clones in hybridization programs to increase genetic diversity (Dunckelman1,2,3, Panje9, Roach10,11, Sankaranarayanan12, Walker13,14). None have reported the derivation of new commercial hybrids from sources of S. spontaneum since those originally produced in Java, India and the Philippines 5 to 7 decades ago (Roach10). As a consequence, presently planted commercial cultivars are progeny of a very few S. spontaneum clones.

This paper reports the development in Hawaii of potential commercial hybrids from S. spontaneum clones collected in Thailand.

MATERIALS AND METHODS

The Thailand S. spontaneum discussed in this paper were collected as seed by Dr. A. J. Mangelsdorf between December 13-24, 1955. The basis for this 1955 expedition was a desire to collect S. spontaneum clones of the “Mandalay” and “Burma” types with flowering dates later than those of S. spontaneum already in Hawaii. Mangelsdorf had collected the Mandalay and Burma clones in 1929 in Burma, but found they flowered in October, too early for hybridizing with commercial cultivars in Hawaii. Also, under Hawaiian conditions, it was difficult to delay flowering of these two S. spontaneum clones. The proximity of Burma to Thailand suggested that the upper regions of Thailand might be an area containing

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later flowering *S. spontaneum* and thus worthy of a collection expedition. Collections were made from 14° to 20° North latitude.

The fuzz from each collected lot was divided into three portions and sent to Hawaii, to Coimbatore, and to the USDA quarantine station, Beltsville, Maryland. The Hawaii consignment was merely for insurance. When the seedlings were established at Beltsville from all but one of 30 lots of seed, the Hawaii lot was destroyed. We have no report on the Coimbatore lot.

Seven crosses between *S. officinarum* and *S. spontaneum* were made during December, 1962 to expose dormant seed to gamma radiation. The objective was to induce translocations between *S. officinarum* and *S. spontaneum* chromosomes. Listed in Table I are the crosses, amount of "fuzz", and level of radiation. A cobalt-60 gamma source was used to irradiate the seed at levels determined in previous work (Heinz).

**TABLE I.** *S. officinarum X S. spontaneum* crosses, amount of fuzz (grams), radiation dosage and number of seedlings selected after sib mating.

<table>
<thead>
<tr>
<th>Cross</th>
<th>Amount of fuzz</th>
<th>Dose</th>
<th>Number of sib seedlings selected</th>
<th>Number of sib seedlings selected</th>
<th>Number of sib seedlings selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>57NG 174 x US56-13-7</td>
<td>18.7</td>
<td>0</td>
<td>50</td>
<td>18.7</td>
<td>36</td>
</tr>
<tr>
<td>Rose Bamboo x US56-15-8</td>
<td>8.7</td>
<td>10KR</td>
<td>60</td>
<td>8.7</td>
<td>42</td>
</tr>
<tr>
<td>57NG 256 x US56-16-11</td>
<td>17.7</td>
<td>13KR</td>
<td>0</td>
<td>17.7</td>
<td>0</td>
</tr>
<tr>
<td>Rose Bamboo x Dacca</td>
<td>16.4</td>
<td></td>
<td>7</td>
<td>16.4</td>
<td>51</td>
</tr>
<tr>
<td>28MQ 1370 x Sumatra</td>
<td>18.2</td>
<td></td>
<td>0</td>
<td>8.2</td>
<td>0</td>
</tr>
<tr>
<td>47NG 256 x SES84-A</td>
<td>16.6</td>
<td></td>
<td>5</td>
<td>16.6</td>
<td>0</td>
</tr>
<tr>
<td>28NG 269 x Krakatau</td>
<td>13.7</td>
<td></td>
<td>3</td>
<td>13.7</td>
<td>2</td>
</tr>
</tbody>
</table>

1*57NG 174 was subsequently identified as being the same clone as Saipan 17, a Japanese developed variety widely distributed throughout the Pacific Region during World War II.*

After irradiation (January 2, 1963), the seed was germinated and hybrids were planted singly in a field at the Maunawili Breeding Station. The hybrids flowered from the 13th to the 26th of November, 1963. No treatment was given to delay flowering. Flowering hybrids within each treatment were intercrossed (Fig. 1), producing a sibbed population. Based on vigor and freedom from diseases, outstanding progeny were selected from within the sibbed populations. The progeny were asexually propagated into 1.5 x 5-meter plots under lights to delay flowering (Moore and Heinz). During subsequent years, these clones were crossed to Hawaiian commercial cultivars. The resulting hybrids were distributed to regional variety selection stations representing the various environments where sugarcane is grown in Hawaii. Selected hybrids were then sent back to the breeding station for crossing with commercial cultivars, especially with those commercial cultivars proven superior in the same environment where the hybrids were selected. Then for the second time, hy-
Figure 1. Crossing and selection scheme for development of potential commercial cultivars from *S. spontaneum*.

Hybrids were sent back to the regional station representing the environmental niche. They were selected and returned to the breeding station for further crossing with commercial cultivars. This occurred up to three or four generations of backcrossing to commercial types. At any stage in the cycles, hybrids could have been selected and installed into yield trials.

Parallel with the radiation study, other crosses were made involving Thailand *S. spontaneum* clones with other commercial hybrids which have produced progeny with commercial potential. Progeny from the crosses were backcrossed and selected using the procedures outlined above.
Yield trials were of two types: the preliminary (FT5) with a plot size of 9 x 7 meters and the advanced (FT70 with a plot size of 12 x 12 meters. Installation of tests and analysis of test data were according to the augmented block design by Federer. Cultural practices, including nutrition, were those used on the plantations where the yield trials were grown. Chromosome counts were determined from microsporocytes and/or young leaf tissue using procedures previously outlined (Heinz et al.). Disease ratings were based on a scale of 1 to 9, 1 for most resistant and 9 for most susceptible to the disease.

RESULTS AND DISCUSSION

Irradiation

Irradiated and control populations were studied for induction of chromosomal translocations and monotypic changes. Although chromosome counts were not taken for all progeny in the irradiated populations, microsporocyte examination of up to 10 individuals in each population at diakinesis and metaphase showed no differences between irradiated and control populations. Normal bivalent pairing and no multivalent pairing were observed. Except for an initial reduction in vigor in the irradiated populations, no phenotypic differences attributable to irradiation could be identified. Between the sibbed populations, no distinguishable differences were observed. With the exception of H65-8425, chromosome counts were not taken from the progeny of the sibbed populations.

Chromosome Transmission

Chromosome numbers are available for some progeny of the crosses under discussion (Fig. 2). Consider, for example, H69-9092 and H69-9103 with chromosome numbers of 2n = ca 120, as the progeny of the commercial female parent H49-134 and the male parent, H65-8458. Since the female parent had a chromosome complement of 2n = ca 117-118, one can by inference assign a chromosome number of 2n = ca 125 for H65-8458. This chromosome number for H65-8458 is reasonable if one assumes a cross between sibs having n + n and 2n + n (2n = 154) chromosomes as the parent material. If this was the case, then a rare event has occurred in which a commercial hybrid, 57NG174 (Saipan 17) has passed on the intact full chromosome complement to its progeny. Another possible explanation for 2n = 125 in H65-8458 is contamination by foreign pollen. This was very unlikely though since the sib mating was conducted under Australian type cloth lanterns which have proven adequate to provide an environment free of foreign pollen.

A more substantive argument for 2n + n and n + n transmission is provided by H65-8425 with a chromosome number of 2n = 100 (Fig. 3), derived from a sibbed population producing H72-8507 (Fig. 2) with a chromosome number of 2n = ca 106-113 (Fig. 4). The only missing chromosome number is for H50-4509, a Hawaiian commercial cultivar which we assume has a chromosome number of about 2n = 120.

One can only speculate on the importance of chromosome number transmission in these progeny. Nevertheless, we would like to emphasize in the case of progeny derived from Thailand S. spontaneum, that 2n + n transmission is a real possibility and suggests that the chromosome balance plays an important role in the yield potential of these clones.
Progeny from radiation study:

A. H69-9092 (2n=ca 116-128)
   (From control population - no irradiation)
   H69-9103 (2n=ca 120-121)

B. H72-8597 (2n=106-113)
   (From fuzzi where F1 received 10kR of irradiation)

II. Progeny from other crosses:

A. H70-9027
   H70-8727
   H70-8727
   H73-7184

B. H69-9022 (2n=ca 117-118)
   commercial cultivar

   H65-8458 (2n=125*)
   F1 (2n=154*)
   Sibbed

   H65-8425 (2n=100)
   H50-4509 commercial cultivar
   F1 (2n=120*)
   Sibbed

   H50-1063 commercial cultivar
   H63-8309
   H67-3418

   H58-728 commercial cultivar
   H58-729 or 87-3292

   H65-7209 commercial cultivar
   H63-8319
   US6-13-7 (1/2)
   Thailand spont.

   US56-15-8 (Thailand spont 2n=80)
   S. Officinarum

   US56-14-4 (Thailand spont 2n=80)
   Rose Bamboo (2n=80)

   S7NG 174 (Saipan 17)

*Chromosome number by inference.

FIGURE 2. Pedigrees of progeny producing acceptable yields, including chromosome number when known. 
S. spontaneum line is shown in detail.
Yield Data

More important, based on our observations, is the source of the S. spontaneum parent materials from the $19^\circ-20^\circ$ north latitude and the elevation from which they were collected in Thailand. Evidently, these S. spontaneums evolved in a climate where they established great buffering capacity for they seem to be prepotent for passing on to progeny regardless of the female parent, the ability to thrive in the low sunlight upper elevations of Hawaii. Commercial parents such as H50-4509 and H50-7209 have not performed well in the low sunlight upper elevations. Progeny from the S. spontaneum X commercial-type crosses were distributed to seven different ecological zones for observation and selection. Generally in the lower elevations, the progeny were spont-like, had small stalk girth, heavy stooling and were very trashy. The cultivars H69-9092, H69-9103 and H72-8597 exhibited more S. spontaneum characteristics at the lower elevations than they did at the higher elevations. These cultivars were vigorous, healthy in appearance and had excellent ratooning ability when grown at the higher elevations. At the lower elevations they were heavy flowering, whereas at 450 meters or higher, flowering was almost completely inhibited.

**FIGURE 3.** Photomicrograph showing 50 bivalents for H65-8425. As in the sibbed progeny studied no multivalent chromosome formations were detected in this clone derived from an irradiated population.
Field data reported were only for those crosses and progeny producing acceptable cane tonnage and sugar yields in FT5 and/or FT7 yield tests. Acceptable yields were obtained from four basic crosses (Fig. 2). Reported in Table 2 are yields of five cultivars showing yield potential. Clones H69-9092, H69-9103 and H72-8597 are planted in replicated tests in the upper elevations and some will be harvested in 1980. Based on their early growth, stalk number, stalk girth and stalk length up to 14 months of age, they appear to be substantially ahead of the control plots. They can produce heavy cane tonnage, but the juice quality is generally poorer than desired. However, enough data were available to suggest that these clones will perform satisfactorily in Hawaii.

The higher cane tonnage potential of these cultivars at the higher elevations of Hawaii, where long crop age is practiced, indicated that they can provide germplasm for improving yields. Based on preliminary yields, the progeny of the first backcross (BC1) may be placed in commercial production under these conditions. With the availability of new chemical ripeners, the inherently lower sucrose content may not be such a yield-limiting factor. While one should not expect the same sucrose percentage from chemically ripened low-sucrose cultivars as one would from similarly ripened high-sucrose cultivars, the high cane tonnage of the S. spontaneum hybrids will give opportunity for the production of the same or higher total sugar per hectare. In addition, there will be a higher yield per hectare in total dry weight including total sugar, molasses and fiber.

The increased production of dry matter per hectare is of importance in Hawaii which is almost totally dependent on imported fuel oil for energy. It is a state government policy to encourage energy self-sufficiency. In part this will come
<table>
<thead>
<tr>
<th>Cultivar</th>
<th>Estimated Tons Cane/HA</th>
<th>Estimated Sucrose Yield % Cane</th>
<th>Estimated Tons Sugar/HA</th>
<th>Harvest Age</th>
<th>Type of Test</th>
<th>Elevation</th>
<th>Eyespot</th>
<th>Disease Leaf Scald</th>
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<tbody>
<tr>
<td>H69-9092</td>
<td>369</td>
<td>9.7</td>
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<td>[US56-13-7(BC₁)]</td>
<td>281</td>
<td>11.9</td>
<td>13.7</td>
<td>33.5</td>
<td>24.5</td>
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<td>471</td>
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<td>578</td>
<td>15.3</td>
<td>12.8</td>
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<td>47.9</td>
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<td>[US56-13-7(BC₁)]</td>
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<td>12.3</td>
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<td>41.4</td>
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<td>FT7</td>
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<tr>
<td>H70-9027</td>
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<td>[US56-14-4(BC₂)]</td>
<td>252</td>
<td>11.1</td>
<td>15.4</td>
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<td>40.1</td>
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<td>FT5</td>
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<td>H73-7154</td>
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<td></td>
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</tr>
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</table>

\( a = \) Rating not available
through increased biomass production. Sugarcane can provide increased energy through increased fiber production. Already on the island of Hawaii, approximately 45% of the electricity generated is from bagasse. This percentage can be increased by increasing total crop yield per hectare. The Thailand S. spontaneum progeny offers the opportunity to develop cultivars higher in total sugar, fiber and molasses per hectare.

Our preliminary data suggested that the Thailand S. spontaneum sources have the potential of producing high-yielding progeny under Hawaiian conditions. Similarly, Dunkelman\(^2\) reported that US56-15-8 produces progeny having high yield potential in Louisiana. Although some BC\(_1\) progeny have promising yield potential, the probability is that BC\(_2\) or BC\(_3\) progeny from the BC\(_1\) cultivars will be the clones having the desired characteristics for high yielding cultivars.

REFERENCES


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LA PROGENIE HIBRIDA DE *S. SPONTANEUM* DE TAILANDIA COMO UNA NUEVA FUENTE DE GERMAPLASMA EN HAWAII

Don. J. Heinz

RESUMEN

La progenie derivada de *S. spontaneum* de Tailandia hibridizada con *S. officinarum* o cultivares comerciales tiene capacidad potencial de brindar cultivares comerciales de altos tonelajes para las zonas mas altas de Hawaii.