

## Breeding of sugar beet cultivars with high quality using self-fertile gene ( $S^f$ )

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### Summary

Most of the sugar beet (*Beta vulgaris* L.) cultivars released recently in Japan are triple-cross hybrids. Breeding for hybrid cultivars, requires improving seed parent lines, which consists of combination of cytoplasmic male sterile (CMS) lines and maintainer (type-O) lines. The breeding of seed parent lines is laborious and time-consuming. Low harmful non-sugars have been added to high yield in breeding objectives of sugar beet. Using crossing between SF lines with  $S^f$  gene in sugar beet, a breeding method was investigated to develop a triple-cross hybrid with high yield and high quality, and presented the results from the genetical study on harmful non-sugars.

#### 1. Male sterility induced by cooling treatment and its application to cross-pollination between self-fertile lines in sugar beet

Castration has been necessary to make crosses between SF lines. Male sterility induced by cooling treatment in reproductive-stage of sugar beet plants, was applied as castration method. Male sterility was completely induced by the cooling treatment (with 24 hour day-length) of 5 for 50 days or 3 for 30 days at the early bud stage of vernalized plants. Female organs in the male sterile plants by the cooling treatment were not injured and produced hybrid seeds by crossing with normal pollen. The seed productivity of the male sterile plants was almost even to hand-castrated plants. Male sterility with

cooling treatment was applicable for cross-pollination as an efficient method of castration in sugar beet. The male sterility was induced in not only type-O lines but also type-Rf (Restorer) lines. The sensitivity to cool temperature of generative cells and tapetum cells is more significant to that of somatic cells in anthers of sugar beet. Unsimultaneous development between these cells caused by cooling treatment is considered to be an indication of developing of male sterility.

#### 2. Consequence of selfing on yield and quality

Performance of SF lines with self-crossing was investigated in consecutive generations from  $S_4$  (selfed four times) to  $S_8$ . Decrease of root weight was recognized in  $S_4$  and  $S_5$ , and not in the advanced generations, and decrease was not observed in sugar content and harmful non-sugars content for almost all SF lines. SF lines are recommended to cross with other lines to produce hybrid seeds in  $S_5$  or advanced generations in the breeding program of sugar beet. When SF lines are used to analyze genetical behavior on root weight or sugar yield, consequence of selfing must be considered.

#### 3. Selection effects on yield and harmful non-sugar content in progeny of hybrids between SF lines

Using breeding materials derived from the crosses between SF lines, selection effects on some important agronomical characteristics of sugar beet, i.e., root weight, sugar content

and harmful non-sugars ( Amino-N, K and Na ) content were investigated. The selection for high root yield seemed successful. As to sugar content, it seemed difficult to select lines with higher content than parental lines, and thus high sugar content lines should be chosen as parents. Selection difference was obvious in harmful non-sugar content, which was lower than that of parental lines of some progenies. Effect of the selection was high in Na, and was moderately in amino-N, and was low in K contents. Breeding of lines with high yield and high quality was shown to be possible through crossing between SF lines.

Root-crown weight, brix and harmful non-sugars were determined in many O-type SF lines, and correlation and principal component analyses were made on lines basis and individual basis. Generally, there were significant negative correlations between brix and Na content. Correlation between brix and K or amino-N content was negative in most lines, but positive in some lines. Consequently, it was suggested that selection by brix is useful for lowering of Na content, but that selection for high brix does not substitute selection for the low content of amino-N and K.

Selection against harmful non-sugars was

carried out repeatedly for O-type SF lines. Selection was effective after only 1 or 2 cycles, and brought about the plants with the low contents. In conclusion, the selection against harmful non-sugars may be done at S<sub>2</sub> generation. The determination of harmful non-sugars is easier by electric conductivity ( EC ) analyzer than by auto-analyzer. Although the analyzing method of EC is simple and efficient, it does not reflect non-electrolyte, amino-N content.

#### 4. Breeding of seed parent lines by crossing between SF lines

In sugar beet, type-O lines with high yield and high quality were produced through crossing between some SF lines. Some seed parent lines of the type-O lines with cytoplasmic male sterile lines showed the high yield and low harmful non-sugar content.

Some triple-cross hybrids of SF lines with the seed parents showed higher yield and higher quality, than the standard cultivar of Japan, 'Monohomare'. Particularly, these hybrids showed low harmful non-sugar content. The breeding method with crossing between SF lines is considered to exceed conventional method for developing the type-O lines. This method may be desirable in improving quality characteristics of sugar beet.