16. PROGRESS IN THE BREEDING OF SUPERIOR MAIZE VARIETIES IN JAPAN

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Introduction

The demand for dry grain maize in Japan is fast increasing each year to keep pace with the rapid growth of livestock industry and maize processing industry, reaching 3.854 million tons in 1966. However, a major portion of the demand is dependent on import because of the stagnation in domestic production increase. In 1966 the import was 3.696 million tons and domestic production was only 63,000 tons which constitutes only 1.6% of the demand. Major reason for such a production stagnation or decrease in the decrease in planted acreage, particularly in the last 10 years.

Fig. 1. Variations of acreage and yield of maize in Japan.

Notwithstanding such an adverse situation in Japan's maize production a marked progress has been achieved in the technique of maize production and the national average yield per hectare has reached 2.85 tons in 1967. In the districts where the maize production is intensive such as in Hokkaido, Aomori and Nagano prefectures the average yield is over 4 tons and some farmers produce as much as 7 to 8 tons. This is largely due to the improvement of cultivation techniques and the breeding of superior varieties. Fig. 1 clearly shows how big the contribution made by the release of hybrids is, in increasing the yield per unit area.

Although the planted acreage of dry grain maize is steadily decreasing, the planted acreage for green fodder and silage maize is increasing, bringing about the importance of breeding superior varieties.

Origin of Japanese Maize

The origin of maize cultivation in Japan can be traced back to two distict periods. The first period was the introduction of the Caribbean flint type belonging to tropical flint type introduced into southwest Japan by Portuguese about 400 years ago in late 16th century. As to the exact date and place no record is available.

This Caribbean flint has spread from southwestern parts of Japan such as Shikoku and Kyushu to central part. Until recently it has been cultivated mainly in comparatively infertile fields in cool and remote mountainous districts of Shikoku, Kyushu and north Kanto as farmers' food because in those districts rice could not be cultivated. The maize cultivation has often been damaged by frequent typhoon attack. Thus, for a period of over 350 years after its introduction, several local strains have been differentiated with many characteristics suited to climate, natural features and cultivation practices of Japan. And those local strains have been maintained or improved by ear selection.

The second period was the introduction of dent and flint varieties from the United States and Europe into Hokkaido by officers of the Hokkaido Development Bureau about 100 years ago in 1870s. After then these varieties have spread southwards to Tohoku district. Among those introduced varieties, the flint has been cultivated mainly in cool and comparatively fertile fields of Hokkaido and not much differentiation to local strains has so far been observed due to its shorter history after introduction.

Since then some varieties occasionally have been introduced mainly from the United States. For instance, varieties suited for green fodder and silage, such as Mammoth White Dent, Wisconsin No. 8, Yellow Dent and Wisconsin No. 12 have been introduced in 1923. And as for dry grain maize such varieties as Long Fellow, Sapporo-hachigyo, Hakushoku-hachigyo, Kiwase, Nakate-shiro, Onoa and Sakashita improved by farmers up to 1924, have been selected as superior varieties. Those varieties have been used as the parents of superior hybrids in Hokkaido.

Improvement of Maize Variety

Until the Kochi Prefectural Agricultural Experiment Station started the collection of local strains of Shikoku Island and the yield comparison test in 1920 the improvement and maintenance of local varieties have been carried out by farmers by ear selection. After 1920 each prefectural agricultural experiment station actively worked to collect and introduce local varieties. The variety improvement by mass selection and the extension of improved varieties were also carried out. The superior varieties selected in southern half of Japan are Aso No. 1, Wada-zairaishu, Ehime-otomorokoshi No. 1 and Koshu No. 15, all of which belong to Caribbean flint type. In Hokkaido yield com-

parison test was reported long ago in 1910. And up to 1924, such varieties mentioned above as Mammoth White, Long Fellow etc. have been selected as superior varieties of dent and flint types. Among those varieties all flint types belong to the North American type.

The breeding of hybrid maize in Japan was started in 1937 by the establishment of breeding stations by the Ministry of Agriculture and Forestry at Hokkaido (Shimamatsu), Nagano (Kikyogahara) and Kumamoto (Aso) prefectures. Later the Shimamatsu Station was moved to Sapporo in 1942. The Aso Station was abolished in 1953 and at present the Sapporo and Kikyogahara Stations are playing a leading role in breeding and cultivation experiments of maize.

In recent years increase in maize production including green fodder has become extremely important. In 1962 new breeding stations were established as Miyazaki Prefecture (Miyakonojo) and Hokkaido (Tokachi), and both stations have actively engaged themselves in breeding experiments by introducing superior breeding materials from abroad. Although Japan has achieved excellent results in the breeding of self-pollinated crops such as rice and wheat, the position is different in maize breeding. Owing to lack of experts and experience in maize, being a cross-pollinated crop, there was much difficulty at the start of the breeding project for maize in this country in 1937.

At that time Dr. Y. Yamasaki, the Director of Kikyogahara Station was one of the promoters of this project. He tried to promote the project with due consideration to the relative importance of maize production in Japan and the level of scientific knowledge of farmers as in the following procedures.

1) In districts where the maize is not important, the interest and knowledge of technicians and farmers on maize are low, so the planting of easily-cultivated and high-yielding varieties selected from the local strains are encouraged avoiding the planting of hybrid maize.
2) In the districts of Shikoku, Kyushu and part of Kanto where the maize has been cultivated for a long period and also the technicians and farmers have a keen interest, the introduction of superior varieties and the improvement of local varieties by line selection are adopted as first step, followed by the extension of synthetics or hybrids.
3) In the upland belts of central mountainous parts and Tohoku region which are considered as potential maize producing districts the extension of hybrids mainly by varietal crossing is carried out.
4) In Hokkaido, where the maize is an important agricultural product and technicians and farmers have a keen interest and natural conditions are favorable for seed production, the extension of hybrids combined with advanced techniques of the United States will be encouraged.

The project which started upon the plan stated above has been continued up to the present day and is steadily accomplishing good results. Particularly, the emphasis has been laid on raising of varietal crossing and on the use of synthetic as parent. This fact is highly evaluated as the work of Dr. Yamasaki.

Since 1937 many native and foreign varieties have been collected and large scale experiments on varietal crossing and raising of inbred lines have been carried out. Consequently, many hybrids, far superior to local varieties have been bred. Most of those superior hybrids were the results of combining local flint type and American dent type.

Superior Maize Varieties

As stated above the direction of hybrid maize breeding of Japan up to now is clas-

Table 1. Recommended maize hybrid in Japan.

Name of hybrid	Year registered	Breeding method	Combination	Experiment station
Choko No. 161	1951	Varietal crossing	Zairaishu×Reid's Early Yellow	Kikyogahara
Choko No. 202	do.	do.	Wis. No. 690×Ehime-otomorokoshi	do.
Ko No. 502	1953	Double crossing	(B8×A25)×(Ind. WF9×M14) introduced from U.S.A.	Hokkaido
Ko No. 503	do.	do.	(B8×Ia 153)×(Ind. WF9×M14) introducted from U.S.A.	do.
Ko No. 1	1954	Varietal crossing	White Dent Corn×Zairaishu	Kikyogahara
Ko No. 2	do.	Top crossing	Ehime-otomorokoshi×Wis. 531-472	do.
Ko No. 3	1957	do.	Okuzuruwase×Wis. 531-466	do.
Ko No. 4	1958	Three way crossing	(N21×N19)[1]×T6[2]	Hokkaido
Ko No. 5	1959	Top crossing	Wis. 690-290ms ×Ehime-otomorokoshi	Kikyogahara
Ko No. 6	1962	Double crossing	(D403×D405)[3]×(T102×T107)[4]	Hokkaido
Ko No. 7	do.	Top crossing	Okuzuruwase 640ms×Wis. 531 (455×466)[5]	Kikyogahara
Ko No. 8	1968	Varietal crossing	Yellow Dent Corn×Wis. 531 (455×466)[5]	do.

Note: 1) Inbred lines selected from Sakashita, a local flint variety in Hokkaido.
2) Inbred line selected from Mais Peta, an Italian flint variety.
3) Inbred lines obtained by recurrent selection from U.S.A. dent hybrid.
4) Inbred lines selected from Koshu, a local flint variety at the foot of Mt. Fuji.
5) Advanced generation from single cross.

sified into two ways; namely, (1) the method of emphasizing the varietal crossing with the Kikyogahara Station as center and (2) the breeding of hybrid by double crossing combining the superior inbreds with the Hokkaido station as center. Table 1 gives the list of main superior varieties so far encouraged in Japan.

Among those superior varieties Ko No. 5 and Ko No. 7 are the hybrids obtained by the use of cytoplasmic male sterility. This male sterile line was originated from the Texas type introduced by Dr. H. Terao from the United States in 1951. It has been ascertained that among the Caribbean local flint strains distributed in Japan there are many strains with restorer against this male sterile type. Therefore, it is safe to assume that breeding by utilizing male sterility will make a further progress.

Prospect for Maize Varieties

Despite successful results in breeding superior hybrids such as Ko No. 7 with the production ability of over 10 tons per hectare at experiment station and 7 to 8 tons by farmers, no increase is reported in the planted acreage of dry grain maize showing a decreasing trend in the use of hybrid with the peak of 45.3% of extention rate (national average) in 1965.

On the other hand, as the planted acreage for green fodder and silage is increasing each year the need for breeding of lodging resistant and high yielding hybrids, is strongly felt. Particularly, in recent years the damage by maize streaked dwarf virus, corn stunt is increasing in the south of the Kanto regions. Therefore, the breeding of varieties resistant to this disease is an urgent requirement.

The varietal crossing using the synthetic has proved equal to hybrid by double crossing in respect of productivity, etc.. Considering seed price and easiness in seed

production, future hybrid breeding in Japan will be directed with greater emphasis on varietal crossing with synthetic.

Discussion

F. Iwata, Japan: The dwarf virus, corn stunt, is increasing and very severe in Japan. How about other countries like U.S.A. and Southeast Asian countries?

Answer: I have not heard that there was the similar type of corn stunt disease in U.S.A. and Southeast Asian countries.

V. R. Carangal, Philippines: Is there any work on improvement of some varieties or synthetics by any scheme of selection?

Answer: Top cross and recurrent selection were conducted in Kikyogahara and Hokkaido Experiment Station, respectively.

P. Phit, Thailand: In the Figure 1.—What is the reason of the decrease in the acreage from 1960 to 1965? How do you explain the up and down of the curve relating to yield per ha from 1945 to 1965?

Answer: 1. The main reason is that farmer's net income in corn production is very low in comparison with the other crop farming as rice, vegetables and so on. 2. It is mainly due to the climatic condition, e.g., lodging by heavy rainfall in Honshu, and cold damage by cool temperature in Hokkaido.