Breeding of Synthetic Variety Cross of Maize in Japan

TORU MACHIDA* and YASUTAKA TAKIZAWA**

Chief,* and Researcher,** Kikyogahara Branch Station
Nagano Prefecture Agricultural Experiment Station

Since 1938, breeding of hybrid maize has been conducted at Kikyogahara Station. The investigation on yield potentiality of many variety crosses resulted in the release of superior variety croses like Choko No. 161 and No. 202, followed by the top cross like Ko No. 3.

These crosses are the hybrids between Japanese local flint type and American dent type, and they showed better performance than the hybrids introduced from the United States after World War II.

Along with these breeding, we selected inbred lines from the parent varieties used for the variety cross and found the several double cross combinations which excelled the variety crosses in performance. The problems, however, were the seed production of these double cross for practical cultivation. The difficulties we met can be summarized as follows:

1) Poor vigor of inbred lines for making double cross, i.e. low number of seeds on plant of inbred lines and their sensitivity to unfavorable conditions and the resultant difficulty in preserving foundation stock seeds.

2) Two years to make double cross seeds are too long for us to forecast and protect plants from damage by disasters such as typhoon, drought, etc.

3) In the United States the hybrid seed production is carried out by seed companies which have many excellent staffs, but in Japan it is mainly placed in the care of farmers who are generally not trained enough to handle it, especially the seed production of double cross. Recent changes in social and economical conditions of Japan have resulted in the shortage of labour in agriculture so that even the seed production of variety cross have become difficult, which has caused the high cost of hybrid maize seeds.

To overcome these difficulties mentioned above, an attempt had been made to breed synthetic varieties which would compare well with the variety cross and double cross in performance. Since 1957, we started developing synthetic varieties with the inbred lines which had been selected for double cross and which proved to have high combining ability. These inbred lines seemed to have lost unfavorable genes and accumulated favorable genes in the procedure of inbreeding and selection.

Out of 150 synthetic varieties developed, however, none showed higher productive ability than the best variety cross, Ko No. 3. The reason for this was that in this particular breeding project, we started with the inbred lines which differed comparatively in their characteristics and therefore in advanced generation strict selection became necessary in developing them into a synthetic variety. Thus the resulting synthetic varieties failed to show remarkable vigor.

It was assumed from the results that if we made a hybrid between synthetic varieties which were diverse to one another in origin (for example one synthetic variety derived from Japanese local flint inbred lines and the other from American dent inbred lines), the hybrid would have higher yield than the variety cross and double cross. From this assumption, we have developed a number of hybrids between only synthetic varieties, and also hybrids between synthetic varieties and original varieties since 1961, resulting in many distinguishable combinations. Table 1 shows the performance of the variety cross, double cross, and synthetic

Table 1. Comparison of performance of variety cross, double cross and synthetic variety cross

Type of cross	Year tested	Number of entries	Mean of entries						Number of entries over check	Percentage of entries over check	Mean of entries over check variety of hybrid					
			Silking date	Barren plant (%)	Grain yield (kg/are)	Yield ratio	1,000 kernel wt. (g)	Kernel number per plant			Silking date	Barren plant (%)	Grain yield (kg/are)	Yield ratio	1,000 kernel wt. (g)	Kernel number per plant
	1952	23	Aug. 13	1.30	56.6	126	345	445	19	82.6	Aug. 15	1.43	59.8	134	357	456
Variety	1953	33	Aug. 13	2.30	45.7	120	285	435	26	78.8	Aug. 14	2.03	49.6	131	289	466
cross	1954	23	Aug. 16	0.73	50.0	116	279	487	21	91.3	Aug. 16	0.67	51.0	118	281	493
	1955	35	Aug. 6	3.97	54.8	114	347	432	26	74.3	Aug. 6	2.32	59.2	124	351	461
	Av.	(114)*	Aug. 11	2.30	51.6	119	315	446	(92)	81.8	Aug. 12	1.68	54.8	126	319	469
Nagano No. 1 (check)	1952 -1955	—	Aug. 11	3.85	43.5	100	303	391	—	—	Aug. 11	3.85	43.5	100	303	391
	1956	79	Aug. 9	1.22	44.3	99	361	333	42	53.2	Aug. 8	0.57	49.3	110	366	366
Double	1957	57	Aug. 13	0.63	61.0	95	356	465	22	38.6	Aug. 13	0.64	68.5	106	368	507
cross	1959	61	Aug. 12	2.36	53.7	122	380	384	58	95.1	Auh. 12	2.07	54.2	123	380	388
	1960	46	Aug. 17	1.57	56.6	112	369	417	40	87.0	Aug. 17	0.95	58.8	117	372	430
	Av.	(243)	Aug. 12	1.43	52.9	106	366	393	(162)	68.5	Aug. 13	1.21	56.0	116	373	409
Choko No. 202 (check)	1956 -1960	—	Aug. 9	6.00	50.8	100	343	402	—	—	Aug. 9	6.00	50.8	100	343	402
Synthetic	1964	66	July 31	1.36	69.1	96	351	533	25	37.9	Aug. 2	0.66	77.8	108	360	585
variety	1965	37	Aug. 3	2.23	61.4	91	317	524	10	27.0	Aug. 5	0.75	70.6	104	316	607
cross	1966	27	Aug. 6	0.75	69.6	97	336	563	10	37.0	Aug. 7	1.00	73.6	102	334	597
	1967	26	July 29	1.06	79.5	95	361	598	6	23.1	July 31	1.88	87.3	105	372	634
	Av.	(156)	Aug. 2	1.41	69.1	95	342	547	(51)	31.3	Aug. 3	0.89	76.7	106	348	598
Ko. No. 3 (check)	1964 -1967	—	Aug. 2	0	73.7	100	314	635	—	—	Aug. 2	0	73.7	100	314	635

Note: * Figures in parenthesis indicates total number of entries.

variety cross (cross between synthetic varieties) comparing with a check variety or hybrid.

Care was taken to select the appropriate data to explain the results on these three types of cross. As was mentioned before, hybrid maize breeding in our station had a long history, i.e. variety cross started in 1938, double cross in 1945, and synthetic variety cross in 1961. The objectives of breeding and also the main type of cross investigated have been different from time to time. Hence the data were taken from each of the four year's experiments in each type of cross.

The breeding materials used are (a) U.S. dent varietes: Wood's Improved Golden, Reid's Eary Yellow, Jarirs Golden Prolific, Reid's Yellow Dent, Wisconsin No. 690, Wisconsin No. 531 etc., (b) Japanese local flint varieties: Ehime-Daitomorokoshi No. 1, Daitomorokoshi, Okuzuruwase etc., and (c) the inbred lines from these varieties.

General description of the results

1) Variety cross

The performance of the variety cross was expressed in terms of the ratio to that of a check variety (Nagano No. 1) in Table 1. The mean ratio was 119%, ranging from 80% to 160%. Out of all the entries 80% of them were higher than the check variety in grain yield. The average ratio of them was 126%. In general it was observed that in variety cross the barren plant percentage was slightly bigger than that of double cross and synthetic variety cross.

2) Double cross

The mean ratio of this type of cross to a check hybrid (Choko No. 202) was 106%, ranging from 60% to 150%. Sixty-eight percent of the entries showed better performance than the check hybrid. The average ratio of them was 116% Percentage of barren plant was quite low, suggesting the effect of selection through inbreeding on this character.

3) Synthetic variety cross

In the case of synthetic varieties, the mean ratio was 78% to a check hybrid (Ko. No. 3). None of them were superior to the check hybrid in performance. In the case of variety synthetic variety cross (cross between a variety and a synthetic variety), however, the mean ratio increased to 95% ranging from 65% to 120% Out of these crosses, 30% showed higher yield than the check hybrid. The average ratio of them was 106%.

We cannot compare directly the performance of this type of cross with the other types because the data for Table 1 were taken from the different experiments in different year. However it would be worthwhile to mention that the average yield of this type of cross reached 69.1 kg/are, whereas those of the double cross and variety cross were 51.6 and 52.9 kg/are, respectively. Therefore the yield potentiality of this type of cross seemed to be considerablly high.

The double cross showed lower percentage of barren plants than variety cross and heavier in kernel weight than the other types of cross, but the number of kernels per plant was lowest. So the average yield of the double cross was slightly higher than the variety cross. In the case of the synthetic variety cross, barren plant percentage was as same as that of the double cross and the number of kernels per plant was quite larger than that of the double cross. Although the kernel weight of synthetic variety cross was in between those of the double cross and variety crosss, the kernel number per plant was considerablly higher than that of the double cross. So the average yield of synthetic variety cross was higher than that of the double cross.

4) Correlations between grain yield and its components

Grain yield is the product of its three components such as number of plants per plot, number of kernels per plant, and average kernel weight. Various factors affect on grain yield through these components. Table 2 shows the correlation between yield and barren plant percentage, of 1,000 kernels, or number of kernels per plant. In variety cross a negative correlation ($r = -0.43$) was obtained indicating that barren plant caused the decrease in grain yield very much in this type of cross. In the other two types of cross, correlation coefficients were low.

Positive correlation coefficients between yield and weight of 1,000 kernels were obtained in three types of cross. The correlation can be shown in the following order:

Table 2. Correlation coefficients between grain yield and its components

(1)	Correlation between yield and barren plant percentage	
	variety cross	r = −0.43213
	double cross	r = −0.09675
	synthetic variety cross	r = −0.24501
(2)	Correlation between yield and 1,000 kernel weight	
	variety cross	r = 0.28826
	double cross	r = 0.31430
	synthetic variety cross	r = 0.42752
(3)	Correlation between yield and kernel number per plant	
	variety cross	r = 0.69545
	double cross	r = 0.71117
	synthetic variety cross	r = 0.72827

Synthetic variety cross>double cross>variety cross.

Significant positive correlation between yield and kernel number per plant were obtained in three types of cross and also the correlation can be shown as follows:

Synthetic variety cross>double cross>variety cross.

Judging from the above results, kernel number per plant is the most important component contributing to grain yield. Although at present, we have no idea on the complete genetic explanation of effectiveness of synthetic variety cross, breeding of a synthetic variety cross is the most promising among the three types of cross and will play an important part in corn breeding in our country.