Performances of Hybrid Populations between Andigena and Tuberosum in Potato*

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Andigena (*Solanum tuberosum* ssp. *andigena*) has attracted the attentions of potato breeders as a new breeding material to improve yield capacity of potato crop, and excellent populations with high yield have been already derived from the cross between Andigena and Tuberosum (*S. tuberosum* ssp. *tuberosum*)^{1,2,3,4,7,8}. In the previous paper⁵), we reported that the two Andigena strains, W553-4 and C10193-1, had some desirable characteristics such as large number of tubers, a long leaf area duration and a small light extinction coefficient, although they showed later tuber formation and higher shoot-tuber ratio compared with the cultivars.

In 1980, the two Andigena strains were crossed with Norin No. 1, and two hybrid populations were produced. This experiment is aimed to assess yield capacities in the populations without artificial selection at the first clonal generation.

Materials and Methods

In 1980 at Hokkaido National Agricultural Experiment Station, the two Andigena (*S. tuberosum* ssp. *andigena*) strains, W553-4 and C10193-1 as a female parent, were crossed with Norin No. 1 (*S. tuberosum* ssp. *tuberosum*) which is one of the leading varieties in Japan. Seedlings of each cross were raised, and 511 and 229 clones were derived from the crosses between W553-4 and Norin No. 1 and between C10193-1 and Norin No. 1 in the

autumn in 1981. The populations of W553-4 × Norin No. 1 and C10193-1 × Norin No. 1 were designated as register number 80135 and 80136, respectively.

On May 13 in 1982, the clones of each population were planted without artificial selection to evaluate single hill progeny traits. A row consisted of 40 hills at 36 cm within-row spacing, and between-row spacing was 75 cm. A combination of N : P₂O₅ : K₂O as a fertilizer at the ratio of 100, 200 and 140 kg/ha respectively, was banded just before planting.

Tubers of each clone were harvested on September 30, and tuber number, mean single tuber weight, fresh tuber weight and starch value were measured on single hill basis. Their maturities were graded into the five groups (I-V) on the basis of days from planting to leaf yellowing; I: —119 days (—Sept. 8), II: 120—126 days (Sept. 9—Sept. 15), III: 127—133 days (Sept. 16—Sept. 22), IV: 134—140 days (Sept. 23—Sept. 29) and V: 141 days— (Sept. 30—), respectively (Table 2).

The three parents were also examined in the same conditions mentioned above. The maturity (the leaf yellowing day) of Norin No. 1 was on September 20 (group III), but the two Andigena strains did not mature by September 30 (group V).

Results

Yields and yield components for the parents and the hybrid populations were given in Table 1. The two Andigena strains, the female parents, are characterized by late

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Table 1. Yields and yield components for the parents and the two hybrid populations.

Parent and population	Population size	Tuber number (/pl.)	Mean single tuber weight (g)	Starch value (%)	Tuber yield (g/pl.)	Starch yield (g/pl.)
Parent						
W553-4	—	20.3	57.2	15.2	1161.0	176.5
C10193-1	—	33.2	19.4	13.7	643.0	88.1
Norin No.1	—	8.4	113.0	17.7	1115.0	197.4
Population						
80135	511	18.0±8.7	59.0±22.8	16.5±2.4	961.9±366.3	146.2±54.9
(W553-4×Norin No.1)		(14.4)	(85.1)	(16.5)	(1138.0)	(187.0)
80136	229	22.9±13.0	40.4±19.5	15.9±2.9	823.0±417.3	119.8±61.4
(C10193-1×Norin No.1)		(20.8)	(66.2)	(15.7)	(879.0)	(142.8)

Note. The values in parentheses are the mid-parent.

Table 2. Frequent distribution of maturity of the clones in the two hybrid populations.

Population	Maturity group (days)					Total
	I (~119)	II (120~126)	III (127~133)	IV (134~140)	V (141~)	
80135	15 (2.9)*	7 (1.4)	102 (20.0)	42 (8.2)	345 (67.5)	511 (100)
80136	7 (3.1)	3 (1.3)	18 (7.9)	16 (7.0)	185 (80.8)	229 (100)

* : Percentage.

maturity and large number of small tubers as reported in the previous paper⁵⁾; W553-4 and C10193-1 had 2.4 and 4 times as many tubers as Norin No. 1 (the male parent), but their mean single tuber weights were adversely only 51% and 17%, respectively. Their starch values were also lower. The yield of W553-4 was slightly low in starch yield but not different in tuber yield when compared with the yields of Norin No. 1. C10193-1, however, produced only about one half of those of Norin No. 1.

The population means of tuber number were superior to their mid-parents, in particular, the mean of 80135 was almost similar to that of the Andigena parent. On the other hand, the means of mean single tuber weight were inferior to the mid-parents in the both populations, although it was 2 times in 80136 but was almost the same in 80135 in comparison with those of the Andigena parents.

Their starch values were intermediate between their parents. The means of tuber and starch yields in the both populations were lower than those of the mid-parents. As shown in Fig. 1, however, the clones out-yielded the mid-parent existed considerably in the both populations. The number of the out-yielded clones were 153(29.9%) and 99 (43.2%) in 80135 and 80136, respectively.

The both hybrid populations consisted of many late maturing clones; 76% and 88% of each of 80135 and 80136 belonged to group IV and V, and early maturing ones (group I and II) were only below 5% in the both populations (Table 2).

Table 3 shows correlation coefficients between yield and yield components. The coefficients of each combination and tendencies of distributions in character associations were almost same in the both populations. Tuber yield was correlated positively

with tuber number and mean single tuber weight, but negatively with starch value. The r values of tuber yield with mean single tuber weight and starch value, however, were considerably low. Moreover, there was a high negative correlation between tuber number and mean single tuber weight. The tendencies of distributions in the character associations for 80135 were shown in Fig. 2. Most of the progenies tended to distribute near to their female parent rather than to the pollen parent. The population segregated widely in number and size of tuber, but the segregation of starch value was relatively narrow.

Discussion

CUBILLOS and PLAISTED¹⁾ and TARN and TAI¹⁰⁾ suggested that heterosis between Andigena and Tuberosum resulted, in large

Table 3. Correlation coefficients between yield and yield components in the two hybrid populations.

Population	Tuber yield -Tuber number	Tuber yield -Mean single tuber weight	Tuber yield -Starch value	Mean single tuber weight -Tuber number	Mean single tuber weight -Starch value
80135	0.626***	0.223***	-0.282***	-0.511***	0.040
80136	0.627***	0.292***	-0.295***	-0.403***	0.074

*** : 0.1% level of significance.

Fig. 2. Relationships between yield and yield components in the hybrid population 80135.
Note. ● : female parent, ▲ : male parent.

Fig. 1. Frequent distribution of tuber yield in the two hybrid populations.

Note. * : The mid-parent.

part, from the multiplicative interactions of the two yield components; large tuber size from Tuberosum and large tuber number from Andigena. Table 4 shows means of yields and yield components for the clones out-yielded their mid-parent. Means of tuber number were considerably large, indicating almost the same values as those of the Andigena parents. On the other hand, their values in mean single tuber weight still remained under those of the mid-parents, though they were superior to those of the Andigena strains. Starch values were not so different from the mid-parents. In this experiment, therefore, the yields of the clones out-yielded the mid-parent might depend mainly on the increase in tuber number. As reported by TAGUCHI⁹⁾, one of the difficulties to improve yield capacity of potato crop is, generally, in existing a high negative correlation between number and size of tubers as shown in Fig. 2-(d). However, a few among the clones which produced large number of tubers as many as the Andigena parents had also large tuber size over the mid-parents. This fact may indicate that there is a possibility to improve this relationship by crossing Tuberosum with Andigena that produces large number of tubers.

MENDOZA and HAYNES⁶⁾ observed in the cross between short-day (SD) Andigena and day-neutral (DN) Tuberosum that F₁ generations showed complete dominance of SD reaction (late tuber initiation) over DN reaction (early tuber initiation). In addition, TARN and TAI¹⁰⁾ mentioned that at medium latitudes, hybrids between SD Andigena and DN Tuberosum would initiate tuberization too late, and mature too late to exhibit heterosis over the Tuberosum parent. In fact,

the Andigena parents used in this experiment had late tuber initiation⁵⁾, and most of their derivatives had late maturity. However, about 4% of the both populations had earlier maturity than Tuberosum, Norin No. 1. Some of them might start to form tubers earlier than the Andigena parents.

Although the canopy structures of the F₁ progenies were not examined in this generation, a lot of them formed large sized canopies, and the plant type of some clones beared a resemblance to that of W553-4 that had a small light extinction coefficient⁵⁾. The detailed analysis about canopy structure and dry matter production will be done for the selected progenies with high yield.

Summary

The two Andigena strains, W553-4 and C10193-1, were crossed with Norin No. 1 to produce hybrid populations such as W553-4 × Norin No. 1(80135) and C10193-1 × Norin No. 1(80136). In this experiment, their yield capacities were examined without artificial selection at the first clonal generation.

1. The population means of tuber number were superior, but those of mean single tuber weight were inferior to the mid-parents. Their starch values were intermediate between their parents. The means of tuber yield and starch yield were lower than those of the mid-parents (Table 1).

2. The two populations consisted of many late maturing clones, but about 4% of the both populations had earlier maturity than Norin No. 1 (Table 2). The number of clones out-yielded their mid-parent were 159 (29.9%) and 99(43.2%) for 80135 and 80136, respectively (Table 4 and Fig. 1).

Table 4. Means of yields and yield components for the clones out-yielded the mid-parent.

Population	Number of clones	Tuber number (/pl.)	Mean single tuber weight (g)	Starch value (%)	Tuber yield (g/pl.)	Starch yield (g/pl.)
80135	153	24.3	64.3	15.9	1391.0	206.2
80136	99	31.5	45.4	15.3	1215.4	174.8

3. In the both populations, there were high positive correlations between tuber yield and tuber number, and negative ones between mean single tuber weight and tuber number (Table 3).

4. In the character associations between yield and yield components, most of the progenies in the both ones tended to distribute near to their female parent (Andigena) rather than to the male parent (Tuberosum) (Fig. 2).

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* In Japanese with English summary.

〔和 文 摘 要〕

バレイシヨ Andigena×Tuberosum 雑種集団の収量特性

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Andigena (*S. tuberosum* ssp. *andigena*) は、近年バレイシヨ育種材料として有望視されている。そこで著者らは、Andigena 2 系統 (W553-4, C10193-1) を栽培品種、農林 1 号と交配し、2 つの雑種集団 (80135: W553-4×農林 1 号, 80136: C10193-1×農林 1 号) を作成した。本報では、実生 2 年目の F₁ 集団を人為的選抜なしに植え付け、その収量性を明らかにするため収量および収量構成要素を調査した。

1. 各集団の平均値は両親平均に比較し、塊茎数で大きかったが、平均一個塊茎重では小さく、デンプン価ではほぼ等しかった。また、各集団の塊茎収量ならびにデンプン収量は小さい値を示した (第 1 表)。

2. 両集団とも晩生および極晩生の個体が多かったが、両集団の 4% は農林 1 号に比べ熟期 (茎葉黄変期) が早かった (第 2 表)。塊茎収量が両親平均を上回った個体数は、80135 で 159 (29.9%), 80136 で 99 (43.2%) であった (第 4 表および第 1 図)。

3. 両集団とも塊茎収量と塊茎数の間に正の、塊茎数と平均一個塊茎重の間には負の高い相関があった (第 3 表)。

4. 収量および収量構成要素間の相関分布図で、Tuberosum 親 (農林 1 号) に比べ Andigena 親に近い値をとる雑種個体が両集団とも多い傾向を示した (第 2 図)。