Increasing Genetic Variability in Common Wheat by Utilizing Alien Cytoplasms—Characteristics of Nearly Fixed Alloplasmic Lines Selected in the Cross, Alloplasmic Norin 26×Norin 61¹⁾

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Effects of the cytoplasms of *Aegilops squarrosa*, *Ae. kotschy*, *Ae. speltoides* and *Ae. longissima* on the effectiveness of selection and association of agronomic characters were investigated using a total of 200 F₄ and F₅ lines which were derived through selection in early generations of the cross combinations between allo- and euplasmic Norin 26 and euplasmic Norin 61. The selection was carried out on heading date, ear length, ear weight, ear number and yield per plant. The selection was effective for heading date and ear length and weight in all of the cytoplasms tested. No remarkable difference was recognized among the cytoplasms regarding the frequency of deviant lines for each selection character. It was observed, however, coincidentally with the previously reported results of F₂ and F₃ populations, that the cytoplasm of *Ae. kotschy* produced the widest range of combination of characters. Some promising early lines which were rather positively modified for the size of ear, were obtained in the cross combination carrying this cytoplasm. These lines may be used effectively as a genetic stock for wheat breeding in Japan. Effects of the other *Aegilops* cytoplasms were neither prominent nor consistent with the results observed in the F₂ and F₃.

KEY WORDS : Alloplasmic cross, Common wheat, *Aegilops* cytoplasm, Selection, Cytoplasmic effects

Introduction

F₂ and F₃ generations of the cross combinations between five alloplasmic lines of Norin 26 and euplasmic Norin 61 have been investigated to evaluate the genetic effect and utility of *Aegilops* cytoplasms for wheat breeding, leading to the conclusion that cytoplasms of some *Aegilops* species such as *Ae. kotschy* and *Ae. speltoides* may be applied for expanding the genetic variability of agronomic characters of common wheat (TSUNEWAKI *et al.*, 1985, YONEZAWA *et al.*, 1986). Plants and lines which were randomly derived in each cross combination were used in these investigations.

Selection experiments have been conducted in parallel with the above investigations, where alloplasmic plants and lines showing promising phenotypic performance for heading date and spike size and number were selected in the F₂ and subsequent generations. Investigation on the selected lines will provide another information about the possibility of incorporating *Aegilops* cytoplasms in the breeding projects of common wheat. Very few reports until now have been published about the characteristics of alloplasmic lines obtained through selection. Effects of four *Aegilops* cytoplasms on the effectiveness of

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selection and character association are presented here in order to promote the application of such a rich but not yet used genetic variation among the cytoplasms of *Triticum* and *Aegilops* (TSUNEWAKI 1980).

Materials and Method

Three groups of lines which were obtained through different procedures of selection, i.e., I, II, and III groups of lines as shown in Table 1, were tested. These lines were selected in the cross combinations between Japanese cultivar Norin 61 and four alloplasmic lines of Norin 26 carrying the cytoplasms of *Aegilops squarrosa*, *Ae. kotschy*, *Ae. speltoides*, and *Ae. longissima*. Reciprocal crosses of euplasmic Norin 26 and Norin 61 were included for the check. The four alloplasmic lines of Norin 26 were raised by repeated backcrosses of Norin 26 to the alloplasmic lines of Chinese Spring; nine backcrosses for *squarrosa* and *kotschy* cytoplasms, ten for *speltoides* cytoplasm, and five for *longissima* cytoplasm had been carried out before use (TSUNEWAKI *et al.*, 1985). These cytoplasms caused no substantial reduction in seed fertility (TSUNEWAKI *et al.*, 1985).

Selection for the lines in group I was operated in the F_3 generation. In deriving these lines, two or three F_3 lines showing the best mean performance (average over two replicate plots) for either character of earliness, ear weight and ear number were selected from 30 to 50 randomly derived F_3 lines in each cross combination, and in the second step, one best plant was chosen from each of the two replicate plots of the selected F_3 lines so that two F_4 lines were derived from each selected F_3 lines. The lines in group II were obtained through selection in two successive generations, i.e., single plant selection in the F_2 and within line selection in the F_3 ; three best F_2 plants (one best from each of the three replicate plots) for earliness, ear length, or grain yield per plant were selected in the F_2 generation of each cross combination, one best F_3 plant being selected for the same character as in the F_2 from each of the two replicate plots of the F_3 lines derived. The lines in group III were obtained by the selection in three successive generations, i.e., F_2 , F_3 , and F_4 generations. Four characters, heading date, ear length and weight, and grain yield per plant were the criterion characters of this selection. The selection procedure in the F_2 and F_3 generations for group III was the same as for group II. The selection in the F_4 generation for group III was carried out in such a way that one best plant regarding the same criterion character as in the foregoing generations was taken up from each F_4 line. Only one replicate plot was allocated for each of the F_4 lines.

These lines of the three different groups together with the allo- and euplasmic parental lines were sown and transplanted following the conventional cultivating procedures of Plant Breeding Laboratory of Kyoto University. Some lines in groups II and III were discarded because of insufficient number of seedlings. A split-plot design with two replicate blocks was applied for field design, where cross combinations (paired reciprocals) were firstly allocated to the main plots, and then, the selected lines and two parental lines of the respective cross combinations were randomly arranged to the sub-plots within the main plot. Four to six sub-plots were grown for the two parental lines in each main plot.

Sub-plots in the main plot were a single row plot consisting of 15 seedlings grown 10

Table 1. Material lines tested

Line group & no.	Cross combination ¹⁾	Cytoplasm possessed	Generation after crossing	Selection		
				Generation	Character ²⁾	Procedure ³⁾
Group I :						
1~18	(<i>squarrosa</i>)-N 26×N 61	<i>Ae. squarrosa</i>	F ₄	F ₃	HD, EN, EW	Best 2-3 F ₃ lines and two best plants from each F ₃ line
19~36	Reciprocal	<i>T. aestivum</i>				
37~54	(<i>kotschyi</i>)-N 26×N 61	<i>Ae. kotschyi</i>				
55~72	Reciprocal	<i>T. aestivum</i>				
73~84	(<i>speltoides</i>)-N 26×N 61	<i>Ae. speltoides</i>				
85~96	(<i>longissima</i>)-N 26×N 61	<i>Ae. longissima</i>				
97~108	N 26×N 61	<i>T. aestivum</i>				
Group II :						
1~18	(<i>speltoides</i>)-N 26×N 61	<i>Ae. speltoides</i>	F ₄	F ₂ & F ₃	HD, EL, Y/P	Three best F ₂ plants. Two best plants from each F ₃ line
19~34	(<i>longissima</i>)-N 26×N 61	<i>Ae. longissima</i>				
35~48	N 26×N 61	<i>T. aestivum</i>				
Group III :						
1~15	(<i>squarrosa</i>)-N 26×N 62	<i>Ae. squarrosa</i>	F ₅	F ₂ , F ₃ & F ₄	HD, EL EW, Y/P	Three best F ₂ plants. Two best plants from each F ₃ line. One best plant from each F ₄ line
16~30	(<i>kotschyi</i>)-N 26×N 61	<i>Ae. kotschyi</i>				
31~45	N 26×N 61	<i>T. aestivum</i>				

¹⁾ N 26=euplasmic Norin 26, N 61=euplasmic Norin 61, (*squarrosa*)-N 26=Norin 26 carrying cytoplasm of *Ae. squarrosa*, and so on.

²⁾ HD=heading date, EL=ear length, EW=ear weight, EN=ear number, Y/P=grain yield per plant

³⁾ See text for details.

cm apart from each other. The row plots were 30 cm distant from each other. Discarding plants at the verges, 13 plants per row plot were measured for 10 characters, i.e., heading date in April (abbreviated by HD), flag leaf length (FL), length of the second leaf (L2), length, weight and number of ears (EL, EW and EN, respectively), culm length (CL), and length of the first, second and third internodes (1I, 2I and 3I, respectively). Two ratios, FL/L2 and 1I/CL, were calculated as measurements related to plant type.

Effectiveness of selection was examined based on the occurrence of promising lines and their superiority over the parental lines. Association of characters in the selected lines was investigated by the principal component analysis.

Results

1. Effectiveness of Selection

Frequencies of promising lines for the four selection characters are presented in Table 2. Promising lines for each character are the ones which showed mean values superior to the best plot mean value (two replicate blocks pooled) of the parents. Lines with earlier heading date and larger measurements for the other selection characters were regarded as promising. Two classes of the superiority as described in the explanatory legend of Table 2, i.e., 'moderate' and 'high', were defined according to the degree of superiority over the parents. Lines in both of the two classes differed statistically significantly from the average of parental plot means for each selection character. Two kinds of frequencies, i.e., one which was counted on the lines selected for the character designated in the head row of the Table, and the other which was counted on the lines selected for other characters, are presented in Table 2. The data for yield per plant of the lines in groups II and III were omitted because they showed no noteworthy trend.

It is seen from Table 2 that selection was quite effective for heading date. In any cross combination that released early lines (excluding the check combination N26×N61 in group II), the percentage of early lines is much higher in the lines selected for earliness than in the lines selected for other characters. The effect of selection was observed also for ear length and weight, though not so much pronounced as in the case of heading date. In these characters, effect of selection was clearly recognized in the highly superior lines, but was not observed in the moderately superior lines. Selection for ear number caused no appreciable result.

Differential effect of the cytoplasm on the effectiveness of selection could not be confirmed from Table 2. Neither statistically significant difference nor any consistent trend over the three groups, I, II and III, was observed among the cytoplasm examined. Some difference might be perceived for heading date in the lines of group I, which, however, cannot be recognized in the lines of groups II and III. It only might be suggested that *longissima* cytoplasm has a lower potential to release early transgressants than the other cytoplasm.

2. Association of Characters

Principal components were extracted from the correlation matrix of the 12 variables (10 characters plus the two derived ratios) to evaluate the effects of *Aegilops* cytoplasm

Table 2. Frequency of prominent lines for the four selection characters

Cross combination	Heading date		Ear length		Ear weight		Ear number	
	Moderate ¹⁾	High	Moderate	High	Moderate	High	Moderate	High
Group I:								
(<i>sq</i> r)-N 26×N 61	3(50%), 3(25)	2(33), 0(0)			1(17), 1(8)	1(17), 5(42)	0(0), 0(0)	0(0), 0(0)
Reciprocal	2(33), 2(17)	2(33), 0(0)			2(33), 5(42)	3(50), 2(17)	0(0), 0(0)	0(0), 0(0)
(<i>kt</i> s)-N 26×N 61	2(33), 0(0)	3(50), 1(8)			1(22), 3(25)	5(83), 6(50)	0(0), 0(0)	1(16), 0(0)
Reciprocal	2(33), 0(0)	1(17), 1(8)			1(17), 1(8)	5(83), 9(75)	2(33), 1(8)	1(17), 0(0)
(<i>sp</i> l)-N 26×N 61	0(0), 0(0)	0(0), 0(0)			0(0), 2(25)	4(100), 1(13)	0(0), 2(25)	1(25), 2(25)
(<i>ng</i>)-N 26×N 61	0(0), 0(0)	0(0), 0(0)			1(25), 3(38)	3(75), 2(25)	0(0), 1(13)	0(0), 0(0)
N 26×N 61	0(0), 0(0)	0(0), 0(0)			1(25), 2(25)	2(50), 4(50)	0(0), 0(0)	0(0), 0(0)
Group II:								
(<i>sp</i> l)-N 26×N 61	2(33), 2(17)	4(67), 0(0)	0(0), 4(33)	6(100), 5(42)				
(<i>ng</i>)-N 26×N 61	0(0), 0(0)	2(50), 0(0)	0(0), 4(44)	6(100), 3(33)				
N 26×N 26	1(25), 3(30)	3(75), 1(40)	1(17), 1(13)	5(83), 5(63)				
Group III:								
(<i>sq</i> r)-N 26×N 61	3(60), 1(8)	1(29), 0(0)	0(0), 1(11)	4(100), 5(56)	1(25), 3(33)	3(75), 4(44)		
(<i>kt</i> s)-N 26×N 61	4(57), 0(0)	1(14), 0(0)	0(0), 2(17)	2(100), 1(8)	1(33), 0(0)	2(67), 4(44)		
N 26×N 61	2(40), 1(14)	1(20), 0(0)	0(0), 4(44)	3(100), 2(22)	0(0), 4(57)	2(40), 1(14)		
Mean value of								
N 26	30.0(in April)		8.1(cm)		2.1(g)		8.3	
N 61	29.6		7.9		2.3		9.4	

¹⁾ Degree of advance over the best plot mean of the parents: Moderate=within one unit of the standard deviation of plot means of the parents, High=more than one unit of the standard deviation.

²⁾ The former figures (number and %) were counted on the lines selected for the character designated in the head row of the Table, and the latter figures, on the lines selected for other characters.

Table 3. Eigenvectors of the first and second principal components calculated on the 12 characters of the selected lines

Character	First component			Second component		
	<i>sqr.</i>	<i>kts.</i>	Pooled	<i>sqr.</i>	<i>kts.</i>	Pooled
HD	0.262	0.319	0.294	-0.240	0.048	-0.133
EL	0.055	-0.095	-0.026	0.446	0.188	0.299
L 2	0.352	0.344	0.342	0.071	-0.040	-0.018
EL	0.311	0.271	0.207	-0.052	-0.296	-0.268
EW	0.290	0.320	0.278	0.043	-0.263	-0.184
EN	0.134	0.007	0.089	0.304	-0.308	-0.065
CL	0.355	0.304	0.356	0.201	0.379	0.347
1 I	0.131	0.063	0.116	0.458	0.520	0.518
2 I	0.365	0.319	0.374	0.215	0.362	0.334
3 I	0.404	0.378	0.430	0.011	0.227	0.188
FL/L 2	-0.275	-0.366	-0.319	0.419	0.193	0.330
1 I/CL	-0.300	-0.347	-0.319	0.408	0.276	0.372
Contribution (%)	40.2	43.2	34.7	24.0	27.2	27.3

on the association of characters in the selected lines. Calculations were made for three cases, i. e., (i) the reciprocal crosses between (*squarrosa*)-N 26 and Norin 61, (ii) the reciprocal crosses between (*kotschy*)-N 26 and Norin 61, and (iii) four alloplasmic and one euplasmic cross combinations excluding the reciprocals. Eigenvectors of the first and second principal components (Z_1 and Z_2) are shown in Table 3, which in the aggregate explain 60 to 70% of the whole variation. The contents of the eigenvectors are rather consistent over the three cases calculated, coinciding with the previously noted trend that the *Aegilops* cytoplasms do not substantially modify the structure of association of characters, while they more or less modify the genetic variability of individual characters (YONEZAWA *et al.*, 1986).

The biological image or meaning of the two principal components drawn are not very clear, but the following interpretation may be made; the lines with a larger score of the first component tend to have a larger plant height and smaller size of upper leaves and internodes relative to lower ones, whereas the lines with a larger score for the second component have a larger plant height, larger relative sizes of upper internodes, and smaller measurements of the three ear characters, EL, EW and EN.

Scattergrams of the first and second principal components for the three cases calculated are presented in Figs. 1(i), (ii) and (iii), respectively, to visualize the cytoplasmic effect on the occurrence of lines with new combinations of characters. Differences between reciprocals in Figs. 1(i) and (ii) show the cytoplasmic effect of *Ae. squarrosa* and *Ae. kotschy*, respectively. It is seen in Fig. 1(i) that the lines with *squarrosa* cytoplasm produced a wider range of character combinations than the euplasmic lines; several alloplasmic lines, in contrast to only one euplasmic line, occupied the positions clearly deviated from other allo- and euplasmic lines, taking scores less than about -2.5 for the first principal component, or less than about -2.0 for the second component. In Fig. 1(ii), some positive and negative deviants for the first principal component are found in the alloplasmic lines carrying *kotschy* cytoplasm. Comparison of Figs. 1 (i)

and (ii) shows that the relative positions of the paired reciprocals in the scattergram are different with the cytoplasms, suggesting that the cytoplasms of *Ae. squarrosa* and *Ae. kotschy* caused different effects on some characters.

Scatter distributions in Fig. 1 (iii) visualize the difference of the four *Aegilops* cytoplasms. In making the distributions, the three groups of lines, I, II and III, in each cross combination were pooled since no remarkable difference was found among them. The lines encircled in this Figure may be regarded as the deviant lines which in some way have different character combinations from other alloplasmic and euplasmic lines. It is demonstrated in Fig. 1(iii) that *kotschy* cytoplasm produced the largest number (six encircled) of deviant lines, coincidentally with the results of the F_2 and F_3 lines where *kotschy* cytoplasm exhibited by far the most prominent effect of expanding the genetic variability of agronomic characters (TSUNEWAKI *et al.*, 1985, YONEZAWA *et al.*, 1986). Very few or no deviant lines were observed for the other *Aegilops* cytoplasms.

3. Characteristics of Deviant Lines

Characteristics of the lines which showed transgressively early heading dates and/or deviant scores for the principal components are presented in Table 4. Some lines with promising character combinations could be found in the alloplasmic lines; a number of lines such as No. 34, 42 and 54 showed substantially earlier heading date than the parents without any deleterious modification, or even with improved combination, of yield-related characters such as ear length, weight and number. The cytoplasm of *kotschy* produced the largest

Fig. 1. Scattergram of the selected lines on the first (Z_1) and second (Z_2) principal components

- (i) Reciprocal crosses of (*squarrosa*)-N 26 and N 61 (I group)
- (ii) Reciprocal crosses of (*kotschy*)-N 26 and N 61 (I group)
- (iii) Alloplasmic and euplasmic crosses (I, II, and III groups excluding the reciprocals)

Table 4. Characteristics of the lines deviant for earliness and principal components

Cross combination	Line no. deviant for		HD	FL	L2	EL	EW	EN	CL	1 I	2 I	3 I	FL/L2	1 I/CL
	Earliness	PC ¹⁾												
Group I :														
(sqr)-N 26×N 61	12	(12) ²⁾	27.86											+ ³⁾
		13	29.90					-	-	-	-			
Reciprocal	18	(18)	27.57							+			+	+
	33		27.73						+	+		+		
(kts)-N 36×N 61	34		26.09				+		-	-	-	-	+	
	41	41	27.70		-				-	-	-	-		
	42	42	26.86		-		+		-	-	-			-
		(44)	30.00	+	+	+	+	+	+	+	+	+		-
	50		27.97		-		+		+					-
		51	32.47		+	+	+		+	+	+	+		-
Reciprocal	54		28.14			+	+	+	+					-
	61		28.09			-								-
	63		27.05			+	+	+	-		-	-		
Group II :														
(spl)-N 36×N 61	5		27.55	-	-	+			-	-	-	-		
	6		26.86		-	+				-	-	-		
		8	29.41	-	-	+			-	-	-	-	-	-
	17		27.12		-				+	+			+	
(lng)-N 26×N 61	18		27.65		-	-			+	+	+	+		
	21		26.95		-				+	+	-		+	
	22		26.04		-	-			+	+	-	-	+	+
	N 26×N 61	37	26.82	+		+		+			-			
	39		26.50	+	-	+	+				-		+	
	40		26.64	+		+	+	-	-	-	-	-	+	
	47		27.24	+					+	+				
Group III :														
(sqr)-N 26×N 61		1	31.17		+	+	+		+	+	+	+	-	-
	9		27.05				+		+	+		+	+	
(kts)-N 26×N 61	17	17	27.62		-					+	-	-	+	
		18	31.78		+	+	+		+	+	+	+		
		20	31.50		-	-	-			+	-	-	+	+
	N 26×N 61	42	42	26.50	+	-		-	+	+			+	+

¹⁾ Principal components²⁾ Line No. with parenthesis were taken up from the scattergram of all of the lines which belong to group I.³⁾ Signs + and - indicate that mean value falls positively and negatively out of the range of parental plots, respectively.

variety of character combinations.

Discussion

Our previous experiments using randomly derived F₂ plants and F₃ lines have shown that the cytoplasm of *Ae. kotschy* caused the most marked increase in the genetic variability of the agronomic characters compared to those of *Ae. squarrosa*, *Ae. speltoides*

and *Ae. longissima* (TSUNEWAKI *et al.*, 1985, YONEZAWA *et al.*, 1986). This trend was recognized also in the present experiment using F_4 and F_5 lines derived through selection. The largest variety of character combinations of earliness and other morphological characters was obtained in the lines carrying *kotschy* cytoplasm. Some promising lines were included in these lines, which are earlier and more favorable for some yield-related characters than Norin 26 and Norin 61. These lines may be used for wheat breeding in Japan where early lines with a sufficiently high yielding ability have continually been the main target of breeding.

The Cytoplasm of *Ae. squarrosa* released the second largest variety of deviant lines, contrasting to the results of F_2 and F_3 generations where no appreciable increase of genetic variation was recognized in the lines alloplasmic for *squarrosa* cytoplasm. Genetic effects of this cytoplasm have been investigated also by some other groups of workers (KIHARA 1980, MAAN *et al.*, 1981, KONZAK and ALLAN 1984), leading to rather conflicting conclusions. KIHARA (1980) and MAAN *et al.*, (1981) could not obtain any alloplasmic lines which had appreciably been improved for yielding characters, whereas KONZAK and ALLAN (1984) have suggested that some desirable lines with a sufficiently high productivity may be selected. Evaluation of the genetic effect of *squarrosa* cytoplasm remains to be an open problem. No remarkable result was observed in the alloplasmic cross combinations of *Ae. speltoides* and *Ae. longissima*. It may be worth noting in this context that the nuclear genomes of *Ae. speltoides* and *Ae. longissima* are closely related to each other; both of these two species belong to the section, *Sitopsis*, and their genomes show a high genetic relatedness with the B genome of common wheat (KIHARA and LILIENTHAL 1951, RILEY *et al.*, 1958).

Principal component analysis in both of the present and previous experiments revealed that eigenvectors of the first and second principal components are essentially the same in all of the cytoplasms examined. This indicates that the *Aegilops* cytoplasms do not substantially modify the phase or structure of character association, while they largely or slightly modify the genetic variation of individual characters.

It has been confirmed that the plasmagones of *Aegilops* and *Triticum* species are genetically very stable, and transmitted only through female gametes. Nor, has any genetical differentiation been revealed in the cytoplasms of common wheat (TSUNEWAKI and TSUJIMOTO 1984). So, if the nuclear genes of the alloplasmic parental lines have completely been replaced by those of Norin 26, there should be no difference among the cross combinations in which euplasmic Norin 61 was used as female parent. Difference was observed among these cross combinations, however, though not statistically significant in most cases. This suggests that some nuclear genes of *Aegilops* species or Chinese Spring (see TSUNEWAKI *et al.*, 1985) still remain unsubstituted in the alloplasmic lines of Norin 26. Differential transmission of particular genes and chromosomes has been suggested as a mechanism by which residual genes are maintained after many backcrosses (KOFOID and MAAN 1980, TSUJI 1980, TSUNEWAKI 1980). Contribution of the residual alien nuclear genes remains to be precisely identified in future experiments.

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異種細胞質利用によるパンコムギの遺伝的変異の拡大——「異種細胞質農林 26 号」×
「農林 61 号」の交雑から選抜した F_4 及び F_5 系統の特性

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コムギ, エギロプス両属の細胞質に存在する大きな遺伝的変異をパンコムギ育種に利用するための試みの 1 つとして, エギロプス細胞質をもつパンコムギ系統に通常のパンコムギ品種を交配して得られた後代に選抜を行い, 実用的に有望な系統が育成可能であるか否かを検討した。

細胞質を異にする農林 26 号の 5 系統, すなわち, *Aegilops squarrosa*, *Ae. kotschy*, *Ae. speltoicles* 及び *Ae. longissima* の 4 つの異種細胞質 (細胞質型はそれぞれ D, S^V, S 及び B) 及び正常細胞質 (細胞質型は B) をもつ農林 26 号と, 正常細胞質をもつ農林 61 号との交雑に由来する F_2 , F_3 及び F_4 世代で, 出穂日, 穂数, 穂長あるいは一穂重に関して選抜をすることによって計約 200 の選抜系統を得た。これら選抜系統を, 交配組合せ正逆こみを主区, 同一交配組合せ内の両親及び選抜系統を副区とする 2 回反復の分割区法で圃場に栽植した。栽植個体数は, 各選抜系統とも 1 ブロック 1 プロット当たり 14~15 個体とした。両親系統については 1 ブロック 1 主区当たり 4~6 プロットを設けた。これら栽植個体のうちボーダー個体を除く 1 プロット当たり 12~13 個体について, 出穂日, 止葉長, 第 2 葉長, 株当たり穂数, 稈長, 穂長, 上位第 1~第 3 節間長, 及び一穂重の 10 形質を調査した。これら 10 形質に加えて, 草型の指標形質として 2 つの特性値, すなわち止葉長と第 2 葉長との比, 及び, 第 1 節間長と稈長との比を求め, 計 12 の形質を分析対象とした。得られた主要結果は以下の通りである。

選抜形質中, 出穂日に関してはいずれの交雑組合せ (細胞質) においても高い選抜効果が認められた。穂長, 一穂重についてもかなり明瞭な選抜効果が認められたが, 穂数については選抜効果は認められなかった。これらの傾向に関し, 交配組合せ (細胞質) 間に差は認められなかった。このことは, 遺伝率に関して細胞質間で差異はないという既報 F_2 (TSUNEWAKI *et al.*, 1985) の結果と一致する。

上記 13 形態に基づく主成分分析を行ったところ, 既報 F_2 , F_3 (TSUNEWAKI *et al.*, 1985, YONEZAWA *et al.*, 1986) の結果と同様, *kotschy* 細胞質をもつ選抜系統で最も多様な形質組合せが認められ, その中には親系統よりも早生で, 穂長及び一穂重などの収量関連形質についても望ましい方向に変異した系統が認められた。しかし, 主成分分析から導かれた第 1 及び第 2 主成分 (累積寄与率 60~70%) の固有ベクトルの内容についてみると, 供試 5 細胞質間で顕著な差は認められず, 従って既報の場合同様, 異種細胞質によって形質相関の構造は影響されないものと推測された。*kotschy* 細胞質をもついくつかの有望選抜系統は, 日本のコムギ育種において母本として利用される可能性がある。*kotschy* 以外のエギロプス細胞質については, F_2 , F_3 , F_4 世代を通じて望ましい効果を示したものが認められなかった。