Field Performance of Anther Culture-Derived Breeding Lines of Barley

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Since 1984, evaluation of anther culture derived lines has been carried out at the University of Saskatchewan. The anther culture method has been compared to pedigree, single seed descent, and Hordeum bulbosum methods of cultivar production. In 1986 and 1987 the lines were evaluated in yield trials with grain yield, heading date, thousand kernel weight, hectolitre weight, kernels per spike and percentage plump kernels were examined. In assessment of the cross of Abee and Norbert the means of the analyzed traits were found to be generally lower for anther culture, but variability was similar among all methods. Furthermore, the best lines of each method expressed similar potential. In the current studies the performance of the Abee/Norbert cross appears to support the previous evidence of lower mean performance. Materials from the crosses of Abee/Harrington and Abee/TR215 were also grown in 1987 for assessment.

Introduction

In 1964, Guha and Maheshwari, observed the formation of embryos with a haploid chromosome number from cultured immature anthers. Since then improvements in the understanding of the process and the techniques required have resulted in the application of anther culture to many crops species including *Hordeum vulgare*. The production of doubled haploid barley lines from F1 plants in sufficient numbers for study has recently become feasible (Kao, 1981; Friedt and Foroughi-Wehr, 1983). The lines described in this study, developed by K.N. Kao from Crop Development Centre materials, have been under evaluation since 1984 at the University of Saskatchewan (Rossnagel, Sariah and Kao, 1986, Sariah, 1987). The objective of this study was to determine whether anther culture is an equivalent technique for production of breeding lines as compared to pedigree, single seed descent and *Hordeum bulbosum* cross methods.

Materials and Methods

Lines from the cross of the 2-row barley cultivars Abee and Norbert were grown in 1986 at Saskatoon, including 71 anther culture (AC), 74 pedigree (PED) and 74 by single seed descent (SSD). These tests were grown in 4.5 m2 plots with 3 replications. Data was collected on yield (YLD), days to heading (D-H), maturity score (MAT), straw strength (SS), height (HGT), thousand kernel weight (MKW), test weight (TWT) and percentage of plump kernels (PLP).

In 1987 materials from three crosses were evaluated. Selection of lines from the 1986 Abee X Norbert test was made to create a test of 12 selected lines each from the AC, PED, SSD material with 7 lines of HB (*Hordeum bulbosum* doubled haploid method) derivation. Selection of these "best" lines was based on 1986 data. Lines were selected for overall superiority with high grain yield only being one of several parameters evaluated. Observations of yield, days to heading, height, thousand kernel weight, test weight and percentage of plump kernels were made. The trials were of the same design in 1987 as 1986.

Lines from the hybrid Abee X TR215 were also evaluated in 1987

with 29 AC, 28 SSD, 28 PED, and 27 HB entries. Yield, days to heading, height, thousand kernel weight, test weight, % plump kernels, heads per m2 (HM2), and kernels per spike (KPS) were assessed. A similar trial using 35 lines each of AC and HB material was carried out for the cross of Abee X Harrington.

Results

The data collected in 1986 is summarized in Table 1. The data was evaluated by analysis of variance. When significant differences occurred, inter-method comparisons were made by a t-test. The yield of AC lines was found to be lower than that of either the PED or SSD

Table 1. Mean values for assessed traits by method from the cross of Abee by Norbert.

Method	Character						
	YLD	D-H	MAT	SS	MKW	TWT	PLP
	100 kg/ha		(1-5)	(1-9)	(g)	(kg/hl)	(%)
AC	58.7 c*	56.5	3.5	5.1 b	43.5 b	63.9 c	71 b
PED	63.3 a	56.1	3.7	5.7 a	45.1 a	65.1 a	77 a
SSD	61.4 b	56.5	3.6	5.0 b	44.0 b	64.4 b	73 b
ABEE	55.4	59.4	2.7	5.8	46.2	64.5	78
NORB	57.7	58.8	2.7	4.7	49.8	64.5	83

*Means in the same column followed by the same letter are not different from each other by Student's t-test, P=0.05.

methods. Similarly, AC mean test weight was found to be lower than either that from the other methods. For the characters of thousand kernel weight, plumpness and straw strength the AC lines were found to be lower than PED entries but not different from the SSD lines. The lower straw strength ratings of the PED entries may be related to their tendency to be higher yielding.

Means of the top (selected solely on the basis of yield) five lines from each method are described in Table 2. Parental means from Table 1 may be used for comparison. In this grouping only yield and maturity were found to be significantly different. Lines from the PED method were ranked higher for yield but were not significantly different from the SSD lines. The AC lines were again lowest ranked but were not significantly different from the SSD entries. The straw strength rating for the selected lines was poorer than the mean for the entire test, suggesting some relationship between high yield and poor straw strength.

Table 2. Mean values of best five lines from each method in the 1986 test of Abee X Norbert.

Method	Character						
	YLD	D-H	MAT	SS	MKW	TWT	PLP
	100 kg/ha		(1-5)	(1-9)	(g	(kg/hl)	(%)
AC	66.74 b	56.2	4.2 a	6.3	45.7	64.7	80
PED	69.50 a	55.9	4.1 a	5.8	47.1	65.6	80
SSD	68.17 ab	56.3	3.5 b	4.6	46.9	65.3	79

Lines combined for the 1987 test of Abee X Norbert were selected on the basis of best combinations of yield, maturity, straw strength and physical grain quality from the 1986 data. The selection was applied as would be normally be found in a breeding program. The observations are reported in Table 3. In this test only days to heading and height showed significant inter-method variation. The

Table 3. Mean values of 1987 Abee X Norbert selected lines arranged by method.

Method	Character					
	YLD	D-H	HGT	MKW	TWT	PLP
	100 kg/ha		(cm)	(g)	(kg/hl)	(%)
AC	35.7	53.2 bc	60 a	43.4	63.8	68
PED	36.9	53.0 c	64 b	43.6	64.7	71
SSD	35.5	53.6 ab	60 a	42.8	64.8	73
HB	36.1	54.4 a	61 a	42.1	65.0	69
ABEE	38.0	52.7	64	40.8	65.4	68
NORB	35.3	54.7	62	44.2	64.4	76

earliest heading lines were found among the PED selections but they did not differ from the AC lines. The HB lines were found to be generally later in time to heading. The PED lines tended to be taller, while the other methods showed no height differences.

Results of the 1987 test of Abee X TR215 lines is summarized in Table 4. All parameters except height and heads per m2 were found to vary from method to method on a mean basis. For this cross the yield of the AC lines was not found to differ from the other methods. The AC and SSD lines were found to be earliest and HB entries the latest

Table 4. Mean values for the 1987 trial of Abee X TR215 at Saskatoon.

Method	Character							
	YLD	D-H	HGT	MKW	TWT	PLP	HM2	KPS
	100 kg/ha		(cm)	(g)	(kg/hl)	(%)		
AC	36.4 ab	52.0 bc	58	38.6 c	66.9 a	63 c	543	20.6 a
PED	37.2 a	52.3 ab	57	40.3 a	66.9 ab	72 a	533	19.8 b
SSD	36.9 a	51.7 c	57	39.6 b	67.4 a	70 ab	543	20.3 ab
HB	35.5 b	52.5 a	57	38.6 c	66.4 b	66 bc	550	19.8 b
ABEE	42.1	52.3	56	40.5	67.2	62	621	18.6
TR215	35.5	55.0	57	40.7	65.0	68	524	21.0

for time to heading. The kernel characteristics showed the AC lines to have lower thousand kernel weights than PED or SSD lines but similar to the HB entries and lower plumpness ratings than the other methods. However, test weights showed no major differences between methods. Furthermore, the AC entries generally had greater numbers of kernels per spike.

Means for the best five lines from each method in this cross, (selected on the basis of yield) are described in Table 5. In this group days to head, thousand kernel weight and percentage plump kernels are the only characters showing significant variation between methods. As in the previous table PED lines are the latest to head

Table 5. Means of best five lines of each method from the cross of Abee X TR215.

Method	Characteristic							
	YLD	D-H	HGT	MKW	TWT	PLP	HM2	KPS
	100 kg/ha		(cm)	(g)	(kg/hl)	(%)		
AC	40.08	51.5 ab	60.7	39.3 b	67.3	67 bc	572	20.6
PED	40.24	52.7 c	60.5	41.4 a	66.6	80 a	533	21.0
SSD	40.09	51.1 a	58.3	39.9 b	67.0	74 ab	552	21.4
HB	39.62	52.6 bc	56.7	38.9 b	67.2	63 c	602	20.4

and AC lines among the earliest in the test. The PED entries had higher thousand kernel weights than those from the other methods. Plumpness testing showed higher levels for PED and SSD and lower values for AC and HB lines.

Mean characteristic values for the Abee X Harrington material is described in Table 6. The characteristics found to vary were days to head, showing AC lines as earlier, test weight, where AC lines were superior, and plumpness, where the HB lines were better. The AC lines also had more kernels per spike.

Table 6. Means of traits assessed for 1987 Abee X Harrington by methods.

Method	Characteristic							
	YLD	D-H	HGT	MKW	TWT	PLP	HM2	KPS
	100 kg/ha		(cm)	(g)	(kg/hl)	(%)		
AC	36.9	51.3 a	60	41.2	68.2 a	53 b	541	20.8 a
HB	36.1	53.1 b	60	41.6	67.7 b	61 a	554	19.7 b
ABEE	41.2	52.3	62	41.9	68.2	61	588	19.3
HARR	40.1	52.3	60	45.8	67.3	83	526	19.3

Discussion

In general the mean yield of AC lines did not differ from that of the other methods, except for the Abee/Norbert combination. This may suggest that the Abee/Norbert selections were a poor choice of lines to use in evaluation of anther culture. Further testing of the Abee/TR215 and Abee/Harrington material may further establish the value of the technique. In all cases the application of selection resulted in reduced variation and the conclusion that the best lines produced from each method are equivalent. The distribution and dispersion of the lines generated may be wider for the AC lines for the characters assessed. This could be explained by the lack of selection during AC, compared to the elimination of obviously inferior types throughout the PED method and incidental elimination of some variation during SSD procedures.

The characteristic days to heading varied across methods and between years. AC entries were generally earlier to head than those from other methods. Further study of the time to heading and grain filling period, as expressed by maturity may suggest some explanation for this variation. Selection for earliness may have been applied to the PED lines as compared to the SSD and HB methods to shorten the days to heading, but no reason has been determined for the earliness

of the AC types.

The kernel characteristics were also noted to vary among methods. The AC entries tended to have lower thousand kernel weights, test weights and plumpness percentages. This may be an expression of some balancing of yield components since yield was not found to vary to the same extent. Further assessment of the characteristics contributing to yield may reveal trends among traits.

In all tests the mean yields were found to be comparable to the parents. For the production of breeding lines the anther culture method for generation of breeding lines appears to produce a valid sample of the potential genotypes which may be derived from a cross. The distributions of the assessed traits appear to be similar among all methods evaluated. Further comparison testing of the methods should establish the validity of anther culture or reveal its deficiencies.

References

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