NOTE

Parental Blends as Predictors of Quality in Spring Wheat Hybrids[1]

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Hybrid wheat may show significant yield advantages as compared to parental inbreds. In a Kansas study, Livers and Heyne (1968) showed that hybrids obtained from intercrossing nine varieties in all combinations outyielded the parents by an average of 32% over four years in Kansas. Additional studies have shown similar hybrid advantage (Johnson and Schmidt 1968, Bitzer et al 1982, Virmani and Edwards 1983), whereas others have reported no hybrid advantage (Allan 1973, Hughes and Bodden 1978). In general, testing results have been sufficiently positive that several companies have initiated and continue to pursue hybrid wheat breeding programs. Due to the difficulties in producing large quantities of F_1 seed on the normally self-pollinating wheat plant, much research effort has been directed toward developing systems of efficient pollination and seed production (Wilson 1984).

As in any breeding program, a vital concern in hybrid wheat breeding is the selection of appropriate parental material. This is somewhat problematic in wheat in that many more inbred lines may be produced than can be effectively tested in hybrid combinations. This may be especially true for the relatively intensive quality analyses that must be conducted to ensure that new wheat varieties meet market specifications. For bread wheat, these specifications involve parameters important in bread-baking. McNeal et al (1968), Livers and Heyne (1968), and Brears et al (1988) showed that the bread-baking quality of hybrids tended to be intermediate to that of their parents.

Several studies have shown that genetically diverse parents are necessary for maximizing the yield of hybrid wheat (Wilson 1984). Relatively little attention has been devoted to methods of parental selection for maximizing the bread-making quality of wheat. In this regard, the present study was designed to determine whether quality measurements of flour made from parental blends might provide a meaningful estimate of hybrid quality in a set of hard red spring wheat lines.

MATERIALS AND METHODS

Reciprocal crosses were made in 1989 and 1990 in all combinations between seven hard red spring wheat varieties adapted to Montana. Parental varieties were Newana (CI 17430), Norana (CI 15927), Lew (CI 17429), Marberg (CI 17829), Pondera (CI 17828), Fortuna (CI 13596), and Hi-Line (PI 549275). Female parents were emasculated by hand. Approximately equal numbers of crosses were made in both directions, and F_1 seed was bulked from all crosses including reciprocals to provide seed for replicated field trials in Bozeman, MT, in 1989 and 1990. Previous results (McNeal et al 1968) showed no significant differences among reciprocal crosses for quality parameters. Trials included an irrigated and a dryland site in 1989 and a dryland site in 1990. Experiments were planted in lattice designs with 49 entries replicated three times. Border rows were not planted adjacent to each plot. However, in a space-planted nursery such as this one, the effects of interplot competition are likely to be minimal. Entries included seed from the seven original parents and from 21 hybrids, as well as 21 analogous parental blends composed of equal mixtures of seed from each parent. Thirty seeds were planted per 3-m row, with 30.5 cm between rows. When plants reached the four-leaf stage, plots were thinned to 15 plants per row. At harvest, 10 plants were pulled for yield analysis from each plot. For the parental blends, five plants from each parent plot (10 plants total) were chosen, while 10 random plants were chosen from each of the hybrid and parent plots. After obtaining yield data from the 10 plants from each plot, the grain was bulked with that of the remaining plants in each of the plots. Thousand-kernel weight was calculated from a 30-g sample for each plot. Grain samples of 10 g were ground for analysis of protein content using a Technicon near-infrared analyzer (AACC 1983, Method 39-10). The remaining grain was tempered to 16.5% moisture with distilled water and milled in a standard Buhler flour mill (AACC 1983). Dough strength was estimated using a 10-g mixograph method as described by Finney and Shogren (1972). A 25-g baking procedure was developed by modifying the procedure of Finney (1984) and Shogren and Finney (1984) and following AACC (1983) Method 10-09. Pearson correlations and paired t-tests of parental blends versus hybrids and of parental averages versus hybrids were calculated using MSUSTAT (Lund 1989) for all parameters measured.

RESULTS

Analyses of variance indicated significant differences ($P = 0.05$) among entries for grain yield, protein content, 1,000-kernel weight, mixograph peak time, mix time (time to optimum dough development), and loaf score. Entries did not differ significantly for mixograph peak height or loaf volume. The hybrid populations yielded significantly ($P < 0.01$) more grain than the parental blends or the parents per se and had a higher average 1,000-kernel weight (Table I). Conversely, protein percentage was lower in the hybrids than in the parental blends. The only additional significant difference between hybrids and parental blends was the short time to mixograph peak shown by hybrids.

Several significant correlations were observed between the hybrids and both the parental blends and parental averages (Table II). Protein content, 1,000-kernel weight, mixograph peak time, mix

TABLE I
Means for Yield and Quality Characteristics of Hybrids (H), Parental Blends (PB), and Parental Averages (PA) Averaged over Three Trials

	Population[a]		
Trait[b]	H ($n^c = 189$)	PB ($n = 189$)	PA ($n = 63$)
Yield per plot, g	172.6 (21.2)	159.0** (13.8)	161.7** (10.2)
Protein, %	15.3 (0.7)	15.7** (0.6)	15.5** (0.6)
Kernel weight, g	37.8 (2.3)	37.2* (2.3)	36.9** (3.1)
MPT, min	4.0 (0.4)	4.2* (0.8)	3.9 (0.3)
MPH, cm	7.5 (0.5)	7.6 (0.5)	7.7 (0.4)
Mix time, min	4.8 (0.2)	4.8 (0.2)	4.7* (0.2)
Loaf volume, cm^3	239.0 (12.7)	237.5 (12.3)	234.3** (8.6)
Loaf score, 1–10	4.3 (0.5)	4.4 (0.5)	4.2 (0.4)

[a] * and ** = means significantly different than the mean of the hybrid at $P \leq 0.05$ and $P \leq 0.01$, respectively. Standard deviations are given in parentheses.
[b] Kernel weight = 1,000-kernel weight, MPT = mixograph peak time, MPH = mixograph peak height, mix time = time to optimum dough development, loaf score = subjective crumb and texture score where 1 = poor and 10 = excellent.
[c] Number of plots estimating mean.

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TABLE II
Pearson Correlations Between Hybrids (H), Parental Blends (PB), and Parental Averages (PA) for Yield and Quality Traits in Spring Wheat

	Trial[b]							
	1989 (dryland)		1989 (irrigated)		1990 (dryland)		Average	
Trait[a]	H-PB	H-PA	H-PB	H-PA	H-PB	H-PA	H-PB	H-PA
Yield	ns	ns	ns	ns	ns	ns	ns	ns
Protein	ns	0.44**	0.26*	0.46**	ns	ns	0.30*	0.42**
Kernel weight	0.35**	0.42**	0.51**	0.57**	0.36**	0.48**	0.59**	0.65**
MPT	ns	ns	ns	ns	ns	0.64**	0.29*	0.49**
MPH	ns	ns	ns	0.29*	ns	ns	ns	ns
Mix time	0.24*	0.31**	ns	ns	ns	ns	0.33**	0.33**
Loaf volume	ns	ns	0.29*	0.30*	0.45**	0.51**	0.36**	ns
Loaf score	ns	ns	ns	ns	ns	0.30*	ns	ns

[a] Kernel weight = 1,000-kernel weight, MPT = mixograph peak time, MPH = mixograph peak height, mix time = time to optimum dough development, loaf score = subjective crumb and texture score where 1 = poor and 10 = excellent.
[b] Significant at $P \leq 0.05$, ** = significant at $P \leq 0.01$, ns = not significant.

time, and loaf volume of hybrids and parental blends showed significant correlations of 0.30, 0.59, 0.29, 0.33, and 0.36, respectively. Correlations between hybrids and parental averages were higher than those between hybrids and parental blends for all traits except mix time and loaf volume. The only trait that showed a significant correlation between hybrids and parental blends in all three trials was 1,000-kernel weight.

DISCUSSION

As with some but not all previous studies, our data suggested a yield advantage of hybrid wheat as compared to the parental inbreds (Table I). Our study showed an average yield advantage of approximately 8%. Conversely, percent protein of hybrids was significantly lower than that of the parents (15.3% vs. 15.7%). However, among hybrids, percent protein and yield were not correlated (data not shown), suggesting that it could be possible to select high-yielding, high-protein hybrids. Additionally, 1,000-kernel weight and loaf volume were slightly higher for the hybrids than for the parents. Thus, overall, neither hybrids nor parents were consistently superior in regard to end-use properties.

Our primary objective was to determine whether parental blends could be used effectively to predict the breadmaking quality of spring wheat hybrids. Correlations between parental blends and hybrids were often nonsignificant (Table II) and were usually low. In fact, correlations were generally as high for hybrids and parental averages as for hybrids and parental blends. These results suggested that parental blends do not provide an effective estimate of hybrid quality. Thus, prescreening potential parents in blends would probably not be helpful in choosing crosses. At any rate, averages of the parents analyzed alone provided as good an estimate of hybrid quality as did analysis of parental blends. Previous results (Livers and Heyne 1968, McNeal et al 1968, Brears et al 1988) have shown that hybrids tend to be intermediate to parents in regard to quality characteristics. As fewer samples need to be tested to produce parental averages, this is apparently a more efficient method than testing combinations of parental blends. However, neither method would seem ideal for selecting crosses likely to produce high-quality hybrids.

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