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Effects of Selected Linkage Blocks on Yield and Yield Components in Wheat

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In conventional breeding methods sizeable linkage blocks are transferred with the desired loci and in some cases whole alien chromosomes are substituted in wheat. Linkage blocks associated with five loci were analyzed singly and in groups of two or three for their influence on yield components and grain yield in soft red winter wheat.

LITERATURE REVIEW

HANSON (1959) showed that chromosomal segments held heterozygous with backcrossing or selfing remain quite long after the four to six backcrosses conventionally used in breeding self-pollinated crops. The approximate average residual block lengths after four and six backcrosses for chromosomes of 50, 100, and 200 centimorgans length are 32 and 22, 43 and 32, and 49 and 33 centimorgans respectively. Chromosome lengths have not been established in wheat.

The characters transferred had been studied genetically previously or in conjunction with the backcrossing. The blocks are designated here as *Du, Su, MA, Tr,* and *Ag.*

Resistance to Hessian fly, *Phytophaga destructor* (Say), was derived from Durum PI94587 which may contain as many as four dominant genes for resistance. One of these (*Du*) was transferred to the variety Knox 62 where it conditions resistance to races A and B (CALDWELL *et al.,* 1963). In unpublished research at Purdue University R. L. GALLUN and F. L. PATTERSON have associated this resistance with chromosome 5A of wheat.

One source of resistance to powdery mildew, *Erysiphe graminis* DC. f. sp. *tritici* EM Marchal, was derived from Suwon 92 (*Su*). This resistance is at the *Pm3* locus probably allelic to the resistance of Indian 1A located on chromosome 1A (BRIGGLE 1966, BRIGGLE and SEARS 1966). Resistance was dominant to four cultures of *E. g. tritici* (RAY *et al.,* 1954).

Resistance to *E. g. tritici* from Michigan Amber 29-1-1-1 was inherited as a simple recessive in the seedling stage under optimum conditions (MAINS 1934) and as a simple dominant to two pathogen cultures at the three- to four-leaf stage (CALDWELL and COMPTON 1947).

The leaf rust resistance of Transfer (*Tr*) was derived from *Aegilops umbellulata* Zhuk. (SEARS 1956) as a terminal translocation in the long arm of chromosome 6B (SEARS 1966). The locus was designated *Lr9* (SOLIMAN, HEYNE and JOHNSTON 1963).

The *Agropyron* chromosome was added to common wheat in research at Purdue University by R. M. CALDWELL and L. E. COMPTON in a stock designated as Agrus. The leaf-rust resistance is carried on a whole substituted chromosome pair (SHARMA and KNOTT 1966). The transfer of the chromosome from Agrus to the Knox variety was described by CALDWELL *et al.*, 1957. Resistance was dominant to the 15 races of *Puccinia recondita* Rob. ex Desm. to which the segregating generations were tested. Agropyron chromosomes have been shown to substitute for 6A (KNOTT 1964) and 3D (XVI) in wheat (BAKSHI and SCHLEHUBER 1959).

MATERIALS AND METHODS

Chromosome blocks about the loci controlling the five selected characters were transferred individually to Knox wheat by backcrossing with resistance identified in the F_1 plant in each generation. Some derived backcross plants were then intercrossed to combine two or three characters (TABLE 1). Four independently derived lines were selected to evaluate the mean effect of each linkage block or linkage block combination on the components of yield and on grain yield. Four random plant selections provided the four lines representing the control variety Knox.

The 56 lines were evaluated in a randomized complete block nursery yield trial with five replications at Lafayette, Indiana, for two years, 1965 and 1966. Yield plots consisted of four rows 2.4 m long with 30.5 cm between rows and the center two rows harvested for yield. The number of spikes per plot was estimated by counting all spikes in one of the two rows harvested for yield. Kernel weight was determined by weighing 200 unselected kernels per plot. The number of kernels per spike was calculated for each plot from data for grain yield, spikes per plot, and kernel weight. The plots were sprayed with lime sulphur to control powdery mildew and rusts so that differential development of these diseases due to the resistances would not influence performance.

In testing differences among groups of four lines for yield for individual years the line (L) within group(G) mean square was used to test the significance of differences among groups (mean linkage block effects) and for error estimate for determining differences among group means.

In testing differences over the two years for all characters, the error mean square was used to test the year (Y) $\times$ line (L) within group (G) mean squares. The Y $\times$ L within G mean square was used to test L within G mean squares and

TABLE 1. Influence of linkage blocks on grain yield and yield components in the Knox variety and its backcross derivative lines.*

Group of four lines	Linkage block	Grain yield (bu/A)	Spikes/ row (no.)	Kernels/ spike (no.)	1000 kernel weight (g)
Knox	Parent	63.3 ab	333.6 ab	55.1 ab	35.8 ab
551	*Du*	64.0 ab	359.2 a	51.9 b	35.4 ab
56152	*Du*	62.3 ab	343.0 ab	55.2 ab	34.2 abcd
5613	*Su*	62.8 ab	327.9 ab	58.8 ab	34.6 abc
5619	*MA*	64.4 a	334.4 ab	57.4 ab	35.6 ab
5817	*Tr*	60.4 ab	321.8 ab	55.1 ab	36.0 a
56143	*Ag*	61.3 ab	336.0 ab	54.6 ab	34.6 abc
5714	*Ag*	61.1 ab	333.8 ab	59.7 a	32.8 bcd
5735	*Du Su*	60.2 ab	298.2 b	56.8 ab	36.7 a
5734	*Du MA*	64.3 a	325.9 ab	58.1 ab	35.3 ab
58122	*Du Tr*	58.4 b	307.9 b	56.9 ab	35.0 ab
58142	*Du MA Ag*	59.5 ab	371.0 a	53.4 ab	31.8 cd
5824	*Du MA Ag*	60.8 ab	362.6 a	56.0 ab	31.4 de
58121	*Du Su Ag*	60.2 ab	371.0 a	59.6 a	28.8 e
SE		1.72	14.9	2.15	0.92

* Averages of two years; significance based on Duncan's New Multiple Range Test at the .05 level.

the Y × L interaction mean square. An F′ was calculated to test significance among group mean squares with n_1' and n_2' degrees of freedom (as outlined by COCHRAN and COX 1957, pp. 566-577). The standard error was calculated:

$$S_{\bar{x}} = \sqrt{\frac{S^{2\prime}}{r}}$$

where $S^{2\prime} = [(\text{m.s. } Y \times G) + (\text{m.s. } L/G)] - [\text{m.s. } (Y \times L)/G]$ with $r = 40$ and and $df = n_2'$.

Significance of differences among lines within groups was determined by individual group analysis using the Y × L within G mean square to estimate error of the mean.

RESULTS AND DISCUSSION

Mean Block Effects

Yields associated with linkage block groups were analyzed separately by years as well as for 1965 and 1966 combined. In 1965 the range in yield for the 14 groups was low, 1.23 bu/A and the precision of measurement was unusually high. In 1966 the range of yields was 11.89 bu/A and the precision of measurement more nearly that generally obtained.

Differences in yield between linkage groups were significant in 1965, in 1966, and for the two-year average. In 1965 the four groups significantly lower than Knox all contained a substituted *Agropyron* chromosome from Agrus. The average loss of the five Agrus derivatives was about 0.8 bu/A. In 1966 only group 58122 (*Du Tr*) was significantly lower in yield than Knox. Other groups with *Tr* or *Du* added singly were not significantly lower in yield than Knox. On a two-year average group 58122 (*Du Tr*) was significantly lower than two other groups but not significantly below Knox (TABLE 1). It appears that the five linkage blocks may be used singly or in combinations in breeding programs without the necessity of reducing block length as received from the donor parent.

The influence of linkage blocks on yield components was examined from two-year averages (TABLE 1). Differences among the 14 groups were significant for each of the three components of yield. The four groups highest in number of spikes were significantly higher than the lowest two groups. None was significantly different from Knox. The two groups highest in kernels per spike (58121 and 5714) were significantly higher than the lowest group (551). None was significantly different from Knox. Three groups, containing linkage block *Ag*, were lower than Knox in kernel weight. The other two groups containing *Ag* were lower than Knox also but not significantly lower. In general the five linkage blocks singly or in combination had only small effects on the components of yield of the Knox type. Lower values for one component were frequently counterbalanced by higher values for another component.

Lines Within Groups

The significance of the differences between lines within groups was examined for two-year averages for the components of yield and grain yield. Only 5 of 56 comparisons were significant. Lines of group 5817 (*Tr*) were significantly different from each other for number of spikes and kernels per spike. The four lines representing Knox were different from each other for kernel weight as were lines in groups 56142 and 58121. None of the lines within groups differed significantly for grain yield. In general the four lines chosen to rate the mean block effects were reasonably similar to one another.

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