Differential Competitive Ability of Morphologically Diverse Spring Wheat Genotypes. D.G.Huel and P.J.Hucl. Dept. of Crop Science and Plant Ecology, and Crop Development Centre, University of Saskatchewan, Saskatoon, Sask.

Abstract

Sixteen genotypes of common spring wheat (T.aestivum) were grown under conditions of simulated weed competition at Saskatoon in 1991 and 1992. Weeds consisted of cultivated oat (Avena sativa cv. Waldern) and Oriental mustard (Brassica juncea cv. Cutlass) sown at two densities (48 and 96 seeds m^2 per weed species), and a weed free control. Seedling establishment, % ground cover, and seed yield for all three species was recorded as was wheat tiller number, spike number, maximum height, LAI(leaf area index), leaf orientation, and flag leaf length and size. Significant ($p=0.01$) weed rate by genotype interactions involving changes in genotype rank were detected for grain yield, indicating differences in competitive ability existed among the wheat genotypes. The highest yielding genotypes under weed free conditions were not necessarily the highest yielding under weedy conditions. Yield reductions averaged over two weed densities ranged from 36 to 52 %. Genotypes which exhibited lower yield reductions also showed greater suppression of weed growth. Although competitive genotypes were generally taller than noncompetitive genotypes, other traits such as tillering capacity and leaf length were important determinants of competitive ability.

Introduction

The presence of weeds in cereal crops can result in substantial yield losses. Crops and weeds compete for essential factors required for growth, such as light, water, and mineral nutrients. Herbicides are typically the primary method of weed control in cereal crops. However, for various economic and environmental reasons, and the potential for the buildup of herbicide resistant weed populations, alternate strategies for weed control are being sought. One of these strategies is increasing crop competitiveness (Richards, 1989).

Genotypic differences in competitiveness with weeds have been noted in several crops such as sorghum (Burnside & Wicks, 1972), rice (Jennings & Acquino, 1968), wheat (Challaiah et al., 1986; Richards, 1989) and barley (Richards, 1989: Siddiqi et al., 1985). Evidence suggests that high yielding semidwarf cultivars of wheat are more susceptible to yield losses due to weed interference than standard cultivars (Kirkland & Hunter, 1991). Differences in competitive ability has been associated with early seedling vigor (Burnside & Wicks, 1972), height, tillering ability, leaf length and spread (Challaiah, 1986: Jennings & Aquino, 1986), ground cover (Richards, 1989), and nutrient uptake efficiency (Siddiqi et al., 1985). Pavlychenko & Harrington (1935) noted the importance of root growth and development in the competition for soil moisture and mineral nutrients between crops and weeds.

The objective of the current study was to determine if genotypic differences in competitive ability existed among a group of common spring wheats and whether observed differences were related to specific morphological characters.

Materials and Methods

Sixteen genotypes of common spring wheat from two crosses, M1417/Ingal, and M1417/Neepawa, were chosen for this study. M1417 is a semidwarf oligoculm line, while Ingal and Neepawa are free tillering genotypes. The sixteen lines were diverse in height, tillering ability, and leaf characters (size, length and angle of inclination). The wheat was seeded at a rate of 180 seeds m^2.The weeds were cultivated oat, Avena sativa cv. Waldern, and Oriental mustard, Brassica juncea cv. Cutlass seeded at two densities (48 and 96 seeds m^2 for each species), and a weed-free control. The oat and mustard were chosen in order to aid in uniform weed population establishment, and to ease seed separation after harvest. The experimental design was a four replicate split-plot design. Mainplot treatments were weed densities and subplot treatments were wheat genotypes. Subplots consisted of five or ten rows spaced 20.3 cm apart, 3.7 m long. The weeds were sown at right angles to the wheat in a separate operation using the same equipment. Five or six rows of wheat (depending on the experiment) were saved for harvesting and the remaining rows were used for destructive sampling throughout the growing season. The experiment was seeded at one location in 1991 (Kernen Crop Research Farm), and two locations in 1992 (Univ.of Sask. Campus, and Kernen). Seedling establishment counts were made on one 0.41 m^2 area in each plot. The area was marked and subsequent tiller and spike counts were made in the same area. Ground cover of all species was measured with a point quadrat when the wheat was at the 5-leaf stage for two experiments only, as was dry matter accumulation, sampled at approximately 5 and 8 weeks after sowing and at maturity. Wheat tillers numbers in the marked area were counted at the time of wheat flag leaf emergence and fertile spikes were counted at maturity. Date of spike emergence (DSE) and physiological maturity (DPM) was recorded in the weed-free control plots. Plot leaf area index (LAI) and mean leaf tip angle (MTA) was measured at heading with a Licor LAI-2000 Plant Canopy Analyzer. Wheat plant and canopy height, and flag leaf length and size were recorded in all plots in two experiments, while wheat plant height was measured only in the weed-free plots in the third experiment. Plots were harvested with a small plot combine. Seed samples were separated into component species, and plot yield recorded for all species. Test weights were determined for the wheat and oat, and thousand seed weights for all three species.

Results and Discussion

Effective oat populations were successfully established in all three experiments. Due to poor seedbed conditions, mustard densities at the 1992 Campus experiment were very low (Table 1). There were no significant differences among the wheat genotypes in established weed populations in any of the experiments.

Significant differences ($p=0.05$) were detected among genotypes for ground cover as measured with a point quadrat. Wheat ground cover was correlated with % wheat yield reduction (pooled $r=-0.49^{**}$), oat yield (pooled $r=-0.59^{**}$), and mustard yield (pooled $r=-0.46^{**}$). Early growth and expansion of leaves likely plays a role in the pre-emption of growing space. In confirmation of the importance of this early rapid crop growth, dry matter accumulation at five weeks was strongly correlated with % wheat yield reduction (pooled $r=-0.51^{**}$), oat yield (pooled $r=-0.64^{**}$), and mustard yield (pooled $r=-0.53^{**}$).

Table 1. Observed weed densities (no./m²).

Seeding Rate	Weed Species	1991 Kernen	1992 Kernen	1992 Campus	Mean
48 m²	Oat	33.4	41.7	40.9	38.9
	Mustard	22.6	29.0	8.2	19.9
96 m²	Oat	68.9	82.2	78.1	76.4
	Mustard	53.4	54.1	9.2	38.9

The presence of weeds reduced the production of tillers, and increased tiller mortality, the result being fewer fertile spikes (Table 2). Significant ($p=0.01$) weed density x genotype interactions were observed for all three traits indicating differential response to the presence of weeds. Increased tiller mortality was correlated with wheat yield reductions at the 1991 and 1992 Kernen experiments ($r=-0.54^*$ and $r=-0.57^*$ respectively) but not at the 1992 Campus site ($r=0.234$ NS). Tiller number was not correlated with % yield reduction in any of the three experiments, or with oat yield in the 1991 or 1992 Kernen experiments. A correlation was present between crop tiller number and oat yield in the 1992 Campus experiment ($r=0.62^*$).

Table 2. Weed Density Effects on Tiller and Spike Numbers.

	Tillers no./m²	Spike no./m²	Tiller Mortality %
Control	501.2	368.9	26.1
48 m²	398.5	275.1	30.3
96 m²	332.9	215.1	34.8
LSD(0.05)	54	56	3.8

A combined analysis of variance revealed the presence of significant ($p=0.01$) weed density x genotype interactions for wheat grain yield. There were large differences in yield potential among the genotypes under weed-free conditions, and large differences in ability to maintain that yield in the presence of competition from weeds. A significant ($p=0.01$) experiment x weed density x genotype interaction indicated that the ability of the genotypes to maintain their yield under conditions of weed competition varied to some degree with environmental conditions. However, some genotypes were consistently poor performers when grown in the presence of weeds in all experiments while others were consistently superior. Mean genotypic yield reductions ranged from 36 to 52 % (Table 3) .

Significant differences were also detected among the genotypes in their ability to suppress weed growth as measured by seed yield of the two weed species (Table 3). A significant (p=0.05) experiment x genotype interaction for oat yield was also detected indicating that the suppressive ability of some wheat genotypes towards oat varied with environment. Suppression of weed growth was strongly correlated with % crop yield reduction (pooled r=0.67** for both oat and mustard yield).

Table 3. Genotype Means. Yield Wheat, Oat, Mustard, and selected wheat characteristics.

	Wheat Yield g/m²				Weed Yield[z] g/m²		GC %	TILL. no./m²	HT. cm
	0	48m²	96m²	%loss[z]	Oat	Must.	Wheat		
TYT5-5[y]	390	284	212	36	222	36	33.5	324	88
TYT5-6	395	244	180	46	250	46	29.3	351	72
TYT5-7	487	284	191	51	261	45	34.3	470	70
TYT5-11	439	250	173	52	275	46	32.7	451	69
TYT5-12	389	257	202	41	221	32	35.6	414	92
TYT5-14	423	278	198	44	237	39	31.1	394	86
TYT5-17	441	281	196	46	233	44	35.0	456	74
TYT5-20	406	264	201	43	226	38	35.3	381	91
TYT6-2	468	292	224	45	222	39	34.9	439	97
TYT6-4	458	315	234	40	213	36	37.8	360	100
TYT6-6	463	317	239	40	213	31	39.0	470	91
TYT6-8	472	299	211	46	258	44	32.8	376	75
TYT6-11	479	314	226	44	221	36	35.0	464	98
TYT6-12	473	277	192	50	274	42	30.7	381	85
TYT6-16	459	277	206	47	240	34	34.8	425	94
TYT6-17	487	333	228	42	224	37	31.5	417	93
LSD(0.05)	36	36	36		28	6	3.4	35	10

z mean of the two weed densities
y TYT5 lines = M1417/Ingal, TYT6 lines = M1417/Neepawa
GC = ground cover, Till. = tillers, HT. = crop height

The wheat genotypes were originally selected for differential tillering abilities and were classified as either high or low tillering a priori, consequently single degree of freedom contrasts were used to determine the effect of tillering capacity on the ability to maintain yield in the presence of weeds and to suppress weed growth. Contrasts revealed a significant cross x tillering class interaction for wheat yield in the presence of weeds versus weed-free conditions. The high tillering M1417/Ingal lines were higher yielding than the low tillering lines in absence of weeds while the low tillering lines were higher yielding when grown with weeds. The reverse was true with the M1417/Neepawa lines. The low tillering TYT6 lines were the highest yielding when no weeds were present, but tended to suffer larger yield reductions when grown with weeds, yielding less than the high tillering lines under those conditions.

There was also a significant cross x tillering class interaction for weed growth. The high tillering M1417/Ingal lines allowed greater weed growth (both oat and mustard) than did the low tillering M1417/Ingal lines. The high tillering M1417/Neepawa lines, however were more suppressive of weed growth than the low tillering lines.

The sixteen wheat genotypes were quite variable with respect to height. Height was correlated with wheat yield reduction (pooled r=-0.53**) and oat yield (pooled r=-0.62**), however the strength of the correlation was much higher in the 1991 Kernen experiment than the two 1992 experiments. Height was also significantly correlated with mustard yield, r=-0.95** and r=-0.47* in the 1991 and 1992 Kernen experiments respectively. Correlation coefficients were not pooled because of heterogeneity.

Flag leaf length was correlated with wheat yield reduction (pooled r=-0.40*) and oat yield (pooled r=-0.37*).

LAI in the weed free controls was positively correlated with wheat yield under weed-free conditions (pooled r=0.72**) but not with wheat yield reductions or weed yield.

Based on the results of this study it appears that the relationship between selected wheat morphological traits and competitiveness is a complex one and that no single morphological character can account for all the observed variability in competitive ability. Of all measured traits height appears to play a critical role as all the the very short genotypes tended to suffer large yield reductions and allow greater weed growth. Among the mediun to tall genotypes there was much variability in yield reduction and weed growth. The reduced strength of the correlations between wheat yield reduction or weed yield with height in the two experiments in 1992 suggests that the nature of competition between wheat genotypes and weeds was somewhat different in the two years. Height should play an important role in the preferential interception of light and the moist conditions in 1991 (sowing date to date of wheat mean spike emergence precipitation, 195 mm) may have increased the level of competition for light by promoting leaf area development. As a result of the considerably drier conditions in 1992 (sowing date to date of mean wheat spike emergence precipitation was 78 and 63 mm for the Kernen and Campus experiments respectively) competition may have been more intense for other environmental factors, perhaps stored soil moisture.

Early rapid growth and expansion of the crop canopy should enable it to capture more of the available environmental resources. The negative correlation between early wheat ground cover and five week wheat dry matter accumulation with wheat yield reduction and weed growth provides evidence of this.

The relationship between tillering and competitive ability is complex. The high tillering M1417/Ingal genotypes were among the shortest in the experiment and suffered greatly from the effects of competition. The low tillering lines tended to have longer larger leaves and some initially exhibited faster rates of growth, both characters which are associated with competitive ability. In addition, others (Morishita & Thill,1988) have found that in barley, main stem yields were less affected by weed competition than tiller yields. Since low tillering genotypes carry a greater portion of their total yield in the main stem, this may make them less susceptible to the effects of competition. However, several of the low tillering M1417/Neepawa lines were severely affected by weed competition. These lines were also fairly short and initially slow growing. In general the high tillering M1417/Neepawa lines were quite suppressive of weed growth.

In summary, it is apparent that competitive ability is a complex resulting from the interaction of many traits. Different wheat genotypes may achieve a competitive advantage through varying trait combinations. Differences do exist among genotypes in their ability to suppress weed growth and maintain yield in the presence of these weeds. These genotypic differences might be exploited in order to develop crop cultivars for situations where efficient control of weeds by other methods is not feasible.

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