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Conclusions

- Tillers are important yield components of Kansas wheat varieties and provide about two-thirds to three-fourths of the grain yield.
- All wheat varieties adapted to Kansas that were tested have potential to develop numerous tillers.
- Over one-half of the tillers that were initiated developed a spike and produced grain.
- Some plant traits, such as the number of kernels per spike, may be inversely related to the number of tillers in wheat.

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RELATIONSHIP BETWEEN TILLERING AND GRAIN YIELD OF KANSAS WHEAT VARIETIES

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Tillers are shoots that arise from buds in the axils of plant leaves. Primary tillers in grasses come from the main stem, and secondary tillers form from primary tillers. Wheat generally begins to tiller after two or three leaves develop on seedlings, and about one new tiller emerges with each additional leaf. In winter wheat, tillers can develop during autumn and when growth resumes during spring. Tillers are an important part of the wheat plant. Grain yield depends on plants per area, tillers per plant, kernels per tiller, and weight per kernel. Therefore, tillering is essential for productivity. Studies estimate that under normal conditions, approximately 30 to 50% of the grain yield of wheat comes from the main stem and 50 to 70% comes from the tillers. However, only some tillers produce grain; others fail to develop a spike (head) and die before the main stem matures.

The ability to tiller gives wheat considerable adaptability to changing conditions. Moisture and nitrogen fertilizer, for instance, increase grain yield to a large extent by stimulating the development and survival of tillers. Planting wheat within the optimum period promotes tillering, whereas delaying planting disfavors tillering and necessitates an increase in the seeding rate. In Kansas, the optimum date ranges from September 10-20 in the northwest to October 5-20 in the southeast.

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Although tillers contribute substantially to the productivity of wheat, little is known about differences in tillering habit among Kansas wheat varieties and the relationship of tillering to grain yield. The objective of these experiments was to measure tiller development and survival, and establish their relationship to grain yield of several popular wheat varieties in Kansas.

Procedures

The experiments used plots in the Kansas Intrastate Wheat Nursery at Hutchinson and Manhattan during the 1995-96 crop season. Plots at Hutchinson were on a Clark clay-loam soil that had a soybean-wheat rotation, and those at Manhattan were on a Muir silt-loam soil that had a soybean-oat-wheat rotation. The seven wheat varieties in the study were planted in early October 1995 at 60 lbs/a of seed in plots that contained six rows 9 in apart and 30 ft long. The plots were arranged in randomized complete block designs with four replications. Plots at both locations were fertilized with 70 lbs N/a and 25 lbs P/a before planting in 1995 and 50 lbs N/a in late February 1996.

Two 20-in.-long sections were marked randomly from the four inner rows of each plot in early spring 1996. The number of tillers in each section was counted at three developmental stages of the wheat, late boot (Feekes stage 9-10), early grain milk stage (Feekes stage 10.5.4), and late grain dough stage (Feekes stage 11.2). The Feekes stage system is a measure of the developmental stage of small grains and goes from Feekes stage 1 (one shoot) to 11.4 (grain ripe). Plants at Feekes stage 9-10 had the maximum number of tillers, since formation of tillers was complete but senescence had not started. The count at Feekes stage 11.2 only included productive tillers that contained grain. Both the main stems and tillers were designated as “tillers” because of the difficulty in distinguishing them.

Areas of 5.5 yd^2 at Hutchinson and 6.1 yd^2 at Manhattan were harvested from each plot with a small combine when the grain was ripe in late June. Grain yield was adjusted to 12% moisture. A sample of 1,000 kernels from each plot was weighed for kernel weight, and the average number of kernels per spike was calculated from the data for productive tillers at Feekes stage 11.2, grain yield, and kernel weight. Analysis of variance and Pearson phenotypic correlations were calculated with the SAS statistics program (SAS Institute, Cary, NC).

Moisture was adequate for germination and excellent stands were produced during early autumn 1995, but moisture was then sparse for growth until May 1996. Temperatures fluctuated greatly during winter and early spring, and subfreezing conditions (-2 °F) during March 7-10, 1996, may have affected tiller survival at Hutchinson. Yield losses from plant diseases were estimated as 2.1%.

Results

Number of tillers was similar for all varieties at each developmental stage at Hutchinson (Table 1). However, the average number of tillers declined substantially from one stage to another. Approximately 29% of the tillers senesced between Feekes 10 and 10.5.4, and an additional 13% senesced between Feekes stages 10.5.4 and 11.2. Thus, at this location,only 58% of the tillers that developed survived to produce grain.

If it is assumed that 80% of the seed developed a seedling that emerged to become a plant, the average plant density at Hutchinson was about 160 plants/yd^2. Therefore, in addition to the main stem, each plant averaged 4.6 tillers at Feekes stage 10 and 2.2 tillers at Feekes stage 11.2.

Tiller numbers were generally greater at Manhattan than at Hutchinson and differed among the varieties during the last two developmental stages (Table 1). Approximately 33% of the tillers senesced between Feekes stages 9 and 10.5.4, and an additional 13% senesced between stages 10.5.4 and 11.2, for an average survival of 54%. The variety Agseco 7853 had a large number of tillers, and Custer had a low number at stage 10.5.4, whereas Ike had a large number and Jagger had a low number of tillers at stage 11.2 at the Manhattan location. Using the same assumptions as above, each plant main stem had an average of 7.2 tillers at stage 9 and 3.4 tillers at stage 11.2.

Grain yields averaged 60.9 bu/a and were similar for all varieties at Hutchinson (Table 2). Yields at Manhattan ranged from 71.6 bu/a for Karl 92 to 88.6 bu/a for 2137 and averaged 76.6 bu/a for all varieties. Ike had the least and Jagger had the most kernels per spike at both study locations (Table 2). The number of kernels per yd^2, the product of the number of spikes at stage 11.2 and the number of kernels per spike, ranged from 9,662 to 11,544 at Hutchinson and from 10,642 to 13,120 at Manhattan. Karl 92 had the least and 2137 had the most kernels per yd^2 at both locations. Kernel weights ranged from 29.2 mg for 2163 to 36.5 mg for Agseco 7853 at Hutchinson, and from 33.6 mg for Jagger to 39.8 mg for Agseco 7853 at Manhattan.

Some significant relationships occurred among the plant characteristics at both locations (Table 3). The number of productive tillers at stage 11.2 was positively correlated with the maximum number of tillers at stage 10 and the kernel weight, but was negatively correlated with the number of kernels per spike at Hutchinson. Kernels per spike also was positively correlated with kernels per yd^2 and negatively correlated with kernel weight at Hutchinson. Both the maximum number of tillers and the number of productive tillers were negatively correlated with the number of kernels per spike at Manhattan. Grain yield and the number of kernels per yd^2 were positively correlated.

Table 1. Tiller number of seven wheat varieties during three developmental stages at Hutchinson and Manhattan, Kansas during 1996.

	Tiller number (no/yd^2)					
	Hutchinson			Manhattan		
Wheat variety	Feekes 10	Feekes 10.5.4	Feekes 11.2	Feekes 9	Feekes 10.5.4	Feekes 11.2
Agseco 7853	911	633	559	1410	1002	717
Custer	797	612	503	1196	774	608
Ike	882	582	538	1380	919	816
Jagger	840	635	443	1156	838	571
Karl 92	1018	720	565	1433	883	739
2137	933	633	532	1341	876	754
2163	867	635	491	1213	805	697
Average	893	636	519	1308	871	700
LSD (0.05)	NS	NS	NS	NS	95	94

Table 2. Grain yields, kernels per spike, and kernel weights of seven wheat varieties at Hutchinson and Manhattan, Kansas during 1996.

	Grain yield (bu/a)		Kernels/spike (no.)		Kernel wt (mg)	
Wheat variety	Hutchinson	Manhattan	Hutchinson	Manhattan	Hutchinson	Manhattan
Agseco 7853	64.7	73.3	17.8	17.4	36.5	39.8
Custer	56.9	78.1	20.2	20.2	31.5	35.6
Ike	60.3	73.6	18.9	14.2	33.3	35.6
Jagger	59.9	74.5	25.4	21.8	29.9	33.6
Karl 92	59.0	71.6	17.1	14.4	34.5	35.4
2137	67.3	88.6	21.7	17.4	32.7	37.9
2163	58.3	76.3	22.8	17.4	29.2	35.3
Average	60.9	76.6	20.6	17.5	32.5	36.2
LSD (0.05)	NS	9.6	——	——	2.3	1.6

Discussion

The high maximum number of tillers — 4.6 and 7.2 per plant at Hutchinson and Manhattan, respectively — demonstrated the ability of Kansas wheat varieties to tiller. The survival of over half of the tillers to produce grain makes them an important component of the yield potential of wheat. If the main stems and tillers produce similar amounts of grain per spike, about 69% of the total grain yield at Hutchinson and 77% of the total yield at Manhattan came from the surviving tillers. However, these should be considered maximum values because the spike of the main stem usually produces more grain than the spike of the tillers.

The number of productive tillers might appear to be unimportant since it was not correlated with grain yield at either location. Lack of any relationship might be expected at Hutchinson because the grain yields were similar for all varieties. While the number of tillers was not correlated with grain yields at Manhattan, it was a critical factor in the number of kernels per yd^2, which was correlated with yield at that location. This relationship suggested that tiller number is both an important yield component in wheat and, at least in part, a determinant of the difference in yield potential among varieties.

The highly significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other factor. As seen at Manhattan, grain yield is usually directly related to the number of kernels per yd^2, the product of productive tillers times kernels per spike. The strong negative relationship between productive tillers and kernels per spike complicates increasing grain yield by increasing the number of tillers by breeding, or by increasing the seeding rate.

Tillers that fail to survive to develop spikes obviously do not contribute directly to grain yield. However, other research suggests that they might contribute indirectly besides making the plant adaptable to different conditions. When the tillers are young and actively growing, nutrients from their photosynthesis may be translocated to other plant parts to enhance growth. When the non-surviving tillers senesce and die, nutrients, such as nitrogen, phosphorus, and potassium, that are stored in their tissues are absorbed by the surviving tillers to increase their yield potential. In this way, all the tillers that develop on wheat contribute in one way or another to grain yield.

Table 3. Pearson phenotypic correlation coefficients among maximum tiller number (Feekes 9-10), productive tiller number (Feekes 11.2), grain yield, kernels per spike, kernels per yd², and kernel weight of seven wheat varieties at Hutchinson and Manhattan, Kansas during 1996.

	Correlation coefficient (r)				
Factor	Productive tillers	Grain yield	Kernels/ spike	Kernels/ yd²	Kernel wt
			Hutchinson		
Maximum tillers	0.713*	0.376	0.555	0.296	0.568
Productive tillers		0.364	0.936**	0.647	0.873**
Grain yield			0.074	0.310	0.479
Kernels/spike				0.869**	0.853**
Kernels/yd²					0.685
			Manhattan		
Maximum tillers	0.540	0.172	0.867**	0.412	0.480
Productive tillers		0.063	0.928**	0.290	0.430
Grain yield			0.206	0.717*	0.275
Kernels/spike				0.614	0.259
Kernels/yd²					0.367

*, ** Significant at 0.05 and 0.01 levels of probability, respectively.