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Conclusions

- Planting date greatly affects grain yield of wheat by influencing development and survival of tillers.
- Early planting causes excessive tillers, which have low survival, low harvest index, and low grain yield.
- Late planting causes inadequate fall tillers, which are not compensated for by spring tillers that have a low harvest index and low grain yield.
- Planting wheat within the optimum period promotes development and survival of fall and spring tillers that have high harvest index and high grain yield.

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PLANTING DATE EFFECTS ON TILLER DEVELOPMENT AND PRODUCTIVITY OF WHEAT

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Much of the grain yield of wheat occurs on tillers that develop from buds in the axils of lower leaves. Under normal conditions, as much as 70% of the grain yield comes from the tillers. Tillering also enables the plant to adapt to different conditions. Few tillers develop when moisture, nutrition, and other conditions are poor, whereas numerous tillers that increase the yield potential form when conditions are favorable.

Date of seeding greatly affects development of tillers in winter wheat. Seeding during the optimum period, which ranges from September 10-20 in northwestern Kansas to October 5-20 in southeastern Kansas, enables wheat to form sufficient but not excessive tillers. Early seeding results in too many fall tillers, which may compete with each other, become diseased, and deplete soil moisture so that grain yields are low. Late seeding gives plants little time to develop tillers, resulting in inadequate numbers of spikes (heads) for high yields the following spring.

Senescence and death might eliminate excessive tillers that form during the fall. Conversely, if too few tillers develop during fall, additional tillers may form during spring. However the yield potential may differ between tillers that develop during fall and those that develop during spring. The objective of this experiment was to determine the effect of fall seeding date on development and survival of tillers during the fall and spring and to measure the productivity of fall tillers and spring tillers of winter wheat.

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Table 3. Mean plot grain yield and kernel weight of Jagger and 2137 wheat varieties planted on four dates.

Planting date (1995)	Grain yield (bu/a)	Kernel weight (mg)
Sept. 28	39.0	24.2
Oct. 11	57.7	29.3
Oct. 28	54.8	29.1
Nov. 13	30.2	27.7
LSD (0.05)	4.9	2.8

Table 4. Correlation coefficients among survival and yield characteristics of Jagger and 2137 wheat varieties planted on four dates.

	Correlation coefficient (r)							
	Fall tillers		Spring tillers					
Factor	Surviving	Productive	Maximum	Productive	Total spikes	Grain yield	Kernel wt	Kernels/yd²
Maximum fall tillers	0.948**	0.847	0.572	-0.121	0.725	0.119	-0.611	0.421
Surviving fall tillers		0.963**	0.660	-0.099	0.840	0.320	-0.365	0.551
Productive fall tillers			0.721	-0.032	0.903*	0.510	-0.101	0.660
Maximum spring tillers				0.667	0.949*	0.844	0.075	0.981**
Productive spring tillers					0.401	0.705	0.282	0.718
Total spikes						0.770	0.028	0.914*
Grain yield							0.598	0.932*
Kernel wt								0.266

*,** Significant at 0.10 and 0.05 levels of probability, respectively.

Procedures

The experiment was conducted on Clark clay-loam soil in a soybean-wheat rotation at Hutchinson, Kansas. Two hard red winter wheat varieties, Jagger and 2137, were planted on four dates in the fall of 1995 (Table 1). The first date, September 28, was during the early part of the recommended period, September 25 to October 20. The second date, October 11, was one day after the Hessian fly-free date, and the last two dates, October 28 and November 11, were after the recommended period. Wheat varieties were planted at 60 lbs/a of seed in plots with six rows 8 in. apart and 30 ft long. Plots received 70 lbs N/a and 25 lbs P/a before planting and 50 lb N/a in late February 1996. The experiment was arranged in a randomized complete block design with four replications.

A 12-in.-long segment was randomly marked in the four inner rows of each plot when plants emerged. The numbers of plants in each segment were counted, and the newest leaves of the main shoots and tillers identified with a permanent marker throughout the fall and winter. Tillers that developed until March 5, when plants came out of dormancy, were considered fall tillers. Main shoots were also designated as tillers because of difficulty in distinguishing them as the season progressed. Fall tillers were periodically re-marked until the jointing stage, when they were labeled with a plastic tag. Tillers that developed after March 5 were considered spring tillers and were not marked or tagged. All tillers in the plots were counted on April 23, when the wheat was at the late boot stage and the maximum number of spring tillers had developed.

Plants in the four, 12-in.-long marked segments in each plot were cut at ground level in late June 1996. The plants were separated into fall and spring tillers, dried, and weighed. The number of spikes and spikelets in each 12-in. segment were counted, and grain was threshed, weighed, and counted. Grain from the remaining plants in the plots was harvested with a small combine, dried to 12% moisture content, and weighed. A 1000-kernel subsample was counted and weighed to determine the kernel weight.

The maximum number of fall tillers was recorded when it occurred during the fall or winter, and the surviving number of fall tillers and maximum number of spring tillers were recorded on April 23. Productive tillers of both types were those that continued to develop a spike with grain, as noted at harvest. Harvest index was calculated as the ratio of the weight of the grain to the total plant weight of fall and spring tillers in the 12-in. row segments. Analyses of variance and correlation coefficients were calculated with SAS (SAS Institute, Cary, NC).

Moisture and temperature conditions varied during the 1995-96 crop season. Soil moisture was adequate for establishing stands but was then limited until May. Temperatures fluctuated throughout the winter. Over 300 growing degree days accumulated during the period, but warm spells followed by subfreezing conditions damaged some plants, particularly of Jagger. Damage to fall tillers may have stimulated development of spring tillers in some cases. Disease and insect incidence was very low throughout the growing season.

Results

Data for Jagger and 2137 were pooled, since results for the two varieties were similar. Nearly equal numbers of seedlings emerged after all planting dates except October 11, when considerably more plants occurred (Table 1). Plants from the first two dates tillered profusely, developing most of their tillers before they became dormant in late fall. Plants from the latter two seedings did not form any tillers before they became dormant, but those from the October 28 seeding developed a few tillers over winter. Only 46 and 65% of the fall tillers on plants from the first two dates, respectively, survived the winter, whereas 100% of the fall tillers on plants from the last two dates survived. About 50 to 60% of the surviving fall tillers from the first two dates formed spikes, while approximately 80% of the surviving tillers from the last two dates produced grain.

Plants from the first three seeding dates developed nearly 600 spring tillers/yd^2, but plants from the last date formed only 213 spring tillers/yd^2 (Table 1). About 30% of the spring tillers from the first two dates, 45% of the spring tillers from the third date, and 68% of the spring tillers from the fourth date produced grain. The total number of productive spikes ranged from 260 to 552/yd^2 or 1.8 tillers per plant from the last seeding to 3.4 tillers per plant from the first seeding.

Weight of both the straw and grain was greater for productive fall tillers than for productive spring tillers (Table 2). The straw and grain weighed most on fall tillers from the October 28 planting, and the grain weight was lowest on spring tillers from the first and last plantings. The harvest index was generally high for both fall and spring tillers from the second and third planting dates and was low for fall and spring tillers from the first planting and spring tillers from the last planting.

Kernel number per spike was always higher for fall tillers than for spring tillers from the same planting date. Fall tillers from the October 28 planting formed most kernels, while spring tillers from the first and last plantings formed the least kernels. Kernel weight did not differ significantly among planting dates or between fall and spring tillers.

Grain yields were highest for plots seeded on October 11 and 28 and were lowest for plots seeded on November 13 (Table 3). Kernel weights were high for the plots that had high yields and were low for plots that had low yields.

The number of surviving fall tillers was significantly correlated with the number of maximum fall tillers and productive fall tillers (Table 4). Total spikes was positively correlated with the number of productive fall tillers, maximum spring tillers, and kernels/yd^2. Kernels/yd^2 was also correlated with maximum spring tillers and was the only trait that was correlated with grain yield.

Table 1. Mean date and number of plants that emerged; maximum, surviving, and productive fall tillers; maximum and productive spring tillers; and total productive spikes by Jagger and 2137 wheat varieties planted on four dates.

Date (1995)		Plants	Fall tillers (no/yd^2)			Spring tillers (no/yd^2)		Total spikes
Planting	Emergence	(no/yd	Maximum	Surviving	Productive	Maximum	Productive	(no/yd^2)
Sept. 28	Oct. 12	141	1266	578	281	584	195	476
Oct. 11	Oct. 18	207	916	594	360	659	192	552
Oct. 28	Nov. 15	141	183	183	152	600	272	424
Nov. 13	Nov. 30	143	147	147	117	213	144	260
LSD (0.05)		38	136	191	92	147	53	106

Table 2. Mean weight of straw and grain, harvest index, kernels per spike, and kernel weight of productive tillers developed during fall and spring by Jagger and 2137 wheat varieties planted on four dates.

Planting date (1995)	Fall/spring tillers	Tiller wt (g)		Harvest index	Kernels/spike (no.)	Kernel wt (mg)
		Straw	Grain			
Sept. 28	Fall	0.92	0.48	0.34	23.6	20.2
	Spring	0.78	0.38	0.33	20.3	18.7
Oct. 11	Fall	0.95	0.77	0.45	27.8	27.6
	Spring	0.82	0.66	0.44	24.7	26.6
Oct. 28	Fall	1.13	0.95	0.46	34.3	27.6
	Spring	0.89	0.68	0.43	28.1	24.3
Nov. 13	Fall	0.98	0.73	0.43	27.5	26.5
	Spring	0.79	0.42	0.35	17.8	23.9
LSD (0.05)		0.08	0.08	0.03	3.4	NS

Discussion

Planting date greatly affected grain yield of wheat by influencing the development and survival of tillers. Adequate seedlings emerged after all planting dates for high yields the following spring, but differences in tillering determined the effect on yield. Marked differences in grain yield between fall tillers and spring tillers demonstrated the importance of time of tiller formation, as well as the number that formed.

Early planting on September 28 promoted high levels of tillering during both fall and spring. However, the low percentage that formed spikes indicated that competition among the numerous tillers was intense. This intense competition was further illustrated by the low harvest indices of both fall and spring tillers, which indicated that less carbohydrates and other nutrients were partitioned to the grain than under the other planting dates.

High yields were obtained after the intermediate planting dates, but the processes differed. Plots planted on October 11 combined excellent emergence, a high number of productive fall tillers, and high harvest indices of both fall and spring tillers to produce a high grain yield. Fall tillers were particularly important: 69% of the total grain yield came from them and only 31% came from spring tillers.

Spring tillers were most important in plots seeded on October 28. A high percentage of the fall tillers were productive, but the number was too low to produce high grain yields. However, the plants tillered profusely during the spring and had a high harvest index. In contrast with the October 11 planting, 44% of the grain yield was from fall tillers and 56% from spring tillers.

Plots seeded on November 13 tillered inadequately during both fall and spring and had too sparse of a stand to produce a high yield of grain. The low number of tillers demonstrated the need for increasing the seeding rate when wheat is planted late. Tillers that developed during the fall were mostly main shoots. They had a high total tiller weight and harvest index and produced 59% of the total grain yield. Spring tillers, on the other hand, had a low weight and low harvest index and produced only 41% of the grain yield. The low number, weight, and harvest index prevented spring tillers from compensating for the inadequate fall tillering.

It is clear that planting date greatly affects yield of wheat, and much of that effect occurs through the development, survival, and harvest index of tillers. Planting during the optimum period encourages tillering during fall and spring, reduces competition among tillers, and promotes a high harvest index. Early planting causes excessive tillering, increases competition, and leads to a low harvest index. Late planting decreases tillering during fall and spring and causes tillers that develop during spring to be small with a low harvest index.