1998

Relationship between Tillering and Grain Yield of Kansas Wheat Varieties

D. E. Thiry
Rollin G. Sears
James P. Shroyer
Gary M. Paulsen

Follow this and additional works at: https://newprairiepress.org/kaesrr

Recommended Citation
Relationship between Tillering and Grain Yield of Kansas Wheat Varieties

Keywords
Keeping up with research; SRL 122 (Oct. 1998); Kansas Agricultural Experiment Station contribution; no. 99-112-S; Tillering; Grain yield; Kansas wheat varieties

Creative Commons License
This work is licensed under a Creative Commons Attribution 4.0 License.
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.

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.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Productive tillers</th>
<th>Grain yield</th>
<th>Kernels/spike</th>
<th>Kernels/yd²</th>
<th>Kernel wt</th>
<th>Hutchinson</th>
<th>Manhattan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum tillers</td>
<td>0.713*</td>
<td>0.376</td>
<td>0.867**</td>
<td>0.412</td>
<td>0.480</td>
<td></td>
<td>0.540</td>
</tr>
<tr>
<td>Productive tillers</td>
<td>0.364</td>
<td>0.936**</td>
<td>0.928**</td>
<td>0.290</td>
<td>0.430</td>
<td></td>
<td>0.063</td>
</tr>
<tr>
<td>Grain yield</td>
<td>0.074</td>
<td>0.310</td>
<td>0.717*</td>
<td>0.614</td>
<td>0.259</td>
<td></td>
<td>0.206</td>
</tr>
<tr>
<td>Kernels/spike</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.685</td>
<td>0.614</td>
</tr>
<tr>
<td>Kernels/yd²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.367</td>
</tr>
</tbody>
</table>

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

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.

*Former graduate student, former professor, and professors, Department of Agronomy, respectively.

Kansas State University Agricultural Experiment Station and Cooperative Extension Service

Copyright © 2002

Table of contents

1. Introduction
2. Methodology
3. Results
4. Discussion
5. Conclusion
6. References

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.

The number of tillers was similar for all varieties at each developmental stage at Hutchinson (Table 1). However, the average number of tillers differed by location. Approximately 29% of the tillers senesced between Feekes 10 and 11.2. This percentage was distributed between Feekes stages 10.4 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 360 plant-yd². In addition, 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. The number of tillers that developed survived to produce grain. 

Number of tillers

<table>
<thead>
<tr>
<th>Variety</th>
<th>Feekes 9</th>
<th>Feekes 10</th>
<th>Feekes 11.2</th>
<th>Feekes 10.5.4</th>
<th>Feekes 11.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agseco 7853</td>
<td>101</td>
<td>68</td>
<td>2.2</td>
<td>29.2</td>
<td>35.3</td>
</tr>
<tr>
<td>Custer</td>
<td>91</td>
<td>63</td>
<td>53</td>
<td>116</td>
<td>77</td>
</tr>
<tr>
<td>Ike</td>
<td>88</td>
<td>58</td>
<td>53</td>
<td>130</td>
<td>95</td>
</tr>
<tr>
<td>Jagger</td>
<td>40</td>
<td>63</td>
<td>43</td>
<td>116</td>
<td>83</td>
</tr>
<tr>
<td>Karl</td>
<td>103</td>
<td>72</td>
<td>56</td>
<td>143</td>
<td>83</td>
</tr>
<tr>
<td>Custer</td>
<td>91</td>
<td>63</td>
<td>53</td>
<td>116</td>
<td>77</td>
</tr>
<tr>
<td>Ike</td>
<td>88</td>
<td>58</td>
<td>53</td>
<td>130</td>
<td>95</td>
</tr>
<tr>
<td>Jagger</td>
<td>40</td>
<td>63</td>
<td>43</td>
<td>116</td>
<td>83</td>
</tr>
<tr>
<td>Karl</td>
<td>103</td>
<td>72</td>
<td>56</td>
<td>143</td>
<td>83</td>
</tr>
</tbody>
</table>

The highly significant negative correlation between the number of productive tillers and kernels per spike at both study 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 yd², the number 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, the results suggest that they might contribute indirectly because they are increasing genetic variation for grain yield. In this way, the tillers that do not contribute directly to grain yield at Mannington, it was a critical factor in the number of kernels per yd².

Table 2. Tiller number of seven wheat varieties during three developmental stages at Hutchinson and Manhattan, Kansas during 1996.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Feekes 9</th>
<th>Feekes 10</th>
<th>Feekes 11.2</th>
<th>Feekes 10.5.4</th>
<th>Feekes 11.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agseco 7853</td>
<td>101</td>
<td>68</td>
<td>2.2</td>
<td>29.2</td>
<td>35.3</td>
</tr>
<tr>
<td>Custer</td>
<td>91</td>
<td>63</td>
<td>53</td>
<td>116</td>
<td>77</td>
</tr>
<tr>
<td>Ike</td>
<td>88</td>
<td>58</td>
<td>53</td>
<td>130</td>
<td>95</td>
</tr>
<tr>
<td>Jagger</td>
<td>40</td>
<td>63</td>
<td>43</td>
<td>116</td>
<td>83</td>
</tr>
<tr>
<td>Karl</td>
<td>103</td>
<td>72</td>
<td>56</td>
<td>143</td>
<td>83</td>
</tr>
</tbody>
</table>

The highly significant negative correlation between the number of productive tillers and kernels per spike at both study 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 yd², the number 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, the results suggest that they might contribute indirectly because they are increasing genetic variation for grain yield. In this way, the tillers that do not contribute directly to grain yield at Hutchinson, it was a critical factor in the number of kernels per yd².

Table 2. Tiller number of seven wheat varieties during three developmental stages at Hutchinson and Manhattan, Kansas during 1996.

Areas of 5.5 yd² at Hutchinson and 6.1 yd² at Manhattan were harvested from each site 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 to determine harvest moisture. The number of tillers in each section was counted at three developmental stages of the wheat, late boot to 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 (all ears have flourished). Plots at Manhattan had an average of 2.2 tillers at stage 10.5.4, whereas Ike had a large number and Jagger had a low number of tillers at stage 11.2. The number of tillers that develop survive to produce grain.

Procedures

Seven species were grown on a clay-loam soil that had a soybean-oat-wheat rotation. The seven wheat varieties in the study were planted in early October 1995. A part of each plot was 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.

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-oat-wheat rotation. The seven wheat varieties in the study were planted in early October 1995.
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 yd² 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. The results support the notion that tillers suggest that they might contribute indirectly besides making the plant adaptable to different conditions. When the tillers are young and actively growing, nutrients from their leaves are translocated to the main stem and grains. 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 68% of the total grain yield at Hutchinson and 77% of the total yield at Manhattan came from the survival of tillers. In this way, all the tillers contribute in one way or another to increase their yield potential. The highly significant negative correlation between the number of productive tillers and kernels per spike at both the Kansas Intrastate Wheat Nursery at Hutchinson and the Manhattan, Kansas during 1996.

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 68% of the total grain yield at Hutchinson and 77% of the total yield at Manhattan came from the survival of tillers. In this way, all the tillers contribute in one way or another to increase their yield potential. 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 yd² 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. The results support the notion that tillers suggest that they might contribute indirectly besides making the plant adaptable to different conditions. When the tillers are young and actively growing, nutrients from their leaves are translocated to the main stem and grains. 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 68% of the total grain yield at Hutchinson and 77% of the total yield at Manhattan came from the survival of tillers. In this way, all the tillers contribute in one way or another to increase their yield potential. 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 yd² 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. The results support the notion that tillers suggest that they might contribute indirectly besides making the plant adaptable to different conditions. When the tillers are young and actively growing, nutrients from their leaves are translocated to the main stem and grains. 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 68% of the total grain yield at Hutchinson and 77% of the total yield at Manhattan came from the survival of tillers. In this way, all the tillers contribute in one way or another to increase their yield potential. 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 yd² 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. The results support the notion that tillers suggest that they might contribute indirectly besides making the plant adaptable to different conditions. When the tillers are young and actively growing, nutrients from their leaves are translocated to the main stem and grains. 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 68% of the total grain yield at Hutchinson and 77% of the total yield at Manhattan came from the survival of tillers. In this way, all the tillers contribute in one way or another to increase their yield potential. 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 yd² 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. The results support the notion that tillers suggest that they might contribute indirectly besides making the plant adaptable to different conditions. When the tillers are young and actively growing, nutrients from their leaves are translocated to the main stem and grains. 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 68% of the total grain yield at Hutchinson and 77% of the total yield at Manhattan came from the survival of tillers. In this way, all the tillers contribute in one way or another to increase their yield potential. 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 yd² 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.
The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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, the results here suggest that they might contribute indirectly besides making them an important component of the number of kernels per yd², 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.

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. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

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. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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.

The high significant negative correlation between the number of productive tillers and kernels per spike at both locations implied that increasing one factor decreases the other. As seen, Manhattan, grain yield is usually directly correlated with the number of kernels per yd², 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 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.

### 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.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Hutchinson</th>
<th>Manhattan</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maximum tillers</strong></td>
<td>0.713*</td>
<td>0.540</td>
</tr>
<tr>
<td><strong>Productive tillers</strong></td>
<td>0.074**</td>
<td>0.063</td>
</tr>
<tr>
<td>Grain yield</td>
<td>0.555</td>
<td>0.310</td>
</tr>
<tr>
<td>Kernels/spike</td>
<td>0.647</td>
<td>0.206</td>
</tr>
<tr>
<td>Kernels/yd²</td>
<td>0.873**</td>
<td>0.717*</td>
</tr>
<tr>
<td>Kernel wt</td>
<td>0.568</td>
<td>0.412</td>
</tr>
<tr>
<td><strong>Productive tillers</strong></td>
<td>0.364</td>
<td>0.063</td>
</tr>
<tr>
<td>Grain yield</td>
<td>0.867**</td>
<td>0.867**</td>
</tr>
<tr>
<td>Kernels/spike</td>
<td>0.853**</td>
<td>0.614</td>
</tr>
<tr>
<td>Kernels/yd²</td>
<td>0.480</td>
<td>0.259</td>
</tr>
</tbody>
</table>

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

### Trade names are used to identify products. No endorsement is intended, nor is any criticism implied of similar products not mentioned.

### Kansas State University Agricultural Experiment Station and Cooperative Extension Service

134

**RELATIONSHIP BETWEEN TILLERING AND GRAIN YIELD OF KANSAS WHEAT VARIETIES**

D.E. Thiry, R.G. Sears, J.P. Shroyer, and G.M. Paulsen*

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.