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INHIBITION OF WHEAT BY SORGHUM RESIDUE UNDER SEVERAL TILLAGE SYSTEMS

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Grain sorghum contains a number of compounds that suppress other plant species, an effect known as allelopathy. These toxic compounds, which include several phenolic acids; cyanogenic glycosides; and a hydroquinone, sorgoleone, occur in both the roots and the shoots of sorghum. After sorghum is harvested for grain, the compounds may leach from the residue into the soil and affect the germination, growth, and yield of the following crop.

Wheat often is double-cropped after sorghum in Kansas. The practice makes efficient use of the land and soil moisture, covers the soil to prevent erosion during winter, and provides income in the following year. However, the wheat may be injured and its yield reduced by allelopathic effects of the sorghum. Injury might be decreased by planting varieties of wheat that are resistant to allelopathy, but none have been identified.

Allelopathy also might be reduced by proper management of the sorghum residue. After the toxic compounds leach from the residue, they are degraded into harmless chemicals by microorganisms in the soil. Tillage of the residue undoubtedly affects leaching and degradation of the allelopathic compounds, but the most effective methods have not been determined.

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Information is needed to help producers avoid the problem of allelopathy in wheat. The objectives of these studies were to (1) ascertain the extent of allelopathic effects of sorghum on wheat, (2) identify wheat varieties that might be resistant to allelopathy, and (3) determine if tillage of sorghum residue affects the severity of allelopathy.

Procedures

Grain sorghum Taylor Evans Y-101G, a hybrid that is highly allelopathic to wheat, was planted in two blocks at the North Agronomy Research Farm in Manhattan in early June of 1996 and 1997. A third block was fallowed in both years, and a block of pearl millet hybrid 79-2068 x 89-0083, a crop that is not allelopathic to wheat, was planted in the second year to equalize soil moisture with that in the sorghum blocks. The sorghum and pearl millet were grown as recommended, and the grain of both crops was harvested in early October.

One of the sorghum blocks and the fallow block were tilled with two passes of a disc immediately after harvest. The other sorghum block and the pearl millet block were left untilled. Nitrogen fertilizer was applied as needed according to the soil analysis to equalize nutrients in all the blocks. Six hard red winter wheat varieties, Coronado, Jagger, 2137, Karl 92, Tomahawk, and Ike, and one soft red winter wheat variety, Cardinal, were planted at 90 lbs seed/a on all blocks in mid-October of both years and grown as recommended.

Wheat seedlings were counted weekly after planting until emergence ceased. The results were expressed as an emergence promptness index (EPI), which was calculated as the sum of the number of seedlings that emerged each week divided by the number of weeks after planting. A high EPI indicates that a large number of seedlings emerged rapidly; a low EPI indicates that seedlings emerged slowly.

The wheat was harvested with a grain bundler and threshed in July 1997 and with a plot combine in July 1998. The test weight and moisture content were measured with a grain analyzer, and yields were calculated at 13.5% moisture.

The experimental design was a completely randomized strip-plot with three replications. The tillage treatments were main plots, and the wheat varieties were subplots. All data were analyzed by standard procedures.

Weather conditions were favorable for sorghum and wheat during both years. Precipitation was generally ample and well distributed for establishing and growing the crops, and temperature was near normal with few extremes.

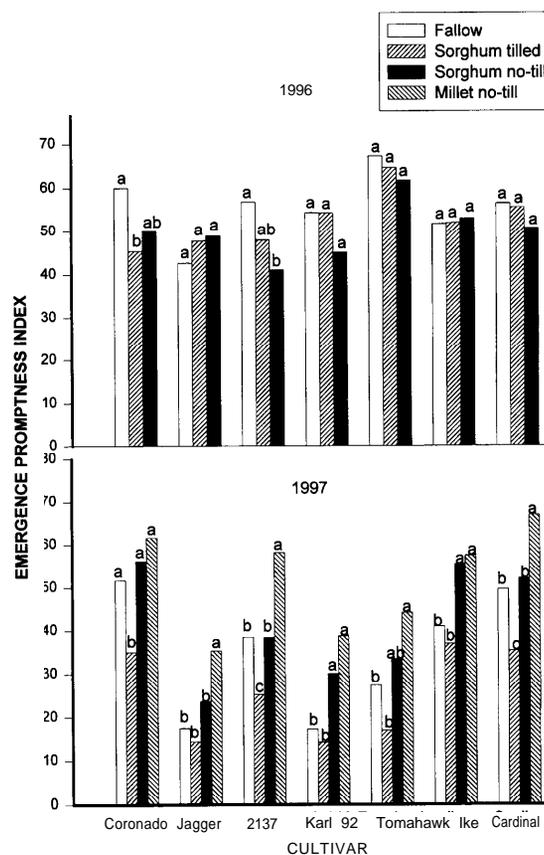


Figure 1. Emergence promptness indices of seven wheat varieties double-cropped after fallow and several sorghum and pearl millet residue-management treatments.

Results

Sorghum yielded 100 to 120 bu/a of grain and produced 5600 to 6700 lbs/a of stover in both years. Two passes with a disc in the tilled sorghum plots incorporated approximately 80% of the residue and left about 1200 lbs/a of stover on the soil surface when wheat was planted. The pearl millet yielded 80 to 100 bu/a of grain in the second year and left about the same amount of stover as the sorghum.

Residue treatment affected the EPI of only two wheat varieties, Coronado and 2137, in autumn 1996 (Fig. 1). Coronado emerged faster in plots that were previously fallowed than in plots that were planted to sorghum and tilled, and 2137 emerged faster in fallowed plots than in no-till sorghum plots. Emergence rates of all varieties differed among

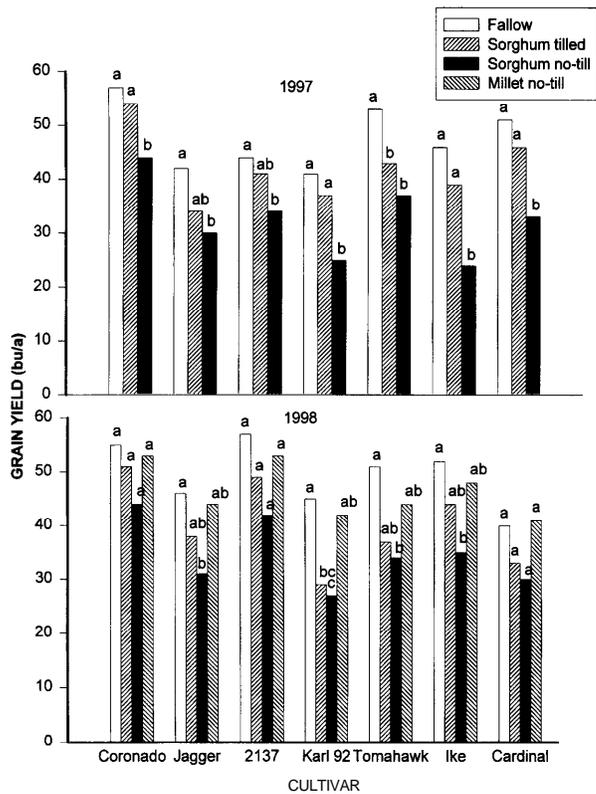


Figure 2. Grain yields of seven wheat varieties double-cropped after fallow and several sorghum and pearl millet residue-management treatments.

residue treatments in the second season (Fig. 1). All the varieties emerged faster in plots that were planted to pearl millet than in plots that were planted to sorghum and tilled. Four varieties emerged faster after no-till sorghum, and three emerged faster after fallow than after tilled sorghum.

Grain yields of all wheat varieties after fallow exceeded yields after no-till sorghum in 1997, and yields following tilled sorghum were usually intermediate (Fig. 2). Four of the varieties—Jagger, Karl 92, Tomahawk, and Ike—responded similarly in 1998, with higher grain yields after fallow than after no-till sorghum. Yields of the other varieties did not differ among the residue treatments.

Straw weights of the seven wheat varieties differed less than the grain yields (data not shown). Tomahawk had more straw after fallow than after both

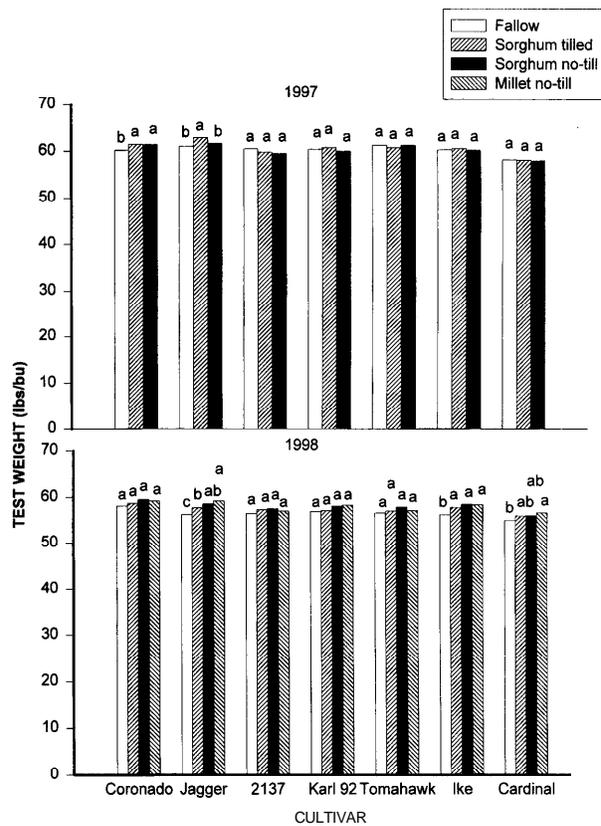


Figure 3. Grain test weights of seven wheat varieties double-cropped after fallow and several sorghum and pearl millet residue-management treatments.

sorghum-residue treatments in 1997, and Karl 92 and Ike had more straw after fallow than after tilled sorghum and no-till sorghum, respectively, in 1998.

Grain test weights of several wheat varieties were lower after fallow than after some residue treatments (Fig. 3). In 1997, Coronado had lower test weight after fallow than after both sorghum-residue treatments, and Jagger had lower test weight after fallow than after tilled sorghum. In 1998, Jagger and Ike both had lowest test weights after fallow, and Jagger also had lower test weight after tilled sorghum than after pearl millet.

Discussion

Favorable weather conditions and the lack of any effect of pearl millet eliminated moisture as a factor affecting yields, and application of nitrogen fertilizer eliminated soil fertility. Therefore, the 10 to 25% reductions in yields of most wheat varieties after no-till sorghum during one or both years of the study must be attributed to allelopathy.

Allelopathic compounds in sorghum that was tilled and incorporated into the soil probably were solubilized rapidly and delayed emergence of most wheat varieties. However, these compounds presumably degraded over time, allowing the wheat varieties to produce similar grain yields following tilled sorghum and fallow. Although emergence was delayed by tilled sorghum in many cases, the marked ability of wheat to compensate for differences in seedling development probably contributed to the absence of any effect on grain yield.

Responses of the wheat varieties to no-till sorghum differed substantially from the responses to tilled sorghum. The small effects of no-till sorghum on emergence of wheat during both autumns suggested that the allelopathic compounds were not released immediately into the soil. However, depressed wheat grain yields in the following summers indicated that the allelopathic compounds had been solubilized and leached from the sorghum stover during the winter and spring. Yields of all seven wheat varieties were reduced in the first year, and yields of four varieties were reduced in the second year after no-till sorghum compared with fallow, suggesting that they had little resistance to the allelopathy.

Higher grain test weights of several wheat varieties after residue than after fallow probably were due to compensation among the different components of grain yield. Residue apparently reduced yields by decreasing kernel numbers, which enabled the remaining kernels to grow larger and have higher test weights.

Our results suggest that the effect of sorghum residue on the following wheat crop depends in large part on the degree of decomposition of the stover before the wheat is planted. Prompt tillage of the stover after harvest of the sorghum could alleviate allelopathy by extending the duration for decomposition and, in many cases, enabling it to occur at a more favorable soil temperature before wheat is planted. Although it was not investigated by us, chopping the sorghum stover finely also could accelerate decomposition. The benefits of adequate soil moisture also suggest that irrigation of dry soil could promote decomposition and lessen the allelopathic effects of sorghum on wheat.

The advantages of practices that reduce allelopathy by sorghum must be weighed against the soil-conserving benefits of not tilling the stover. Tillage might not be compatible with conservation compliance plans that require specific amounts of plant residue on the soil surface.

Conclusions

- Allelopathy by toxic compounds in sorghum residue may reduce grain yield of double-cropped wheat by 10 to 25%.
- Tilled sorghum residue delayed emergence of wheat but had no allelopathic effects on grain yields.
- No-till sorghum residue did not affect emergence of wheat but frequently reduced grain yields.
- Tillage of sorghum residue to prevent allelopathic effects on wheat might not be compatible with conservation compliance plans.
- Little genetic resistance to allelopathy by sorghum is present in popular varieties of hard red winter wheat in Kansas.

Acknowledgements

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