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Fumonisin B_1 Levels in 1995 and 1996 Kansas Corn

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Fumonisins constitute a group of toxins produced by *Fusarium moniliforme*, *F. proliferatum*, and other *Fusarium* species commonly associated with corn and other cereal grains. Of the fifteen fumonisin analogues currently described (Plattner, 1995), three (FB_1, FB_2, and FB_3) have been reported to occur naturally at significant levels in corn and corn-based products (Sydenham et al. 1991, Doko et al. 1995). FB_1 is the most abundant and accounts for about 70% of the fumonisins in naturally contaminated corn samples and its effects on horses, swine, and other animals are well known (Ross et al. 1992).

Surveys in different parts of the world indicate the common occurrence of fumonisins. In the U.S.A., the FB_1 has been reported in several places. Stack and Eppley (1992) reported levels of FB_1 from 0.1 to 16 μg/g in corn and from 1 to 196 μg/g in corn screenings in Louisiana, Maryland, and Iowa. Murphy et al (1993) reported that FB_1 levels in corn from Iowa, Illinois, and Wisconsin ranged from 0 to 14.9, 0 to 37.9, 0 to 19.1, and 0 to 15.8 μg/g during the 1988, 1989, 1990, and 1991 crop years, respectively. They further reported that corn screenings contain about 10 times higher fumonisin contents than intact corn. In Indiana, Binkerd et al. (1993) reported FB_1 levels of 0 to 50 μg/g. This study was conducted to assess the level and distribution of FB_1 in Kansas corn and to compare the effects of cultivar, irrigation, and growing location on FB_1 levels.

MATERIALS AND METHODS

Samples were obtained from the corn performance tests conducted by the Kansas Agricultural Experiment Station, Kansas State University. One-hundred thirty samples were obtained from the 1995 harvest and 132 from the 1996 harvest. Samples were from dryland and irrigated plots on various experimental fields across the state.

Upon receipt of samples, moisture content was determined using a Motomco 919A moisture tester. Samples with high moisture content were oven-dried at 40°C to ≤13.0% (wet basis). Samples were passed over a 12/64" round aluminum sieve to remove dust, weed seeds, and other impurities. Samples were hand-cleaned of non-corn materials and stored at 5°C until processed.

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The corn was ground finely using a Romer Series II mill. To avoid contamination between samples, the first 50 g of each were discarded, then the sample for fumonisin analysis was collected. Ground samples were placed in plastic bags and stored at 5°C until analyzed.

Extraction procedures and FB_1 analysis were based on the quantitative Fumonitest® Immunoaffinity Column method from VICAM (Fumonitest Manual). The lower and upper detection limits of this methods were 1 and 5 μg/g, respectively. High performance liquid chromatography was used to confirm FB_1 levels on random samples (Stack and Eppley, 1992).

The FB_1 levels were analyzed using the General Linear Models (GLM) procedure for unbalanced data (Milliken and Johnson, 1992). Comparisons were made to determine whether FB_1 levels were affected significantly by year of harvest, variety, location, and irrigation. For comparison of the year of harvest, only locations with data for both years were included. To compare locations, data were grouped based on crop reporting districts in Kansas.

RESULTS AND DISCUSSION

Only 9% of Kansas corn samples and 2% of samples from 1996 contained ≤1 μg/g FB_1. Approximately 25 and 30% of the samples from 1995 and 1996 harvests, respectively, contained FB_1 levels from 1 to 5 μg/g over the years, more than 65% of the samples contained >5.0 μg/g FB_1 (Figure 1). The FB_1 levels ranged from <1 to 14.0 μg/g using the fumonitest method. The highest level of FB_1 (14.0 μg/g) observed in this study is similar to that in 1988 Iowa corn reported by Murphy et al. (1993). The levels obtained with the fumonitest method were higher (4.2 ± 3.7 μg/g) than the levels obtained using HPLC. Petska et al. (1994) reported higher fumonisin levels using enzyme-linked immunoassay method compared to HPLC and GC-MS (gas chromatography – mass spectrometry), particularly on samples contaminated at ≥ 5 μg/g. The levels of FB_1 in Kansas corn were affected significantly by year of harvest ($p < 0.05$). The mean levels of FB_1 were 5.6 ± 0.22 μg/g in 1995 and 6.2 ± 0.23 μg/g in 1996. The higher level in 1996 was probably due to the occurrence of *Fusarium* ear rot. *Fusarium moniliforme*, the causal organism of corn ear rot, is a producer of fumonisins. Roozeboom and Jardine (1996) reported *Fusarium* ear rot in many fields after frequent rains and damage. Most districts had higher precipitation in the 1996 crop year (Table 1). The effect of growing location also was significant ($p < 0.001$). However, it was compounded by the effect of irrigation. The numbers of samples from irrigated fields that were included in the analysis for each district are shown in the Table 1. Over both years, corn samples from Northwest Kansas had the lowest FB_1 levels (2.7 ± 0.33 μg/g), whereas samples from East central, South central, and West central Kansas had the highest levels (6.7 ± 0.23, 7.1 ± 0.43, and 7.5 ± 0.50 μg/g FB_1, respectively).

A significant interaction between year of harvest and location ($p < 0.001$) was shown. Corn samples from Northwest had the lowest FB_1 levels in 1995 and 1996 (Table 1); however, the FB_1 level in 1996 was significantly higher. Northeast

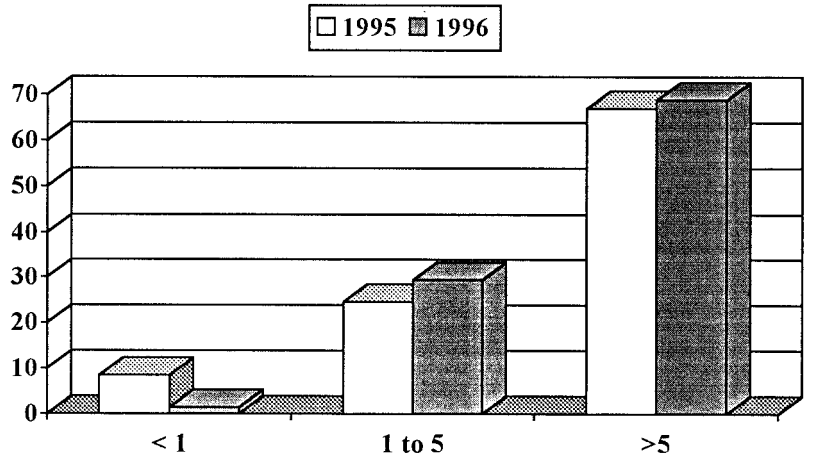

Figure 1. Fumonisin B_1 levels in Kansas corn samples (μg/g).

Table 1. Fumonisin B_1 (FB_1) levels (μg/g) in Kansas corn from various locations, % irrigated samples, and total precipitation during April–September 1995 and 1996 growing seasons.

Location	Mean FB_1 level (μg/g)[y]		% Irrigated samples		Total precipitation (in)[z]		
	1995	1996	1995	1996	1995	1996	Normal
Northwest	1.95 a	3.75 b	67	60	19.8	24.6	14.6
South central	5.40 c	7.70 d	100	100	22.9	22.9	16.9
West central	6.10 c	7.60 d	100	100	16.4	18.0	12.3
East central	6.60 c	7.20 cd	35	38	24.2	25.0	23.4
Northeast	7.70 cd	5.70 b	0	0	32.6	26.7	24.6

[y] Means followed by the same letter within a row and a column are nor significantly different at $p < 0.01$.
[z] Data from Roozeboom (1995), Roozeboom and Jardine (1996).

Kansas corn had the highest FB_1 level in 1995 but had a significantly lower level in 1996. These differences in FB_1 levels may have been due to occurrence of *Fusarium* stalk and ear rots. Occurrence of *Fusarium* stalk rot was moderate in Northeast Kansas in 1995 (Roozeboom, 1995). In 1996, *Fusarium* ear rot was reported frequently in the Northwest and Southwest production areas (Roozeboom and Jardine, 1996). In addition, precipitation is another factor affecting the occurrence of *Fusarium* ear rot and, thus, the level of FB_1. Kommedahl and Windels (1981) stated that rainfall affects the prevalence of *Fusarium* ear rot because it spreads the inoculum that is present in corn plants. As stated earlier, total precipitation was higher in most districts in 1996.

The FB_1 levels in corn grown under dryland conditions were significantly higher (6.4 ± 0.28 μg/g) than those on corn grown with irrigation (5.3 ± 0.21 μg/g). Leslie et al. (1990) stated that many species of *Fusarium* are viewed as opportunistic or weak pathogens that are capable of attacking only plants are weakened previously by some other stress. Dry conditions are known to affect the amount of stalk rot on corn caused by *F. moniliforme*. The FB_1 levels did not significantly differ among corn varieties. The full season (standard) corn varieties used in this study were: Cargill 7777, Northrup King N7590, Dekalb DK626, Ohlde 331, and the maturity checks were Shorts C-4327, Mid H-2530, Full B73 x N204, and Full B73RHM x MO17.

The fumonisin-producing *Fusarium* species were common in Kansas corn. *F. moniliforme* was the most common species when kernels were plated in culture, approximately 90% of the kernels were invaded. Nelson (1992) reported that *F. moniliforme* is the species isolated most frequently from shelled corn, and seed lots of corn frequently can show 100% infection. Leslie et al. (1990) stated that the widespread occurrence of *F. moniliforme* indicates a potential for toxicological problems in corn. However, in Kansas corn, no significant correlation ($r = 0.215$, $p = 0.02$) occurred between FB_1 contamination and level of invasion by *F. moniliforme*. This is consistent with results of Ramirez et al. (1996) for Argentinean corn hybrids. Presently, no tolerance limits exist for fumonisins. The FDA currently is gathering more data on the occurrence of fumonisins and their toxicity. Because of effects on animals, the American Association of Veterinary Laboratory Diagnosticians has issued guidance levels for FB_1 in livestock feed. The limits are 5 ppm for horses, 10 ppm for swine, and 50 ppm for poultry and beef cattle. Our results indicate that approximately 65% of Kansas corn samples in 1995 and 1996, respectively, exceeded the limit for swine.

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