OKLAHOMA

Wheat Grain Cadmium under Long-Term Fertilization and Continuous Winter Wheat Production

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Long-term nitrogen (N) or phosphorus (P) fertilization in seven continuous winter wheat experiments did not increase grain cadmium (Cd) or soil Cd. Grain Cd was inversely related to soil pH, but not related to N or P fertilization.

Excessive Cd accumulation in humans from Cd pollution can result in health problems that include bone disease, lung edema, renal dysfunction, liver damage, anemia, and hypertension. However, Cd is ubiquitous in the environment and uncontaminated baseline levels in soil pose little risk to human and ecosystem health. Human activities may lead to enrichment of Cd in agricultural land and food products and may present a human health concern. A major pathway for Cd intake by humans is through consumption of various food products. Cereal and other grain products are primary sources of this nonessential and potentially toxic metal, accounting for about 20 percent of the daily intake of Cd in the U.S. adult population.

Because P fertilizers sometimes contain significant amounts of Cd, the effect of phosphate fertilizer use on grain Cd has been of concern. Soil acidification from ammonium-containing N fertilizers may increase Cd availability in soil and Cd uptake by crops.

The objective of this study was to evaluate the effect of long-term N and P fertilization on wheat grain Cd. Soil and wheat grain from seven long-term (15 to 63 years) continuous wheat experiments were collected in June of 1993. The wheat variety 'Karl' was planted at all locations for the sampled crop cycle. Total soil Cd and zinc (Zn) content and grain Cd and Zn were determined. Only Cd results are reported.

Soil pH and soil and wheat grain Cd contents for each experiment and fertilizer treatment are given in **Table 1**. Grain Cd and soil Cd were not affected by N fertilization in most of the experiments. In general, P fertilizer did not affect grain Cd. Grain Cd content was increased by 8 parts per billion (ppb) with 40 lb P_2O_5/A/year in experiment 407. Except for the 100-600-100 treatment in experiment 802, P fertilizer did not increase soil Cd (**Table 1**). The 600 lb P_2O_5/A is much greater than normal P rates (about 37 lb P_2O_5/A) recommended for wheat production. Although the exact source of the phosphate rock (PR) used to manufacture the P fertilizer is unknown, most PR produced in the U.S. is from Florida and North Carolina. These PRs contain low levels of Cd...5 to 50 parts per million (ppm). The low Cd content of these P fertilizers did not significantly increase soil Cd and, subsequently, had no effect on grain Cd.

In general, soil pH had little effect on grain Cd for each experiment. However, many studies have shown that soil acidity (with or without fertilizer application) increases Cd uptake by crops. The lack of a

TABLE 1. Treatment means for soil and wheat grain of long-term experiments.

Experiment	Fertilizer, lb/A/year[1] N	P_2O_5	K_2O	Total P_2O_5 loading, lb/A	pH	Cd, ppb Soil	Grain
222	0	0	0	0	5.9	111	19
	80	0	40	0	5.5	96	15
	80	90	40	2,070	5.6	90	13
LSD 0.05					0.2	41.0	4.7
407	0	0	0	0	6.8	133	7
	40	0	0	0	6.6	123	7
	40	40	0	1,040	6.7	124	15
LSD 0.05					0.4	24.1	5.2
502	0	0	0	0	5.6	103	44
	0	40	60	880	5.7	100	42
	60	40	60	880	5.4	90	43
	60	80	60	1,760	5.3	82	44
LSD 0.05					0.2	18.9	8.3
503	80	0	40	0	5.0	109	45
	80	80[2]	40	1,760	5.0	110	46
	80	80[3]	40	1,760	5.0	117	45
LSD 0.05					0.2	29.5	6.3
801	0	0	0	0	4.3	78	44
	0	120	120	1,800	4.6	68	43
	100	0	120	0	3.9	84	–
	100	120	120	1,800	4.4	57	52
LSD 0.05					0.5	33.1	6.5
802	100	0	100	0	3.8	54	–
	100	240[4]	100	240	3.9	41	–
	100	600[4]	100	600	5.0	67	–
	100	1,200[4]	100	1,200	4.4	63	44
LSD 0.05					0.9	12.9	
Magruder	0	0	0	0	5.7	152	32
	0	30	0	1,890	5.7	109	22
	60[5]	30	0	1,890	5.2	124	31
	60[5]	30	30	1,890	5.2	85	27

[1]Ammonium nitrate, superphosphate and potassium chloride, unless otherwise specified.
[2]Monoammonium phosphate.
[3]Diammonium phosphate.
[4]Applied once at the beginning of the experiment.
[5]N rate was 30 and 60 lb N/A for 1929-1967 and 1968-1993 periods, respectively.

strong relationship between soil pH and grain Cd in this study may be attributed to the narrow range of soil pH and grain Cd observed within each experiment. However, when data from all experiments were combined, soil acidity was shown to have a large effect on grain Cd.

In this study, the maximum Cd accumulation in grain for the wheat cultivar was 52 ppb at soil pH 4.4. This grain Cd is about half the safety limit for Cd in select

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TABLE 3. Summary of starter responsive and non-responsive corn and grain sorghum hybrids, 1995-1997.

Hybrid type	Number of hybrids	Yield response, bu/A	Reduction in: days to midsilk/bloom	Reduction in: grain moisture, % points
Corn:				
Responsive	7	17	5.7	3.8
Non-responsive	5	0	0	0
Sorghum:				
Responsive	8	15	5.4	5.5
Non-responsive	4	1	1.0	-0.1

This early season growth advantage did not last into anthesis for all corn and grain sorghum hybrids. In this high residue, no-tillage production system, starter fertilizer consistently improved grain yield and hastened maturity for some but not all hybrids evaluated. However, seven of the eight highest corn yields and nine of the ten highest sorghum yields were treatments including starter. This indicates it is unlikely that all of the yield loss from not using starter can be avoided by hybrid selection. Results of this work suggest that responses to starter fertilizer in high residue systems can be beneficial for most hybrids even on soils testing very high in available nutrients. BC

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commodities (100 ppb) established in several European countries and less than the maximum limit (50 ppb) for unspecified foods in Australia. A maximum limit of Cd in wheat has not been established in the U.S. because detrimental effects of Cd from normal wheat grain production have not been reported.

Summary

Nitrogen fertilization over periods of 15 to 63 years was associated with decreases in soil pH for two experiments, but these decreases were small and did not affect grain Cd from seven long-term field experiments in Oklahoma. In general, long-term N or P fertilization did not affect grain or soil content of Cd.

Comparison of results from all long-term experiments clearly shows grain Cd was inversely related to soil pH. Increases in grain Cd were not associated with total content of Cd in soil. In part, N and P fertilizer did not increase grain Cd because they did not increase soil Cd. Results from this study suggest soil pH controls Cd solubility, bioavailability, and wheat grain Cd. Grain Cd was directly related to soil acidity, not to N or P fertilization. Further decreases in wheat grain Cd can be realized by management practices that prevent development of strongly acidic soil conditions. BC

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