FLY ASH AS A LIMING MATERIAL FOR COTTON: A RATE STUDY

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Abstract

Fly ash from a coal burning electric power plant was used to reduce the soil acidity in a Southeast Missouri cotton field. Three rates of fly ash as well as an untreated check were compared. Fly ash treatments raised soil pH levels over a 5-month period. Fly ash rate did not significantly effect cotton lint yields. Boron, potassium, and sodium levels in cotton leaves and petioles collected during full bloom were increased for fly ash treatments. The magnitude of these increases corresponds to the fly ash application rates. Manganese levels in leaf and petiole were reduced for fly ash treatments. Total soil manganese levels were similar for all treatments. DTPA extractable manganese levels were lower for fly ash treatments.

Introduction

Coal burning power plants produce large quantities of fly ash by-product each year. Disposing of this material is costly and poses a potential problem with the environment. The Missouri Department of Natural Resources now regards fly ash as solid waste, requiring monitoring of groundwater and run-off. This makes obtaining permits for new disposal ponds more difficult to obtain.

One use for fly ash that is being explored is applying it on agricultural fields with low soil pH to reduce soil acidity. Soil test results showed that 26% of the samples sent to the University of Missouri Soil Test Laboratories in 1997 had soil pH values less than 5.4 and needed lime to correct the acidity (Nathan, 1998). The primary effect of soil pH on plant growth is not the H^+ or OH^- activities *per se* but the associated chemical environment (Foth and Ellis). Low soil pH increases the ion activities of aluminum and manganese, which are toxic to plants in high concentrations. Conversely, low soil pH reduces the availability of needed plant nutrients such as phosphorus and potassium.

Field tests conducted by the University of Arkansas in the 1980's showed that 4 to 6 tons of fly ash was equivalent to 2 tons of agricultural lime in raising soil pH (Chapman, 1984). Wheat plants showed a three-fold increase in total boron in plots treated with fly ash. Boron is an essential nutrient for plant growth, but high concentrations of boron can be toxic. In a 1998 study at the University of Missouri- Delta Center fly ash was found to be effective at raising soil pH. However fly ash applications lowered soybean yields. In 1999, an agronomic research project was begun at the University of Missouri- Delta Center to determine if at varying rates of application fly ash can be used as a substitute for lime on cotton fields in Southeast Missouri.

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Materials and Methods

A cotton field test was conducted on a Bosket fine sandy loam soil with an acid pH. Soil test results averaged pH 4.8, neutralizable acidity 3.0, and cation exchange capacity of 5.2 meq/100g of soil. Soil test recommendations were that 1000 pounds of effective neutralizing material (ENM) be applied to bring the soil pH to 6.1. This corresponds to 3 tons of fly ash per acre. Plots were 30 feet long and four 38-inch rows (12.67 feet) wide. Each treatment was randomized and replicated four times. Three fly ash rates were compared to an untreated control. These rates were one-half (1.5 ton/a) of, full rate (3.0 ton/a) of, and one and one half (4.5 ton/a) of the recommended ENM. The materials were incorporated in the soil with tillage. Then the plots were rebedded and planted. Stoneville variety BXN 47was planted on May 13, 1999.

Soil samples were collected from the 0 to 6-inch depth each month from planting till harvest. Tests were made to determine soil pH, electrical conductivity (EC), and boron, sulfur, and sodium content. Soil samples were also collected for each plot representing the 0-12, 12-24, and 24-36 inch depths on November 15, 1999. These samples were tested for the content of 31 elements.

Cotton leaf and petiole samples were collected from each plot at full bloom (July 20, 1998) and tested for the content of 31 elements. The center two rows of each plot were mechanically harvested for yield on October 15, 1999.

Results and Discussion

At harvest soil pH were found to be higher for fly ash treatments than for the control (Table 1). The magnitude of this increase was positively correlated with the rate of fly as application.

The cotton lint yields for all treatments were found to be statistically equivalent at the alpha = .05 level for all treatments (Table 2). Average cotton lint yields were lower for treatments of greater amounts of fly ash. This suggests that the chemical nature of the fly ash is limiting lint production.

Cotton leaf and petiole boron levels were higher for fly ash treatments than the control (Table 3). The magnitude of this increase was the same for all treatments in the petioles. In the leaf however the magnitude of this increase was positively correlated to the rate of fly ash application. Cotton leaf and petiole potassium levels were higher for fly ash treatments than the control (Table 4). Cotton leaf and petiole sodium levels were higher for fly ash treatments than the control (Table 5). This increase is positively correlated to the rate of fly ash application. Cotton leaf and petiole manganese levels were lower for fly ash treatments than the control (Table 6). This decrease is positively correlated to the rate of fly ash application.

Soil test levels of boron were higher for fly ash treatments than the control (Table 7). The magnitude of this increase was positively correlated to the rate of fly ash application. Total soil test levels for manganese were similar for all treatments. (Table 8). DTPA extractable manganese levels were lower for fly treatments than the control (Table 6). This decrease is positively correlated with fly ash application rate.

References

Chapman, S. 1984. Fly ash a fertilizer and lime source in Arkansas. Ark. Acad. of Sci. Proc. 38: 20-22.

Foth, H. and B. Ellis. 1997. *Soil Fertility.* Second Ed. CRC Lewis Publ. New York, NY.

Nathan, M. 1998. University of Missouri soil test results in 1997 by county. Personal communication.

Table 1. Soil pH(salt) results for fly as treatments.

Treatment	pH(salt) 5/13/99	pH(salt) 10/15/99
Control	4.8	5.1
1.5 ton/a fly ash	4.8	6.0
3.0 ton/a fly ash	4.8	6.6
4.5 ton/a fly ash	4.8	6.8

Table 2. Cotton lint yields for fly ash treatments.

Treatment	Lint yield (lbs/a)	T group
Control	519	a
1.5 ton/a fly ash	469	a
3.0 ton/a fly ash	436	a
4.5 ton/a fly ash	400	a

Table 3. Boron levels for cotton leaf and petiole samples collected at full bloom (7/20/99).

Treatment	ppm B leaf	ppm B petiole
Control	40	31
1.5 ton/a fly ash	72	40
3.0 ton/a fly ash	82	40
4.5 ton/a fly ash	84	39

Table 4. Potassium levels for cotton leaf and petiole samples collected at full bloom (7/20/99).

Treatment	% K leaf	% K petiole
Control	1.60	3.65
1.5 ton/a fly ash	1.83	4.61
3.0 ton/a fly ash	1.80	4.28
4.5 ton/a fly ash	1.74	4.54

Table 5. Sodium levels for cotton leaf and petiole samples collected at full bloom (7/20/99).

Treatment	% Na leaf	% Na petiole
Control	0.05	0.05
1.5 ton/a fly ash	0.07	0.09
3.0 ton/a fly ash	0.08	0.09
4.5 ton/a fly ash	0.08	0.10

Table 6. Manganese levels for cotton leaf and petiole samples collected at full bloom (7/20/99).

Treatment	ppm Mn leaf	ppm Mn petiole
Control	328	151
1.5 ton/a fly ash	324	115
3.0 ton/a fly ash	269	94
4.5 ton/a fly ash	301	100

Table 7. Boron levels for soil samples (0-12 inches depth) collected 11/15/99.

Treatment	ppm B
Control	.21
1.5 ton/a fly ash	.33
3.0 ton/a fly ash	.41
4.5 ton/a fly ash	.44

Table 8. Manganese levels for soil samples(0-12 inches depth) collected 11/15/99.

Treatment	ppm Mn Total	ppm Mn DTPA
Control	633	21.9
1.5 ton/a fly ash	600	20.7
3.0 ton/a fly ash	617	18.8
4.5 ton/a fly ash	599	15.3