Plant Growth in Sandy Soil/Compost Mixture and Commercial Peat Moss both Amended with Illinois Coal Fly Ash

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ABSTRACT

Burning coal for energy produces a by-product known as fly ash. Fly ash is not currently regulated as a hazardous material by the US EPA and is discarded as waste to ponds or landfills if no other uses can be found. Successful value-added applications would help to reduce the cost and concern of fly ash disposal. Fly ash contains several minerals needed for plant growth, and has a high surface tension and high water-holding capacity. This study examined the potential benefits of using a high pH (>8) Illinois coal fly ash to amend growth media for tomato plants, turfgrass, and chrysanthemums. Both turfgrass and tomato plants were grown in sandy soil/compost/fly ash mixed media with fly ash at 0, 12.5, 25, and 37.5 v%, respectively, while chrysanthemums were grown in commercial peat moss/fly ash mixed media with fly ash at 0, 25, 50, 75, and 100 v%, respectively. In each case, the plant height, soil pH, electrical conductivity, and appearance were monitored. The results of this study indicated that Illinois coal fly ash could be beneficial to typical plant growth if it is applied at an adequate rate and to an acceptable medium, but further case-by-case detailed evaluation is warranted.

INTRODUCTION

Approximately 15-30% of the total amount of waste generated during coal burning is in the form of fly ash (1). Three million tons of fly ash generated each year from burning Illinois coals is readily available for value-added applications (2). Fly ash is not currently regulated as a hazardous material by the US EPA, and is typically disposed of in landfills or holding ponds if no other uses can be found. In fact, about 70% of power plants use landfills and impoundments as the primary means of fly ash disposal (3). Fly ash has a high water holding capacity and contains minerals needed for plant growth (3, 4). Other studies with Class F fly ash have demonstrated its ability to significantly improve water holding capacity and plant-available water (3). Previous studies have shown great success with fly ash as a soil amendment for growing tomato plants. Fly ash applied at levels of 50-60% provided the most benefit in terms of increased plant growth and yield (flowering, fruiting, fruit weight/plant, mean fruit weight) (5). This study examined if there is any potential benefit in using Illinois coal fly ash to amend the growth media for chrysanthemums and tomato plants, and for turfgrass seeding.

RAW MATERIALS AND EXPERIMENTAL

Fly Ash Sample

In this study, typically high pH (>8) Illinois coal fly ash samples of the same source were used. The first batch (No. 1) was sampled for use in the chrysanthemum experiments, and the second batch (No.2) was sampled for the tomato and turfgrass experiments. The chemical composition of the fly ash was examined as indicated in Table 1.

Table 1. Results of chemical analysis of the fly ash sample - metal oxides composition (wt %), and the components of sulfur, mercury, boron, arsenic, and selenium

Sample	SiO_2	Al_2O_3	Fe_2O_3	TiO_2	MnO	MgO	CaO	Na_2O	K_2O	P_2O_5
No.1	51.30	19.60	10.62	1.03	0.05	1.03	3.55	1.19	2.20	0.16
No. 2	47.52	18.15	19.00	0.97	0.05	0.84	3.15	1.08	1.99	0.15

	S, %	Hg, ppm	B, ppm	As, ppm	Se, ppm
No. 1	0.191	0.121	714.00	70.00	9.00
No. 2	0.187	0.014	513.00	108.00	<5.00

Growth Media

Chrysanthemum plants – The first set of growth media (mixes) were prepared using commercial peat moss as a balance material to blend with various amount of fly ash. The five growth mixes were prepared to contain fly ash at 0, 25, 50, 75, and 100% by volume, respectively.

Tomato plants and turfgrass seeds – The second set of growth media was prepared using sandy soil from Beardstown, IL and commercially available compost as a balance material to blend with various amount of fly ash as indicated in Table 2. These five growth media were used for the growth of tomato plants and turfgrass seeds.

Table 2. Composition for the second set of growth media

Growth Mix ID	Composition		
	% Sandy Soil	% Compost	% Fly Ash
A	100	0	0
B	75	25	0
C	75	12.5	12.5
D	50	25	25
E	25	37.5	37.5

*Percentages by volume.

Plant Growth

Chrysanthemum plants – In order to monitor the progress of the experiment, the plant height, soil pH, electrical conductivity, and appearance were monitored on a weekly basis. The final assessment was conducted six weeks after planting.

Tomato plants and turfgrass seeds – The height and appearance of the plants were monitored on a daily basis. To control a possible leaching effect from daily watering, a limited amount of water (200 mL per day) with a standard nitrate and phosphate nutrient solution was used to assist plant growth. The Fe and Mn contents in tomato leaves were analyzed and compared with those of healthy leaves. The media pH and electrical conductivity were measured for an initial and a final assessment. The final plant quality was assessed eight weeks after planting.

RESULTS AND DISCUSSION

The Growth of Chrysanthemum Plants

The results indicated that the addition of fly ash to the potting medium negatively impacted chrysanthemum growth and development. Plant height and quality decreased as fly ash percentage increased, and plant death occurred with 75% and 100% fly ash. The photos of final plants growth with various media are shown in Figure 1 (6).

Figure 1: Final plant health as indicated by plant height, amount of defoliation, and death (6)

The Growth of Tomato Plants and Turfgrass Seeds

The results show a potentially beneficial result in the growth of tomato plants by using fly ash to amend, especially poor, soil. As indicated in Figures 2 and 3, the addition of fly ash at low levels, 12.5% (plant C), to the sandy soil/compost mixed medium enhanced tomato plant growth after about four weeks of planting and had no negative impact on fruit development. On the other hand, growth medium with a high level of fly ash added, such as 37.5% (E), hindered plant growth during the entire planting period, and had negative impact on fruit development. The tomato leaves were analyzed for their Fe and Mn nutrients and the values were within the range for healthy leaves (Figure 4) (7). The results also indicate that the Fe concentration was improved from below the healthy range (deficient) to the healthy range (sufficient) for eight of the nine plants grown in fly ash (the ninth reached marginally phytotoxic levels). All of the samples had a Mn concentration within the acceptable limits; however, the tomato leaves grown in soils with fly ash had more Mn than those without fly ash. From an initial assessment, as anticipated, the media containing fly ash had higher pH values than those without ash. A final

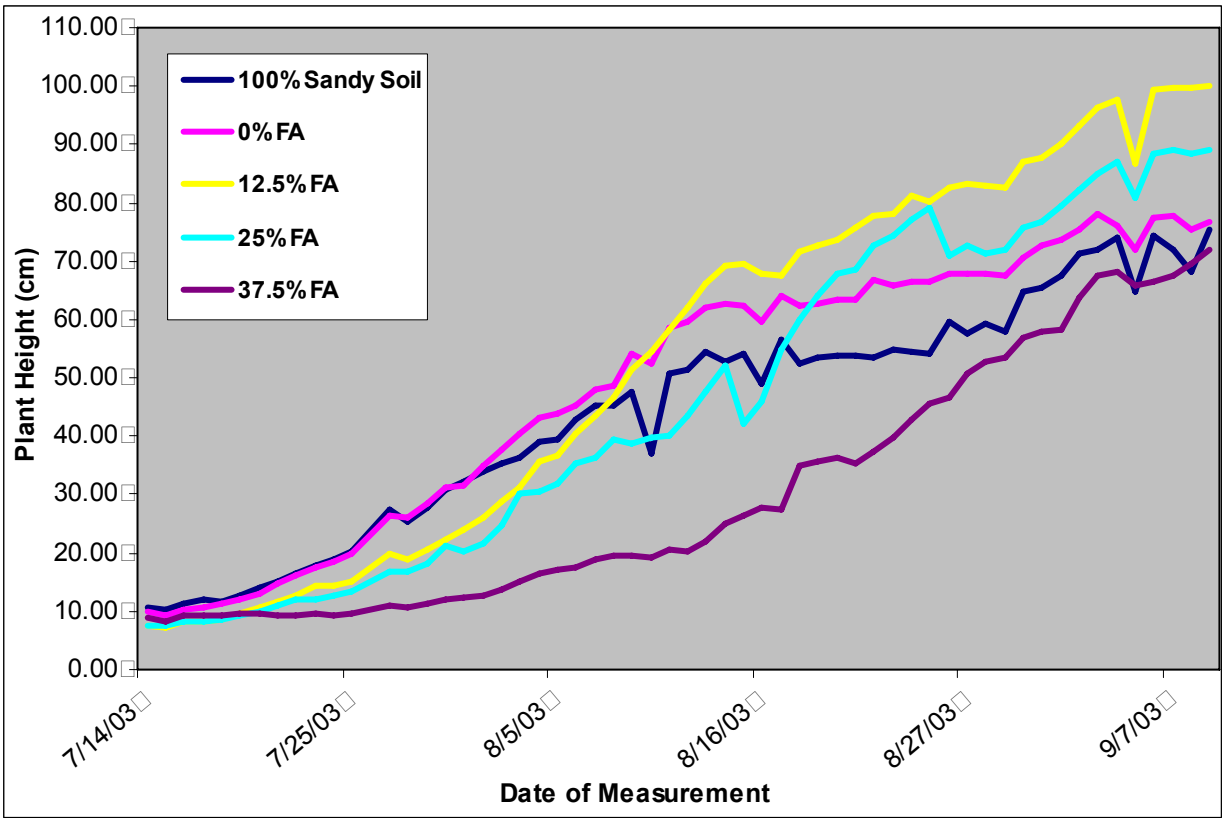

Figure 2. The height of tomato plants - grown with various media

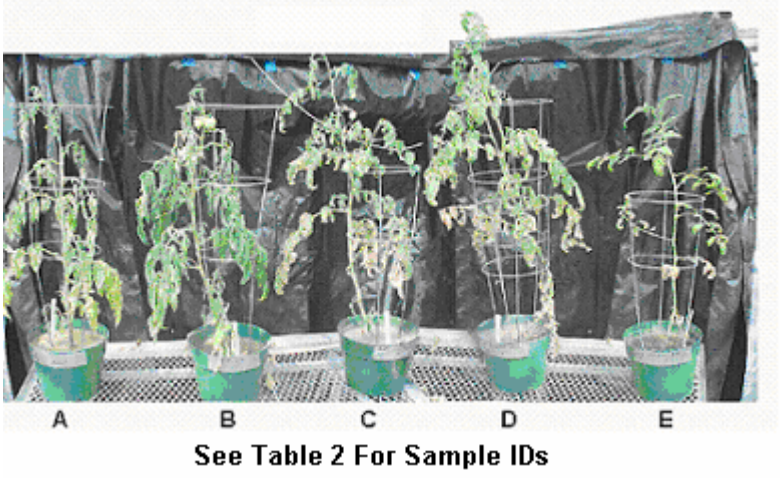

Figure 3. The appearance of tomato plants – grown with various media

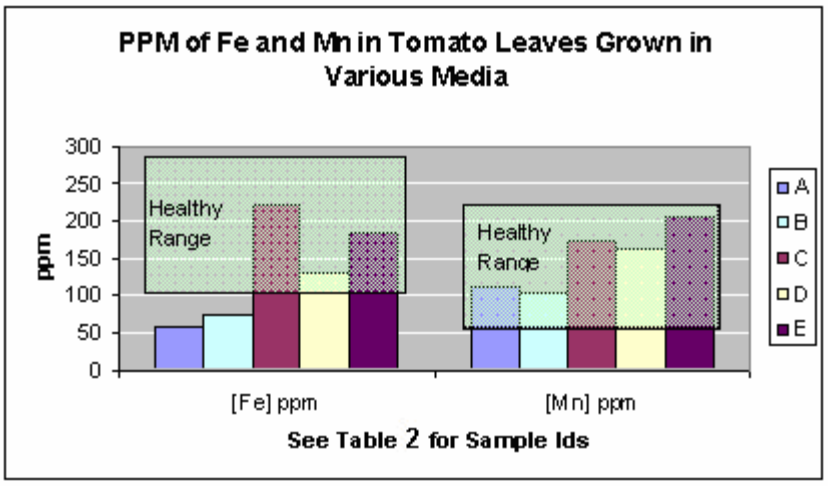

Figure 4. Amount of vital nutrients present in tomato leaves grown in different media

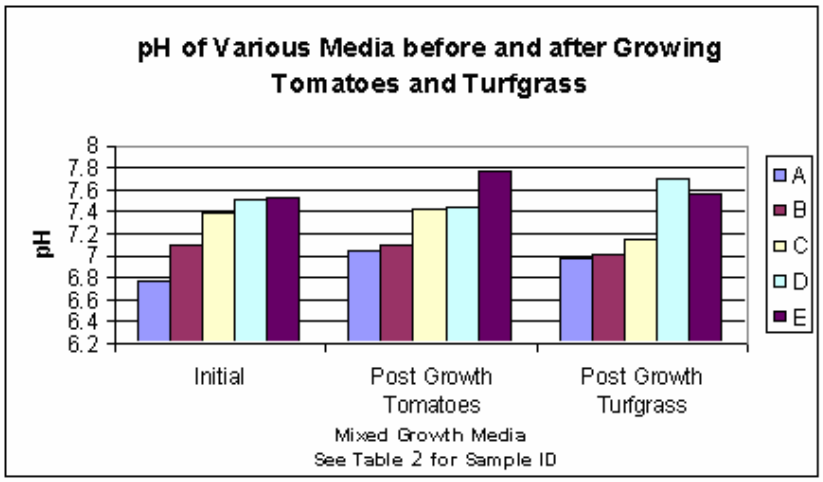

Figure 5. pH of media from tomato and turfgrass experiments before and after growth period

pH assessment of the post-growth media (Figure 5) indicated that watering with limited water during the planting period did not greatly change the pH of the media.

The addition of fly ash to the sandy soil/compost mixed medium hindered the seed germination process and further hindered plant growth for turfgrass. Figure 6 shows the final appearance of turfgrass as the input of fly ash increased through the range 0% (A, B), 12.5% (C), 25% (D), 37.5% (E).

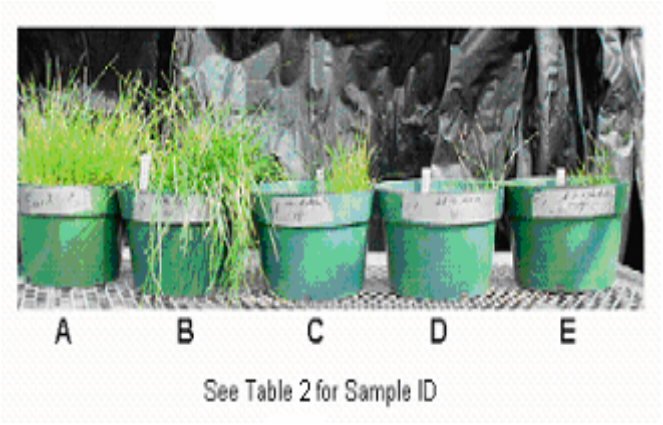

Figure 6. Final products from turfgrass experiment

CONCLUSIONS AND RECOMMENDATIONS

The results indicated that the addition of fly ash to the commercial peat moss negatively impacted chrysanthemum growth and development. Poor plant growth resulted in part, from high alkalinity and high surface tension (hindering water flow). Plant height and quality decreased as fly ash percentage increased. However, the addition of fly ash at a rate of 12.5 % to the sandy soil/compost mixed medium enhanced tomato plant growth and had no negative impact on fruit development. The addition of fly ash to the sandy soil/compost mixed medium hindered the seed germination process and further plant growth for turfgrass. The results of this study indicated that Illinois coal fly ash could be beneficial to typical plant growth if it is applied at an adequate rate and to an acceptable medium, but further study on a case-by-case evaluation is warranted.

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