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WOOD ASH FROM BIOENERGY SYSTEMS AS A SOIL AMENDMENT FOR CROP PRODUCTION

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Abstract: Wood is a renewable energy source that can be practical for many applications. Wood ash produced as a byproduct of commercial, industrial, and institutional bioenergy operations can be an economical, effective, and environmentally friendly soil amendment for crop production. Wood ash provides liming benefits along with potassium, phosphorus, calcium, magnesium, and micronutrients. Research in Wisconsin has demonstrated that wood ash benefits a variety of agronomic crops and can be practical for farmers to use.

We conducted greenhouse and field studies to evaluate the effects of landspreading industrial wood ash on the yield and elemental composition of forage crops and on soil nutrient levels. Biomass yields generally increased with ash application up to 20 tons/acre and decreased at applications exceeding this level (Meyers and Kopecky, 1998). Wood ash application usually produced yields greater than those obtained with the limed and fertilized control treatment. No undesirable elements accumulated in forage tissue at ash application rates up to 20 tons/acre.

Clean wood ash (produced from only wood and bark without synthetic substances in the fuel stream) is permitted for organic crop production systems in the United States. It is especially valuable in areas with acidic soils, and can be landspread with equipment that is commonly used in cropping systems. Wood ash is already being used as a soil amendment in some areas of North America, but in other cases it is disposed of in landfills. Using wood ash for crop production can save money for farmers and bioenergy users and is a more sustainable stewardship practice.

Key Words: organic, liming, byproduct, landspreading, landfills, sustainability, stewardship

USE OF WOOD AS A BIOENERGY SOURCE

Industrial, commercial, and institutional bioenergy applications

Wood has traditionally been used as a fuel source throughout ages. In areas with cold climates, it is a common home heating energy source. In recent decades, many industrial, commercial, and institutional applications of wood-based bioenergy have been used. In Wisconsin alone, there are over 200 industries, businesses, and schools that burn wood (Wisconsin Department of Natural Resources, 2009). Well-designed and –operated systems are relatively efficient and non-polluting, with the added benefit of having no net effect on atmospheric carbon dioxide. The

resulting ash from these operations may be used as a beneficial soil amendment, but is sometimes landfilled as a waste product.

AGONOMIC USE OF WOOD ASH

General characteristics, historical use, and current potential

Wood ash has historically been known as a valuable soil amendment (the term "potash" originated from the potassium carbonate produced by leaching wood ash). In general, wood ash can substitute as a lime source for use on acidic soils and contains a number of plant nutrients that may be beneficial for crop production. Wood ash produced from burning "clean" wood and bark with no foreign materials included in the waste stream is approved as a soil amendment for organic crop production under the U.S. Department of Agriculture's National Organic Program standards.

Wisconsin research: Agronomic effects of ash application

We analyzed sixteen ash samples from northern Wisconsin sources, including bottom ash and fly ash, to determine the range of elemental concentrations of 15 elements (Table 1). From 1990 to 1994, we conducted greenhouse and field research to ascertain the agronomic value of ash from several wood burning industries in northern Wisconsin. Ash was added to the soil at rates equivalent to 0, 5, 10, 20, and 40 tons per acre and the effect on crop yield, soil pH, and nutrient levels were measured.

Greenhouse studies showed alfalfa and barley yield response from wood ash applications of five to twenty tons per acre to be significantly greater than those from commercial lime and fertilizer applied at rates recommended by soil test. The field research trials also showed favorable crop responses from wood ash application. Alfalfa plots in Price County, Wisconsin treated with ash at rates from 2.5 to 20 tons per acre, exhibited yields comparable to plots treated with commercial lime and fertilizer applied at rates recommended by soil test. No harmful effects on crops were observed when ash was applied at rates up to 20 tons per acre.

Table 1. Elemental content of sixteen ash samples from northern Wisconsin.[1]

Element	Range of Concentrations	Pounds Applied in 10 Ton/Acre Ash Application
Calcium (Ca)	22-45%	4,400-9,200
Magnesium (Mg)	1.2-2.2%	240-440
Phosphorus (P_2O_5 equivalent)	1.1-2.3%	230-460
Potassium (K_2O equivalent)	1.3-4.6%	260-910
Aluminum (Al)	0.2-1.1%	42-230
Iron (Fe)	0.1-1.1%	26-210
Manganese (Mn)	0.06-0.3%	12-56
Zinc (Zn)	0.01-0.5%	3-100
Boron (B)	0-210 ppm[2]	0-4
Chromium (Cr)	0-14 ppm	0-0.3
Copper (Cu)	0-54 ppm	0-1.1
Nickel (Ni)	0-7 ppm	0-0.1
Cadmium (Cd)	0-22 ppm	0.4
Cobalt (Co)	0-6 ppm	0-0.1
Lead (Pb)	0-17 pm	0-0.3
Sulfur (S)	See Footnote 3	See Footnote 3

[1]From Kopecky et al., 1995
[2]ppm = parts per million
[3]Sulfur concentration was not determined in the Wisconsin research. Other research reports sulfur concentrations of 0.38% to 2.0% in wood ash, which would yield 76 to 400 lb in a 10 T/A application.

Lime and Fertilizer Value of Wood Ash

The monetary value of wood ash is highest in areas where agricultural limestone prices are high and where ash sources are located nearby, but the plant nutrient content of ash is also substantial. The potential dollar value of wood ash is shown in Table 2. In addition to the value of lime and macronutrients, ash can also supply significant amounts of sulfur, boron, and other micro-nutrients.

Table 2. Economic value of wood ash at various nutrient levels and limestone costs.[1]

Constituent	Range in Content	Economic Value (Dollars Per Ton)[2] at Different Limestone Costs[3]
Lime Value (NI)	40-49 to 80-89	$9-30
Potash (K_2O)	26 to 92 lb/ton	$17.70-62.70
Phosphate (P_2O_5)	22 to 46 lb/ton	$11.00-23.10
	Total Range in Value:	$37.70-115.80

[1] From Kopecky et al., 1995
[2]Assumes cost of potash (from 0-0-60) equals $0.68/lb of K_2O; cost of phosphate (from diammonium phosphate) equals $0.50/lb P_2O_5.
[3] Based on NI 80-89 limestone, ranging from $20-30/ton.

Heavy Metal Content

The concentration of heavy metals in wood ash is very low. The element that is present in the highest amounts relative to cumulative loading limit restrictions in Wisconsin is Zn. Based on average concentration in the ash samples we tested, it would require eighty-one 10 T/A application to reach the legal loading limit for this element.

PRACTICAL CONSIDERATIONS

Using Wood Ash: Transportation and Storage

Wood ash is a caustic material (strongly alkaline) and quite dusty when first taken out of the combustion facility. Ash that is stockpiled in the open tends to hydrate after several months and becomes less dusty. Some facilities add water to ash directly to reduce its dustiness. Dry ash must always be covered during transport. Ash can be stockpiled adjacent to fields where it will be used until it is spread. If the ash is very fluid, storage areas can be banked with low earthen berms to contain the pile. Once ash is stockpiled it crusts quickly, so loss to wind is not usually a problem.

Spreading Wood Ash

Fresh ash can be difficult to spread because of its fluidity and dustiness, and therefore should be hydrated by adding water before spreading. Wood ash that has been hydrated can be spread with manure spreaders, lime trucks, or fertilizer wagons, depending on the equipment available. For many farmers, manure spreaders will be the most practical means. Ash can be loaded from the stockpile with a skid steer or a tractor with a front end loader.

Safety Considerations

When working around ash, wear personal protection equipment (goggles, dust mask and protective clothing). Ash can be harmful if it comes in contact with eyes or skin or is inhaled. Fresh ash can be very hot - be careful to keep flammables away from fresh ash.

CONCLUSIONS

Industrial wood ash can be used as a safe, effective, and economical soil amendment. It is especially useful where lime is required, but is useful for other situations where potassium needs are high or where forage legumes are to be grown. Ash is approved as a soil amendment for organic crop production in the United States.

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