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Effects on nodulation and early growth of soybeans grown in sewage sludge-amended soil of McPherson

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ABSTRACT

Sewage sludge, which once was a great environmental concern, is now being widely and safely used as a fertilizer for agricultural crops. Because of sludge's high nitrogen content, it has been used mainly on crops with relatively high nitrogen requirements. These crops have benefited from the sludge as they would from commercial fertilizers, but the effect of sludge on crops with low or no nitrogen requirements is relatively unknown. For example, soybeans have a symbiotic relationship with certain soil microbes that can make adequate nitrogen (inside root nodules) for the soybeans, so that no additional nitrogen fertilizer is needed. In this experiment, eight soybean plants were grown in non sludge-amended soil, and eight were grown in sludge-amended soil. Those grown in the non sludge-amended soil had more nodules, lower dry weights, and lower percent nitrogen than did those plants grown in the sludge-amended soil. Therefore, adding sewage sludge as a fertilizer even to crops that do not need it, may be beneficial.

Keywords: *fertilizer, McPherson, nitrogen, sludge-amended, soybeans.*

INTRODUCTION

Since the early 1970s, sewage treatment facilities have been appearing in communities nationwide. This was most likely due to increasing environmental concerns stemming from the dumping of raw sewage into the Atlantic Ocean. These sewage treatment facilities currently produce huge amounts of residual solids, known as sludge. As a reduced (partially dehydrated and decomposed) form of sewage, sludge also has to be disposed of. In the past it has been disposed of by putting it in landfills, by incineration, and by application to agricultural land.

Application of sludge to agricultural land has proven to be a beneficial, as well as a safe method of disposal. The costs of disposal in this manner are low in comparison to alternative methods; farmers normally receive this sludge free. Sludge contains nutrients that farmers normally buy and apply through commercial fertilizer. Sludge has been reported as providing as much as 5% nitrogen, 9.2% phosphate (P_2O_5), and 2.4% potash (K_2O) by dry weight (Searcy, 1994).

Along with the use of sludge as a fertilizer have come many studies to determine the effects of sludge on the environment. These studies include a review by Lake, et al. (1984), summarizing ways of determining the availability of heavy metals in sewage sludge and sludge-amended soils. A special concern in this review was the potential for groundwater contamination. The studies that followed involved experiments predicting available zinc in sewage sludge-amended soil (Rappaport, et al., 1986), determining phosphorus solubility in sludge-amended calcareous soils (O'Connor, et al., 1986), determining metal availability for plant uptake in sludge-amended soils with elevated metal levels (Rappaport, et al., 1988), determining effects on nitrification in sludge-amended Michigan forest soils (Burton, et al., 1990), and many others.

Most studies involved experiments with grain crops, due to grains' high nitrogen demands, sludge's nitrogen availability, and unused nitrogen's potential for contamination. However, an experiment by Dowdy and Ham, (1977), was done to determine the influences of sewage sludge and heavy metals on soybean growth and elemental content. They found that inorganic salts could not substitute for sludge-borne metals in experiments to determine heavy metal uptake by plants. According to Dowdy and Ham, many research studies had already been done in which this inappropriate substitution had been made.

In 1987, an experiment by Heckman, et al., was done to determine the residual effects of sewage sludge on soybeans, due to accumulation of soil and symbiotically fixed nitrogen. The results of the experiment suggested that soybean growth might benefit from sludge-amended soil, but that this might be true only for low metal sludges.

The purpose of this project was to determine the effects of sludge-amended soil of McPherson, KS, on nodulation and early growth of soybeans.

MATERIALS AND METHODS

Soil samples 15 cm deep were taken from a field near McPherson, KS. The soil was air dried, mixed with sand (2250 g soil + 750 g sand/pot), and placed in paper towel lined plastic pots. Dried sludge from the McPherson Wastewater Treatment plant was mixed in the top 3 in of the potted soil-sand mixture, at application rates of 21 g/pot (73.5 Mg/ha), excluding the control pots.

Six soybean seeds were planted in each pot and the pots were placed under grow lamps (12 hrs light) in a greenhouse. After emergence of at least one

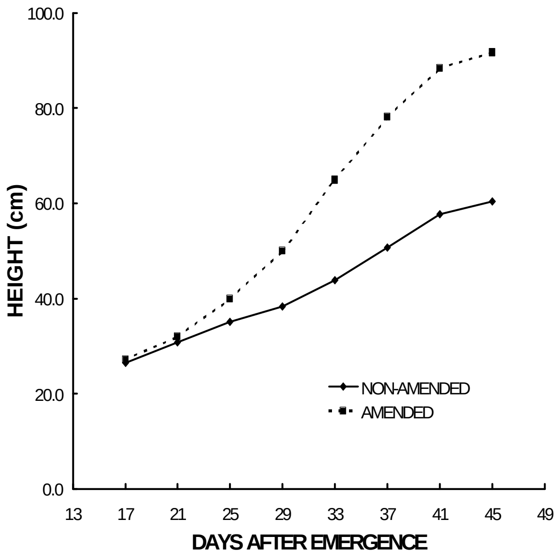

Figure 1. Days after emergence as a function of plant heights (cm). From 17 days after emergence, plants in sludge-amended soil grew faster than plants grown in non-amended soil.

soybean/pot, soybeans were thinned to one plant/pot and grown for six weeks. Plants were selected to remain based upon their closeness to the same day of emergence. Plants were measured every four days beginning two weeks after emergence. Growth stages were recorded every four days from the emergence to the reproductive stage.

After six weeks, all soil was washed from the roots and the plants were air-dried. Nodules were counted on each plant. Plants were oven-dried at 100° C for six days before being weighed. Plants were then ground in a Wiley mill through a 2 mm screen. Plants were analyzed in duplicate by the Kjeldahl procedure for nitrogen determination. Data was statistically analyzed using the t-test with an alpha value set at 0.05.

RESULTS

In the first three weeks of growth, all plants matured equally from emergence to the second node stage (two fully formed trifoliate leaves above the cotyledons). In the next ten days, the non-amended group grew to the third node stage and the sludge-amended group grew to the fourth node stage. Over the next week, all but one plant in the non-amended group grew to the next node stage. In this same time, seven plants in the sludge-amended group grew to the next node stage and one grew two stages. In the next four days all plants in both groups entered the reproductive stage and began to fill bean pods. The sludge-amended group grew much longer stems than did the non-amended group (Figure 1).

The total number of nodules on those plants grown in the non-amended soil was 238, and the number on those grown in the sludge-amended soil was 178. The

Table 1. Nodule count, plant dry weight(g), and nitrogen percentage of soybeans grown in sludge-amended and non-amended soil. Values are means ± SE (df = 14).

	Nodules	Plant wt	Nitrogen %
Non-amended	29.75 ± 4.31	2.46 ± 0.22	2.61 ± 0.04
Sludge-amended	22.25 ± 3.60	4.67 ± 0.43	3.02 ± 0.08
T value	1.34[a]	4.59[b]	4.47[c]

nodules of those plants grown in the non-amended soil also appeared much larger. Plant weight and nitrogen percentages were significantly higher (P=0.0004 and P=0.0005 respectively) in the sludge-amended soil (Table 1).

DISCUSSION

The sludge-amended group grew more vegetation, but both groups reached reproductive maturity at the same time.

The decreased nodule number for soybeans under this level of sludge application (73.5 Mg/ha) is similar to the findings of Eivazi, (1990). Finding significantly increased dry weights of soybeans at this rate of application is also similar to findings by Heckman, et al. (1987), and Eivazi, (1990). The beneficial effect of increased growth can be attributed to additional nutrients in the sewage sludge.

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LITERATURE CITED

Burton, AJ, JB Hart, and DH Urie. 1990. Nitrification in sludge-amended Michigan forest soils. Journal of Environmental Quality 19:609-616.

Dowdy, RH, and GE Ham. 1977. Soybean growth and elemental content as influenced by soil amendments of sewage sludge and heavy metals: seedling studies. Agronomy Journal 69:300-303.

Eivazi, F. 1990. Nitrogen fixation of soybean and alfalfa on sewage sludge-amended soils. Agricultural Ecosystems in the Environment 30:129-136.

Heckman, JR, JS Angle, and RL Chaney. 1987. Residual effects of sewage sludge on soybean: II. Accumulation of soil and symbiotically fixed

nitrogen. Journal of Environmental Quality 16:118-124.
Lake, LD, PWW Kirk, and JN Lester. 1984. Fractionation, characterization, and speciation of heavy metals in sewage sludge and sludge-amended soils: a review. Journal of Environmental Quality 13:175-183.
O'Connor, GA, KL Knudtsen, and GA Connel. 1986. Phosphorus stability in sludge-amended calcareous soils. Journal of Environmental Quality 15:308-312.
Rappaport, BD, DC Martens, and RB Reneau. 1988. Metal availability in sludge-amended soils with elevated metal levels. Journal of Environmental Quality. 17:42-47.
Rappaport, BD, DC Martens, and TW Simpson. 1986. Prediction of available zinc in sewage sludge-amended soils. Journal of Environmental Quality. 15:133-136.
Searcy, Jenny. Feb. 1994. What's in Sludge? Ohio Farmer. pp. 8-9.