Effect of Oily Waste Amendments on Nutrition and Growth of Oats

R. Abujnah, J.Schoenau, T. Fonstad and B.Biederbeck

Key words: microbial immobilization, oat plant, oil decomposition.

Introduction

The application of oily waste to soil may lead to undesirable conditions, which may affect plant growth. One of these conditions is nutrient deficiency resulting from the competition between plants and microorganisms responsible for oil decomposition. Nitrogen is usually the limiting nutrient. Thus application of oily sludge to soil must be accomplished with nutrient addition. This study examines the effect of adding oily waste alone & in combination with nitrogen fertilizer & hog manure on soil nutrient supply, plant growth and plant nutrition.

Materials and Methods

A growth chamber experiment was conducted over the period of late November 1997 to late January 1998 at the University of Saskatchewan. The growth chamber experiment involved 96 pots, consisting of four oily sludge application rates (none, 0.5%, 1%, 2% sludge content wt/wt of soil), two cropping systems: fallow, cropped and two type of amendments (manure and urea). All treatments were replicated four times and the pots were arranged in a completely randomized design.

The soil used was taken from the Ap horizon of Hatton loamy sand near Richmound. The clay, silt and sand content of the soil were 6.6, 9.3, 84 %, respectively. The nutrients content of the soil was 12 μg/g NO_3-N, 26 μg/g available P, 230μg/g exchangeable K and <1 μg/g SO_4-S.

The waste is an oily sludge waste originating from the heavy oil up-grader in Regina. The oily sludge has a total composition of 61% water, 31% hydrocarbons and 8% solids. The content of polyaromatic hydrocarbons (PAH) in the sludge is 6,196 ppm with the two main PAHs being dimethyl napthalines (1,500-ppm) and methyl napthalenes (1,300 ppm).

The same rate of total nitrogen (120 mg N/ kg) application was used for urea and manure addition. The anions (NO_3^-, PO_4^-) supply rates (in μg / 10cm^2 / two weeks) in non-seeded pots were measured using anion exchange membrane probe burial technique (Greer and Schoenau,1996).

Approximately 8 to 10 of oat seeds, (CV. Calibre) were planted in each pot and after germination, the seedlings were thinned down to 5 per pot. The plants were watered daily to about field capacity throughout the growing period. Plant samples were oven dried at 60 C°, then ground to pass through a 40-mesh sieve using a Cyclone™ mill, before analysis for N and P concentration and uptake. Total N&P of the plant tissue was measured by a standard

H_2SO_4 digestion (Thomas et al., 1967) and analyzed with a Technicon Autoanalyzer II. The same digestion was used to determine the total K, Mg, Ca using Inductively Coupled Plasma.

Results and Discussion

The nitrate supply rate of the soil was significantly ($p<0.05$) Fig (1) higher in urea & manure amended soil than in non-amended for the controls and sludge treatments. In all treatments, the nitrate supply rate was found to decrease with sludge addition. High nitrate supply rate in urea amended soil was consistent with the observed high plant nitrogen uptake and high plant yield. The reduction in nitrate supply rate with increasing sludge addition rate may be due to microbial immobilization resulting from the use of carbon materials present in sludge for microbial cell production & a concomitant increase in the microbial demand for nitrogen and thus the available nitrogen in the soil would decrease. Many researchers have reported increase in microbial population & activity following oil or oily waste addition (Jenson, 1975; Lianos. et al. 1976; Pinholt. et al.1979; Salih et al. 1985; Pritchard 1991).

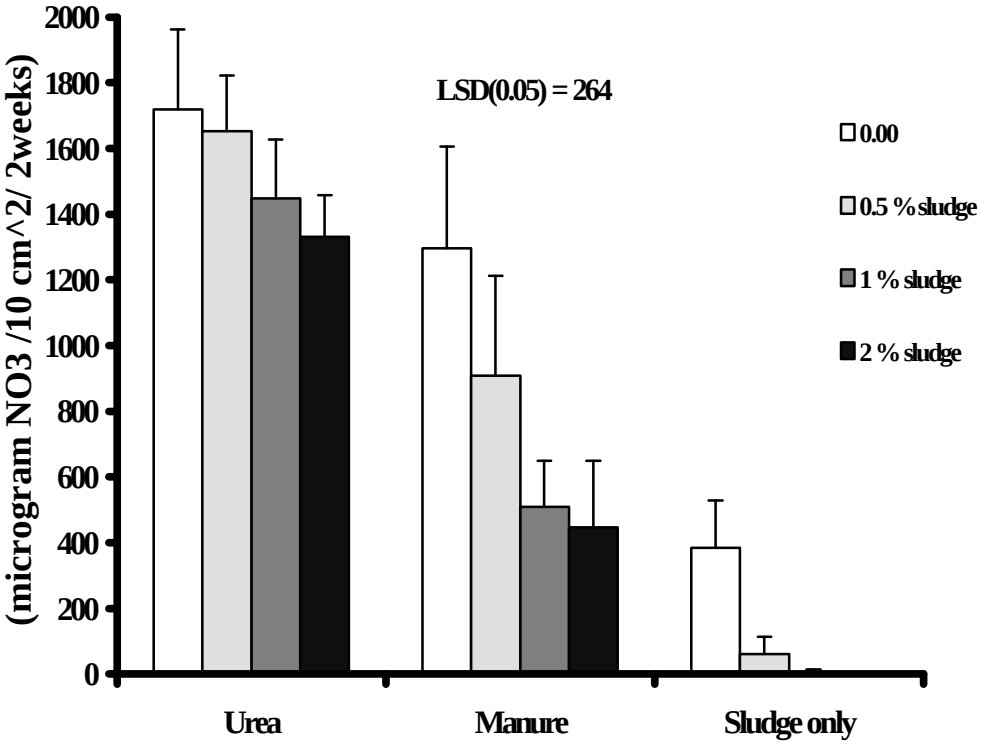

Figure .1. Nitrate supply rate of unseeded pots taken eight weeks after amendments. Nitrate supply rate expressed in μg/10cm^2/2 weeks. Error bars are S.D, n = 4

The larger nitrate supply rate in the urea amended soil than manure amended soil can be attributed to the fact that some of the nitrogen in the manure is in organic form and not mineralized to ammonium & nitrate. Only about 20-30% of the organic N in swine manure may be converted to ammonium & nitrate over a growing season (Schoenau et al. 1999).

The statistical analysis of phosphate supply rate measurements indicates that there is a high significant difference ($p<0.01$) between phosphate supply in sludge + urea and sludge + manure when compared with sludge only treated soil Fig (2). The sludge only treated soil had the highest phosphate supply rate and there was no significance difference in phosphate supply rate between the levels of added sludge for the different amendments.

The higher phosphate supply rate in the sludge only treated soil than manure and urea amended soil is possibly a result of microbial immobilization and demand for other nutrients induced by the N. The slightly lower phosphate supply rate in urea amended soil as compared to manure amended soil could reflect a contribution of phosphate from the hog manure (Eghball and Power, 1995).

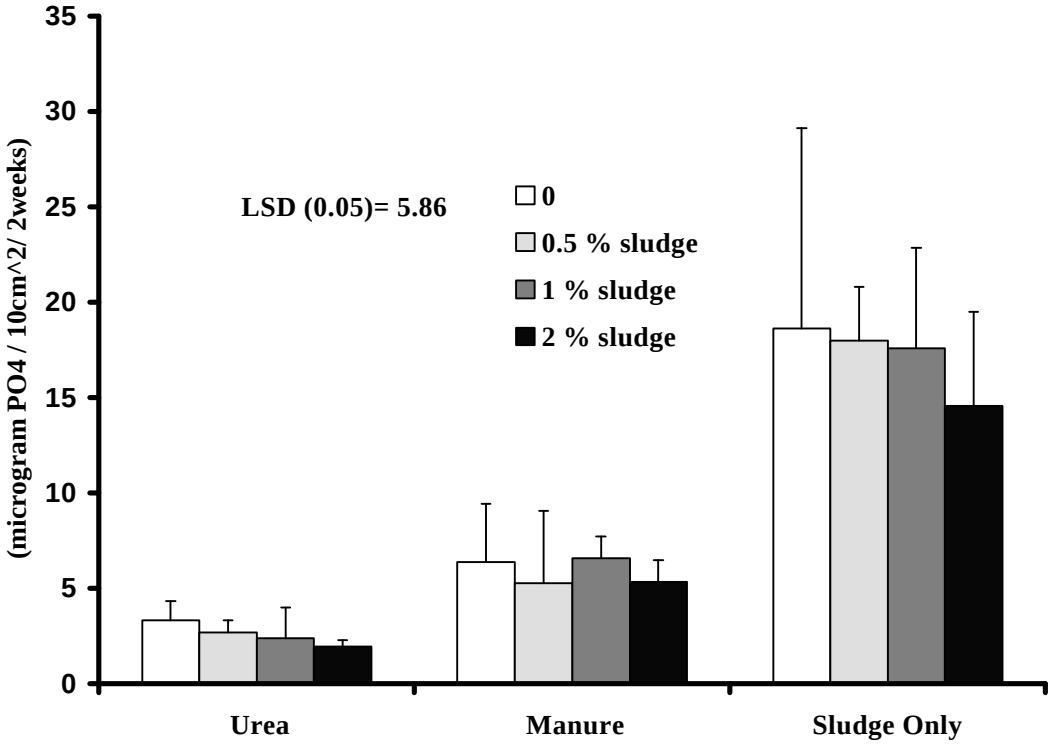

Figure .2. Phosphate supply rate of unseeded pots taken two weeks after amendments Phosphate supply rate expressed in μg/10cm^2/2 weeks. Error bars are S.D, n = 4

The growth rate and color of the oat plants were noticeably affected by the treatments imposed (see photo 1). Plants grown in urea-amended soil were of green color while the coloration of the oat plants in manure-amended soil, and sludge alone were lighter green color. Without sludge, yields were highest in the urea-amended soil, followed by manure amended with the lowest yield in the unamended soil. The dry matter yield of sludge alone and sludge + manure amended soil was significantly reduced as sludge rate increased. Urea was most effective in maintaining yield as sludge rates increased.

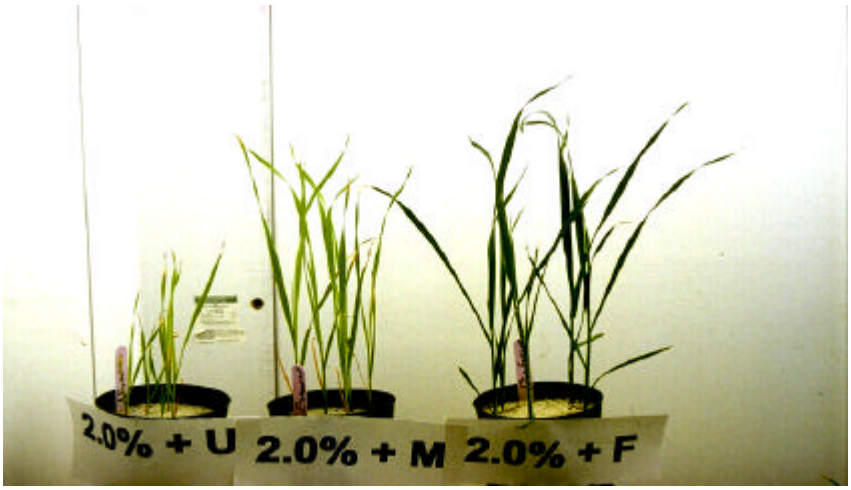

Photo. 1 The effect of amendments on oat plant
2%=sludge level U= unfertilized M= Manure F= fertilized with urea

Total N, P, K, Ca, and Mg uptake by the plants was highly affected by the type of fertilization. Urea treated soil had higher N, K, Ca, and Mg plant uptake, than manure and sludge alone treated soil. In contrast sludge alone-amended soil was generally found to have higher nutrient concentrations than manure and urea amended soil. This was probably the result of dilution effects due to increased plant yield in these two treatments. The alleviation of N deficiency in the soil by the urea & manure may be an explanation but plant N concentrations did not decrease with increasing rate of sludge. Therefore, the urea and manure may also have an indirect effect such as increasing decomposition of phytotoxic constituents in the sludge.

Conclusion

In this type of soil, the addition of urea with sludge is most effective in overcoming the limitations on plant growth induced by oily sludge addition.

Acknowledgment

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Sludge (%)	Treatments					
	Sludge alone		Sludge with Urea		Sludge with manure	
	----------Nitrogen----------					
	Total N uptake (mg)	N %	Total N uptake (mg)	N %	Total N uptake (mg)	N %
0.0	12.77 a	1.65 a	51.90 b	1.38 a	29.32 b	1.11 a
0.5	9.95 a	2.04 b	39.98 a	1.29 a	20.97 a	1.29 a
1	7.5 a	2.26 b	42.71 a	1.29 a	13.62 b	1.41 a
2	3.15 a	1.42 a	36.11 b	1.23 a	9.79 b	1.31 a
	----------Phosphorous----------					
	Total P uptake (mg)	P %	Total P uptake (mg)	P %	Total P uptake (mg)	P %
0.0	11.96 a	1.13 a	13.26 a	0.35 a	14.07 a	0.45 a
0.5	9.72 b	1.36 b	13.0 a	0.39 a	13.65 a	0.65 b
1	6.93 a	1.50 a	12.14 a	0.37 a	12.36 a	0.94 a
2	3.99 b	1.17 b	9.93 b	0.35 a	8.08 b	0.79 b
	----------Potassium----------					
	Total K uptake (mg)	K %	Total K uptake (mg)	K%	Total K uptake (mg)	K %
0.0	51.41 a	4.36 a	190 a	3.34 a	163.86 b	3.64 a
0.5	40.62 a	4.83 a	178 a	3.39 a	101.47a	3.87 a
1	27.32 a	5.0 a	192 a	3.63 a	75.75 a	4.9 a
2	13.99 a	3.37 b	126 b	2.96 a	48.77 a	3.94 a
	----------Calcium----------					
	Total Ca uptake (mg)	Ca %	Total Ca uptake (mg)	Ca %	Total Ca uptake (mg)	Ca %
0.0	6.13 a	0.53 a	30.54 b	0.57 a	12.32 a	0.30 a
0.5	5.72 a	0.72 a	22.75 a	0.45 a	9.11 a	0.37 a
1	4.53 a	0.86 a	28.78 a	0.56 a	9.25 a	0.62 b
2	2.89 a	0.78 a	18.91 b	0.46 a	5.31 a	0.46 b
	----------Magnesium----------					
	Total Mg uptake (mg)	Mg %	Total Mg uptake (mg)	Mg %	Total Mg uptake (mg)	Mg %
0.0	4.27 a	0.42 a	21.24 a	0.43 a	9.95 a	0.28 a
0.5	3.33 a	0.49 a	13.33 b	0.31 b	6.91 b	0.32 a
1	2.38 a	0.55 a	16.09 a	0.36 b	5.65 b	0.43 a
2	1.31 a	0.43 b	9.20 b	0.26 b	2.84 a	0.28 a

Table .1. Amendment effects on oat macronutrient contents. a-b Means within a column followed by the same letter are not significantly different at the 5% probability level.

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