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Influence of Hog Manure and Fertilize N on P Supply Rate in Soil and Uptake by Canola under Controlled Environment Conditions

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Abstract

The effect of manure and urea on P availability to canola was investigated under controlled environment condition. Canola (B.napus) was grown in pots with manure and urea added to two Saskatchewan soils (sandy loam and clay loam) at rates equivalent to 0 (as controls) and 100 mg N/kg. Plants were grown to maturity, and yield and nutrient content determined. Phosphorus supply rates in soils were measured in the pots using anion exchange resin membrane probes.

Additions of manure and urea enhanced canola P accumulation and led to a higher P stored in seeds. This response was more evident in the manure treatment. Soil amended with manure significantly increased both N and P supply rates in soils as the manure contains both N and P. On the contrary, application of urea significantly increased N supply rate but led to a slight decrease in soil supply of available P. When fertilizer N was applied, canola maintained its N:P ratio by increasing P adsorption, possibly due to a greater root mass.

Introduction

Animal manures are considered an important source of N for crop production in many areas in North America, especially in the livestock-intensive regions (Bandel and Fox, 1984; Freeze and Sommerfeldt, 1985; Campbell et at., 1986). Although N content in manure is often the main consideration for the use of manure in farming practice, phosphorus is also important as phosphorus in livestock manure may be readily used by crops (Tunney, 1981; Stewart, 1992).

When livestock manure is applied to soil, the incorporation of manure P leads to an increase in total P availability to crops (Kubota et al., 1947; Vitosh et al., 1973; Change et al., 1991; Eghball and Power, 1995). When N is applied to soil, such as manure or as fertilizer, the increase in N concentration alters microbial activity which can lead to a change in P availability to the crop. Few studies have examined the impact of liquid swine effluent on soil phosphorus availability. This paper reports on a controlled environment experiment to assess how addition of liquid manure effluent affects the supply of available P in the soil. Soil phosphate supply rates, plant yield and P uptake are used to determine the effects.

Material and Methods

Soil and fertilizer sources

Two soil types (associations), Blaine Lake and Meota, were selected from East Central Saskatchewan. The soils were agricultural soils in annual crop production and had never received manure in the past. Soils were collected from the field (O-15 cm), air-dried, crushed, passed through 2-mm sieve and stored at room temperature. Texture was estimated by hand. Electrical conductivity (EC) and pH were measured using a 1:1 soil:water suspension. Organic C was measured using Leco carbon analyzer. CEC measurement was made using 1 N NH4OAc at pH 7.0 (Sumner & Miller, 1996). Amount of available P was determined by the modified Kelowna method (Qian at al., 1994). The selected soil characteristics are summarized in Table 1.

Table 1. Some characteristics of soils used in the experiment.

Soil Association	Texture	pH	EC m S/cm^2	CEC cmol/kg	Organic C %	Available P mg/kg
Blaine Lake	Clay loam	**7.3**	0.51	23.4	**3.66**	**34**
Meota	Sandy loam	**7.6**	0.47	14.5	**3.30**	**24**

The swine manure used in this study was liquid effluent obtained from a single cell earthen storage unit near the location where the soils were collected. Total N and P in the swine manure were measured by sulfuric acid-hydrogen peroxide digestion using a temperature-controlled digestion block (Thomas et al., 1987), followed by determination of the ion concentration in the digest using automated colorimetry. In order to calculate the proportion of organic N in the manure, inorganic N (ammonium-N and nitrate-N) were measured colorimetrically in filtered samples extracted by KC1 solution (Keeney and Nelson, 1982). Available P in the manure was assessed by shaking ion exchange resin membrane in the liquid manure sample for 16 hours followed by colorimetric measurement (Qian at al., 1992). About 7% of the total P in the manure was extracted using membrane technique and considered initially available to the plants (Table 2). Urea was used as an inorganic N source. To compare with manure, rate of ureas used were calculated on the basis of the total N level to match the same amount of total N added in the manure.

Table 2. Nitrogen and phosphorus contents of liquid hog manure (fresh weight basis)*

Analysis	Total N	Organic N		Total P	Available P		PH
	mg/kg	**mg/kg**	**% of total N**	**mg/kg**	**mg/kg**	**% of total P**	
Mean	3356	2092	62.3	1148	76	6.6	8.4
CV	3.7	6.2		12.0	13.1		

***Average of triplicate analyses**

Pot experiment

The pot experiment was designed with 2 treatments (urea and swine manure) and 2 application rates (0 and 100 mg N/kg of soil) with four replicates and conducted in a growth chamber. Eight hundred gram of air-dried soil were weighed and mixed thoroughly with urea solution or liquid manure effluent in each pot. The manure was shaken vigorously to maximize homogeneity before it was applied to the soils. The same amount of water was added to the control soils to maintain moisture at the same level as all the other treatments. After amendment, the soils were equilibrated for 96 hours. The test crop was canola B.napus). No other additional nutrients were applied in any of the treatments.

Approximately 10 seeds were sown in each pot. Seeds were almost completely germinated within 3 to 5 days after seeding in all the treatments. After germination, seedlings were thinned to 3 plants per pot. The growth chamber temperature was kept at 25°C during the day and 12°C at night. Soil moisture was kept near field capacity by daily watering. The pots were completely randomized and rotated each week. Plants were grown to maturity and harvested. Seeds, pods and aerial tissue were separated and dried at 50*C prior to yield determination and nutrient analysis. P content in seed, pod and aerial tissue was measured by colorimetry using autoanalyzer after H_2SO_4-H_2O_2 digestion (Thomas et al., 1967).

Procedure for assessing soil phosphate supply rates

Another set of pot experiment was prepared for assessing phosphate supply rate in the soil. This experiment used the same treatments as the pot experiment but without plant growth and was conducted for the same length of time in the same growth chamber. Ion exchange resin membrane probes were inserted vertically into the soil in each pot. Before insertion of the membrane probes, soils were also equilibrated for up to **96** hours after amendments. Ion exchange membrane probes were allowed to remain in soils for 1 hour, 2 days, 5 days, 1 week, and 5 successive 2 week intervals and were inserted in the same slot each time when the previous probes were retrieved. Therefore, a total of 84 days of cumulative supply of available P was recorded. After the membrane was removed from soils and washed free of adhering soil, the membrane was eluted in 0.5 A4 HC1 for an hour, to desorb the nutrient ions from anion resin membrane into HC1 solution. The concentration of P in the eluents were determined by colorimetry (Qian and Schoenau, 1995).

Results and Discussion

Effect of manure and urea application on P accumulation and yield of canola

A significant increase in P accumulation by canola was observed in both manure and urea treatments (Table 3). This is because nitrogen fertilization in agricultural crops is usually associated with promotion of P absorption by plant (Grunes, 1959). Higher P accumulation in the manure treatment than in the urea treatment is attributed to the contribution of available P from manure. In this study, an amount of 2.26 mg available P per kg of soil was added as manure to the two soils, which represents 6.3 %and 9.4% of the extractable available P originally present in the Blaine Lake and Meota soils, respectively. This amount of readily available P added as manure plus some mineralization of organic P in manure would be expected to contribute to greater plant uptake.

Table 3. Effect of manure and urea addition on P accumulation and distribution in canola plants

Treatment	Total P mg P/kg of soil	Seed P mg P/kg of soil	(%)*	PodP mg P/kg of soil	(%)	Straw P mg P/kg of soil	(%)
<u>Blaine Lake soil</u>							
Control	15.3	2.06	(13.5)	1.18	(7.7)	12.0	(78.7)
Urea	22.0	4.37	(19.9)	2.34	(10.6)	15.6	(70.7)
Manure	25.3	8.50	(33.5)	2.89	(11.4)	14.0	(55.4)
<u>Meota soil</u>							
Control	**6.5**	2.54	(39.4)	0.26	(4.0)	**3.7**	**(56.6)**
Urea	**11.9**	7.47	(62.8)	0.64	(5.4)	**3.8**	**(32.0)**
Manure	**15.8**	7.66	(48.6)	1.28	(8.1)	**6.8**	**(43.1)**
Analysis of Variance			***P value***				
<u>Blaine Lake soil</u>							
Ctr. vs. Urea	**<0.01**	**<0.20**		**=0.10**		**<0.** 10	
Urea vs. manure	co.05	CO.05		NS		NS	
<u>Meota soil</u>							
Ctr. vs. Urea	**<0.01**	**<0.01**		NS		**NS**	
Urea vs. manure	co.05	NS		NS		**=0.10**	
<u>Between soils</u>							
Controls	**<0.01**	NS		co.20		**<0.01**	
Ureas	co.01	**<0.** 10		**<0.05**		**<0.01**	
Manure 100s	**<0.01**	NS		co.05		co.01	

NS = no significant at the P = 0.20 level
*% of total plant P uptake contained in each plant part

Application of manure and urea not only enhanced the P accumulation by canola but also affected the distribution of P storage among the plant parts. Both treatments led to a significantly higher percentage of P stored in seeds (Table 3), which may reflect prolonged P uptake accompanied by higher N adsorption.

Plant yield (seed and straw) was significantly increased as a result of additions of manure and urea (Table 4). Increase in seed yield was closely related to increase in both N and P accumulation as revealed in consistent N:P ratios. However, straw N:P ratios were higher in the urea treatments than the manure treatments, especially in the Meota soil where available P was lower (Table 1). Under conditions of lower P availability as in the urea treatment, translocation of more P from the straw to the seed to satisfy P storage requirement in the seed would result in higher N:P ratios in the straw.

Table 4. Effect of manure and urea addition on canola seed and straw yields and N:P ratios

Treatment	Seed yield (g/pot)	Seed N:P	Straw ield (g/pot)	Straw N:P
Blaine Lake soil				
Control	0.16a	3.8	3.8a	2.2
Urea	0.23a	3.5	7.5b	3.4
Manure	0.71b	3.6	7.1b	2.2
Meota soil				
Control	0.26a	3.9	2.0a	3.5
Urea	0.72b	3.5	5.1b	6.0
Manure	0.70b	3.4	4.7b	2.5

Value in a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's new multiple range test.

Effects of manure and urea applied in soil on soil phosphorus supply rate

The supply rates of available P in the soil were significantly higher in the manure treatments than in the controls (Pig. 1). The gradual conversion of manure organic P to phosphate by mineralization would contribute to continued increase in total phosphate supplied throughout the 84 day period. Higher phosphate supplied to the resin membrane in the manured treatments is consistent with the higher phosphorus uptake by canola.

The supply of available P over the 84 day period in the urea treatment was slightly but significantly lower than in the controls (Pig. 1). Addition of N into the soil significantly alters N:P ratio and can accelerate P immobilization due to balanced absorption of nutrients by microorganisms (Barrow, 1960). It has also been reported that chemical factors lead to lower availability of P in N-only fertilization than combined N and P topdressings in forest nursery soils (Teng and Timmer, 1995). Despite lower P supply rates in urea ameended soils, plant uptake increased in response to N, likely as a result of greater root production and access and demand for soil P.

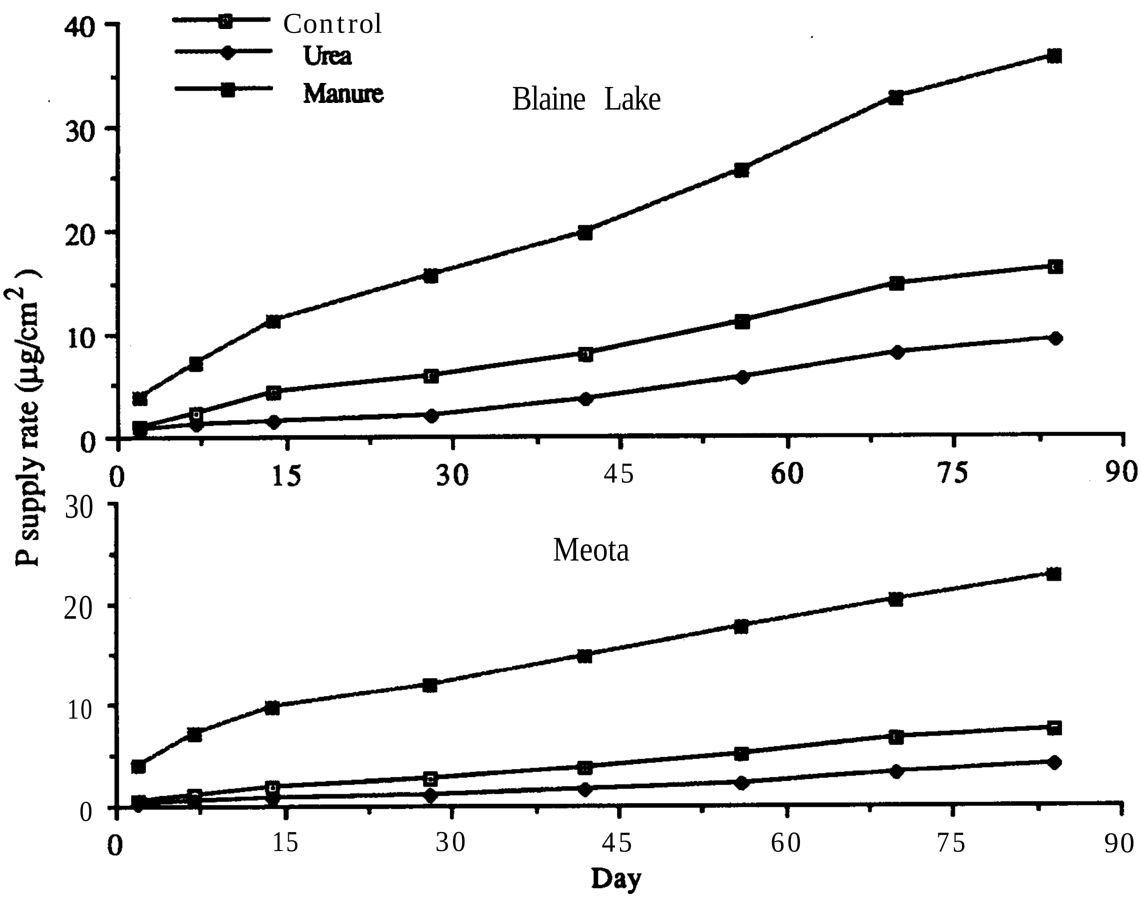

Fig. 1. Cumulative available P supply over time in treatments

Conclusion

Incorporation of swine manure effluent into soils results in an increase in the measured supply rates of available P which appears to be related to mineralization of organic P as well as relatively available inorganic P already present in the manure.. Phosphorus uptake by canola was enhanced by the use of both manure and urea. In the case of the manure, this is attributed to enhancement of available P supplies in the manure as well as promotion of root growth and greater plant access to the P. Increased P uptake in the urea amended soil appears to be related solely to the influence of N on shoot and root growth and access to soil P.

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