Linking Organic Knowledge
OACC
Organic Agriculture Centre of Canada
oacc.info
Le réseau du savoir biologique
CABC
Centre d'agriculture biologique du Canada
agbio.ca

SOIL P STATUS AND NITROGEN FIXATION ON ORGANIC DAIRY FARMS IN ONTARIO AND NOVA SCOTIA

Interim Research Report E2010-40

BACKGROUND

Legumes are a key source of nitrogen (N) in organic production systems. However, there is evidence that reduced inputs may be leading to deficient soil phosphorus (P) on some organic dairy farms (Roberts et. al. 2008). This may affect crop performance and N fixation in forage legumes. This study aims to gauge the relationship between soil P dynamics in organic dairy systems and legume biological nitrogen fixation (BNF).

The study has two main sub-projects:

1. A field survey of soil-test P and legume forage productivity and N fixation on dairy farms in Ontario and Nova Scotia.
2. Growth chamber and greenhouse studies examining:
    a) The role of P nutrition in legume growth and N fixation, and
    b) The P-supplying power of composts, struvite, and a rock P source.

Field data was commenced in the 2008 season, and was completed in 2009. Growth chamber and greenhouse studies were conducted in 2009. Analyses of 2009 samples are not complete at the report date.

METHODS

Field Study

In 2008, soil P and forage-crop yield, N uptake, and BNF were explored on 28 mixed-legume forage fields on organic and transitional dairy farms in Ontario and Nova Scotia. This was repeated in 2009 on 23 of the same fields. In each field, between 7 and 25 sample points were arranged at fixed intervals along linear transects. At each point, soil samples were collected at first cut, and 0.5 m^2 of forage was collected at each cut.

Soils were extracted according to standard soil test procedures for each province (Mehlich III in NS, Olsen bicarbonate in ON), and analyzed for P and other minerals. Forage samples were sorted into alfalfa, clovers, grass and weeds, and each portion was dried, weighed and ground. Separated forage was analyzed for N and P, and selected samples for 15N. N fixation was estimated by the 15N natural abundance technique.

Growth Chamber and Greenhouse Study

Soil was collected from known low soil-test P fields in Ontario and Nova Scotia, with levels assessed at 8.4 mg P kg^{-1} and 8.1 mg P kg^{-1}, respectively, by provincial soil test procedures. Two experiments were conducted on soybean (cv. Evans) with increased rates of added P. At harvest, plant growth was measured and N fixation was assessed. A similar experiment was conducted on alfalfa (cv. Iroquois). The plants were cut three times prior to harvest. Each cut occurred during the early flowering stage.

Collecting forage samples in Nova Scotia, July 2009 (M. Main)

Table 1. Summary of field results for Nova Scotia and Ontario trials

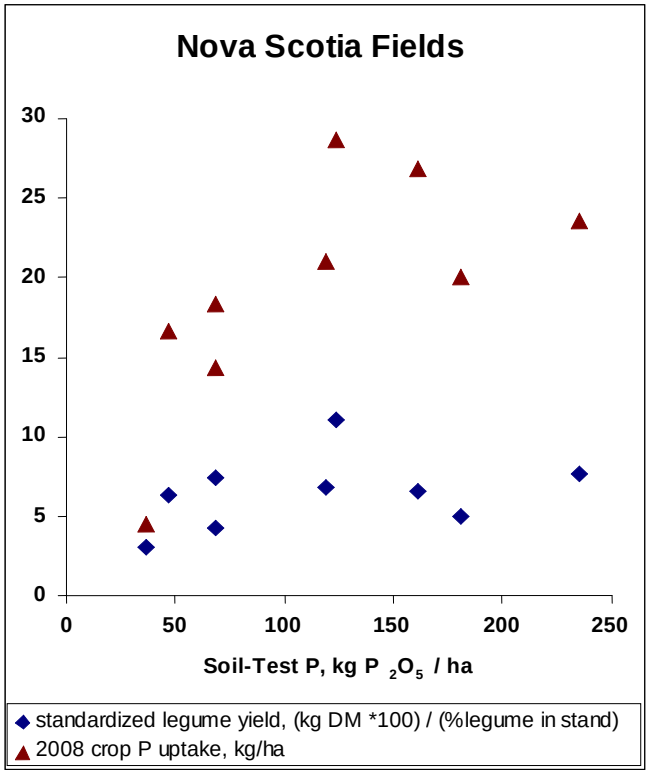
Field ID	Prov.	Main legume	2008 Legume content	2009 Legume content	2008 Soil-test P	Soil-test P rating	Yield 2008	Yield, 2009	2008 N yield	2008 N fixation	2008 Mean tissue P conc.	2008 Crop P uptake
			%	%	*		kg ha^{-1}		kg ha^{-1}	kg ha^{-1}		kg ha^{-1}
101008	NS	alfalfa	70%	59%	68	L-	6349	8656	212	55	0.29%	18.4
101012	NS	clover	34%	26%	46	L-	6286	6461	175	30	0.27%	16.7
102003	NS	clover	17%	5%	68	L-	4150	4466	97	19	0.35%	14.4
102021	NS	clover	51%	22%	234	M+	6676	8760	194	72	0.35%	23.6
102024	NS	clover	58%	23%	118	L	6174	7655	190	58	0.34%	21.0
102026	NS	clover	34%	11%	181	M-	4645	5574	162	29	0.43%	20.1
103002	NS	clover	14%	2%	36	L-	3422	2921	41	10	0.13%	4.5
104108	NS	clover	14%	15%	161	L+	7129	7714	156	25	0.38%	26.9
104109	NS	clover	11%	8%	124	L	7459	8614	167	36	0.38%	28.7
205010	ON	alfalfa	77%	59%	6	L	7841	8617	243	121	0.27%	21.5
205013	ON	alfalfa	76%	61%	7	L	6460	5013	225	158	0.27%	17.6
206016	ON	alfalfa	56%	38%	12	M	2449	2504	82	46	0.32%	7.8
207001	ON	alfalfa	65%	31%	9	L	7023	6930	220	78	0.33%	22.9
207101	ON	alfalfa	81%	51%	14	M	7047	7459	260	143	0.30%	21.5
208001	ON	alfalfa	59%	43%	4	L	4093	6722	145	84	0.25%	10.1
209008	ON	alfalfa	85%	72%	8	L	7954	6642	260	99	0.32%	25.4
209011	ON	alfalfa	74%	30%	9	L	6030	4242	211	79	0.26%	15.5
211002	ON	alfalfa	46%	25%	10	M	5988	5179	170	77	0.37%	22.3
211007	ON	alfalfa	62%	46%	6	L	5111	2755	147	93	0.28%	14.4
212105	ON	alfalfa	57%	57%	14	M	4477	6884	143	75	0.34%	15.2
212108	ON	alfalfa	45%	34%	10	M	4787	6728	144	67	0.31%	14.7
214408	ON	alfalfa	57%	11%	4	L	3314	5594	108	43	0.29%	9.6

**** Units: NS: Kg P_2O_5 per ha in Mehlich III extractable; ON: mg P per kg soil in Olsen bicarbonate extractable***

The final experiment evaluated three soil amendments for their ability to supply an adequate amount of P for plant growth. The amendments tested were phosphate rock partially solubilized by citric acid, MSW compost and a struvite product sold as Crystal Green®. Struvite is a P rich product, 28% P_2O_5, formed by a precipitate from wastewater. These products were tested on soybeans at approximately 15 and 30 mg P kg^{-1}.

INTERIM RESULTS: FIELD STUDY

Table 1 shows a broad summary of results for the majority of fields. Yields correlated strongly with legume percentage in Ontario. The majority of N yield in Ontario systems is from legumes. In Nova Scotia, this is also true but less pronounced, because comparatively more N is imported in feeds and passed into the manure; also, average legume content of swards was lower in Nova Scotia.



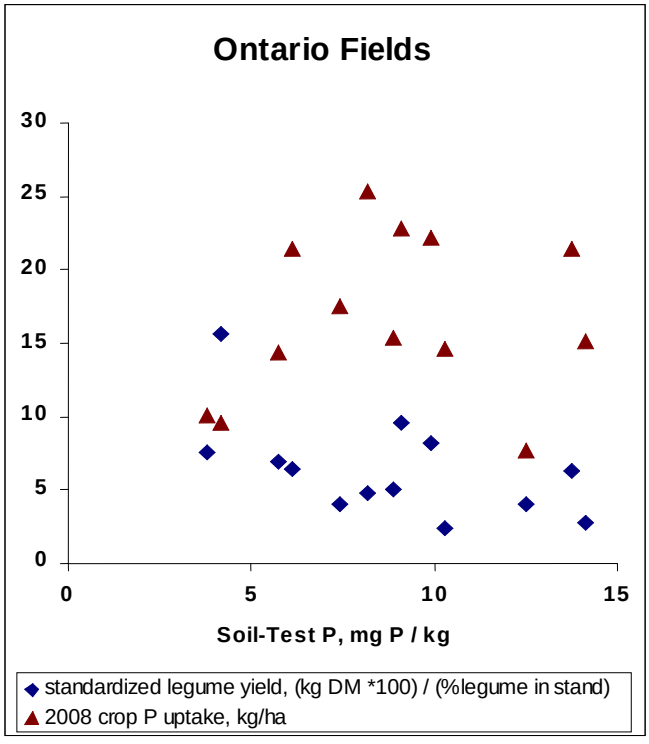


Figure 1. Field soil-test P versus standardized legume yield and crop P uptake for fields in Nova Scotia (top) and Ontario (bottom)

Grass and weed N uptake averaged 55 kg ha^{-1}, with the balance obtained from legumes. N fixation varied widely between fields, but tended to be lower on those fields that received manure N. Most Nova Scotia fields received manure.

Tissue P concentrations ranged between 0.2% and 0.5% on most fields, and were usually in a range considered sufficient for growth in studies of legume physiology. Crop P uptake tended to rise with increasing soil test P, but this did not obviously affect legume yield or N fixation, except on one NS field which was extremely low in soil-test P. Figure 1 shows trends in crop P uptake and yields as a function of soil-test P.

In summary, sufficient crop P uptake is important to N fixation, but this trial suggests that low soil P is only an issue at the lowest soil-test ratings. Further analysis will reveal more information on the relationship of soil P to crop performance and N fixation. Legumes are the main source of forage crop N supply on most of the farms in the study.

INTERIM RESULTS: GROWTH CHAMBER & GREENHOUSE TRIAL

The first two experiments conducted on soybean showed a plant growth response to added P. Total shoot N and P increased in a linear fashion with added P (Figure 2). The total N content was always lower in the reference plants indicating an increase in N fixation. As well, shoot height, shoot dry mass and dry nodule mass increased with increased added P. In the alfalfa, the plant dry mass at the second cut increased with increased added P.

The trial for the evaluation of amendment ability to supply P was recently harvested and data analysis has not been completed. In general, plant growth was better with the amendments than the control with no additions.

In general, there was a plant response to added P including: increased total shoot N and P, increased nodule dry mass and shoot dry mass. This indicates sufficient soil available P is necessary to maximize the amount of N obtained from legume N fixation.

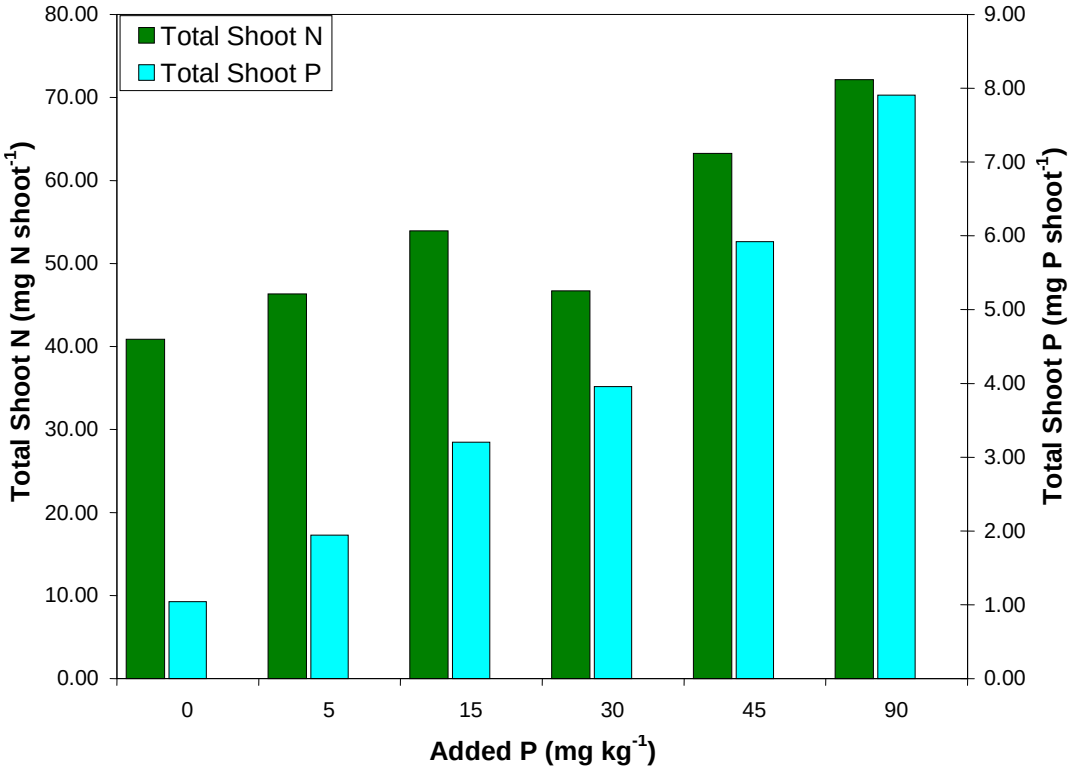


Figure 2. Evans soybean total shoot N and P in response to added P fertilizer grown in Nova Scotia soil

REFERENCE

Roberts, C.J., Lynch, D.H., Voroney, R.P., Martin, R.C. and S.D. Juurlink. 2008. Nutrient budgets of Ontario organic dairy farms. Canadian Journal of Soil Science 88:107-114.

CREDITS

Michael Main (Organic Meadow/OACC), Derek Lynch and Amanda Ward (NSAC), Paul Voroney and Kim Schneider (University of Guelph) and Shelly Juurlink (Organic Meadow).

FUNDING

Organic Meadow Cooperative
Natural Sciences and Engineering Research Council
Canada Research Chairs Program
Agricultural Research Institute of Ontario

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

THE BOTTOM LINE...

Where soil-test P is extremely low (as in the growth-chamber study), crop growth and N fixation will be substantially reduced. However, at moderately low soil-test P, forage legumes can perform quite well. It is likely that annual legumes will be more sensitive to low soil P, since they have more limited root systems. While low soil P has potential to limit N fixation, this study shows that even soils testing low in P can support good forage yields on organic farms. A final report with conclusions on the P-supplying power of organic amendments will be presented in 2011.

NSAC. Embrace Your World.

For more information:
Visit **oacc.info** or contact us at
P. O. Box 550 Truro, NS B2N 5E3
Tel: (902) 893-7256
Fax: (902) 896-7095
Email: oacc@nsac.ca