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

# FERTILITY MANAGEMENT FOR ORGANIC CEREAL PRODUCTION

*Interim Research Report E2010-60*

## BACKGROUND

Organic grain producers in the Maritimes have struggled to maintain yields on land where manure is not readily available on the farm. They have been seeking options for both cultivar selection and the use of soil amendments as compared with the standard practice of using a forage green manure. This research compares the use of red clover ploughdown with pelletized poultry manure as a nitrogen (N) source for organic cereal production in Prince Edward Island, Canada. Green manures improve the diversification of crop rotations, and help retain nutrients in the soil while increasing the organic matter content. Legumes which fix nitrogen, such as clover and vetch, add nitrogen to the soil and can therefore offset or help meet the fertility requirements of the subsequent crops.

## WHAT WAS DONE

In 2008 and 2009, the Organic Agriculture Centre of Canada began a Previous Crop Trial on an organic farm in Prince Edward Island to assess the effects of different previous crops (clover or oats) on six barley cultivars (AC Legend, Chapais, AC Klink, AC Encore, CDC McGwire and AC Queens) and two oat cultivars (AC Baton and Nova).

A Fertility Trial was also conducted over the two year period in PEI to compare:

i) Previous crop of oats ploughdown ($oats_{prev}$),
ii) Previous crop of clover ploughdown ($clover_{prev}$),
iii) $oats_{prev}$ + N (Nutriwave™), and
iv) $clover_{prev}$ + N

For the Fertility Trial, three barley cultivars (AC Queens, AC Encore and CDC McGwire) and one oat cultivar (AC Baton) were examined. AC Queens is a hulled 2-row cultivar, whereas CDC McGwire is a hulless 2-row cultivar. The others are all hulled 6-row cultivars.

**Barley planted after clover ploughdown (J. MacKenzie)**

Small plot (1.5 m x 8 m) research trials were established as strip plots bisected by previous crop histories. As such, half of each strip was previously a two-year old red clover stand, while the other half of the strip was oat stubble. The clover and oat residue were incorporated 2-3 weeks prior to planting to allow initial decomposition of the residues and to avoid potential toxicity problems. The supplemental pelletized poultry manure was applied to the selected plots one week before seeding at a rate of 60 kg N $ha^{-1}$ (3000 kg $ha^{-1}$ of 4-1-2 product, assuming 50% N availability).

Plots were seeded in May with a small plot seeder and harvested at maturity using a plot combine. The grain was dried and weighed for yield (adjusted for moisture content of 13.5%), thousand kernel weight, test weight and protein content. Biomass subsamples from each of the treatments used in the Fertility Trial were also collected in the summer, at the soft dough stage, to assess N uptake by the crop.

### *Previous Crop Trial*

There was a significant cultivar effect observed in the Previous Crop Trial for the barley cultivars; however, there was no interaction between cultivar and previous crop.

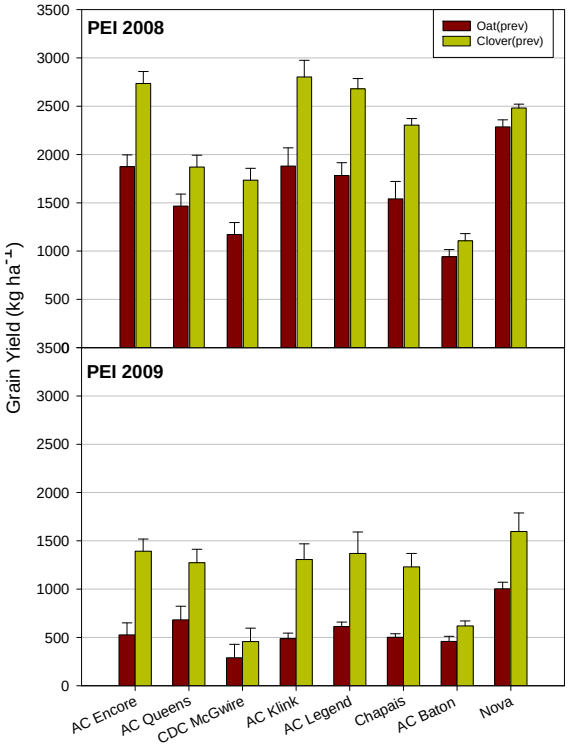


**Figure 1. Yield of barley and oat cultivars following either a previous crop of oats or red clover.**

The clover$_{prev}$ treatment increased yield (Fig. 1) and thousand kernel weight in all barley cultivars, but did not affect test weight (data not shown). Yield was 54% higher on average across all barley cultivars following the clover$_{prev}$ treatment compared to the oats$_{prev}$ treatment (Fig. 1). However, cultivar performance varied across the two site years. In 2008, AC Legend, AC Encore and AC Klink yielded significantly higher than the other cultivars; whereas in 2009, only CDC McGwire (hulless barley) had significantly lower yield. The reduced grain yields in the 2009 site year may have occurred due to drier conditions in late May to mid-June limiting establishment and yield potential, followed by wet conditions which prevented opportunities for mechanical weed control.

For the oats, cultivar differences outweighed the effects of the green manure for most traits. Nova had greater grain yield (Fig. 1) and higher thousand kernel weight, with lower test weight (data not shown) than AC Baton.

### *Fertility Trial*

The three barley cultivars (AC Queens, AC Encore, CDC McGwire) that received the Nutriwave™ amendments had increased yields in 2008 and 2009 as a result of the amendment (Fig. 2). The relative amount of increase was smaller for the CDC McGwire than for AC Encore and AC Queens. Yield in 2009 (600-1700 kg ha$^{-1}$) was lower overall than in 2008 (1500-2500 kg ha$^{-1}$) which may have been caused by the dry conditions in late May to mid-June limiting yield potential.

Yield in the oats$_{prev}$ treatments were typically lower than in the other treatments, although for CDC McGwire these differences were not always significant (data not shown). Interestingly, when Nutriwave™ was applied to the oats$_{prev}$ ploughdown it provided the same yield advantage as the clover$_{prev}$ treatment (Fig. 2). The addition of the Nutriwave™ to the previous crop of clover (clover$_{prev}$) resulted in even greater yields for the barley crops, particularly for the cultivars AC Encore and AC Queens.

N uptake by the crop+weeds was significantly higher under clover$_{prev}$+N in both years, whereas the N uptake by crop+weeds in the oat$_{prev}$ was consistently lower (Fig. 3). The N content of the crop ranged from 1.1-1.4% in 2008 and 1.0-1.2% in 2009, and weed N content ranged from 1.5-1.6% in 2008 and 1.4-1.9% in 2009.

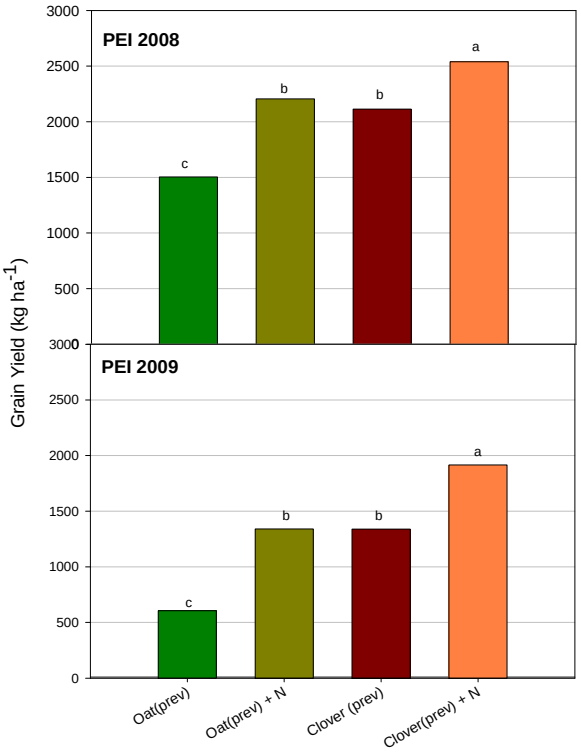


**Figure 2. Previous crop and Nutriwave™ effects on barley grain yields. Bars with the same letter, within a year are not significantly different (p<0.05).**

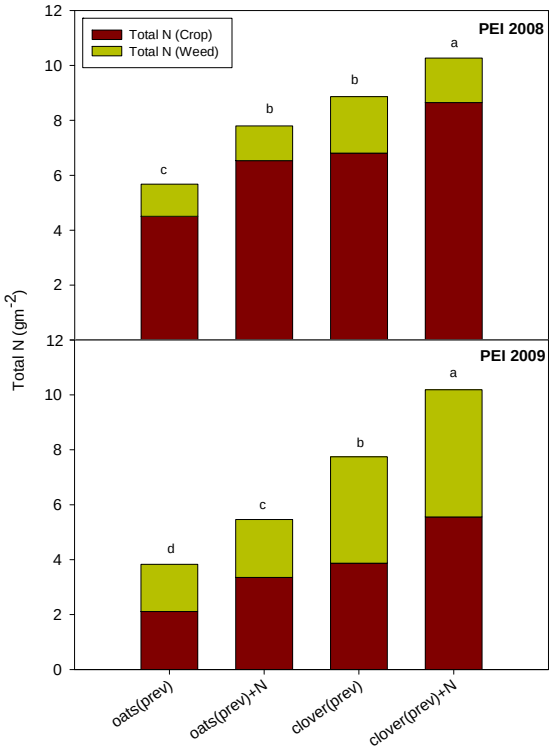


**Figure 3. Previous crop and Nutriwave™ effects on total N content in the biomass of barley and of weeds. Bars with the same letter are not significantly different (p<0.05).**

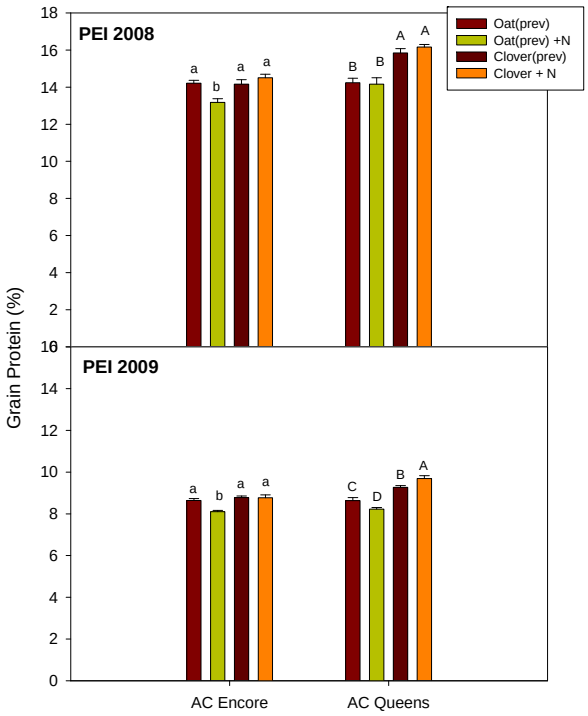


**Figure 4. Previous crop and Nutriwave™ effects on grain protein content in two barley cultivars. Bars with the same letter, within each cultivar, are not significantly different (p<0.05).**

The clover$_{prev}$ treatments only increased plant N uptake by 25-40 kg ha$^{-1}$ above the 40-60 kg ha$^{-1}$ provided by the soil in the oats$_{prev}$ treatment. However, the contribution of a previous crop of clover was greater than that received from 3000 kg ha$^{-1}$ of Nutriwave™, which supplied 15-25 kg ha$^{-1}$ of N for plant uptake.

Protein content of the barley cultivars was also found to be lower on the oats$_{prev}$ compared to the clover$_{prev}$. Furthermore, the application of the Nutriwave™ to the oats$_{prev}$ treatment reduced the protein content further still (Fig. 4). This was attributed to higher N availability during early plant growth (at the 3$^{rd}$ leaf stage) associated with the poultry manure, resulting in higher yield potential but protein dilution at seed filling. In contrast, the N released from the previous crop of clover was expected to extend longer through the season. While providing the same yield effect, the poultry manure and clover differed in their impact on protein.

Compared with oats$_{prev}$, thousand kernel weight (TKW) and test weight for barley cultivars were higher for clover$_{prev}$ and +N treatments although differences were not always significant (Table 1).

Grain yield and TKW for the oat cultivar AC Baton were not as responsive as for the barley cultivars. Only in 2009 was there a significantly greater yield reported for the clover$_{prev}$ + N treatment (Fig. 4). However, test weight for AC Baton grown on the oats$_{prev}$ treatment was significantly greater than found on the other fertility treatments (Table 2). Similar to the barley cultivars, oats had greatly reduced yields in 2009 in comparison with 2008.

**Table 1. Previous crop and Nutriwave™ effects on thousand kernel weight (TKW) and test weight for three barley cultivars. Within a year, treatments with the same letter are not significantly different (p<0.05).**

| Treatment | TKW (g) | Test Weight (kg hL$^{-1}$) |
|---|---|---|
| | 2008 | |
| oat$_{prev}$ | 36.50c | 56.7a |
| clover$_{prev}$ | 38.12bc | 58.1a |
| oat$_{prev}$ + N | 37.08b | 57.5a |
| clover$_{prev}$ + N | 39.79a | 57.6a |
| | 2009 | |
| oat$_{prev}$ | 33.23d | 55.5b |
| clover$_{prev}$ | 38.53c | 58.1a |
| oat$_{prev}$ + N | 37.16b | 57.6a |
| clover$_{prev}$ + N | 40.12a | 58.7a |

**Table 2. Previous crop and Nutriwave™ effects on AC Baton oat yield, thousand kernel weight (TKW), test weight and protein content. Within a year, treatments with the same letter are not significantly different ($p<0.05$).**

| Treatment | Yield (kg ha$^{-1}$) | TKW (g) | Test Weight (kg hl$^{-1}$) | Protein (%) |
|---|---|---|---|---|
| | | 2008 | | |
| oat$_{prev}$ | 941a | 28.50a | 528a | nd* |
| clover$_{prev}$ | 1106a | 28.75a | 503b | nd |
| oat$_{prev}$ + N | 1142a | 28.38a | 506ab | nd |
| clover$_{prev}$ + N | 1120a | 28.00a | 495b | nd |
| | | 2009 | | |
| oat$_{prev}$ | 459b | 32.37a | 566a | 12.17a |
| clover$_{prev}$ | 619ab | 32.00a | 532ab | 12.49a |
| oat$_{prev}$ + N | 580ab | 32.00a | 532ab | 12.07a |
| clover$_{prev}$ + N | 681a | 32.50a | 516b | 12.51a |

*nd- data was not analysed.

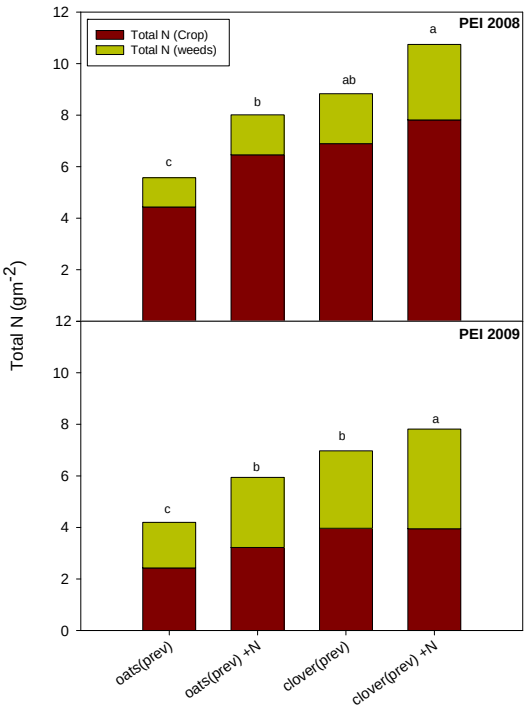


**Figure 5. Previous crop and Nutriwave™ effects on total N content in the biomass of oats and weeds. Bars with the same letter are not significantly different ($p<0.05$).**

## CREDITS

Karen Nelson, Joanna MacKenzie and Andy Hammermeister (OACC)

## ACKNOWLEDGEMENTS

Thanks to Mark Bernard (Barnyard Organics), Susan MacKinnon (PEIDA), and OACC technicians.

Yield in 2009 ranged from 450 to 700 kg ha$^{-1}$, whereas in 2008 oat yield was in the range of 900 to 1100 kg ha$^{-1}$. Total N for the oat crop+weeds was found to be significantly greater under the clover$_{prev}$+N. Overall, total N was lower in 2009 than 2008. Total crop N content ranged from 1.1-1.5% in 2008 and 1.1-1.3% in 2009, with the total weed N in the range of 1.5-2.3% in 2008 and 1.2-1.7% in 2009. The average crop biomass was larger in 2008 (418-538 g m$^{-2}$) compared to 2009 (208-331 g m$^{-2}$). Average weed biomass ranged from 76-124 g m$^{-2}$ in 2008 compared to 104-320 g m$^{-2}$ in 2009. Protein content was only analysed for the 2009 site year. The incorporation of clover$_{prev}$ and Nutriwave™ did not affect protein content for the oat cultivar AC Baton. Protein content for all four treatments was approximately 12%.

## THE BOTTOM LINE...

Barley response after the clover ploughdown was equivalent to the application of 3000 kg ha$^{-1}$ of pelletized poultry manure (approx. 60 kg ha$^{-1}$ of available N). Barley protein content was increased when grown following clover, but may be reduced with application of poultry manure. The cost of poultry manure purchase and application must be considered in comparison to putting land into clover for 1-2 years. Oats were not as responsive to the use of a green manure or pelletized poultry manure.

## FUNDING & PARTNERS

Funding and in-kind support for this research and this bulletin has been provided in part by:
Prince Edward Island Department of Agriculture
Prince Edward Island ADAPT Council
Agri-Futures, Nova Scotia's ACAAF Council
New Brunswick Agriculture Council
NSAC Department of Plant and Animal Sciences
Atlantic Canadian Organic Regional Network

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

***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