CORD-9015 Nitrogen management in fresh vegetables – Peppers.

CORD IV #9015

Grant # 048291

Final Report
30 November 2007

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Fresh Vegetable Growers of Ontario
Agricultural Adaptation Council
Canada-Ontario Research and Development Program IV

CORD-9015 Nitrogen management in fresh vegetables – Peppers.
Final Report: March 2007 – November 2007

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Executive Summary:
New legislation such as source water protection, as well as nutrient management regulations may limit nutrient applications. If fertilizer rates are reduced without appropriate increases in nutrient use efficiency, which in turn causes a modest 10% reduction in yield, this could represent a $1.3 million decrease in farm revenues for pepper producers alone (based on 2005 OMAFRA data). Therefore, field experiments were conducted in 2005-2007 to determine 1) the most economic rate of N in fresh market peppers, 2) N cycling and dynamics in pepper including potential for nitrate leaching, 3) methods to increase nitrogen use efficiency such as split N applications and nitrification inhibitors and 4) assess the implications of OMAFRA's N index on pepper producers. At both sites, there were no differences in pepper yield or quality between other nitrogen treatments. In-season nitrogen applications and UMAXX® did not improve yields, quality, or nitrogen use efficiency in peppers. The amount of N taken up by the crop (ie N in shoots and fruit) was approximately 110 lb N/ac and did not increase with more fertilizer. However, the amount of nitrate in the soil increased significantly with more fertilizer applied. Therefore N use efficiency could be improved by reducing N rates with minimal impact on pepper yield or quality. In its current form, the nitrogen index component of OMAFRA's nutrient management should not impact growers applying N at the provincial recommended (63 lb N/ac). But, those growers applying three times the provincial rate (188 lb N/ac) must, according to the N index, consider alternative management practices, such as reducing rates or planting cover crops. Results from this research have been used in revised nutrient management (NMan)calculations by OMAFRA to ensure that accurate Ontario data is represented. Moreover, this research will improve the long-term competitive position of Ontario agriculture and food sector by demonstrating that Canadian growers are environmentally responsible stewards of the land and water.

Project Results and Milestones:

Most Economic Rate of N (MERN)

At the Harwich site, total marketable pepper yield was higher in the zero fertilizer N treatment compared to the split application of 63+31 lb N/ac, but the remaining treatments were not statistically different (Table 1). At the Harwich site, first-pick yields were higher in the split N treatments compared to the zero N treatment. Thus, in 2007, the split application treatments put on peppers early but do not out perform other treatments. At Ridgetown Campus, there were no statistical differences in first pick and total marketable pepper yield between the different nitrogen treatments (Table 1).

The lack of response to nitrogen may be partially explained by drought shortly after planting; where water not N was limiting. Moreover, soil mineral N was greater than 23 ppm at the time of sidedress (data not shown), which indicates that N was not limiting at Ridgetown. The different yield responses to nitrogen observed between the two sites was likely due to the previous crops – soybeans at Ridgetown and seed corn at Harwich.

Table 1. Green pepper yield response to different nitrogen applications [*].

N Application	Marketable yield (T/ha)			
	Ridgetown		Harwich	
lbs N/ac	1st Pick	Total	1st Pick	Total
0	9.5	23.2	11.8 c[**]	27.5 a
31	7.6	21.7	15.9 ab	23.6 ab
63	7.6	21.4	15.7 ab	25.3 ab
125	9.4	23.4	12.7 bc	22.9 ab
188	10.2	22.2	12.8 bc	26.6 ab
31+ 31	8.2	20.8	16.8 a	23.1 ab
63 + 31	5.9	20.3	16.6 a	21.5 b
UMAXX	7.2	21.7	15.6 ab	24.9 ab
0 + 31	8.6	22.6	na	na

[*] Data are expressed as averages of 4 replicates.
[**]For each column, different letters indicates a statistically significant difference in pepper yield.

Quality Individual pepper weight, length, width, and wall thickness were measured. On the first pick, pepper length was longer with 125 and 63+31 lb N/ac compared to 188 and 31 lb N/ac but trends were not consistent with N rate. Results were similar for pepper wall thickness. There were no differences in these quality parameters with the different N fertilizer treatments on the other three picks. Generally individual peppers were smaller on the first (mid August) and last harvest (early October). Thus, over the whole season quality was not affected by N rate.

Split-application of N fertilizer

There was no yield or quality advantage of split applying N. As well, there were no differences in crop nitrogen uptake or removal between the split-application compared to the same amount applied pre-plant. Therefore, there was little to no benefit to split N application of the same amount of N fertilizer because split applications do not consistently 1) provide a yield or quality benefit, 2) improve nitrogen use efficiency, or 3) reduce NO_3-N quantities at harvest. From a BMP perspective, the main potential environmental benefit of split applications would be if the second application was not applied, thereby reducing the total fertilizer application.

Slow release fertilizers - UMAXX®

UMAXX® is a urea-based fertilizer containing a urease inhibitor and a nitrification inhibitor, which slows the conversion of urea to nitrate. The principle is that nitrate is released when the plant takes up nitrogen. Results from our research indicates that there was no yield or quality advantage of using UMAXX®.

Split applied N and to a lesser extent UMAXX® and other slow release fertilizers have been shown to increase nitrogen use efficiency in field corn and sugar beets. This is due to differences in N dynamics and requirements between field and horticultural crops. For instance, compared to field crops, horticultural crops are typically transplanted into warm soils with a shorter growing season (as short as 6 weeks vs. 6 months) and are typically harvested prior to maturity. These differences may explain the lack of advantage of split applications and UMAXX® in peppers and thus these practices are not recommended for peppers.

Crop N Uptake and Removal Values

Crop N uptake is the amount of nitrogen in the leaves and shoots, and crop removal is the quantity of nitrogen in the pepper fruits. Compared to the non-fertilized control, applied fertilizer N increased crop N uptake, but there was no difference between 63, 125, and 188 lb N/ac treatments (Table 2). With fertilizer the average quantity of N in the crop fruit (crop N removal) was 75 lb N/ac and in the plant shoots only 35 lb N/ac. On average a pepper crop takes up approximately 110 lb N/ac, regardless of how much fertilizer is applied (Table 2). Thus, if a grower applies twice as much N fertilizer, the plant does not take up twice as much N and yields do not increase to pay for the extra fertilizer. Therefore it would be an advantage to reduce fertilizer applications to the most economical rate of N. At the final harvest, there was no difference in shoot weight between N treatments. Thus pepper plants were luxury consumers of N because increasing N fertilizer does not increase plant shoot weight or fruit yield. These data have been used in nutrient management calculations by OMAFRA to ensure that accurate Ontario data is represented.

Table 2. Partitioning of nitrogen (lb N/ac) in the pepper crop and soil at harvest.

N applied	crop N uptake	crop N removal	total crop nitrogen	Soil nitrate (0-3 ft)
0	27 a*	70 a	101 a	40 a
63	34 b	76 a	110 a	57 b
125	36 b	79 a	116 a	86 c
188	36 b	75 a	113 a	162 d

*For each column, different letters indicates a statistically significant difference.

Soil Residual N at Harvest

It must be noted that even without N fertilizer applied, there was 40 lb of nitrate/ac to the three foot depth at harvest. This is typical for SW Ontario soils. As expected, with more fertilizer applied there was more residual soil nitrate at harvest (Table 2). Nitrate, especially after crop harvest, is susceptible to leaching over the fall and winter. For example, with 188 lb N/ac applied pre-plant to peppers, on average 162 lb N/ac of nitrate was in the soil to the three foot depth. But, if you apply twice as much N fertilizer, the plant does not take up twice as much N and yields do not increase significantly (Table 1). At the recommended N rate for peppers, there was only 17 lb N/ac more nitrate in the soil to the 1 ft depth than when no fertilizer was applied.

N Index

The nitrogen index is part of OMAFRA's nutrient management workbook. It is a tool designed to identify management practices and soil conditions that pose a significant risk of nitrate leaching to groundwater. A component of the N index is the crop removal balance, which is fertilizer N minus crop N removal (Table 3). If the calculation is less than 15 lb N/ac, then there is little leaching concern; if greater than 15 lb N/ac, then depending on soil type (Table 4), alternative management practices may be necessary.

Based on research results (Table 3), if a grower applies the recommended rate (63 lb N/ac), then there is no need to further calculate the N index because the crop removal balance value is less than 15 lb/ac (Table 3 and 4). But many growers often apply more than OMAFRA's recommended rate. Based on our research, an application of 188 lb N/ac gives a crop removal balance value of 113 lb N/ac, which corresponds to N index value A of 5 (Table 3 and 4). Fresh pepper production in SW Ontario tends to be lighter soil from sand to loam, which is prone to nitrate leaching. The maximum N index A value on a sandy loam soil is 3, therefore, the above scenario exceeds the maximum allowable N-index value, dictating that alternative management practices, such as reducing N rates or planting a cover crop, are necessary. At 125 lb N/ac – a more typical grower rate – the maximum allowable N-index value is exceeded only in the most sensitive shallow sandy soils (Table 3 and 4). Thus, growers on these soils will have to modify management practices in order to comply with the N index in its current form. It should be noted that this research did not include manure, which is part of OMAFRA's N-index and would greatly affect N-index values.

Table 3. Pepper crop removal balance calculation is fertilizer minus crop N removal or N in the fruit (lb N/ac).

N Applied	Crop N Removal	Crop Removal Balance**	Notes:
0	70 a*	-70 a	**A negative value indicates that more N was removed from the field in the fruit than fertilizer applied
63	76 a	-13 b	
125	79 a	46 c	**A positive crop removal value is used to obtain value A from Table 4. A crop removal balance of 46 equates to a A value of 3
188	75 a	113 d	

*Different letters indicates a statistically significant difference.

Table 4. Modified OMAFRA tables to calculate N index –crop removal balance and soil type influences on leaching risk.

Crop removal balance (lb N/ac)	N index value A
< 15	0
15 - 30	1
31 - 45	2
46 - 60	3
61 - 80	4
81 - 120	5
121 - 180	6
>180	stop

Hydrological soil group	Soil Type	Risk of leaching	Max. N index value A
AA	shallow A soils	v. high	1
A	sand, loamy sand, sandy loam	high	3
B	silt loam or loam	medium	4
C	sandy clay loam	low	6
D	heavier soils	v. low	9

Nutrient management and source water protection may severely impact Ontario vegetable production. The nutrient management (Nman) program and N-index are currently part of Ontario's regulations. This research provides current Ontario vegetable data that will be incorporated into the Nman program by OMAFRA. These short-term results strengthen Ontario's nutrient management program in horticulture and provides confidence in Ontario's nutrient management program as well as identifying limitations in the program. Long-term goals are to validate (or refute) the N-index and includes the development of best management practices of N management that reduce N losses while maintaining crop yield and quality.

This research project supported one full-time temporary research assistants during the summer and contributed support for one during the fall. These university students were hired to assist with the plot work such as, establishing field plot experiments, planting crops, applying fertilizer, soil sampling, plot maintenance, harvesting vegetable crops, assessing plant and yield quality parameters, and recording data.

Project Expenditures:

The Office of Research at the University of Guelph has provided a full accounting of the project's financial statements, including a listing of matching funding and in-kind contributions.

Reach and Technology Transfer Activities:

Primary Target: Ontario fresh vegetable producers are the primary target of this research, along with processing pepper growers, relevant OMAFRA staff, and agribusiness personnel, and crop consultants. Through presentations and reports to Fruit and Vegetable Growers of Ontario and the following technology transfer activities described below, it is anticipated that approximately 30-50% of the growers were/will be reached.

Support Identified: The Fresh Vegetable Growers of Ontario, Agricultural Adaptation Council, the Canada-Ontario R&D Program, and the Ontario Ministry of Agriculture, Food, and Rural Affairs were listed as supports in the acknowledgements of all reports/papers. As well, these organizations were acknowledged as a sponsor in all presentations.

Method of Technology Transfer: *Bold names indicates principle presenter/writer. All reports will be posted on the University of Guelph Ridgetown Campus website. http://www.ridgetownc.on.ca/research/research_vaneerd.cfm

Research Articles

Van Eerd, L.L. 2007. Assessing different nitrogen use efficiency indices using field-grown green bell peppers. Canadian Journal of Plant Science: 87:565–569.

Technical Reports and Conference Proceedings

Van Eerd, L.L. 2007. Nitrogen management in fresh vegetables – Peppers. CORD-1625. Final Report to Agricultural Adaptation Council and Fresh Vegetable Growers of Ontario. November 2007. pp 8.

Van Eerd, L.L. 2007. On-farm nitrogen tests to minimize nitrogen inputs and optimize yields in processing green peppers. Report to Ontario Processing Vegetable Growers and Ontario Food Processors Association. November 2007. pp. 8.

Van Eerd, L.L. 2007. Do You Need More Nitrogen on Your Peppers? Great Lakes EXPO Proceedings and Session Summaries. December 2007. pp 3. *Available on-line www.glexpo.com*

Presentations

Van Eerd, L.L. 2007. Do You Need More Nitrogen on Your Peppers? Great Lakes Fruit Vegetable and Farm Market EXPO. Grand Rapids, Michigan. *Invited Presenter to estimated 50 growers, governmental and industry reps. December 4th*

Field Days and Tours

Van Eerd, L.L. 2007. Overview of N fertility research in vegetable crops. ARIO Research Tour. Ridgetown. ON. 22 June 2007. *Presenter to 14 staff*

Van Eerd, L.L. 2007. Highlights of N fertility research in vegetable crops. OMAFRA Research Tour. Dover. ON. 7 Aug 2007. O*rganizer & presenter to 6 OMAFRA staff*

Van Eerd, L.L. 2007. Highlights of N fertility research in vegetable crops. Vegetable Research Open House. Ridgetown. ON. 28 July 2007. *Presenter to 55 people*

Popular Press Articles

Van Eerd, L.L. 2007. Do you need to apply more N during the growing season? HortMatters. 9 February 2007. 7(2):9

Radio Reports – written and recorded by L.L. Van Eerd. Broadcasted on local farm radio stations and available on OMAFRA website.

Van Eerd, L.L. Need more N? Find out with a pre-sidedress soil nitrogen test (PSNT). 18 June 2007. Radio Report on the Noon Farm Show. CFCO AM 630. Chatham ON radio station. Available on-line OMAFRA crop reports: http://www.omafra.gov.on.ca/english/crops/updates/soundadvice/index.html

Acknowledgements: Funding for this project was provided in part by Agriculture and Agri-Food Canada through the Agricultural Adaptation Council CORD IV program. Other sources of funding include the Fresh Vegetable Growers of Ontario, Ontario Processing Vegetable Growers, Ontario Food Processors Association, and Ontario Ministry of Agriculture, Food and Rural Affairs as well as in-kind analysis from Agri-Food Laboratories Ltd., and A&L Laboratories Inc. and in-kind donation of pepper transplants from Omstead Foods Inc. The small plot yields presented in this report are for comparative purposes only and may not accurately reflect commercial yields. We welcome any questions, comments, concerns on this report, particularly suggestions on how to improve or make the trials more meaningful.

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