Agriculture et Agroalimentaire Canada

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Managing nutrient needs in organic farming

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Managing nutrient supply

- **One of the main challenge facing the organic farmer:**

➢ **In short-term: supply sufficient nutrient to the crop to achieve economically viable yields**

➢ **In long-term: balance inputs and outputs to avoid nutrient rundown and sustain soil productivity**

➢ **Inputs versus outputs?**

Output component :crop nutrient removals

Crops		N	P_2O_5	K_2O	Ca	Mg
Grain Corn	uptake	170 – 240	75 – 110	130 – 240	25 – 50	18 – 30
150 bu/A	removal	100 – 150	55 – 66	39 – 44	1	13
Soybean	uptake	230 – 290	40 – 50	120 – 220	25 – 30	20 – 25
50 bu/A	removal	187 – 200	40 – 44	69 – 70	9. – 11	7. – 9
Winter Wheat	uptake	140 – 160	50 – 55	95 – 150	13	17 – 23
75 bu/A	removal	85 – 95	40 – 50	26 – 28	2	12
Barley	uptake	90 – 110	35 – 40	75 – 110	17	8. – 13
75 bu/A	removal	65 – 85	28 – 30	20 – 25	2	4
Oats	uptake	70 – 85	30 – 35	90 – 110	9	10. – 15
75 bu/A	removal	45 – 60	19	14 – 15	2	3
Winter Rye	uptake	80 – 85	30 – 40	50 – 120	13	7
50 bu/A	removal	55 – 60	15 – 25	17 – 18	3	4
Canola	uptake	130 – 150	60 – 75	100 – 120	-	-
45 bu/A	removal	90 – 100	50 – 60	25 – 30	9. – 12	12. – 15
Potato	uptake	210 – 230	65 – 75	300 – 440	20	40
20 tons/A	removal	125 – 135	35 – 50	210 – 250	5	10

Uptake: total nutrient taken up by the crop (lb/A)
Removal: removed in harvested portion (lb/A.

Eastern Canada data

http://mbforagecouncil.mb.ca/resources/forage-grassland-manual/5-forage-fertility/545-nutrient-uptake-and-removal-by-field-crops-eastern-canada/#bottom

The soil as an important source of N

Corn-silage N removals (2005)			
Treatments	Removed N by the crop (kg ha^{-1})	N from mineral fertilizer (kg ha^{-1})	N from the soil (kg ha^{-1})
CC	135	88	47
CCM	194	96	98
CFM	272	64	208

40 - 60 %

34 - 76 %

CC: silage-corn cereal (silage-corn-barley-wheat) without manure
CCM: silage-corn cereal (silage-corn-barley-wheat) with manure
CFM: silage-corn forage with manure
Forage system was established with barley under seeded with red clover, timothy and millet (3 yr)
Manure: dairy cattle manure (20t/ha wet basis was applied each fall from 1977 to 2003. The study was conducted in 2005

Nyiraneza et al.2010

Components of managing nutrients

- **Amount**
- **Sources**
- **Timing**
- **Nutrient application methods**

Nutrient budget

- Know nutrient in the soil
- Amount of nutrient needed by the crops
- Account all potential sources of nutrients (manure, compost, green manures)
- Some nutrients are needed in higher amount such as Nitrogen

Nitrogen

THE MAIN FACTOR LIMITING PRODUCTION IN ORGANIC FARMING

Nitrogen sources

Soil organic matter

Crop residues (green manures)

Manure and composts

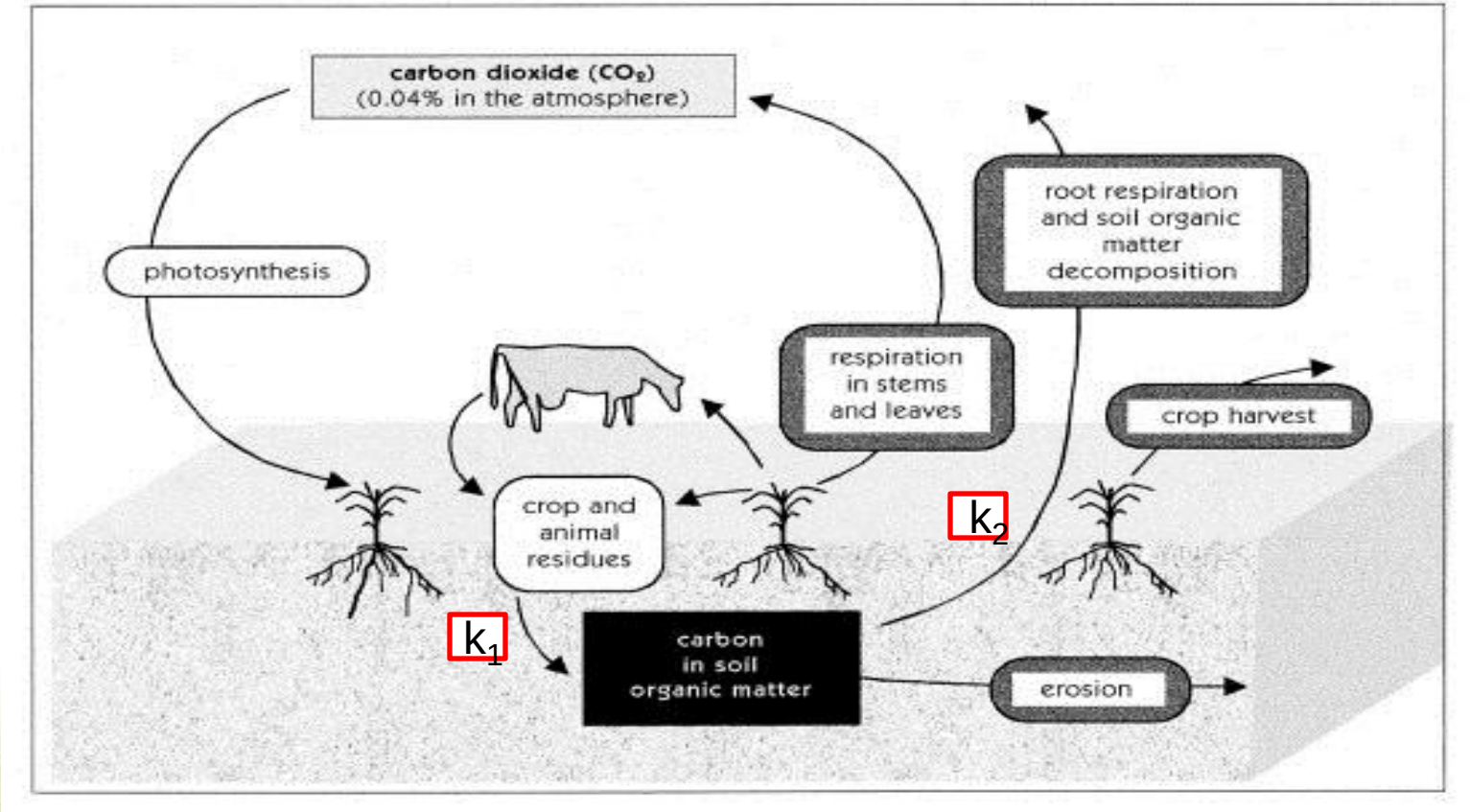
Organic fertilizers

Organic matter as source of N

Organic matter is essential for soil fertility

- Maintains soil quality
- Sustains soil structure which affects nutrient retention and water movement through the soil
- Food source for soil microbes which break down OM and release nutrients to the crop

Organic carbon cycle



Decomposition rate of OM

- **Soil compaction**
- **Soil texture: OM mineralisation is higher in coarse-textured soils than in fine-textured soils**
- **pH**
- **Climatic conditions: growing season length**

Organic matter as source of N

- **Total N in plow layer can be surprisingly high (around 4500 kg N/ha in a soil with 4% OM)**
- **The amount that can be available ranges from 1 to 4% per growing season**
- **On well-managed soil with good structure: estimated available N varies between 20 to 30 kg N/ha for every 1% of OM**

Organic matter as source of N

- **40 to 60% of crop N nutrition derives from the soil**
- **However, N credits from SOM is often not considered or underestimated because mineralization conditions may not be ideal**

N fixed by legumes

Cornestone of most organic rotations

N fixing species to build soil fertility

- **Provide N to cash crop, forage for animals and aid weed, pest and disease control**
- **How much N is fixed and how much is released after incorporation?**

➢ **Depend on legume species, soil type, climate, pest and diseases**

Organic residues as source of N

Crop	Stems and roots at mature stage Kg N/ha
Alfalfa	**80-100**
Pasture and forages (> 40% legumes)	**60-85**
Pasture and forage (> 80% legumes)	**80-120**
Pasture and forages (60% grasses)	**35-50**
Old prairie (more than 5 years)	**60-80**
No N credits is normally given when using cereals and grasses even when incorporated	
Adapted from CRAAQ, 2010	

If **the soil is warm and well aerated, about 50% of total N will be available during summer following incorporation**

N fixing species to build soil fertility

- **Legumes fix significant amount of N when N is not available in the soil**
- **Adding N into the soil reduces N fixation (the use of manure with readily available N)**

N fixing species to build soil fertility

- If possible add manure with readily available N to boost your cash crop or
- Use well composted manure on ley that has N in stable form
- Optimum ley growth length is 3 year to maximize N fixation

Nitrogen released from legumes

- **Large peak in N availability soon after ley incorporation that is vulnerable to leaching**
- **Losses can be minimized with spring cropping to better matches release of N**
- **When spring plowing is not possible late autumn incorporation is preferred when soil temperature decreases and mineralization rate slows down**

Nitrogen from manure and compost

Manure and composts

- All manure not created equally (manure analysis is important)
- The nutrient contents depend on a animal species &storage/management
- Greater availability if incorporated without delay

Manure and composts

- **Good source of nutrient especially N, P, K, S, Mg**
- **Source of valuable OM**
- **Fresh manure especially slurry and poultry manure contains a considerable proportion of readily available N (NH_4-N) but can be easily lost to the atmosphere**

Available N

- **Total N = NH_4-N+organic N**

Available but can be lost via volatilization

Not available until mineralized

- **Available N = NH_4-N that is not lost plus Mineralized N from organic N**

Organic amendments

Two parameters to indicate the quality:

- **C/N ratio**
- **Mineral N (NH_4-N) versus total N ratio**

Two categories:

- **Slurry manure with C/N < 10 and $N\text{-}NH_4$/total N > 50%**
- **Manure with 10 < C/N <25 and $N\text{-}NH_4$/total N < 50%**

Average manure N analyses

Organic amendments	Dry matter	C/N	Total N (kg/t)	$N\text{-}NH_4$ (kg/t)	$N\text{-}NH_4$/N total (%)
Fattening pig slury	3	3	3.2	2.2	75
Dairy cattle manure	19	15	5.3	1.2	23
Dairy cattle slurry	7	10	2.6	1.8	69
Poultry manure	68	11	27.5	10.4	38
Compost	29	15	7.3	0.3	4

Adapted from Perron and Hébert, 2007a; Hebert, 2005a; CRAAQ, 2003b

Manure nutrient credits vary with

- **Amount** applied among other things
- **Time** between **spreading and incorporation**
- **Equipment** used to apply manure or slurry
- **Atmospheric condition** during application
- **Soil conditions** (pH, soil moisture content)
- Time of application (**spring versus fall**)





Estimation of available nitrogen

Fertilizer (150 kg N/ha as urea)

Check plot, no N applied

Slurry manure (150 kg TN/ha (equivalent to fertilizer)

Example. Corn grain. N uptake removed in plot with urea= 144 kg N/ ha; N removed in plot with swine slurry = 136 kg N/ ha and N removed in check plot= 72 kg N/ha

We want to calculate the manure fertilizer equivalency

We calculate first the Nitrogen utilization coefficient (NUC)

NUC_{urea}= (144- 72)/150=0.48

NUC_{manure}= (136-72)/150= 0.43

Slurry fertilizer equivalency= 0.43/0.48= 0.90

Estimation of available nitrogen

Check plot, no N applied

Plot with manure

Method II (appropriate at organic farm level where N fertilizer can't be applied

Nitrogen utilization coefficient (availability factor) = (N removal plot with manure – N removal check plot)/TN

Estimated percentage of organic N available in first year

Manure Type	
Liquid - poultry	0.3
Liquid - all other	0.2
Liquid & solid - biosolids	0.3
Solid - poultry/mink/fox	0.3
Solid - swine	0.25
Solid - < 50% DM	0.15
Solid - > 50 % DM	0.05
Account for losses	

Retention factor for organic N in PEI=0.25

http://www.omafra.gov.on.ca/english/crops/pub811/9manure.htm

Estimated percentage of mineral N of liquid manure with NH_4-N/totalN > 50%

Spreading way	Incorporation time		
	Spring	During growing season	Post-harvest
Immediate incorporation or injection	0.90	1.00	0.60
Low aspersion			
<3 h	0.85	0.85	0.45
3-24h	0.70	0.65	0.40
>24 hours	0.65	0.55	0.30
Using drop hoses			
<3h	0.90	1.00	0.50
3-24h	0.75	0.75	0.45
>24h	0.70	0.65	0.35

Adapted from CRAAQ, 2010

Ammonium nitrogen application retention factor/PEI

Application method	Spring application	Fall application
Injection	**0.98**	**0.80**
Broadcast and incorporated within 2 days	**0.80**	**0.65**
Broadcast and incorporated within 3 days	**0.70**	**0.55**
Not incorporated	**0.50**	**0.40**
Broadcast on forages	**0.65**	**0.50**

Nitrogen (TN) storage and application retention factor (PEI)

Storage method	Application method		
	Injection	Broadcast and incorporated within 24 hrs	Broadcast and not incorporated
Liquid manure and semisolid system			
Enclosed	0.83	0.68	0.43
Open (except earthen)	0.78	0.64	0.4
Earthen	0.59	0.48	0.3
Solid manure systems			
Daily scrape		0.60	0.38
Manure pack		0.56	0.35
Open lot		0.50	0.25

Reported values are for spring applications. Multiply by 0.8 for fall application

Estimated percentage of phosphorus and potassium available in the first year

	P_2O_5 (% available)	K_2O (% available)
Cattle		
Manure	**65**	**80-100**
Slurry	**80**	**80-100**
Pig		
Slurry	**80**	**80-100**
Poultry		
Manure	**65**	**80-100**
Slurry	**80**	**80-100**

Adapted from CRAAQ, 2003

Calculating nutrient application rate

- **Website of PEI Department of Agriculture and Forestry. Guidelines for manure management in Prince Edward Island/manure application rates (http://www.gov.pe.ca/af/agweb/index.php3?number=1012103#table4)**
- **Soil fertility and nutrient use: manure management) (http://www.omafra.gov.on.ca/english/crops/pub811/9manure.htm)**

Land based calculation

- **Useful in case manure and soil test results are not available**
- **Factors to consider:**

➢ **Annual livestock nutrient production (available on website)**

➢ **Crop nutrient requirements (available on website)**

➢ **Estimated percentage available nutrients (available on website)**

Annual livestock nutrient production (PEI)

Livestock		Annual Nitrogen Production (kg.) by one animal	Annual Phosphate Production (kg.) of (P_2O_5) by one animal
Dairy			
	Milking cows, including associated livestock	**145 kg.**	**68 kg.**
Beef *			
	Beef cows, inc. associated livestock	**87**	**67**
	Feeders, 100 day backgrounder	**33**	**20**
	200 day backgrounder	**36**	**22**
	Summer pasture	**44**	**27**
	Short keep	**58**	**35**
	Long keep	**51**	**31**
Hogs			
	Sows, farrow to finish	**91**	**68**
	Sows, farrow to weaning	**24**	**18**
	Sows, farrow to nursery	**18**	**14**
	Weanlings	**01**	**01**
	Feeders	**10**	**08**
Chickens			

Nutrient recommendation in PEI

Crop with Soil Test Groups From M+ to H	Nitrogen (N)	Phosphate (P_2O_5)	Potash (K_2O)
Barley	50	50 - 25	50 - 25
Carrots	100	150 - 100	150 - 100
Cole Crops	150	200 - 150	150 - 100
Corn	60	45 - 0	75 - 50
Corn - Sweet	130	130	130
Fall Rye	20	45 - 30	45 - 30
Field Peas	20	60 - 40	40 - 25
Grass - Hay (Over 70% Grass)	75	40 - 15	75 - 40
Grass/Pasture (Over 70% Grass)	75	40 - 15	75 - 40
Legume/Hay (Over 60% Legume)	20	70 - 40	140 - 75
Legume/Pasture (Over 60% Legume)	20	40 - 15	140 - 75
Mixed Grain	40	40	30
Mixed Hay	50	40 - 15	75 - 40
Potatoes (Kennebec)	100	200 - 135	135
Potatoes (Russet Burbank)	180	200 - 135	135
Potatoes (Shepody)	160	200 - 135	135
Potatoes (Yukon)	155	200 - 135	135
Rutabaga	45	150 - 90	90 - 45
Soy Beans	20	60 - 40	40 - 25
Wheat	60	45 - 30	60 - 30
Winter Wheat	20	45 - 30	30

Land based calculation

Crop: mixed grain (40 kg N). Livestock chicken broilers (2000)	
Step 1. Enter the number of livestock	**2000**
Step 2. Write the annual nutrient production for one animal	**0.43 kg N**
Step 3. Enter the N retention factor (broadcast and not incorporated)	**0.35**
Step 4. Determine the crop N requirement	**40 kg N/ha for mixed grain**
Step 5. calculate the land based required(step1 x step2 x step3)/ step 4	
(2000 x 0.43 x 0.35)/40 = 7 ha	
http://www.gov.pe.ca/af/agweb/index.php3?number=1012103#table4	

Example of calculation/detailed method

	Pig farm
Soil type	Sandy loam with 4% OM
Manure type	Pig slurry
N-P_2O_5-K_2O contents (kg/t)	4-2-3
C/N	5
N-NH_4 (kg/t)	3
Crop grown and nutrient needs	Wheat (60 kg N; 45-30 kg P_2O_5, 60-30 kg K_2O
Spreading ways	Preplant, incorporated within 24h
Previous crop	Barley

How much pig slurry to satisfy wheat nutrient needs

Example of calculation/detailed method

Detailed method. Soil and manures analysis are available	
Step 1. Write credits from SOM, and previous crop	**SOM=4%; N credit= 15 kg N ha^{-1} (underestimated)** **N credits from previous crop =0kg N**
Step 2, calculate the remaining crop N requirements	**60 kg -15 kg= 45 kg N/ha**
Step 3. Calculate manure available N	**NH_4-N x availability factor+ organic N x availability factor** **3 kg NH_4-N x 0.70 + 1kg N organ x 0.25 = 2.35 kg/t available N**
Step 4.Enter the remaining N required	**45 kg N/ha**
Step 5 Calculate the manure application rate (step 4/step 3)	**19 t need to be applied to satisfy N demand**

Calculate phosphorus and potassium supplied by 19t/ha

Step 5. Calculate P_2O_5 and K_2O supplied	Manure rate x K or P contents x percent available
Supplied P_2O_5	**2 P_2O_5 kg/t x 0.80 x 19t= 30 kg $P_2O_{5/}$ha** **Recommended P_2O_5 (30-45 kg/ha)**
Supplied K_2O	**3 K_2O kg/t x 0.90 x 19 t= 51 kg K_2O/ha** **Recommended K_2O rate (30-60 kg/ha)**

When P_2O_5 and K_2O supplied are < recommended values

- **Check soil test K and P levels (low, medium or high) to decide if you apply remaining P and K**
- **It may be preferred to increase the slurry rate to meet K and P requirements but this will create excess available N**

Conclusion

- **An effective nutrient management in organic production is farm specific**
  - **Requires record keeping and calculations**
  - **Estimated available nutrient percentages used as guidelines**
  - **Requires soil tests and crop nutrient recommendations**

	N	P_2O_5	K_2O
Recommendations			
Nutrients credits			
Manure			
Compost			
Prior crop/cover			
Soil organic matter			
Total credits			

Conclusions (con't)

- Factsheets with tables showing percentage available nitrogen from manure (check if values are referred to : organic, mineral N or total N)
- When N is limiting it may be beneficial to choose crops with lower N requirements such as oats, peas, barley instead of long season crops such as potatoes and corn

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Thanks for your attention

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