Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Fertilization management of organic greenhouse soil-less cucumber

Martine Dorais[1]

Mireille Thériault[1], Julie Lefort[2] and Steeve Pepin[3]

[1]Agriculture and Agri-Food Canada

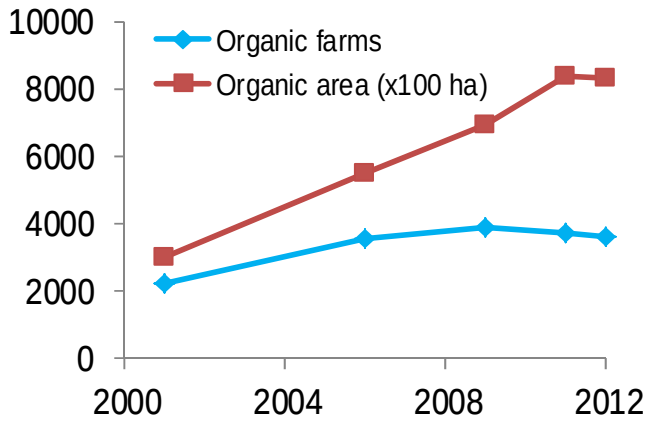
[2]Les Serres Lefort

[3]Universit/ Laval

UNIVERSITÉ LAVAL

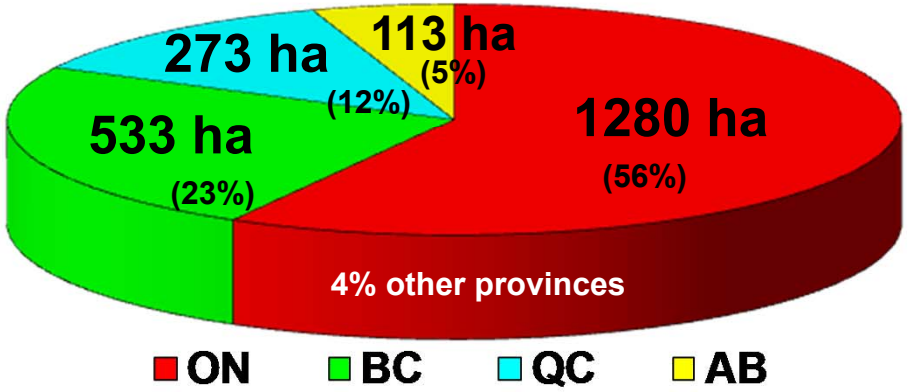
Organic greenhouse farming - Canada

Canada : 4 678 ha organic F&V



900 000 ha
Excluding pasture and wild berry

3732 farms
8% fruit farms
8% vegetable farms



Canada

~ 214 ha (15%)
Organic greenhouse vegetables
Tomato
Sweet pepper
Cucumber
Leafy vegetables, herbs

1439 ha Vegetable – 1.3 billion $ (2015)

Challenge of organic greenhouse vegetable farming

Soil nutrient release that will perfectly match plant nutrient uptake, without any leaching or emissions into the environment

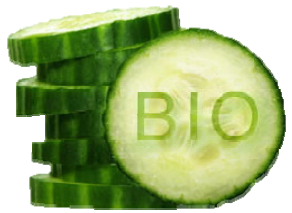
Plant nutrient uptake

✓ High mineralization rate ➡ High nutrient plant demand

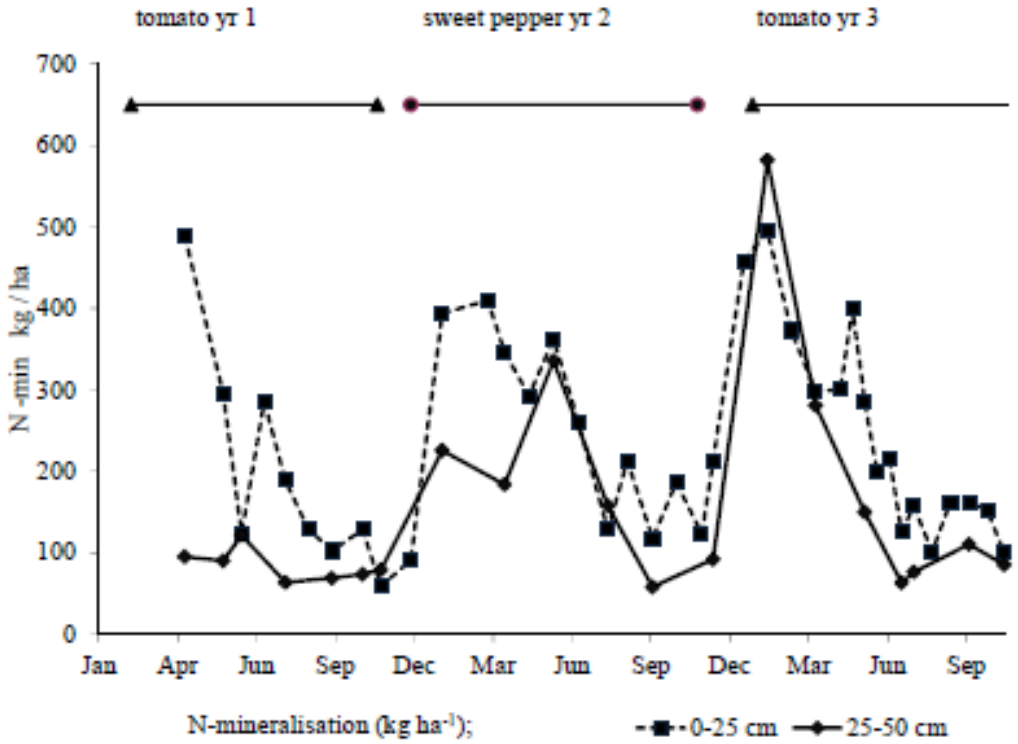
✓ Optimal fertilization ➡ Limit salinization + GHG emission

✓ Optimal irrigation ➡ No nutrient leaching (*e.g.* N, Ca, Mg)

Fertilization management ➡ ↑ Fruit quality



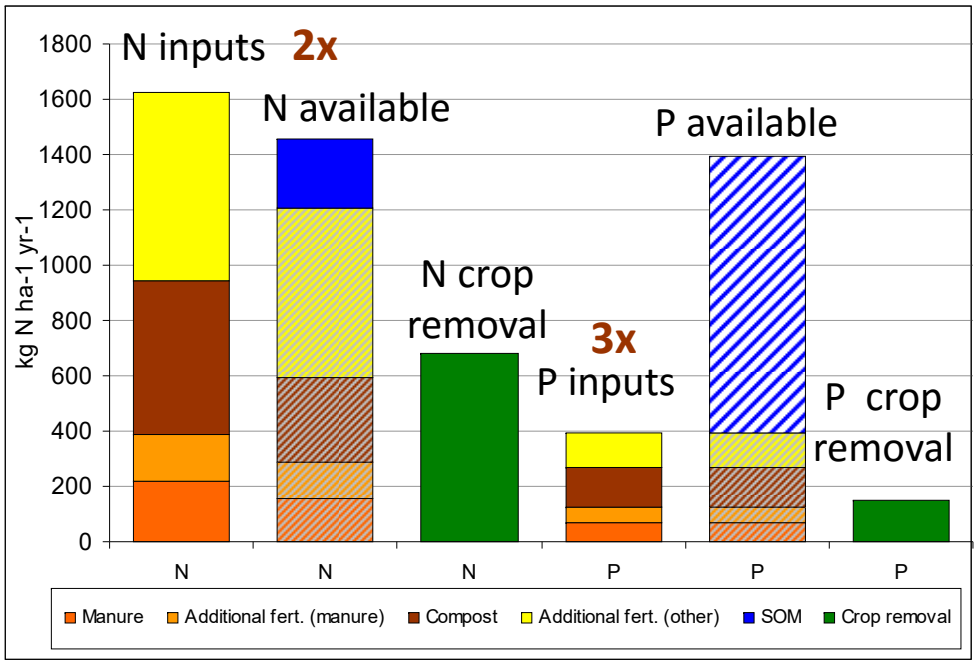
Variation of the N content during three consecutive crops



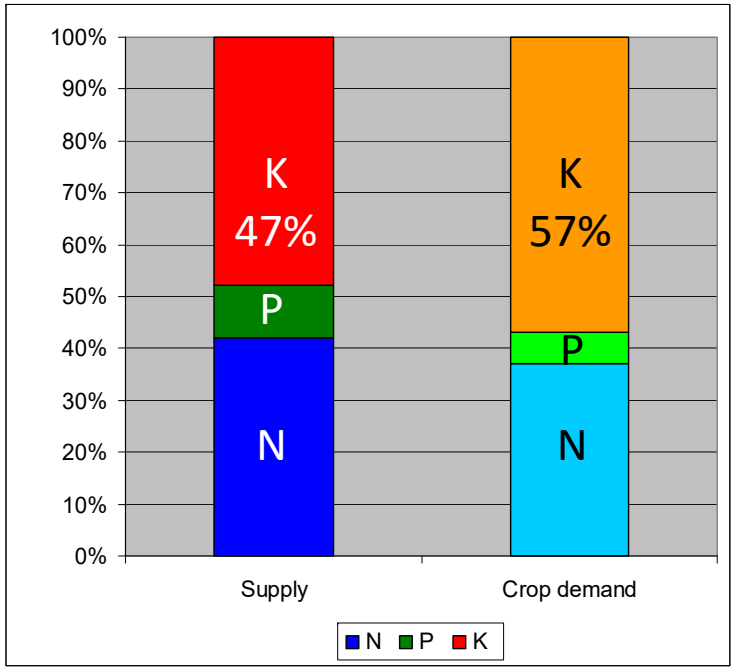
N-mineralisation content in the top soil (0-25 cm) and in the second layer (25-50 cm) during three years of organic greenhouse trials of successive tomato – sweet pepper – tomato crop production.

(Voogt 2014)

Soil fertility – Organic greenhouse soil-grown vegetables



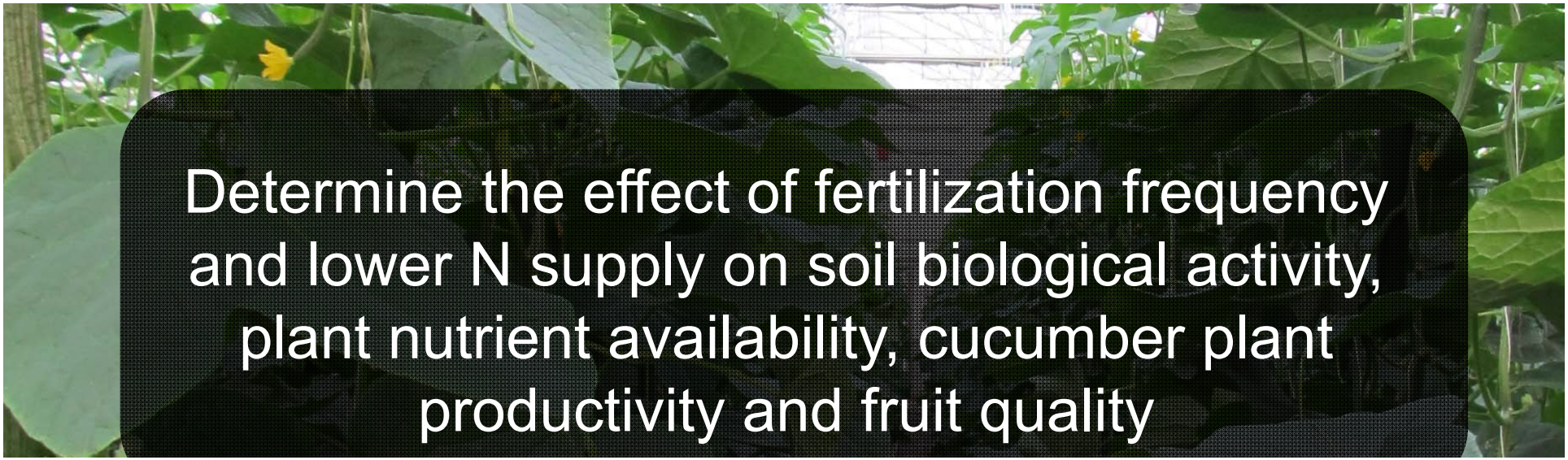
Average yearly N and P inputs and uptake, in eight organic vegetable greenhouses (2002–2009). Inputs are divided over total manure, compost and additional fertilizers, compared with the estimated available N and P by fertilizer mineralization and soil organic matter (SOM) and the soil buffer (for P the hatched bar). The uptake is the result of the monitored crop N and P removal.



Mutual ratios of the N P and K supplied in total by fertilizers and soil amendments and of the crop demand, based on the crop removal, at the eight monitored greenhouses.

(Voogt et al., 2011)

Goal



⇨ Soil nutrient release that will better match plant nutrient uptake

Material and Mehods

- Peat-based growing media
- Experiments 1 (summer) & 2 (winter) – Fertilization events
  - a) 1 wk interval
  - b) 2 wk interval
  - c) 3 wk interval
  - d) 4 wk interval
- Experiment 3 (winter) – High & Low N X 2-wk & 4-wk intervals
- Organic amendments – same total amount of nutrients per year
  - 995 kg N/ha 299 kg P_2O_5/ha 782 kg K_2O/ha (experiment 1)
  - 793 kg N/ha 254 kg P_2O_5/ha 370 kg K_2O/ha (experiment 2)
  - 793 kg N/ha 254 kg P_2O_5/ha 370 kg K_2O/ha (experiment 3 – high N; 100%)
  - 662 kg N/ha 211 kg P_2O_5/ha 362 kg K_2O/ha (experiment 3 – low N; 83%)
- Latin square 4 x 4 : 278 m^2 greenhouse per experiment
- 43-53 plants/e.u. (exp 1); 21/26 to 42/53 plants/e.u. (exp. 2 & 3)

Organic fertilizers

Solid fertilization consisted of a mix of :

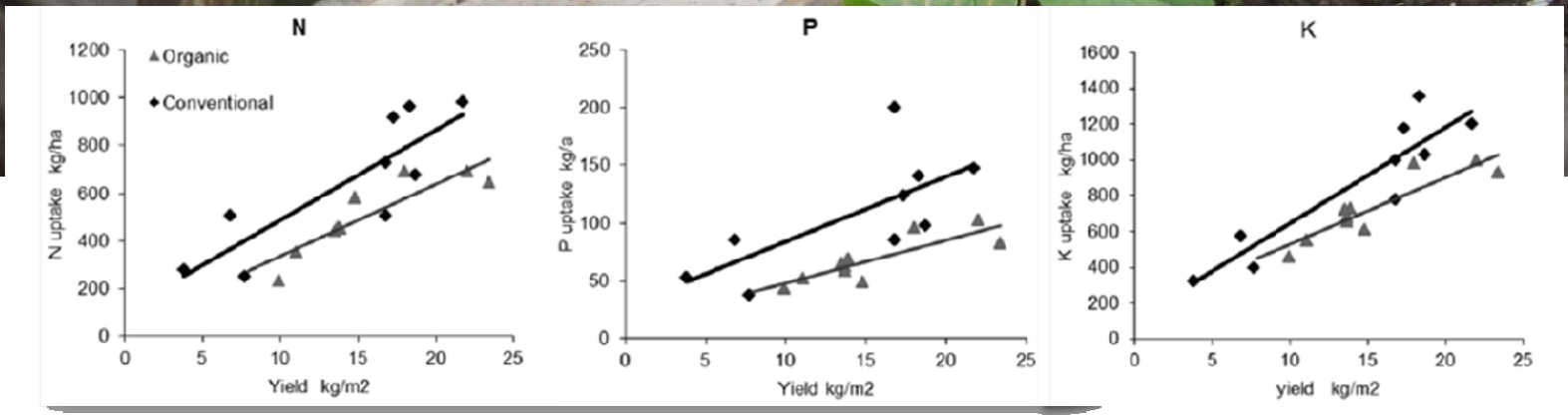
- ✓ Poultry pellets (4-4-2; Acti-sol)
- ✓ Blood meal (12-0-0; Eco-plus)
- ✓ Feather meal (13-0-0; Gaia Green)
- ✓ Shrimp meal (6-4-0; OrganicOcean)
- ✓ Potassium sulfate (0-0-50)
- ✓ Biosol & Fertilo composts (4-4-2 / 5-3-2)

Based on 60 kg fruits/m^2

- 995 kg N/ha
- 148 kg P/ha
- 1407 kg K/ha
- 127 kg Mg/ha

Voogt 2014

50% N mineralization : ratios N/P=3.3 K/N=1.4 Ca/Mg= 2.7



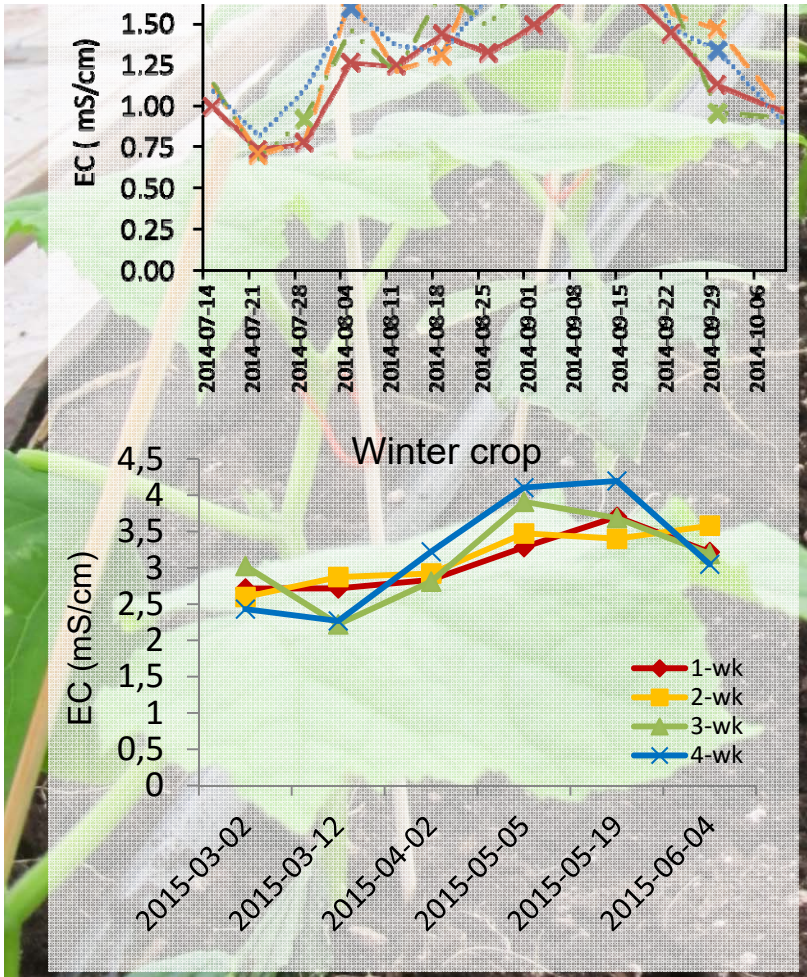
Linear correlations between the total fruit yield (kg/m^2) and total N, P and K uptake (kg/ha) (Voogt 2014)

Measured parameters & Data analysis

- Mineral analysis - Soil samples (0-20 cm) every week
  - ✓ Ions were extracted using the 2:1 method
  - ✓ Ion chromatography analyser ICS-1100 (Dionex)
  - ✓ Soil pH and EC on the water extract
- Overall microbial activity was evaluated monthly
  - ✓ FDA (fluorescein diacetate hydrolysis)
- Soil respiration (LI-6400 and LI-6400-09) was evaluated twice
- Plant growth was measured every week
  - ✓ leaf length, stem diameter, stem length, number of fruits
- Fruits were harvested every two days
- Dry weight of the stem, leaves and fruits

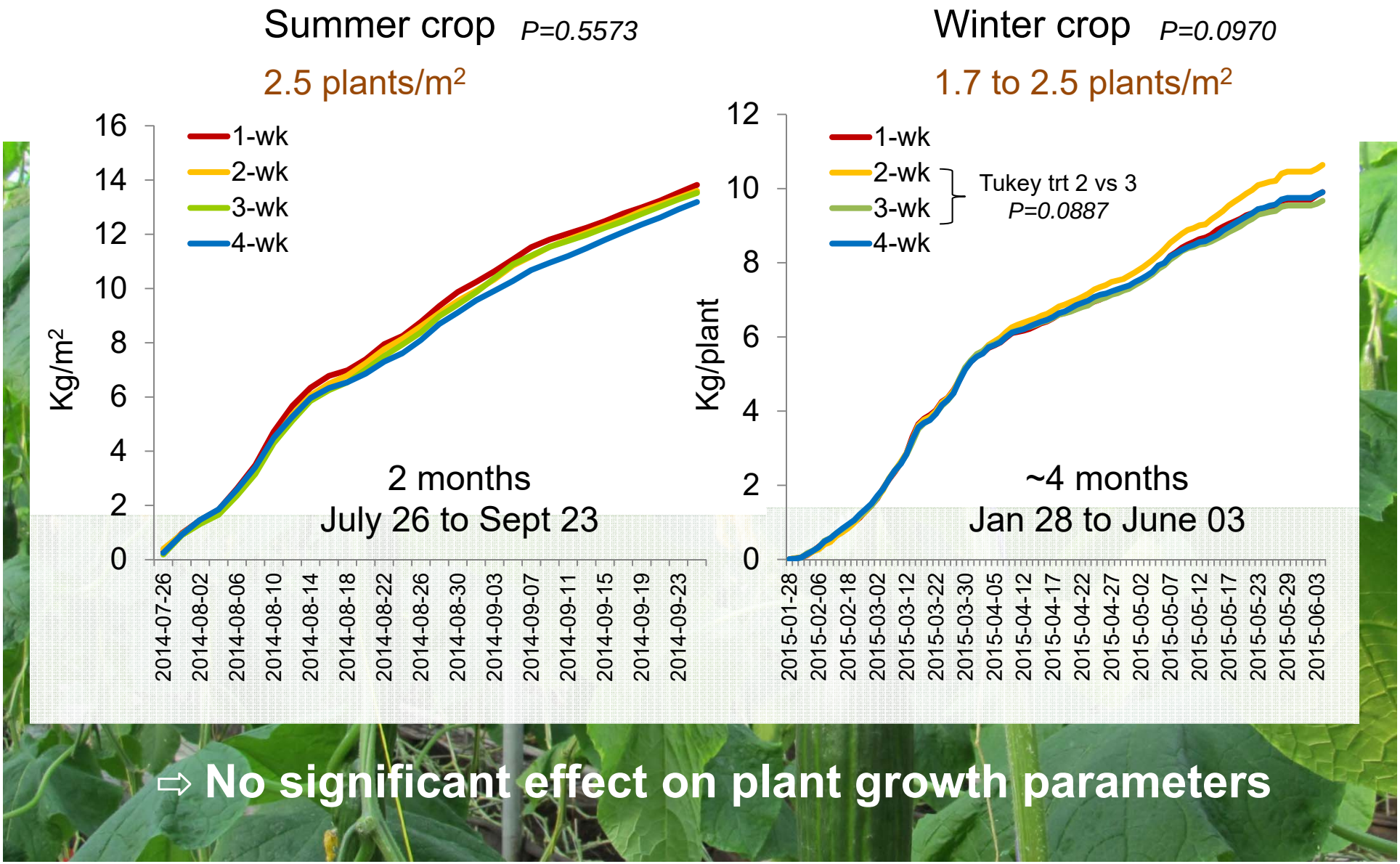
MIXED procedure (SAS Institute) at $P<0.05$
Means were compared using the Tukey's multiple range test

Effects of fertilization events – Soil properties



FDA (µg fluorescein per g soil h^{-1})	160	147	139	155	*0.2742*
Root mycorrhization (%)	8.9	10.1	19.5	8.6	*0.1542*
CO_2 efflux (µmol m^{-2} s^{-1})	11.5	10.6	14.3	13.0	*0.3236*
Winter crop					
FDA (µg fluorescein per g soil h^{-1})	133	137	145	154	*0.1900*
CO_2 efflux (µmol m^{-2} s^{-1})	6.1	6.8	6.8	5.8	*0.1082*
EC (mS cm^{-1})	3.08	3.14	3.14	3.52	*0.3407*
$N\text{-}NO_3$ (mg L^{-1})	188	187	180	181	*0.5904*
PO_4 (mg L^{-1})	50	58	59	63	***0.0280***
K (mg L^{-1})	271	310	317	331	*0.1037*
Ca (mg L^{-1})	359	365	345	354	*0.2910*
Mg (mg L^{-1})	97	100	101	102	*0.7980*
Na (mg L^{-1})	50	54	57	60	*0.1366*
SO_4 (mg L^{-1})	742	768	792	833	*0.1818*
Cl (mg L^{-1})	50	54	57	63	*0.1438*

Effects of fertilization events – Yield

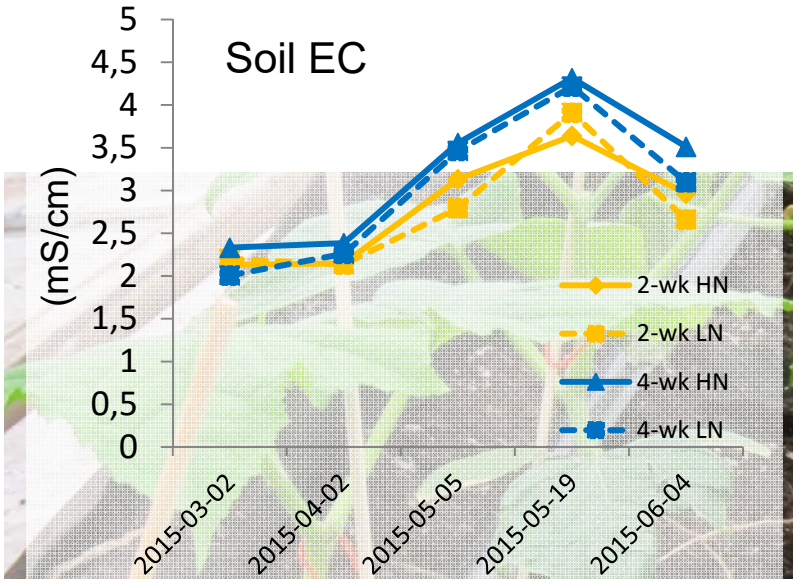


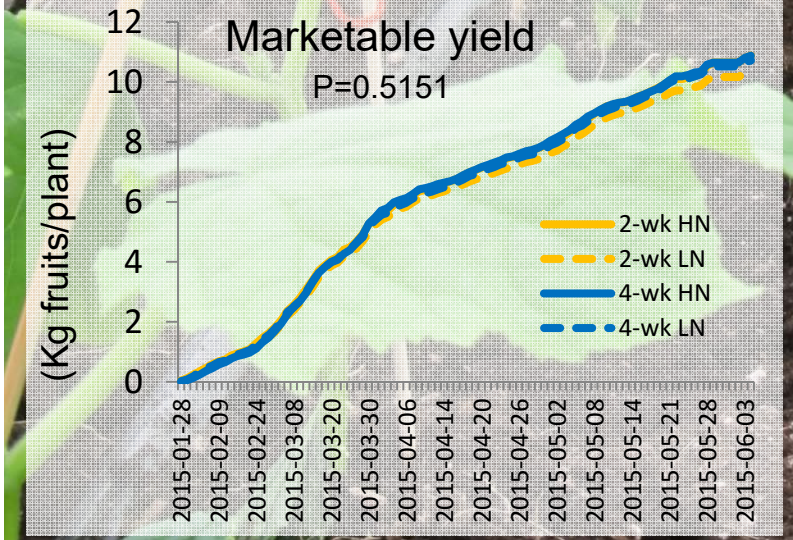
Effects of fertilization events – Quality

Soluble sugar (Brix)		3.0	3.0		3.0	*NS*
EC (mS/cm)		4.5				*NS*
Titratable acid (% citric acid)		0.07				*NS*
Vitamin C (µg/g)		321				*0.2871*
Phenols (mg EAG/g)		1.20				*0.2142*
Carotenoids (µg/g)	Xanthophyll	10.6				*0.2974*
	Trans-β-carotene	29				*0.1480*
	Lutein	30				*0.2502*
	Cis–β-carotene	4.1				*0.1981*
Winter crop						
Soluble sugar (Brix)		3.2				*NS*
EC (mS/cm)		4.1	4.1	4.1	4.0	*NS*
Titratable acid (% citric acid)		0.05	0.05	0.05	0.05	*NS*
Vitamin C (µg/g)		292	250	215	276	*0.3624*
Phenols (mg EAG/g)		1.08	1.02	1.00	1.17	*0.1465*
Carotenoids (µg/g)	Xanthophyll	13.7	12.9	14.7	13.0	*0.2655*
	Trans-β-carotene	36	31	44	38	*0.0951*
	Lutein	29	23	34	33	*0.2307*
	Cis-β-carotene	4.5	3.8	4.9	4.8	*0.1915*

No significant effect

Effects of a lower fertilization rate





Fertilization frequency and N dose treatments					
	2-wk : HN	2-wk : LN	4-wk : HN	4-wk : LN	P value
FDA (µg fluorescein per g soil h^{-1})	139	167	131	160	*0.2632*
CO_2 efflux (µmol m^{-2} s^{-1})	9.1a	10.0a	7.3b	6.3b	*0.0001*
EC (mS cm^{-1})	2.80	2.74	3.09	3.01	*0.4918*
$N\text{-}NO_3$ (mg L^{-1})	180	156	189	162	*0.1607*
PO_4 (mg L^{-1})	56	52	64	57	*0.6527*
K (mg L^{-1})	211	198	283	257	*0.2089*
Ca (mg L^{-1})	353	347	375	356	*0.5917*
Mg (mg L^{-1})	104	101	117	115	*0.3400*
Na (mg L^{-1})	58	49	64	62	*0.5009*
SO_4 (mg L^{-1})	682	711	853	854	*0.0740*
Cl (mg L^{-1})	54	45	67	62	*0.0486*

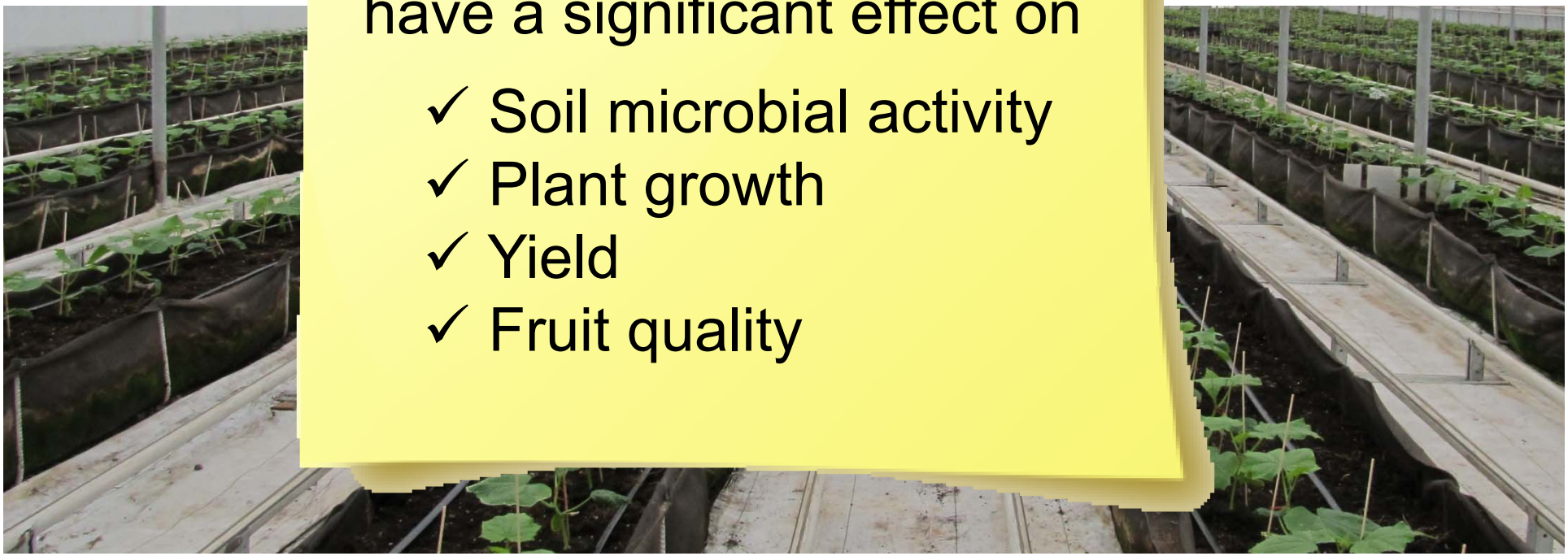
No significant effect on :

- ✓ Plant growth parameters
- ✓ Yield
- ✓ Fruit quality

Effects of fertilization frequency treatments

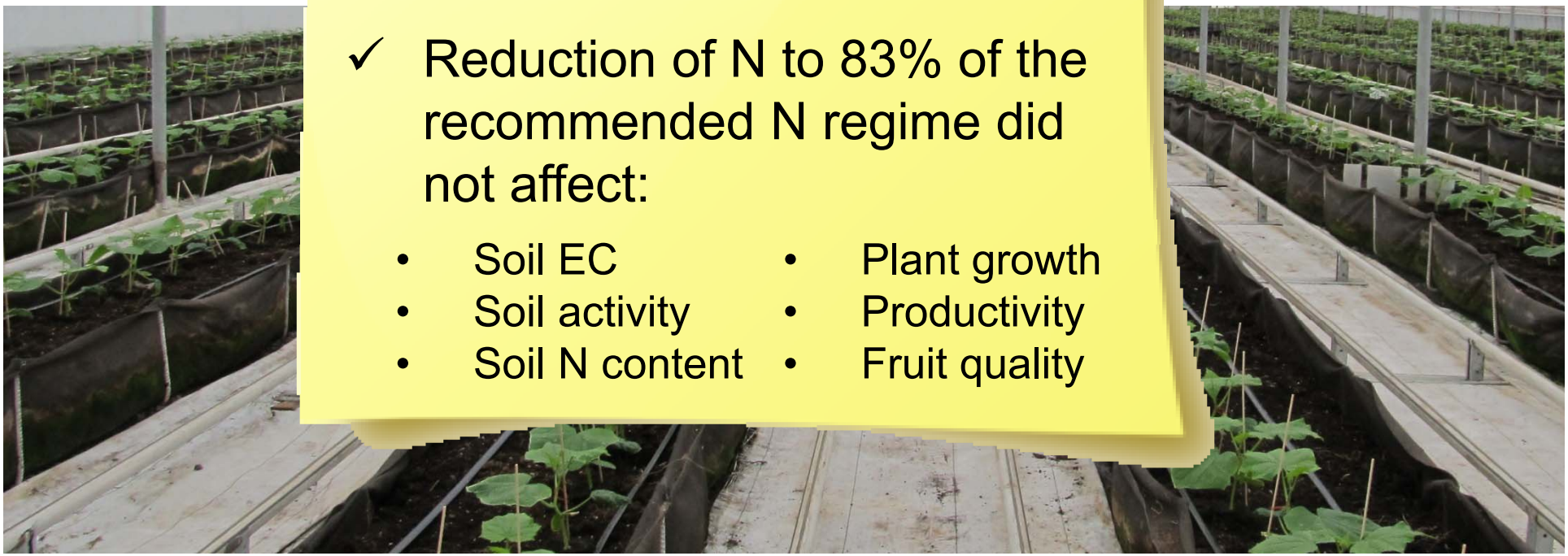
Increasing the number of fertilization events did not have a significant effect on

- ✓ Soil microbial activity
- ✓ Plant growth
- ✓ Yield
- ✓ Fruit quality



Effects of N regime X fertilization frequency treatments

- ✓ Two-week interval fertilization with HN or LN regime increased CO_2 efflux as compared to 4-wk interval
- ✓ Reduction of N to 83% of the recommended N regime did not affect:
  - Soil EC
  - Soil activity
  - Soil N content
  - Plant growth
  - Productivity
  - Fruit quality



Concluding remarks

- ✓ **Weekly application of nutrient amendments has not improved plant nutrient availability compared to two-week, three-week and four-week intervals as no significant differences were observed for plant growth and crop productivity.**
- ✓ **However, weekly nutrient applications decreased the soil EC variability.**
- ✓ **Lower N regime did not reduce productivity and might reduce N losses by N denitrification and leaching.**

Research team & collaborators

Dr C. Ménard

M. Thériault, MSc

P.P. Dion, PhD student

Professor- Researcher

S. Pepin, ULaval

UNIVERSITÉ LAVAL

Isabelle Clermont, MSc.

Les Serres Lefort

ACKNOWLEDGEMENTS

Financial support was provided by the Canadian Agri-Science Clusters (Organic Science Cluster II) and Les Serres Lefort.

OFC FBC

OACC Organic Agriculture Centre of Canada

Growing Forward 2

A federal-provincial-territorial initiative

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Thank you very much

Martine.Dorais@agr.gc.ca
Martine.Dorais.1@ulaval.ca

Université Laval