Can Apple Replant Disease be Controlled through use of Compost?

Compost Council of Canada
Compost Matters in AC Workshop

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Apple Replant Disease (ARD) ?

World wide phenomenon of apple industries

Young apple trees in a newly re-planted old orchard site do not thrive.

Symptoms often non-specific, reduced terminal shoot growth, smaller leaves, shorter internodes, foliage may be chlorotic with purplish tinges

Disease complex: pathogenic soil fungi working in concert with plant parasitic nematodes

Causes economic losses to the grower (re-establishment costs $75,000 / ha)

Casual ARD organisms in Nova Scotia*

- *Pythium sp.*
- *Cylindrocarpon sp.*
- Combinations of these organisms.

Potting medium amendment	Shoot height increase $\log_{10}$ (mm)	Root volume $\log_{10}$ (cm^3)
1. None	2.459 (288)	1.085 (12.2)
2. *C. lucidum*	2.417 (261)	0.957 (9.1)
3. *P. irregulare*	2.357 (228)	0.941 (8.7)
4. *P. irregulare* + *C. lucidum*	2.117 (131)	0.507 (3.2)
SEM	0.0312	0.0724
Significance of probability	<0.001	<0.001

***Braun, P.G. 1991. The combination of *Cylindrocarpon lucidum* and *Pythium irregulare* as a possible cause of apple replant disease in Nova Scotia. Can. J Plant Path. 13 (4): 291-297.**

History of ARD management in NS

Has never been an issue until 2014 regulatory loss of pre-plant, broad spectrum agro-chemical soil fumigant

- Methylbromide (banned)
- 1,3 dichloropropene (banned)

Chloropicrin – only partially effective

Other semi-selectives: partially effective

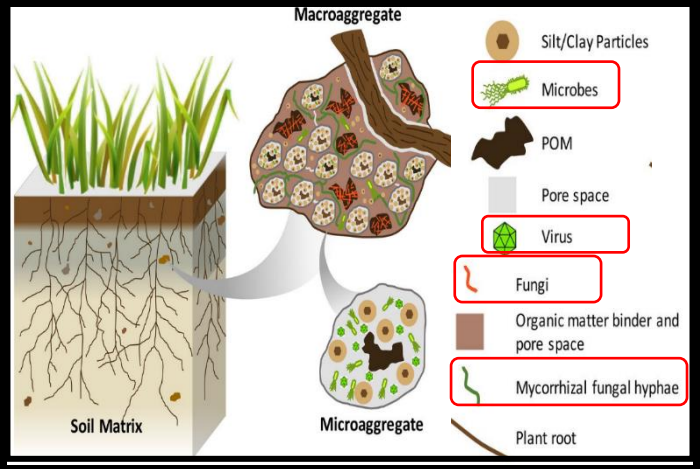
Anticipatory research: 2001 hypothesis

- *Replant disease is the result of the long term cultivation of a single crop in one site. This accumulates a population of micro-organisms, both parasitic or pathogenic, on apple roots. It alters the physical structure and chemical composition of the soil. Mature trees tolerate the condition because their new root growth continually expands into fresh soil……..*

- *Therefore, by returning the soil in an apple replant site to a more favourable soil structure, chemistry and microbiome, apple replant disease can be suppressed or even eliminated.*

✓ **Soil aggregation**

Disease suppression increases with increasing rates of compost application.
Noble and Coventry 2005. Biocontrol Sci. Technol. 15:3–20.



Greenhouse experiments with ARD soils and apple seedlings

1. Non-pasteurized soil / perlite control
2. Non-pasteurized soil mixed with manure
3. Non-pasteurized soil mixed with compost
4. Pasteurized soil mixed with manure
5. Pasteurized soil mixed with compost

Composts used

Single source substrates:
- horse manure
- hog manure
- mink manure

Mixed with equal volumes of hay and dry leaves

Composted indoors in bins

Piles turned weekly, water addition as required

Composting for 8 weeks until odourless

Maximum composting temperature:

66.7 ^{o} C (horse)
68.9 ^{o} C (hog)
31.1 ^{o} C (mink)

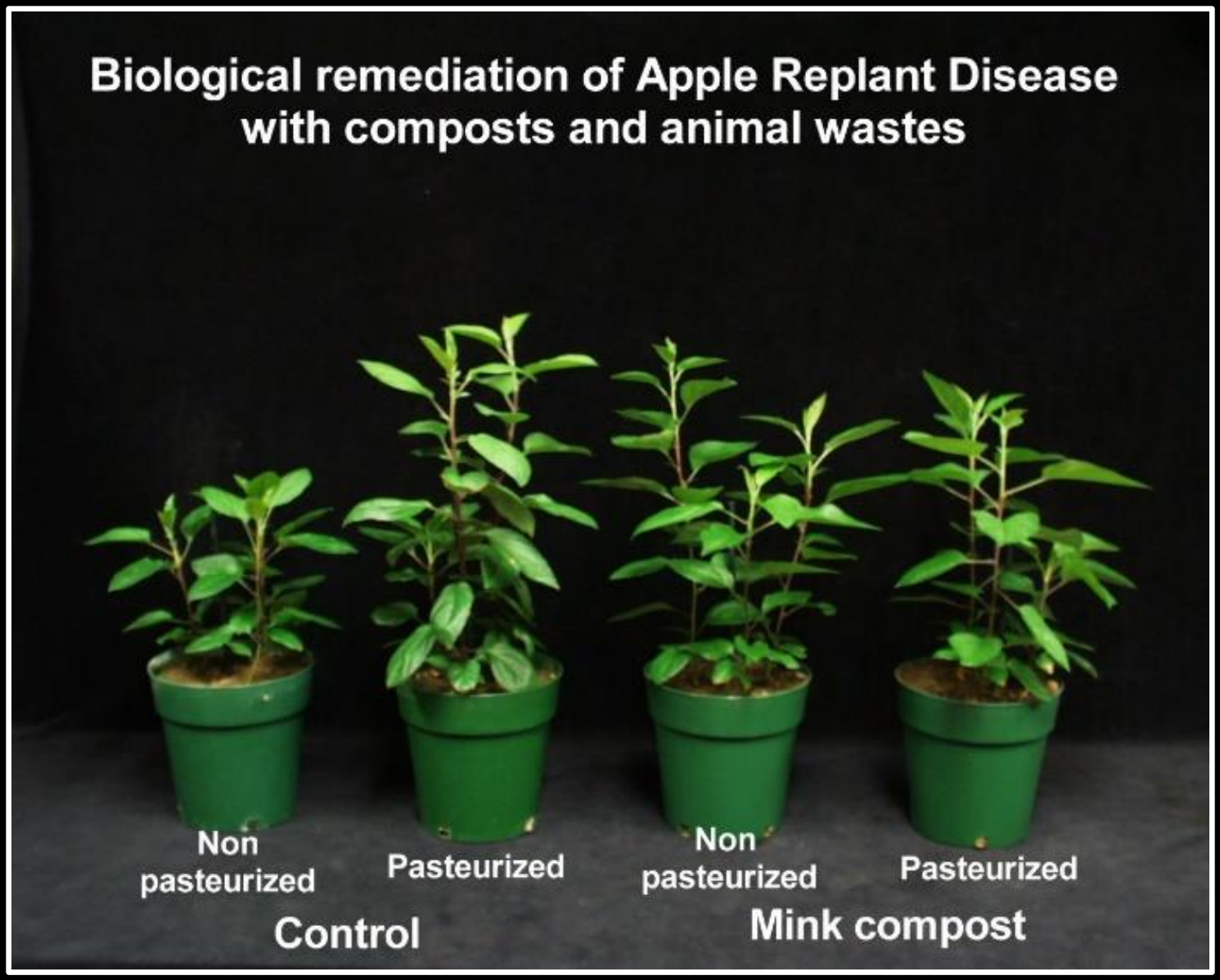
Properties of two ARD soils

Old Orchard	Soil Textural	pH	SOM	P2O5	K2O	Ca	Mg	S	CEC
	Class	(H20	%	---------- kg / ha ----------					me/100g
Canard soil	SaLm	6.4	2.9	847	223	3401	455	59	14.7
Kingston soil	LmSa	6.4	3.9	415	333	2866	515	67	15.2

Analyses of manures and composts

Sample	% N	% P	% K	% Ca	% Mg	% C	C:N Ratio
Hog Manure	2.10	1.22	0.86	1.90	0.36	47.28	22.5
Hog Compost	2.66	1.24	1.12	2.49	0.46	37.78	14.2
Horse Manure	0.61	0.14	0.75	0.33	0.15	36.92	60.5
Horse Compost	0.64	0.20	0.78	0.57	0.15	40.92	63.9
Mink Manure	0.82	1.80	0.31	3.79	0.32	12.67	15.5
Mink Compost	0.66	1.13	0.34	2.55	0.21	7.90	12.0

a, b – significant different at the 0.05 probability level


Biological remediation of Apple Replant Disease
with composts and animal wastes
Non pasteurized
Pasteurized
Non pasteurized
Pasteurized
Control
Mink compost

Conclusion: greenhouse pilot

- Significant response to soil pasteurization confirmed presence of ARD in the two orchard soils
- When different composts were mixed with the ARD soils, the growth of apple seedlings was dependent on N supply
- *The magnitude of growth response to pasteurization was also dependent on N supply when composts were mixed with the ARD soil.*
- The incorporation of hog and mink composts appeared to show some promise as alternatives to agro-chemical soil fumigants

Into the field .....(no shortage of ARD sites)

Characteristics of the experimental soil

Orthic Humo-Ferric Podzol, locally known as Hebert soil

- often cemented subsoils
- low soil water retentivity (droughty)
- low CEC, naturally acid
- pH = 6.2 (limed), OM = 3.5%,
- P_2O_5 = 1790 and K_2O = 399 kg / ha
- in apple production since 1942

Exp. design and treatments

- 1) No soil treatment (neg. control)
- 2) Pre-plant soil fumigation only (pos. control, Telone C-17)
- 3) Deep ripping only
- 4) Deep ripping + fumigation
- 5) Deep ripping + compost incorporation

Randomized complete block, with 5 trts and 4 reps, 12 trees / EU

Planted to Honeycrisp / M4 rootstock

Composted hog manure

Chosen as it best alleviated ARD symptoms in a greenhouse study

Composted for 6 weeks, turned weekly or when the internal temperature of the pile exceeded 60^{o}C, water added as needed.

Compost parameters 2.7% N 1.2% P 1.1% K C:N 14.2.

Applied to plots by opening a trench 40 cm deep and 50 cm wide with a mouldboard plough centered on the planting row and filling it with compost at 0.17 m^3 per m of tree row.

Harrowed over to cover the compost-filled trench and to loosen and level the soil.

Treatments implemented in the fall of 2001

Trees planted spring 2002

Data collection 2002 - 2007

Results*

- Pathogens isolated from apple roots in experimental orchard:

  - *Cylindrocarpon* and *Pythium* species confirmed

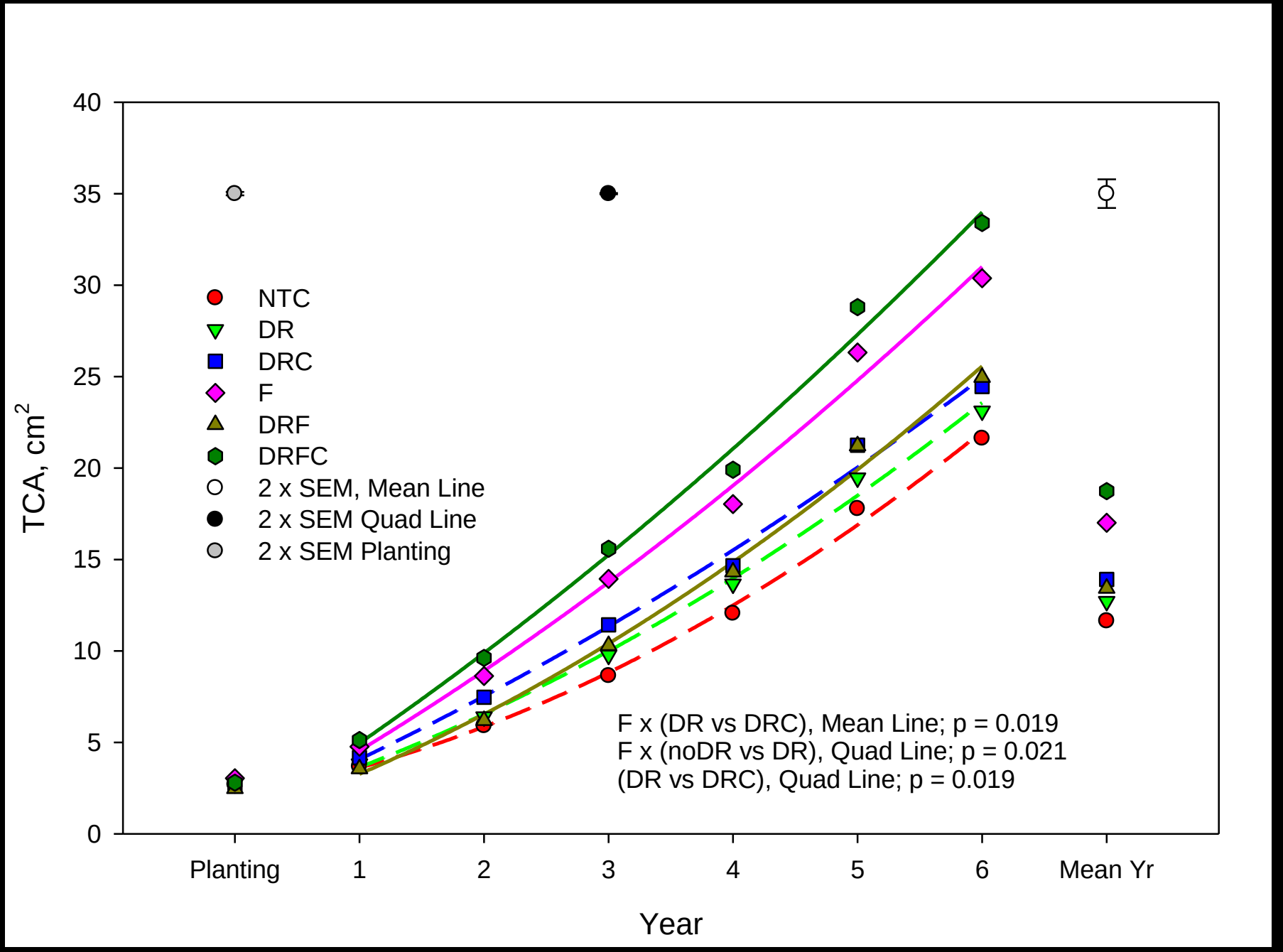
  - *Pratylenchus* (root lesion nematodes), counts:

• Control	1860	per L soil
• Other treatments (incl. compost)	0-750	per L soil

- Root activity in the 4th growing season:

  significantly greater numbers of fine roots in the compost treatments

*Braun, P.G, Fuller, K.D., et al. 2010. Response of Honeycrisp apple trees to combinations of pre-plant fumigation, deep ripping, and hog manure compost incorporation in a soil with replant disease. *HortScience 45 (11): 1702-1707.*


TCA, cm2
40
35
30
25
20
15
10
5
0
NTC
DR
DRC
F
DRF
DRFC
2 x SEM, Mean Line
2 x SEM Quad Line
2 x SEM Planting
F x (DR vs DRC), Mean Line; p = 0.019
F x (noDR vs DR), Quad Line; p = 0.021
(DR vs DRC), Quad Line; p = 0.019
Planting
1
2
3
4
5
6
Mean Yr
Year

Treatment	Yield (kg / tree)			TCSA (cm $^{-2}$)	Yield Efficiency
	2005	2006	2007	2007	kg cm^{-2} TCA '07
Control	5.4^{c}	6.4^{b}	7.2^{d}	22.1^{e}	0.76^{c}
Fumigation	15.6^{a}	8.9^{b}	28.0^{bc}	30.4^{b}	0.98^{abc}
Ripping	5.3^{c}	6.8^{b}	15.7^{d}	22.7^{de}	0.74^{c}
Ripping + Fumigation	8.6^{bc}	6.4^{b}	21.6^{cd}	25.9^{c}	0.88^{bc}
Ripping + Compost	11.0^{b}	10.7^{ab}	30.0^{ab}	24.4^{cd}	**1.24^{a}**

Summary

- Pre-plant compost incorporation has the potential to increase root activity in newly re-established apple orchards.
- Compost incorporation increased TCA, yield
  - did not appear to be the result of increased N, P, K uptake
  - specific alterations to the soil microbial community should be investigated.
- Compost incorporation shows good promise as a replacement for agro-chemical soil fumigants.
- Practical challenges
  - handling large volumes of compost on a commercial scale
  - incorporation of compost to significant soil depth not easy

Current Research

NSFGA-AAFC Project **(4 years: 2019 – 2023)**

"Clean technologies to mitigate the re-emerging threat of apple replant disease"

Objectives:

1. Elucidating the ARD complex at multiple sites in NS

2. Annual crops for biofumigation

3. Organics for improved soil health and microbiome

4. Carbon substrates for anaerobic soil disinfestation

5. Pre-plant root-soak treatments for nursery trees

Thank You