FINAL REPORT
WTFRC Project # AH-02-205

Project title: Influences of selected mulches and soil amendments on dynamics of nitrogen and phosphorus availability in the apple root zone

PI: Tom Forge
Organization: Agriculture & Agri-Food Canada
Pacific Agri-Food Research Centre
Agassiz, BC V0M 1A0
forgeta@em.agr.ca
604-796-8791

Co-PI's: Gerry Neilsen, Gene Hogue, Denise Neilsen
Agriculture & Agri-Food Canada
Pacific Agri-Food Research Centre, Summerland

Cooperators: David Granatstein, WSU-TFREC, Wenatchee
Dana Faubion, WSU Cooperative Extension, Yakima

OBJECTIVES:
I: Measure the release of N and P from several selected organic materials at two experimental sites.
II: Measure seasonal dynamics of bio-indicators of nutrient mineralization in root zone soil under organic mulches and amendments.

SIGNIFICANT FINDINGS
Objective I: Decomposition and release of N and P from selected organic materials:
- **Application rates can be adjusted to attain desired release of N during the growing season.**
- **Surface mulches do not affect decomposition of organic amendments in underlying soil.**

Objective II. Indicators of enhanced nutrient cycling in soil under mulches and amendments:
- **Organic amendments but not mulches increase phosphorus availability in the root zone.**
- **Surface mulches but not amendments increase biological activity indicative of increased nutrient cycling in the root zone.**

New findings:
- **Mulch can increase microbial turnover and nutrient mineralization even with subsurface irrigation.**
- **The root-lesion nematode, *Pratylenchus penetrans*, is becoming a complicating variable in these field experiments.**

Objective 1: Release of N and P from selected organic materials.
Organic materials chosen for study in 2002 were: (1) composted poultry manure, (2) composted dairy manure, (3) Ogogrow-a municipal compost from Kelowna, (4) alfalfa hay, and (5) a commercial fishmeal organic fertilizer. The materials were placed in porous ceramic cups in mulched and non-mulched plots at Naches and the Spray-on-mulch/Ogogrow experiments at Summerland. Ceramic cups were retrieved in October, and contents of the remaining material were analyzed for dry mass and percent N and P.

Results and Discussion
Decomposition rates varied considerably among the various materials and were similar to rates expected from other studies (Figure 1). Using estimates of nutrient contents of these materials from the literature, we have made estimates of the amount of each material that must be applied in order to release 100 lbs of mineral N per acre in the first growing season (Table 1). These calculations are intended to serve as preliminary examples of how the data will be used and illustrate the importance of actually knowing decomposition rates. Final calculations will depend on final chemical analyses of the materials actually used in the study; these analyses are in progress.

Figure 1. Effects of mulches on decomposition (percent loss of mass) of composted poultry manure, composted dairy manure, municipal compost (Ogogrow), alfalfa hay, and a commercial fishmeal fertilizer in porous ceramic cups in field plots during the May-October interval of 2002.

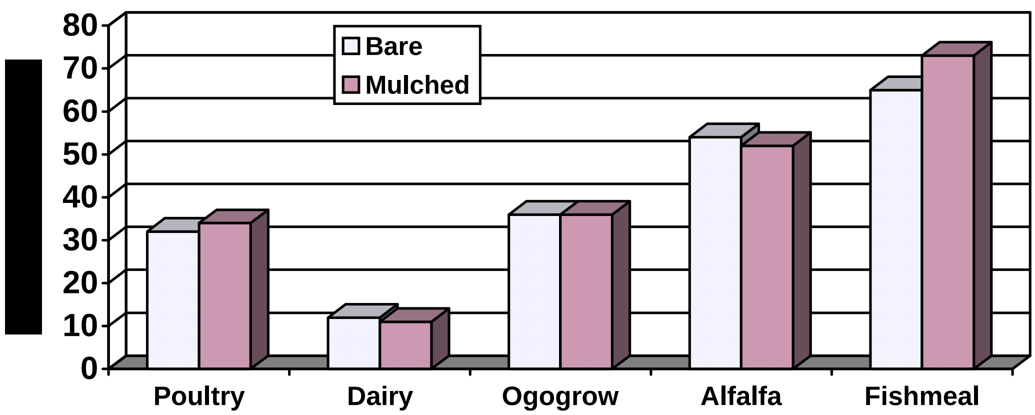

Table 1. Estimates of percent N, percent mass loss in first year (averages of data from mulched and non-mulched plots), and estimates of quantities of selected organic materials that must be added in order to release 100 lbs of N/acre over the course of one growing season. Estimates of organic N contents at the time of application were taken from the literature. Analyses to obtain actual values for materials used in this study are in progress.

	Dairy compost	**Poultry compost**	**Ogogrow**	**Alfalfa hay**	**Fishmeal fertilizer**
Estimated N content (%)	1.5	2.5	2.0	2.5	9.0
Percent loss in first year (%)	12	33	36	53	65
Material needed to get 100 lbs N /acre in first year:	**27 t/acre**	**6.1 t/acre**	**6.9 t/acre**	**3.8 t/acre**	**0.9 t/acre**

Objective II. Indicators of enhanced nutrient cycling in soil under mulches and amendments.
Earlier research had shown that leaf P can be increased in plots treated with biosolids or partially composted dairy manure, particularly in the presence of mulches (Neilsen, 2002 progress report; Neilsen et al. 2002). These results led us to consider that the actual release of P via decomposition, and the degree of enhanced P availability in root zone soil, warranted more detailed examination. In 2002 we began measuring “resin-adsorbed” P and microbial biomass P in root zone soil from three different experiments: (1) Naches alfalfa hay/dairy solids; (2) Summerland Spray-on-mulch/Ogogrow; and (3) Summerland Shredded paper mulch/biosolids. Resin-P is a measure of the

availability of P for crop uptake at a given point in time. Nematode indicators of enhanced nutrient cycling were also assessed in corresponding soil samples from these three experiments.

Results and Discussion

Naches alfalfa hay/dairy solids experiment (Table 2): Application of partially composted dairy manure solids in 2000 increased P availability in 2002. The presence of alfalfa hay mulch decreased P availability in plots that had been amended with dairy manure solids, but not in plots that had not been amended with dairy manure solids. The key nematode indicators of nutrient cycling were not increased significantly by the dairy manure solids in 2002, but were increased by the presence of alfalfa mulch (Table 2).

Table 2. Selected indicators of soil fertility and the abundance of root-lesion nematodes (*Pratylenchus penetrans*) at the Naches experiment. BN = bacterivorous nematodes (per 100 g soil), EO = enrichment opportunist nematodes. For *Pratylenchus penetrans* data, values in parentheses are the range of values. Phosphorus data from the October sample date are in progress.

	Resin-P	Microbial Biomass-P	BN	EO	*Pratylenchus Penetrans*
	----mg per kg soil----		-----Nematodes per 100 g soil----		
May					
Control	14 c	3	802 b	338 b	61 a (0-267)
Amendment	94 a	26	709 b	511 b	20 a (0-61)
Mulch	29 c	16	3586 a	3279 a	0 b
Mulch/Amendment	54 b	13	1638 b	1409 b	8 b (0-41)
October					
Control	not avail.	n.a.	266 b	100 b	61 (0-291)
Amendment	n.a.	n.a.	525 ab	220 b	20 (0-81)
Mulch	n.a.	n.a.	714 a	630 a	9 (0-51)
Mulch/Amendment	n.a.	n.a.	670 ab	539 a	18 (0-43)

Summerland Spray-on-mulch/Ogogrow experiment (Table 3): Results were similar to Naches. Application of Ogogrow in spring of 2001 increased P availability in 2002 in both mulched and non-mulched plots. For the Ogogrow-amended plots, P availability tended to be greater in drip-irrigated plots than in micro-sprinkler irrigated plots. Mulch appeared to reduce P availability in amended plots under drip irrigation. These results correspond with leaf P concentrations (data presented in Neilsen progress report), confirming that resin-P may be a good indicator of mulch and/or amendment enhanced availability of P. One of the nematode bio-indicators (enrichment opportunists, EO) was significantly greater in mulched than in non-mulched plots.

Table 3. Selected indicators of soil fertility and the abundance of root-lesion nematodes (*Pratylenchus penetrans*) in the Summerland Spray-on-mulch/Ogogrow experiment. BN = bacterivorous nematodes; EO = enrichment opportunist nematodes. For *Pratylenchus penetrans* data, values in parentheses are the range of values. Effects of irrigation system were not significant for the nematode indicators and presented values are averages of data from the two systems. Phosphorus data are means from three sample dates whereas nematode data are from the July sample date only; additional data are in progress. Data within a column labeled with the same letter are not significantly different. For the P data, values in the drip irrigation column labeled with '*' are significantly different from the same treatment under micro-sprinkler irrigation.

	Resin-P		Mic. Biomass P				
	------------mg per kg soil-------------				--Nematodes per 100 g soil--		
	Drip	MS	Drip	MS	BN	EO	*P. penetrans*
Control	14 c	19 b	9	11	1355	332 b	11 (0-36)
Amendment	58 a*	36 a	7	7	1016	461 b	39 (0-177)
Mulch	16 c	12 b	9	12	1544	717 a	7 (0-40)
Mulch/Amendment	46 b	39 a	13	13	935	473 b	44 (0-126)

Summerland Shredded paper/biosolids experiment (Table 4): Application of biosolids (from the Greater Vancouver Regional District) increased P availability in both mulched and non-mulched plots. In contrast, microbial biomass P and nematode indicators of enhanced nutrient cycling were increased by shredded paper mulch but not the biosolids; paper mulch had a significant effect on bacterivorous nematodes, and the combination of mulch over biosolids increased the abundance of enrichment opportunist nematodes relative to the biosolids treatment. Amendment of soil with biosolids alone had no effect on either nematode indicator. This experiment was sampled monthly through 2002, in order to gain fundamental information on how microbial turnover of nutrients varies through the growing season. At the time of the progress report complete data were available for only one of the sample dates.

Table 4. Selected indicators of soil fertility and the abundance of root-lesion nematodes (*Pratylenchus penetrans*) at the Summerland Shredded paper/biosolids experiment.

	Resin-P	Microbial Biomass-P	BN	EO	*Pratylenchus penetrans*
	-----mg per kg soil-----		---------Nematodes per 100 g soil-------		
Control	17 b	1.8 b	897 b	148 b	235
Amendment	21 a	1.9 b	1207 b	400 b	313
Mulch	12 c	2.7 a	2114 a	339 b	373
Mulch/Amendment	20 a	2.7 a	2703 a	1444 a	466

Quincy municipal yard waste compost experiment (Table 5): As a new trial (municipal yard waste compost was applied in 2002), only one set of samples was taken in October (Table 5). Both nematode indicators of enhanced nutrient cycling were greater in soil under mulched than in non-mulched soil at Quincy.

Table 5. Selected nematode indicators of soil fertility and the abundance of root-lesion nematodes (*Pratylenchus penetrans*) at the Quincy municipal compost experiment.

	Bacterivores	Enrichment Opportunists	*Pratylenchus penetrans*
	-------------Nematodes per 100 gram soil-------------		
Mulched	611*	109*	1325
Not mulched	375	32	1263

Root-lesion nematodes: The Naches and Summerland Spray-on-mulch/Ogogrow experiments were fumigated prior to establishment. Nonetheless, *P. penetrans* populations are becoming re-established in both experiments (Tables 3 and 4). Population densities at both sites are generally below the damage threshold of 100 nematodes per 100 grams soil, with the exception of a few plots where population densities were above the threshold level in 2002 (Tables 2 and 3). Population densities were generally high at the Summerland/Shredded paper experiment and the Quincy experiment; the nematodes are very likely influencing tree growth at those sites (Tables 4 and 5). *P. penetrans* population densities tended to be lower under mulches at Naches (Table 3), which is consistent with our previous findings on the effect of shredded paper mulches (Forge et al. 2003). However, mulches do not appear to have influenced *P. penetrans* population densities at the Summerland Shredded paper/biosolids experiment or the Quincy experiment (Tables 5 and 6).

Literature cited:

Forge, T., Hogue, E., Neilsen, G., and Neilsen, D. 2003. Effects of organic mulches on soil microfauna in the root zone of apple: Implications for nutrient fluxes and functional diversity of the soil food web. Applied Soil Ecology 22: 39-54.

Myers, R.G., Thien, S.J., and Pierzynski, G.M. 1999. Using an ion sink to extract microbial phosphorus from soil. Soil Sci. Soc. Am. J. 63: 1229-1237.

Neilsen, G.H., Hogue, E.J., Forge, T., and Neilsen, D. 2002. Mulches and biosolids affect vigor, yield and leaf nutrition of irrigated and fertigated high density apple. HortScience (in press).

BUDGET

Project title: Influences of selected mulches and soil amendments on dynamics of nitrogen and phosphorus availability in the apple root zone

PI: Tom Forge

Project duration: 1 year

Year	**2002**
Salary	$15,300
Equipment[1]	$500
Supplies[2]	$400
Travel	$800
Total	$17,000

[1] Ceramic cups, pvc caps, nylon mesh, and materials for assembly of mineralization tubes; coring tools.

[2] Expendable supplies: hexanol, ion-exchange resins, plasticware, reagents & materials for ion-chromatography P analyses and LECO N analyses.