Short-term effect of soil disturbance by mechanical weeding on plant available nutrients in an organic vs. conventional rotations experiment

By J OWEN[1], S LEBLANC[1] and S A E FILLMORE[2]

Agriculture and Agri-Food Canada, Atlantic Food and Horticulture Research Centre, 1P.O. Box 2069, Bouctouche, New Brunswick, E4S 2J2, Canada
232 Main Street, Kentville Nova Scotia, B4N 1J5, Canada

ABSTRACT

Tillage decreases soil organic nitrogen and carbon pools because disturbing the soil structure exposes protected soil organic matter to microbial degradation (Kristensen et al., 2003). In organic systems, compost may be a source of fertility, and mechanical weeding may be effective against weeds. The question arises whether soil disturbance from mechanical weeding in organic systems affects nutrient release from organic matter in compost-amended soil.

This question was examined in the context of years two, three and four of a recently initiated long term organic-versus-conventional rotational cropping system experiment. The experimental design included continuous snap beans, and a fully phased snap beans/fall rye rotation. Treatments consisted of combinations of yearly applied fertility (chemical fertilizer, 1x compost, 3x compost) and weed control (herbicide, mechanical weeding). Nutrient availabilities were monitored beginning 12 hours post mechanical weeding in both mechanically weeded and herbicide treated plots, using anion and cation exchange membranes, which were buried for 24 hours, and then removed from the soil. The cations and anions bound to the membranes were eluted and analyzed.

Availability of ammonium was not affected by weeding treatment. Nitrate availability, however, was consistently less in mechanically weeded plots than in plots treated with herbicide. This may indicate that mechanical weeding caused carbon mineralization from organic matter leading to nitrogen immobilization. A flush of carbon mineralization occurred in the period of 0 to 3 days following soil disturbance in another study, which resulted in the immobilization of nitrogen in disturbed soil samples (Franzluebbers, 1999). Principal component analysis of NH_4-N, NO_3-N, P, K, Ca and Mg availabilities showed distinct groupings of treatments according to fertility treatment rather than weeding treatment, and that the effect of crop rotational sequence on nutrient availabilities was pronounced only in plots amended with synthetic fertilizers.

MATERIALS and METHODS

Long-term organic-versus-conventional rotations experiment

This research was conducted over three years of a long term organic-versus-conventional rotations experiment. The layout consisted of three replicates at a research farm site and three replicates at a commercial farm site, each comprising three strips, to which each was assigned a rotational cropping sequence. This was continuous beans (CB), or one of the two phases of a beans/fall rye two-year rotation (BRB or RBR). Strips were divided into six plots. To each was assigned a treatment combination (Table 1) of yearly applied fertiliser and weeding method. Compost had a carbon to nitrogen ratio of 15.2, with total nitrogen on a dry matter basis of 1.5%. The 1x compost rate was calculated to deliver the equivalent of 50 kg N ha^{-1}: the same rate of N applied in synthetically fertilised plots. In herbicide-treated plots, herbicides were applied following commercial standard practices. Mechanical weeding was carried out twice per season using a tractor-mounted implement with metal fingers mounted on spinning disks, which disturbed soil to a depth of 15 cm.

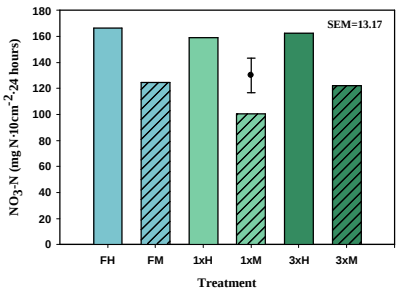
Table 1: Details of the six weed control and yearly applied fertiliser treatment combinations

Treatment identification	Combined factors	
	Yearly applied fertiliser	Weed control method
FH	Synthetic fertiliser	Herbicide
1xH	1x rate of compost	Herbicide
3xH	3x rate of compost	Herbicide
FM	Synthetic fertiliser	Mechanical weeding
1xM	1x rate of compost	Mechanical weeding
3xM	3x rate of compost	Mechanical weeding

Monitoring of nutrients using anion and cation exchange membranes

Anion and cation exchange membrane technology was used to monitor plant-available ions in the soil solution of bean plots following weeding events. Four pairs of anion and cation probes were buried in the inter-row of each bean plot to form composite samples to account for soil heterogeneity. Probes were buried 12 hours after mechanical weeding events, and were removed 24 hours later. They were rinsed with distilled water, and the adsorbed ions were quantified colorimetrically. Analysis of Variance (ANOVA) was conducted on resulting nutrient availability data.

Fig. 1: Plant available NO_3-N from 12 to 36 hours following mechanical weeding in bean plots treated with combinations of weeding method (**H**erbicide or **M**echanical weeding) and fertiliser (Synthetic **F**ertiliser, **1x** rate compost or **3x** rate compost) in 2005 at the experimental farm site across two burials and rotational cropping sequence.



A) Snap beans and fall rye in rotation strips at the experimental site

B) Mechanical weeding using spinning disks with fingers that can be moved in and out around the bean row.

Table 2: Mean plant available nutrients across sites and years from 12 to 36 hours following mechanical weeding in bean plots treated with combinations of weeding method (**M**echanical weeding or **H**erbicide) and fertiliser (Synthetic **F**ertiliser, **1x** rate compost or **3x** rate compost) in different cropping sequences (**C**ontinuous **B**eans, **B**eans/ **R**ye/**B**eans or **R**ye-**B**eans-**R**ye).

Weed control	Fertiliser	Cropping sequence	Three-year mean nutrient availabilities (µg·10 cm^{-2}·24 hrs)					
			NH_4-N	NO_3-N	P	K	Ca	Mg
M	F	CB	24.3	153.3	3.4	177.7	408.3	77.3
M	F	BRB	12.3	110.5	2.8	139.2	340.2	63.7
M	F	RBR	32.8	262.3	5.8	220.6	571.8	83.7
M	F		23.1	175.3	4.0	179.2	440.1	74.9
M	1x	CB	7.7	114.8	3.8	136.7	390.8	78.1
M	1x	BRB	3.5	81.0	4.6	146.7	366.2	69.7
M	1x	RBR	3.4	151.1	6.0	180.8	503.0	85.4
M	1x		4.9	115.6	4.8	154.7	420.0	77.7
M	3x	CB	3.4	116.3	7.6	220.4	461.2	94.4
M	3x	BRB	3.8	100.8	8.1	266.1	413.6	93.1
M	3x	RBR	3.0	129.2	9.9	269.4	475.9	90.6
M	3x		3.4	115.4	8.5	252.0	450.2	92.7
M			10.47	135.5	5.8	195.3	436.8	81.8
H	F	CB	24.7	165.9	3.0	201.6	447.7	84.4
H	F	BRB	15.3	131.9	3.4	165.0	395.0	76.6
H	F	RBR	32.5	222.0	6.8	192.0	585.2	96.7
H	F		24.2	173.2	4.4	186.2	475.9	85.9
H	1x	CB	3.9	121.4	3.4	147.0	413.6	83.0
H	1x	BRB	3.9	118.1	4.1	167.5	387.6	77.4
H	1x	RBR	2.6	152.1	5.7	138.3	486.6	75.6
H	1x		3.5	130.5	4.4	151.0	429.3	78.7
H	3x	CB	3.8	139.7	6.8	260.4	485.5	103.7
H	3x	BRB	3.4	131.7	8.4	291.8	486.0	112.5
H	3x	RBR	3.3	143.7	9.9	278.0	509.1	110.1
H	3x		3.5	138.3	8.4	276.7	493.5	105.4
H			10.39	147.4	5.7	204.6	466.2	90.0
SEM individual means			7.44	13.61	0.95	17.58	32.68	7.30
SEM Weed control*Fertiliser group means			4.87	6.76	0.54	10.85	15.73	4.21
SEM Weed control group means			0.90	3.74	0.19	4.29	9.64	1.69
F probabilities								
Fertiliser			**	***	***	***	**	***
Weeding			ns	*	ns	ns	*	***
Weeding* Fertiliser			ns	ns	ns	ns	ns	ns

Statistical significance: p=0.001 indicated by ***, p=0.01 indicated by **, p=0.05 indicated by *, and p>0.05 indicated as non-significant by ns.

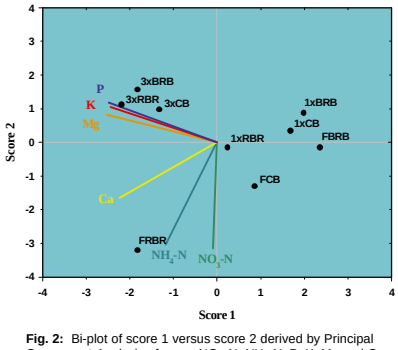


Fig. 2: Bi-plot of score 1 versus score 2 derived by Principal Component Analysis of mean NO_3-N, NH_4-N, P, K, Mg and Ca availabilities from 12 to 36 hours following mechanical weeding averaged across three years, two sites and weeding treatments.

DISCUSSION and CONCLUSIONS

Soil disturbance from mechanical weeding had a short term effect of depressing available NO_3-N and, to a lesser extent, Ca and Mg.

Soil drying and increased aeration in mechanically weeded plots may have inhibited N mineralisation. Another possibility is that a flush of carbon mineralisation caused NO_3-N to be immobilized, as occurred in another report (Franzluebbers, 1999).

Fertility regime affected available nutrients. In the PCA (Fig. 2), a clear grouping of treatments involving 3x compost rate emerged, whereas with no organic amendment, synthetically fertilised cropping sequences were separated. This points to a greater mineralisable reserve of nutrients in compost-amended treatments, resulting in reduced effects of cropping system factors such as crop removal.

References
Kristensen, H.L., Debosz, K., McCarty, G.W. 2003. *Soil Biology and Biochemistry* 35: 979-986.
Franzluebbers, A.J. 1999. *Soil Biology and Biochemistry* 31: 1083-1090.

Agriculture and Agri-Food Canada | Agriculture et Agroalimentaire Canada

Acknowledgements
This research was supported by Agriculture and Agri-Food Canada's Matching Investment Initiative in collaboration with la Ferme Michaud, Western Ag Innovations, Cardwell Farms Compost Products and Béatrice Allain.