

Soils-based evaluation of labile organic carbon and the role this may play in net soil mineralisation rates in Kiwifruit Orchard - Kaharoa ash soils of the Bay of Plenty, New Zealand

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Abstract

Nitrogen mineralisation processes are driven by factors that influence the microbial activity in soil which include soil temperature, moisture and soil carbon.

In order to describe the seasonal fluctuations of labile organic carbon samples from two conventionally managed blocks located at the Te Puke Research Orchard were collected monthly over 12 months. The soils of the two blocks are comparable with irrigated Hort16A vines growing in one block and un-irrigated Hayward vines in the other. These monthly samples were evaluated for mineral N and soil microbial activity, as measured using dehydrogenase assay, as well as for labile carbon. Soil evaluations for sites with contrasting management strategies (conventional verses organic) but soils of the same series and similar textures have also been compared.

Mineral-N levels are slightly higher at the 150-300 mm and the 300-450mm depths within the unirrigated Hayward block when compared to the irrigated Hort16A block. These differences may be due to the differences in vine activity at this stage of the season with the Hort16A block being further advanced with regard to canopy development and thus better able to take up the mineral-N available. There is no significant difference in labile carbon recorded between the two blocks. Microbial activity is reduced with profile depth and at this stage appears to demonstrate a reduction with time also. This drop in microbial activity may be linked to the overall drop in soil moisture content as the season progresses especially within the top 0-150mm. A strong statistical relationship was found between soil dehydrogenase activity and soil labile C concentrations within any one date over the 3 sampling depths. Within Kaharoa ash soils the organically managed orchard blocks demonstrate higher labile carbon and higher overall microbial activity than the conventionally managed systems.

Key Words

Nitrogen mineralisation, Hot water carbon, Microbial activity.

Introduction

Nitrogen (N)-mineralisation is driven by factors that influence the microbial activity in soil, including soil temperature, moisture (Cabrera and Kissel 1988; Sierra 1997), and the easily decomposable fraction of soil carbon, being the micro-organisms' energy source. This fraction is often termed "labile carbon". Hot-water-extractable carbon (HWC) is well suited to characterize the labile carbon fraction in pastures (Ghani *et al.* 2003) and orchards (Kim *et al.* 2008). Strong positive correlations between HWC and N-mineralisation rates in New Zealand soils have been observed. In apple orchards, HWC alone described about 50% of the variation in soil N mineralization rates in contrasting soils (Kim *et al.* 2008; Figure 1), or 80% when complemented by soil temperature and moisture.

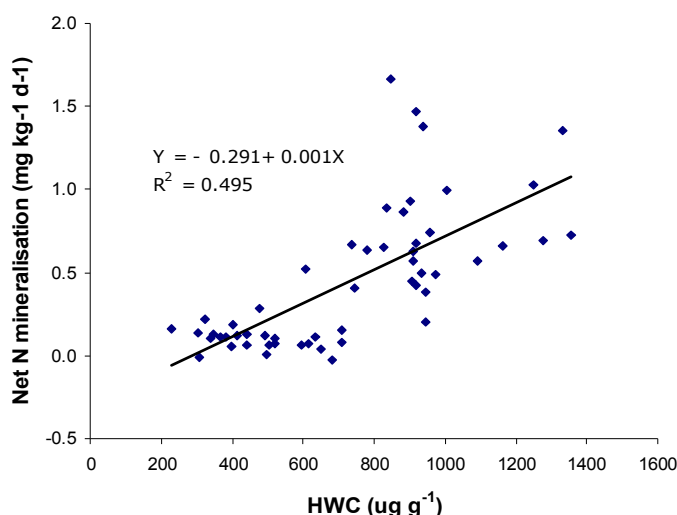


Figure 1. Net-N mineralization rate, evaluated following incubation for 40 days, as a function of the labile soil carbon (= hot water extractable carbon, HWC), (Kim *et al.* 2008).

A soil's labile carbon fraction is the result of both total carbon amount, and specific orchard management practices (Deurer *et al.* 2008). However, nothing is known of the impact that different management practices within kiwifruit orchards may have on this fraction and on actual or potential N-mineralization rates. We have focused on the Kaharoa ash soils of the Bay of Plenty, a predominant soil type for commercial kiwifruit.

Methods

Comparable soils from two conventional blocks at the Te Puke Research Orchard were sampled (0-15, 15-30, and 30-45 cm) monthly. Irrigated 'Hort16A' vines grow in one block (vine age 9 y) and un-irrigated 'Hayward' vines (vine age 36 y) in the other. Mineral N (Keeney and Nelson 1982), microbial activity (dehydrogenase assay (Chandler and Brooks 1991)), as well as labile C (hot water extraction (Ghani *et al.* (2003))) were determined over the course of a year (October 2008 to October 2009)

Soil samples were also taken from five conventional and five organic orchards in August 2008 to examine differences in labile C due to contrasting management strategies both within and between orchard rows, and to enable model parameterisation for calculation of N-mineralisation rates.

Results

Temporal changes in soil mineral N and labile C

Mineral-N levels (0-15 cm) varied little over the year except for peaks in December, February and September coinciding with the application of approximately 50 kg N/ha prior to sampling (Figure 2a).

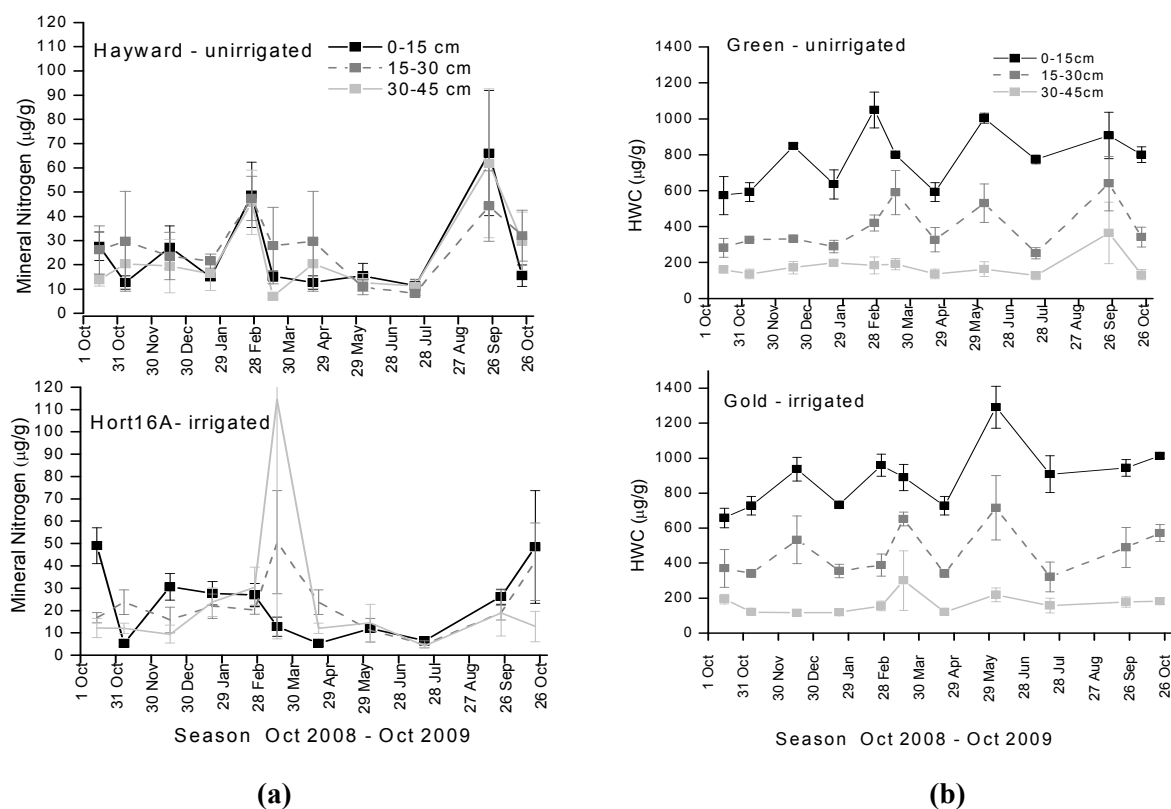


Figure 2. (a) & (b) Left. Mineral-N at three depths. Right. Hot water extractable C at three depths. Values are means of three samples \pm one SE.

Mineral-N levels were slightly higher at the 15-30-cm and 30-45-cm depths in the unirrigated 'Hayward' block than in the irrigated 'Hort16A' block. These differences may be due to 'Hort16A' being further advanced in canopy development and thus better able to take up the available mineral-N.

Overall, there was no significant difference in labile C between the two blocks (Figure 2b). Labile C showed large temporal fluctuations, particularly in the 0-15 cm depth. There was a positive relationship between dehydrogenase activity and soil labile C within each sampling date (Figure 3). Labile C and dehydrogenase activity rates were both higher in the surface soils and declined with depth.

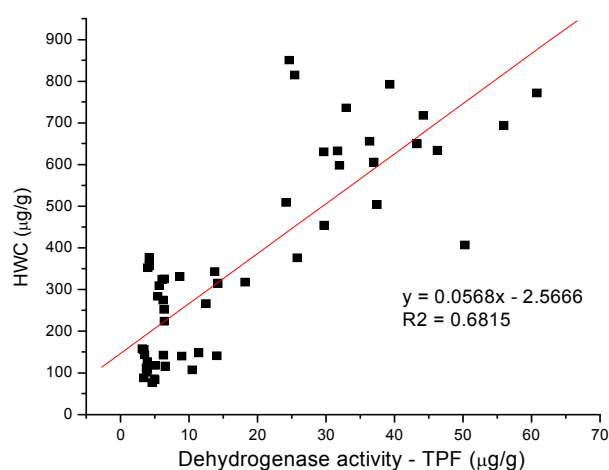


Figure 3. Labile soil carbon (= hot water extractable carbon, HWC) as a function of the microbial activity (Dehydrogenase activity).

2. Conventional versus organic orchard

Labile C was generally higher in organic than in conventional orchards (Figure 4), likely due to addition of compost and mulched plant material from vine clippings for N supply.

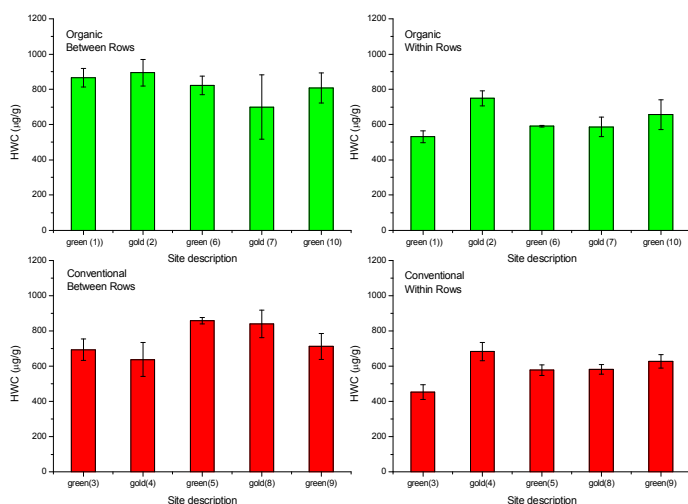


Figure 4. Soil labile C in organic and conventional orchards. Columns represent the mean (\pm one SE) of four samples per property.

Conclusion

A good relationship with dehydrogenase activity within sampling dates suggests that hot water extractable C provides a useful measure of labile C in kiwifruit orchards.

Labile C can show large temporal fluctuations in irrigated and non-irrigated orchards; further work is needed to identify the cause(s) of this variation.

There was no clear evidence of a relationship between hot water extractable C and mineral N but further research is needed to examine the contributions of hot water extractable C to N mineralisation.

Organic orchards tended to be higher in labile C than conventional orchards, possibly due to inputs such as compost and mulched plant material from vine clippings.

Acknowledgements

Andrew Barnett and Steven Owen (Plant and Food Research, Te Puke Research Centre) and the kiwifruit growers who granted access to their properties. This research was funded by FRST under the Sustainable Land Use Research Initiative (SLURI, CO2X0813).

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