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WINTER TEMPERATURE AS A DETERMINANT OF SOIL ORGANIC MATTER TURNOVER AND PLANT GROWTH DURING THE YEAR

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Pastoral ecosystems are, in general, chronically deficient in nitrogen (N). This means that changes in N supply are often reflected in changed plant growth rates. The decomposition of soil organic matter (SOM) is the dominant process supplying N to non-legumes. While this process is strongly affected by temperature and soil water content, it has become clear that other environmental factors can have a dominant influence. Field studies of N release from soils in Southland and Northland (Gore and Kaikohe) showed distinctive patterns at each site that could not be reconciled with coventional temperature and moisture models.

The pattern at Gore (Waimumu silt loam) was characterised by fairly constant rates of N release throughout the year and a sharp burst of activity from late September to mid November. During this 8 week period about 40% of the total release of N occurs. The Kaikohe pattern (Wharekohe silt loam) contrasts with this in showing lowest N release values during the same period and having no clear peaks in activity.

Two hypotheses were proposed:

(1) Fluctuating soil temperatures in spring at the "cool" site (Gore) cause rapid growth and death cycles in soil organisms accelerating N release.
(2) Low winter temperatures at Gore inhibit N release and allow substrates to build up. These are then decomposed to give a "flush" as the soil begins to warm in spring but are soon exhausted.

To test these two hypotheses intact microplots (75 x 250 mm) were formed from pasture soils at each site. On 1 June microplots were allocated to remain on site or move to the other site. A second allocation was made on 7 September to give these treatments:

(1) Remains on site of origin for duration (360 days).
(2) Transferred to other site for duration.
(3) Transferred to other site for winter then returns.
(4) Remains on site of origin for winter then transfers to other site.

Ten replicates of each were used. Grass yield and N uptake were determined as an index of N release.

The site at which the soils wintered had a dominant effect on both winter and spring mineralisation rates. Winter rates were higher for both soils at the warm site but spring rates were highest for soils that had spent the winter at the cool site regardless of their spring location. The Waimumu soil gave an extra 20 kg N/ha over winter at Kaikohe but an extra 37 kg N/ha during spring after wintering at Gore. The effects were smaller with the infertile Wharekohe soil.

This suggests that "cool storage" of substrates contributes to the spring flush but additional substrates are exposed at cooler sites possibly through freeze and thaw processes. The physical disruption of soil particles, that occurs when the associated water freezes, can expose organic matter to microbial attack. A cold winter may, therefore, create a more dynamic condition in the soil which results in less organic matter being held in protected or in accessible sites.

For those studying the impacts of climate change this has some major consequences. First, it indicates that regions that have cool winters may suffer both lost plant production and a changed seasonal pattern of production. Both these affect the nature of the region's agricultural endeavours. Second, the complex negative feedback of temperature on nitrogen supply and hence plant growth is intrinsically difficult to model. These relationships leave great uncertainty about the final outcome of any temperature change in terms of farming operations.