Moisture key in nutrient stratification

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Stratification of nutrients occurs in all cropping systems and seems likely to be accentuated in no-till systems.

'Nutrient stratification' is used to describe the accumulation of poorly mobile nutrients such as phosphorus (P) and zinc at or near the soil surface in cropping paddocks; typically in the top 10 cm of soil and often in the top 5 cm in no-till systems.

The concentration of P in the topsoil is accentuated in no-till systems because there is little tillage to mix the nutrient-rich topsoil and fertiliser with sub-soil layers.

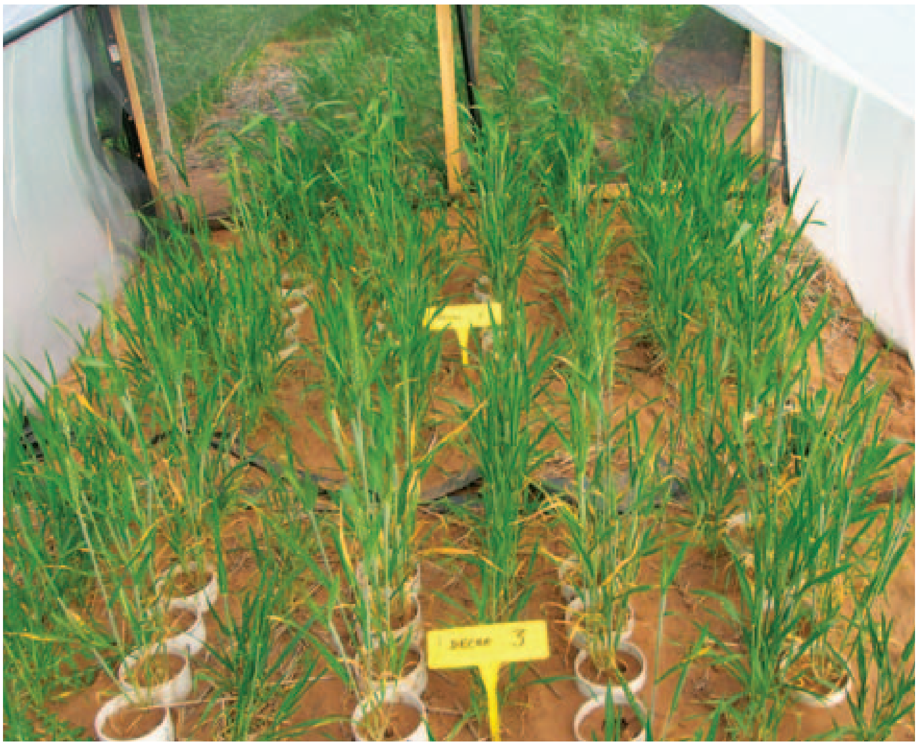
According to Dr Robert Norton, Regional Director of the International Plant Nutrition Institute, stratification can be caused by tillage, or lack of it, and rainfall, or lack of it.

In southern Australia where winter rainfall dominates, the shift to minimum tillage and wider rows may be contributing to nutrient stratification through reduced mixing of the soil and fertiliser bands, he suggests.

Concern about nutrient stratification is driven by the idea that crops may not be able to access nutrients concentrated in the surface layer of soils because this is the first layer to dry out and plants can not extract nutrients from dry soil.

However, while no-till means there is minimal soil disturbance to mix nutrients deeper into the soil, which implies higher concentrations of nutrients at or near the surface in no-till systems, a combination of no-till and stubble retention is likely to maximise the periods for which topsoils contain adequate levels of moisture to enable crop root activity; extending the period over which crops can access those shallow nutrients.

CSIRO and University of Adelaide scientist Dr Therese McBeath agrees that P stratification occurs in southern cropping systems but suggests that subsoil P levels in many southern soils have always been low. However, this may not be the case in more fertile clay soils such as cracking clays, where there is a form of 'biological cultivation' with topsoil moving deeper into the soil via the cracks that open up in dry conditions.



PLANTS INSIDE A 'RAIN OUT' TENT BEING USED TO HELP EXPLORE P NUTRITION AT MINNIPA.

Much of the P used by crops comes from P fertiliser applied in the top 5 cm or so of soil that, despite the relatively high incidence of winter rainfall in southern cropping regions, can often be dry during the growing season.

"When these upper soil layers are dry the crop roots are less active and the P in these layers is less accessible to roots," Dr McBeath said.

"A number of trials have shown the benefit of placing additional nutrients deeper in the profile provided there is sufficient P available to the germinating plant to stimulate good early root growth.

"Ensuring crop seedlings can access sufficient P can maximise early root development, equipping the crop plants to better forage for nutrients, including further P, from throughout the root zone.

"There has also been work showing that deep P can make a useful contribution to P nutrition."

Victorian research from some years ago showed that the availability of soil P is closely related to soil water content, which is generally higher under conservation tillage practices and long fallows.

Some crop species may be able to use a hydraulic lift mechanism to access sub-soil moisture and relocate it across the root system to roots in dry soil so they can access concentrations of available nutrients from the topsoil or other areas. However, this is no substitute for good levels of soil moisture, because plant roots are less active and soil nutrients like P and zinc are less available in dry soil.

These factors mean crops in mature no-till stubble retention systems with good levels of surface cover and soil organic matter at or near the soil surface are likely to be able to make maximum use of upper-level nutrients because of the moisture-conserving attributes of the surface cover and higher levels of soil organic matter.

However, this is far from the complete picture, said SARDI Leader of Farming Systems Dr Nigel Wilhelm. "While nutrient levels tend to be higher in the top 5 cm of soil in no-till systems this does not mean there are less nutrients

THIS 'RAIN OUT' TENT IS ABOUT THE ONLY FEATURE IN A VERY DRY PADDOCK AT A KAROONDA TRIAL SITE.

than cultivated systems deeper in the soil.

"The data I have seen show that deeper soil layers in no-till systems have nutrient concentrations no lower than conventional systems. This means that, overall, fertility improves under no-till.

"The extra nutrients near the soil surface in no-till systems will not be available when the topsoil is dry, but since the deeper soil layers under no-till are no lower in nutrients than subsoils in other tillage systems, no-till systems do not suffer any penalties from the accumulation of nutrients in the upper layers."

However, the long-term mining of nutrients from the bottom of the root zone is an issue for agriculture generally, regardless of the tillage system, Dr Wilhelm said.

"Deep-rooted crop and pasture plants extract nutrients from deep in the profile and very little replacement of these nutrients is occurring. Even the best-managed and most 'sustainable' systems seem to suffer from this issue, with poorly-mobile nutrients such as P the most vulnerable to this mining. Carbon or organic matter levels are also being depleted at depth."

'Double shoot' seeding in which most or all fertiliser applied at sowing is placed under the seed may help counter any adverse effect of stratification because the nutrients are positioned deeper in the soil, where moisture levels are likely to be more stable than in the top 5 cm.

WA research suggests deep fertiliser placement may improve nutrient uptake by crops in soils with nutrient stratification in some conditions.

Murdoch University and Department of Agriculture and Food researchers headed by Wen Chen used Agricultural Production Systems Simulator (APSIM) modelling to show that, on a duplex soil in WA conditions, P fertiliser placed 8 cm below the soil surface can increase wheat yields more than the same rate of fertiliser applied at 4 cm, particularly when early-season conditions are dry.

Deeper placement did not further improve grain yield.

Wheat yield benefits from the 8 cm placement were variable – from nil to 700 kg/ha – with the best results when grain yield was less than 2.5 t/ha and growing seasonal rainfall less than 300 mm.

Similar results have also been obtained in field trials.

The WA researchers also found that crop species respond differently to P placement,

A 'RAIN OUT' TENT USED IN RESEARCH EXPLORING THE RELATIONSHIP BETWEEN MOISTURE AND P NUTRITION IN A LUSH LANG CREEK PADDOCK.

with wheat's need for P during its early growth stages making it less likely to benefit from deep placement of P in a water-limited environment than crops such as lupin and canola.

Lupins respond best to deep P placement – down to 14 cm – in seasons with above-average growing-seasonal rainfall and high yield potential, a result the researchers suggest is due to lupins' need for P late in the growing season.

Organic matter may also have a significant role to play it the stratification equation.

University of Adelaide researcher Dr Ann McNeill, in a paper titled 'Options for managing soil phosphorus supply', says 'practices that increase organic matter in soil should, generally, increase the capacity to cycle P.'

The role of organic matter was also addressed in Victorian research published in the Australian Journal of Soil Research.

The researchers found that the accumulation of soil organic carbon (SOC) in conservation tillage systems has led to changes in nutrient cycling, especially the stratification of SOC, extractable P, and other nutrients in the soil', possibly as a result of improved soil structure stimulating root growth and providing the crop with greater opportunity to exploit moisture and P in the soil.

One of those changes is an increase in soluble P levels under conservation tillage as a result of higher levels of SOC, probably due to the microbial activity around decomposition of soil organic matter, said Victorian DPI scientist Dr Roger Armstrong.

Dr Armstrong, one of the authors of the paper, which explores the effects of tillage system on phosphorus form and depth, said higher levels of organic carbon increased the level of soluble P in the surface layer of a non-cracking clay soil, but in a cracking soil this mobile P moved down through the cracks and accumulated deeper in the profile.

The researchers found that while the concentration of P at different depths in the soil varied considerably across the three soil types with which they worked, P content was always greatest in the top 10 cm of the soil and decreased with depth.

And, as suggested by Dr Wilhelm, while reduced tillage significantly increased the vertical stratification, available P levels remained 'more than adequate for crop growth' at all the trial sites.

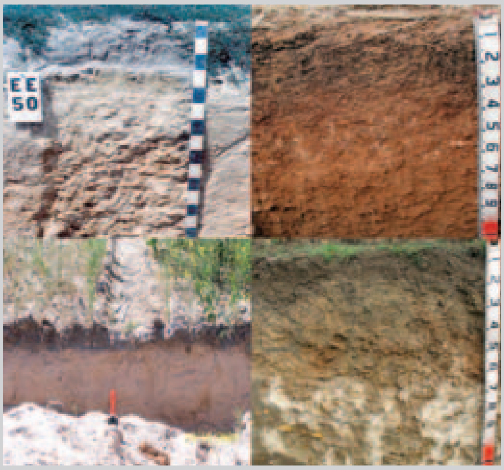
These results are consistent with a previous study that showed topsoil P levels can be 15% higher in minimum and zero-tillage systems than under conventional tillage.

Such concentration of nutrients in the topsoil may result in lower P-use efficiency, especially in semi-arid regions where rapid drying of soil surfaces due to high temperature and evaporation rates can occur. In such circumstances higher rates of P fertilisers may be needed to maximise yields.

Deep-banding P into the subsoil is considered a solution to this problem provided some fertiliser P is also banded with the seed, Dr Armstrong said, but while deep placement can increase P-use efficiency it involves significant cost and time and may not be cost-efficient.

The paper suggests there may be benefits from matching fertiliser management practices to district and soil conditions, with deep placement of P rather than 'single shooting' seed and fertiliser together likely to increase P-use efficiency in low-rainfall regions such as the Mallee, for example.

SOIL PROFILES



ALL THESE SOILS SHOW SYMPTOMS OF COMPACTION FROM WHEELED TRAFFIC OVER MANY YEARS.