SWICP WEBINAR: SUSTAINABLE VEGETABLE SYSTEMS (SVS) TOOL

Q&A

1. **What are the side effects of prolonged application of nitrogen inorganic fertilisers in one location?**

Dr Bruce Searle (BS), Plant & Food Research NZ: This depends on the amount of nitrogen that is applied. If the supply is 'best management' and meets the demand of the crop, the side effects are not large and can be positive in some instances. If nitrogen is oversupplied, there can be detrimental.

I made a list of possible effects on soil and environment below:

Aspect	Nitrogen meets crop demand	Nitrogen oversupplied
Soil structure	Minimal – healthy roots and exudation help stabilise soil structure, helps maintain organic matter inputs to soil from roots.	Excess nitrogen can increase root mass, but increase decomposition of organic matter, reducing supply to soil.
Soil chemistry	Minimal. Can be slight acidification if high amount of ammonium-based fertilisers used.	Can result in acidification, affecting nutrient function and microbial activity. Can cause nutrient imbalances such as reduced uptake of K, Ca and Mg.
Soil biology	Should be maintained if balanced nutrient availability. Healthy roots encourage healthy rhizosphere.	Excess nitrogen favours fast growing bacteria, so reduces microbial diversity. Acidification can also reduce microbial population.
Environmental	Losses are kept to a minimum. Carbon stocks maintained at least, if not lightly improved over time.	Losses could be increased; ground water contamination could increase. Runoff could become more of problem for water ways.

This project has been funded by Hort Innovation using the vegetable, fresh potato and potato processing research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for

Dr Doris Blaesing (DB), RMCG/SWICP: Generally, prolonged application of inorganic nitrogen fertilisers in the same location can have several negative impacts on soil, water quality, and the broader environment. As Bruce mentioned above, oversupply can be detrimental and have the following impacts:

1. Soil Degradation

Soil acidification - Ammonium-based fertilisers (e.g., ammonium sulphate, urea) lead to acid formation during nitrification, lowering soil pH. Acidic soils can harm beneficial microbes and reduce availability of some nutrients.

Nutrient imbalance - excess nitrogen may suppress the uptake of other essential nutrients like potassium, magnesium, or calcium, causing deficiencies.

Loss of organic matter - High nitrogen inputs can accelerate the decomposition of soil organic matter, leading to reduced soil structure, nutrient and water retention.

2. Water Pollution

Nitrate leaching - Excess nitrate (NO_3^-) not taken up by plants leaches into groundwater and other waterways potentially contaminating drinking water supplies and aquatic ecosystems.

Eutrophication - Runoff containing nitrogen fertilisers stimulates algal blooms in water bodies, leading to oxygen depletion and harming aquatic life.

3. Other environmental impacts

Greenhouse gas (GHG) emissions - Nitrous oxide (N_2O), a potent greenhouse gas, is released through nitrification and denitrification processes in soils receiving high nitrogen inputs.

Ammonia volatilisation - In alkaline soils, nitrogen loss as ammonia gas can contribute to air pollution and further GHG effects.

4. Plant health issues

Salt accumulation - Continuous use of certain nitrogen fertilisers can increase soil salinity, impairing root function, nutrient uptake and plant growth.

Lodging and disease susceptibility - Over-fertilisation with nitrogen fertilisers promotes excessive vegetative growth, making crops more prone to lodging, lush growth and diseases. Fruit set may be reduced.

5. Microbial and biological effects

Microbial Imbalance - Overuse of mineral N sources can disrupt the natural balance of soil microbes, favouring nitrate-producing bacteria over beneficial species like nitrogen-fixing bacteria or mycorrhizal fungi.

This project has been funded by Hort Innovation using the vegetable, fresh potato and potato processing research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for

Loss of Biodiversity - Intensive nitrogen inputs can harm soil fauna, reducing ecosystem resilience.

6. Strategies to mitigate long-term effects

Match nitrogen inputs to crop requirements using soil testing and monitor via soil N and pant testing.

Use crop rotation and cover crops to make use of N left over after harvest and to improve soil health and reduce reliance on inorganic nitrogen.

Use of organic amendments: such as compost or composted manure to enhance soil organic matter. Manure use, if excessive, can lead to nutrient imbalances; monitoring is important to avoid this.

Precision agriculture technologies like controlled-release fertilisers and nitrogen modelling tools and sensors can be used to optimize application. Still, N budgeting and crop soil and plant monitoring should still be used for fine tuning.

Combining inorganic fertilisers with organic sources can be used for sustainable nutrient supply.

2. Explain Amine uptake and utilisation, is it better than other N sources?

DB: Amine nitrogen (NH_2) is found in products like urea or urease inhibitors It can be an effective nitrogen source for vegetable crops, but its uptake and utilisation depend on the specific crop, soil conditions, and management practices including how it is used.

A comparison between amine and other nitrogen forms

<u>Amine nitrogen uptake and utilisation</u>

- Amine nitrogen is converted to ammonium (NH_4^+) and then nitrate (NO_3^-) in the soil through microbial processes. Vegetable crops can take up ammonium directly but generally prefer nitrate unless they are adapted to grow in acid soils (e.g. blueberries).
- Some studies suggest that amine nitrogen can be absorbed directly by plant roots, bypassing the need for full conversion, which may reduce losses under certain conditions.
- Amine nitrogen is susceptible to volatilisation, especially in warm, alkaline soils. Proper application (e.g., incorporation into the soil or using urease inhibitors) can minimise these losses.

<u>Comparison with other nitrogen sources</u>

Ammonium (NH_4^+) sources are readily available to plants and, as a cation that can adhere to negatively charged exchanges sites (clay minerals, organic matter), less prone to leaching than nitrate (NO_3^-). However, excess ammonium can lead to soil acidification over time and cause

This project has been funded by Hort Innovation using the vegetable, fresh potato and potato processing research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for

toxicity in sensitive plants. Ammonium as a cation competes with other cations (e.g. calcium, potassium, magnesium) for uptake.

Nitrate (NO_3^-) sources are highly mobile in the soil and immediately available to plants, making it ideal for rapid uptake. Nitrate is due to its mobility prone to leaching, especially in sandy soils or under irrigation and during high rainfall periods.

Organic nitrogen

Organic nitrogen for organic matter, compost and crop residues gradually releases plant available nitrogen and thus supports sustained crop growth. However, slower and weather and soil type dependent mineralisation rates may not meet peak nitrogen demands. Tools like the NZ SVS tool together with monitoring of mineralisable N and available soil nitrogen can assist in better managing organic nitrogen.

Is amine better for N nutrition of crops than other N sources?

Amine nitrogen is not inherently better or worse than other forms; its effectiveness depends on:

- Soil type - amine forms are more prone to volatilisation in alkaline soils than other N sources
- Environmental conditions - warm and moist conditions favour the conversion of amin to ammonium and nitrate, improving availability but also the risk of losses via leaching.
- Crop needs - Vegetables with high and rapid nitrogen demands (e.g., leafy greens) may benefit from nitrate, while others might utilise ammonium sources effectively. When using ammonium or urea, timing of availability can vary with soil and weather conditions.

In practice, combining several nitrogen sources and using inhibitors to stabilise amine and urea or ammonium sources forms can optimise uptake and utilisation in vegetable crops. Regular soil and plant testing and fertilisation strategies developed according to the crop and soils (N budgets) are essential for good nitrogen use efficiency and to minimise losses pass the rootzone, to the air or as run-off.

BS: Crops can take up a wide range of different nitrogen forms. Most tend to easily use nitrate because it is soluble and mobile in the soil making it readily available, and it provides a continuous supply to the crop in most soils and cropping systems. And plants tend to have specific transporters to ensure good uptake at the root.

Ammonium is another form of inorganic nitrogen supply. Most crops also have transporters for ammonium. However, ammonium is not as mobile in the soil as nitrate (so not as easy for plants to get), though it is very common in acidic soils, or anaerobic soils (like a rice paddy).

Amines applied to the soil can be easily absorbed by roots once they are converted to ammonium by soil microbial activity.

This project has been funded by Hort Innovation using the vegetable, fresh potato and potato processing research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for

When crops take up nitrate, it goes through a process of being converted to ammonium in any case, and this uses energy by the crop. Amines don't have to go through this process and so can be more energy efficient for some crops. However, some crops need the metabolic pathway that involves the nitrate being transformed to ammonium. So amines are not useful for crops like rice, maize, potato, citrus.

Stabilised amine nitrogen (also referred to as SAN) has been reported used on wheat and onions. I haven' seen reports looking at the effect of amine production of the tubers themselves (amines can affect flavour and cooking behaviour). And I haven't seen SAN work where the supply of N by soil was properly considered. Some work in this space would be useful, I think.

3. Is there value in collaboration between AUS and N on similar projects?

BS: Absolutely.

Collaboration brings in different growing conditions so that better science answers can be found, it leads to new science questions, it increases the robustness of data, and so also conclusions. Collaborations fosters new questions; it also fosters an exchange of ideas from practitioners that leads to new and better ideas on how to apply findings for better production.

Collaborations should involve growers as well as scientists.

DB: Absolutely. As neighbouring countries with similar growing conditions, climate, and shared challenges, there is always room for learning and exchanging information between Australia and New Zealand. By collaborating and tackling these challenges together, we can work towards our common goal of producing healthy, nutritious food that benefits both people and the planet.

4. With the irrigation component of the tool, can you add real soil moisture data to improve the tool's output? e.g. using soil moisture probes?

Andrew Barber (AB), Agrilink NZ: Yes, the model could be worked on and continually improved. As you identified Irrigation, but equally crop residue breakdown, and real time weather are 3 areas where further improvements could be made to the model. However, it is still just a model that is trying to predict reality. I think it is better to override the model with an in-season soil mineral N test. This is the culmination of how all these variables captured in a soil test. Afterall this is what the crop is seeing. I believe make the model reasonably accurate, so people don't rubbish it and disengage, but then put your time and resources into getting people to use the decision support tool. Afterall measured numbers beat modelled numbers every time.

This project has been funded by Hort Innovation using the vegetable, fresh potato and potato processing research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for

BS: I might add, addressing this issue, incorporating adding real time soil moisture data into the tool, and monitoring outcomes across the different soils, climates and production practices of NZ and Aus seems ideal collaboration point.

5. Can you please explain a little more about how the tool's linkage between irrigation and N dynamics can support decision making?

BS: If the soil moisture part of the tool suggests that any additional rain or irrigation in the near future might lead to drainage below the 30 cm soil layer, then it will not suggest putting on any fertiliser if needed. If the soil moisture part of the tool suggests that any additional rain or irrigation in the near future might lead to drainage below the 30 cm soil layer, then it will not suggest putting on any fertiliser if needed. Once likely drainage events are unlikely, it will suggest application.

Likewise, if too dry, it will suggest irrigation so that any mineral nitrogen in the soil can be accessed by the roots more effectively.

This project has been funded by Hort Innovation using the vegetable, fresh potato and potato processing research and development levies and contributions from the Australian Government. Hort Innovation is the grower-owned, not-for-profit research and development corporation for