THE CHANGING NUTRITION NEEDS OF A GROWING CROP

Surging fertiliser prices have put the spotlight on fertiliser budgets. Approaching nutrition through the 4R framework can keep up with crop nutritional needs while taking the sting out of high fertiliser prices.

by Alisa Bryce

The 4R's of fertiliser management means putting the **RIGHT** nutrients on at the **RIGHT** rate, at the **RIGHT** time, in the **RIGHT** place.

Pre-planting soil testing is the best way to gauge the right nutrients and rates to start the season.

In-season tissue testing (Figure 1) can identify which nutrients need a boost, or where the fertiliser program can be scaled back. Using in-season tissue testing can catch deficiencies early, before visual symptoms appear and yield is penalised.

For potatoes, the right time and place are particularly important. For the first few weeks, potato plants get most (but not all) of their nutrition from the seed piece. From stage 2 (stolon initiation) the plant transitions from using energy reserves in the seed piece to accessing soil nutrients through the developing roots.

Nutrient demand is highest from tuber initiation through to maturity, (Figure 2) so nutrients need to be both available and accessible. Potatoes have shallow, sparse root systems that are poor nutrient scavengers. Ensuring nutrients are within easy reach, especially immobile nutrients like phosphorus, is critical.

Potato nutrition requirements change throughout the season (Figure 5). Matching fertiliser inputs to these requirements helps avoid deficiencies (Figure 3) and maximise yield while avoiding waste of expensive inputs.

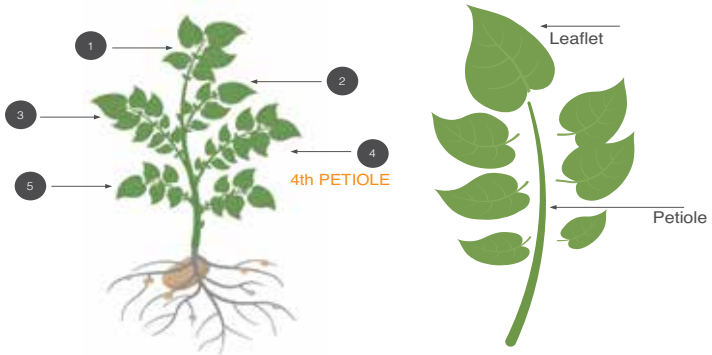

Figure 1. Nitrogen status may be assessed by sampling the fourth petiole (from the newest leaf down) from at least 30 plants around the field. Petiole nitrate-N levels during tuber bulking are; <10,000ppm = low; 10-15,000ppm = medium and >15,000ppm = sufficient

ROLES OF NUTRIENTS IN POTATOES

Nitrogen needs the most management. It is critical for developing tubers and overall crop growth. Nitrogen must be managed carefully throughout the season, as either inadequate or excessive supply can reduce crop quality and yields. In-crop mineralisation can supply some nitrogen but repeat applications are likely necessary.

Only a small amount of nitrogen is needed during establishment and stolon initiation. Crops need enough to encourage leaf growth and help deal with early blight infestations. Conversely, too much nitrogen during these growth stages can delay tuber initiation and maturity, promote excess vine growth, increase risks from disease and potentially result in internal defects in tubers.

Potatoes take up 60 – 70% of their total nitrogen requirements during tuber bulking (Ojala et al. 1990). In contrast, very little nitrogen is taken up during maturation.

Phosphorus helps the root system develop, regulates tuber set and promotes tuber maturity. Inadequate

phosphorus leads to lower tuber numbers. Because phosphorus is quite immobile in the soil, it should be applied pre-planting, near the seed, where the developing root systems can access it.

Potassium optimises tuber yield, size and quality and regulates water balance. It is also essential for root elongation, leaf expansion and photosynthesis. Potassium deficient plants have lower specific gravity and are more susceptible to disease. Being heavy potassium users, in-crop applications of potassium are common. As with nitrogen, potassium requirement peaks during tuber bulking. However, too much potassium late in the season can reduce specific gravity.

Calcium creates stronger cell walls which improves skin quality, maximises tuber storage life, and reduces susceptibility to disease. Regular calcium supply is needed throughout the season, but supply is particularly important during tuber initiation and for protection against quality disorders such as internal brown spot.

Sulfur is useful for increasing tuber numbers and can help mitigate the risk of Common and Powdery Scab. Like calcium, regular sulfur supply is important.

Magnesium is essential for photosynthesis. It is particularly important during tuber bulking for maintaining tuber size and yield.

Although only required in small amounts, trace element deficiencies can restrict root growth, yield, and disease resistance.

Boron is the trace element needed most by potatoes. It affects cell wall strength and therefore tuber storage quality, as well as supporting root growth. Boron also helps potatoes absorb and use calcium.

Manganese and **Zinc** deficiencies affect yield and skin quality. Low zinc can affect nitrogen metabolism and starch content. Too much manganese can severely reduce yield.

Copper and **Iron** deficiencies are rare. **Molybdenum** deficiency is also uncommon, being more likely if the seed piece was grown in low molybdenum soil. Without enough molybdenum, plants can't use nitrogen to make protein; symptoms look like nitrogen deficiency.

NUTRIENT INTERACTIONS

Nutrient interactions in plants are complex, but important to consider as imbalances can penalise yield and quality. In potatoes, the more commonly recognised interactions are:

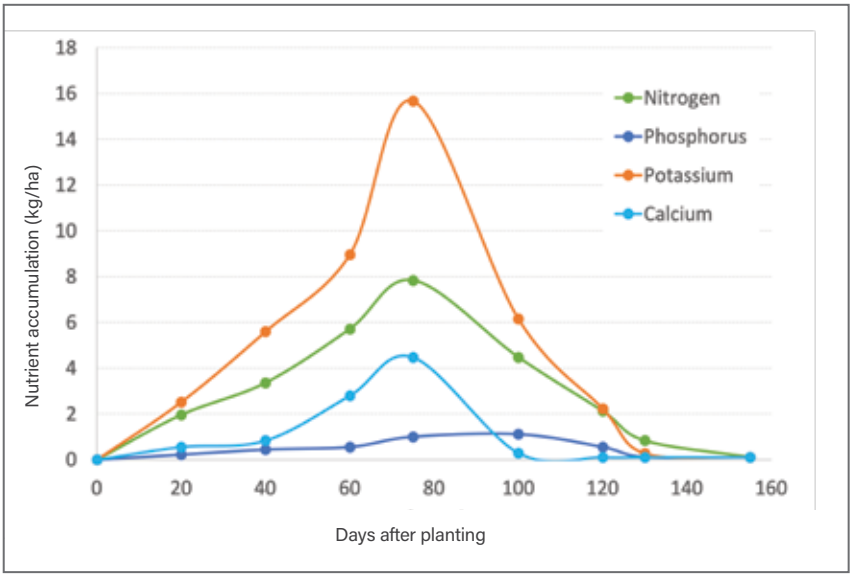

Figure 2. Daily nutrient accumulation by Russet Burbank potatoes. Derived from Horneck and Rosen, 2008.

- High rates of potassium fertiliser can induce magnesium deficiency, as potassium and magnesium compete for uptake.
- Boron improves calcium absorption.
- Increased available phosphorus can affect manganese uptake.
- Zinc deficiency can result from excess phosphorus uptake, or phosphorus-induced zinc deficiency.
- Trace element interactions can partition between the shoots and dry matter. For example, increased available soil manganese depresses iron in shoots (Reichman 2002).
- A study by Barben et al. (2011) suggested that balancing zinc and manganese availability – especially avoiding low zinc and high manganese – is vital as these nutrients can have negative impacts on phosphorus, copper and iron.

READING THE PLANT

The symptoms of nutrient deficiencies or excess vary in where they first appear in the plant. Mobile elements can be relocated from older leaves to growing shoots (e.g. potassium and magnesium), whereas deficiency symptoms of immobile elements will be most obvious in the growing tips (e.g. calcium and sulfur; see Figure 4 for illustration of zinc and sulfur deficiency).

Other ways to fine-tune fertiliser management:

- Remember Leibig's law of the minimum—yield is only as good as the most limiting nutrient i.e. more nitrogen won't help if lack of boron is suppressing growth. Addressing the full suite of nutritional needs gets the most out of the fertiliser budget.
- Match zones in paddocks to fertiliser needs based on soil type and cultivar.

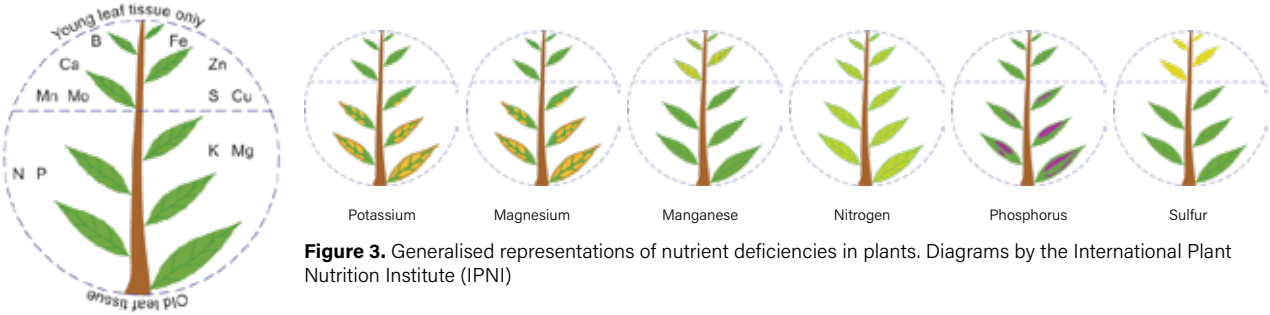

Figure 3. Generalised representations of nutrient deficiencies in plants. Diagrams by the International Plant Nutrition Institute (IPNI)

Figure 4. Both zinc (left) and sulfur (right) are immobile in the plant, so deficiencies show first in the youngest leaves. Photos by IPNI.

					
	Stage 1 – Establishment	**Stage 2 – Stolon initiation**	**Stage 3 – Tuber initiation**	**Stage 4 – Tuber bulking**	**Stage 5 – Maturation**
Nitrogen	Too much N risks delaying tuber initiation and internal defects	Too much N risks delaying tuber initiation and internal defects	N needs increasing but don't overdo it	Peak N demand	N uptake drops significantly
Phosphorus	Early shoot development and root elongation	Maximises tuber number set	Maximises tuber number set	Supports tuber bulking	
Potassium	Protection against disease and frost tolerance	Root development and photosynthesis	Root development	Peak K demand	
Magnesium				Mg most important. Maintains tuber quality	
Calcium			Ca most important. Protection against quality disorders	Improves skin finish	
Sulphur		Tuber numbers and disease protection			

Figure 5. Key potato nutritional needs across the five growth stages.

FERTILISER APPLICATION METHODS

Choosing an appropriate fertiliser application method is important for nutrient timing and placement. Broadcasting or banding granular fertiliser pre-season sets the crop up for a good start. Fertigation and foliar applications are more common in season as the fertiliser budget gets adjusted in response to tissue testing. Each method has pros and cons.

Method	Pros	Cons
Broadcasting (not incorporated)	▪ Fast, easy to apply. ▪ Can be done with cheaper equipment than other methods.	▪ Uses more fertiliser than banding. ▪ More fertiliser available for weeds. ▪ Greater chance of nitrogen loss through volatilisation and denitrification. ▪ Requires rain or irrigation to move more mobile nutrients like nitrogen into the rootzone. ▪ Less mobile nutrients like phosphorus and traces remain on the surface, away from the roots.
Banding / side dressing	▪ Puts nutrients closer to the roots for better access. Particularly important for phosphorus. ▪ Better root growth through more access to nutrients. ▪ Less nutrients for weeds. ▪ Uses less fertiliser than broadcasting. ▪ Less risk of nutrient loss with erosion. ▪ Less risk of nitrogen loss from volatilisation and denitrification.	▪ Equipment costs more than broadcasting equipment. ▪ Slower than broadcasting. ▪ Risks salt damage if fertiliser is placed too close to the seed piece.
Fertigation	▪ Can be precise with fertiliser amounts and timing. ▪ Faster nutrient uptake because nutrients are already in water. ▪ Flexibility to adjust rates throughout the season.	▪ Troublesome if it's a wet year and the soil is already saturated. ▪ Higher risk of leaching nutrients, especially nitrogen if applied early in the season. ▪ Uneven applications and wasted fertiliser if windy. ▪ Higher risk of N loss from volatilisation on hot, windy days. ▪ High calcium and/or magnesium in water can make phosphorus unavailable.
Foliar applications	▪ Fast way to correct trace element deficiencies. ▪ Useful is the soil is alkaline and some nutrients are less available for uptake. ▪ Useful for in-crop phosphorus applications if irrigation water has high calcium and magnesium. ▪ Faster nutrient uptake than fertigation and other soil application methods.	▪ Less useful for macronutrient deficiencies. ▪ Risks scorching or leaf burn if rates are too high. ▪ Shouldn't apply on moisture stressed plants.

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