In-crop applications of nitrogen

By Guy Lafond[1], Bill May[1] and Chris Holzapfel[2]

Worldwide, nitrogen is the most limiting and applied nutrient in crop production. Nitrogen also requires a lot of energy for production, and it accounts for the largest portion of total energy required for the production of non-nitrogen fixing crops.

There is interest in increasing the efficiency of nitrogen fertilisers for environmental and economic reasons. The recent large increase in nitrogen fertiliser prices is making those interests more urgent.

Mismanagement of nitrogen fertilisers can also have important environmental consequences such as surface and ground water contamination with nitrates and emissions of nitrous oxide – a potent greenhouse gas.

Nitrogen fertility management encompasses four major components – source, placement, timing and rate.

Research has demonstrated that there is very little difference between fertiliser forms, provided that they are managed accordingly. Placing the fertiliser in the soil as opposed to on the surface will greatly minimise losses from volatilisation and immobilisation and enhance overall nitrogen fertiliser recovery.

The goal is to ensure that nitrogen is available as close to the time of maximum crop uptake. With cereals this corresponds to the period from the start of elongation to heading with peak uptake during flag leaf extension. And in canola, it corresponds to the start of flowering to the end of pod formation.

But applying nitrogen fertilisers at these critical times and ensuring the availability for crop growth is not always possible for practical reasons because rainfall is required to move the nitrogen fertiliser into the root zone when the nitrogen is surface applied.

The more recent no-till production systems on the Canadian Prairies (and in Australia) apply all nitrogen fertiliser at the time of seeding either in a side-banded or mid-row banded position.

This has been shown to have positive effects on the recovery of applied nitrogen by the crop. The more challenging aspect of nitrogen fertiliser management is deciding on an appropriate rate.

What's the best rate?

Nitrogen fertiliser rate recommendations take into consideration factors such as soil texture, residual soil nitrate levels, soil moisture at seeding, average growing season precipitation, previous crop grown, crop to be grown, target crop yield, expected commodity prices, and nitrogen fertiliser prices.

But there is much uncertainty with all of these factors due to temporal variations in climatic conditions and spatial variability in soil nutrient levels and inherent fertility.

Nitrogen release from mineralisation during the growing season and the major pathways of nitrogen losses (immobilisation, volatilisation, denitrification and leaching) are also greatly influenced by climatic conditions making their amounts difficult to

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estimate. Consequently, whatever the chosen rate, much uncertainty exists and rates can easily be either under or overestimated with important economic and environmental consequences in both situations.

Post-emergent N

There is interest in exploring post-emergent nitrogen applications in crops to refine our ability to optimise rates of nitrogen fertiliser. Delaying either some or all of the nitrogen fertiliser after crop emergence may allow for a better sense of yield potential and expected growing conditions.

With the recent introduction of commercial optical crop sensors as a nitrogen management tool, it is now possible to estimate crop yield potential early in the growing season in cereals (five to six leaf stage) and the start to mid-bolting stage of canola and still allow enough time to adjust the rates of nitrogen accordingly.

Studies were conducted at Indian Head, Swift Current and Brandon (Canada) over three seasons. The research analysed the effectiveness of using different proportions of recommended nitrogen rates at seeding with the balance at different crop growth stages to minimise the risks of yield losses from in-crop nitrogen applications in spring wheat and canola.

The treatments consisted of applying 100, 67, 50, 33 or 0 per cent of the targeted N rate at seeding and the balance in-crop at the 1.5, 3.5 or 5.5 leaf stages in spring wheat and at the five to six leaf stage, the bolting, or start, of the flowering stage in canola.

SUMMARY OF RESULTS

With spring wheat, applying 33 per cent of the recommended N rate at seeding with the balance in-crop, for all crop stages investigated, resulted in similar yields to when all nitrogen was applied at seeding. There was no effect on grain protein.

With canola, a minimum of 50 per cent of the recommended nitrogen rate was required at seeding and the in-crop application either at or before the bolting phase to give yields equivalent to when all fertiliser was applied at seeding.

Consequently, applying either 50 per cent or more of the recommended N at seeding greatly reduces the risks of in-crop N applications and greatly enhances the opportunity of in-crop applications of nitrogen in spring wheat and canola to better match the soil and climatic conditions.

In-crop applications of nitrogen are all about fine-tuning N rates to more effectively match crop needs for N with the current growing conditions.

This approach can potentially be enhanced when combined with crop sensing technology like the *GreenSeeker*. This optical sensor provides estimates of yield potential early enough in the growing season, and when compared to a non-N limiting strip in the field, it provides a more objective evaluation of whether more nitrogen is required to realise that potential.

The dilemma

The dilemma is deciding on an overall strategy for incorporating in-crop applications of N in a farming operation. Currently in our studies, we are looking at applying either 50 per cent or 66 per cent of the recommended N at seeding and the balance in-crop using the *GreenSeeker*.

It may be more practical at a farm level to apply nitrogen according to average grain yields with some adjustments either up or down to allow for spring soil moisture reserves, and then use the non-N limiting strip in the field and compare it to the rest of the field to decide if more N should be applied. A decision can then be made to apply a uniform amount across the field.

If a grower purchases a commercial unit for his sprayer, they will have the added advantage of being able to take into consideration spatial variability and adjust the N rates accordingly to make it an even more powerful nitrogen management tool.

1. Ag & Agri-Food Canada, Indian Head.
2. Indian Head Agricultural Research Foundation.
More information: judymkell@sasktel.net ■

VOLATILE LOSSES OF SURFACE-APPLIED N

Although most nitrogen (N) fertiliser in the Canadian Prairies and Australia is applied either at or before the time of seeding, certain situations may warrant in-crop applications of N. But when they wish to do so, producers have limited options for applying N to established crops.

Many farms already utilise a high-clearance sprayer. This means equipping the sprayer with specialised dribblebanding nozzles and using it to apply N is a relatively inexpensive option for liquid products such as UAN.

But for granular sources such as urea, broadcasting is often still the most practical application method available.

The obvious problem with applying N fertiliser to the soil surface is that it leaves the N vulnerable to volatile losses.

Volatilisation occurs when soil ammonium (NH^{4+}) is converted to ammonia (NH_3), which is a gas at normal temperatures and pressures (consider anhydrous ammonia fertiliser), and lost to the free atmosphere. Once the NH^{4+} has been converted to nitrate (NO_3^-), it is no longer susceptible to volatilisation, which is why ammonium-nitrate has traditionally been the preferred source for established forage crops and winter cereals.

Recent Canadian studies quantified the amounts of N lost as NH_3 from in-crop, surface applications of UAN, and from urea relative to urea banded at seeding under varying environmental conditions.

Overall, research results confirmed that placing ammoniacal fertilisers beneath the soil surface is the most effective method for minimising volatile losses of N.

But in situations where this is not possible, such as when applying N to established crops, N fertiliser can generally be surface-applied without losing too much N as NH_3. The results indicated that losses from UAN or urea will seldom exceed 10 per cent of the applied N and will often be less than five per cent.

Although fertilisers protected by either polymer coats or chemical inhibitors may be better suited to post-emergent N applications than either UAN or urea, they are also more expensive than traditional products.

A certain amount of volatile loss is expected from surface applications of either UAN or urea, and they should be considered when either calculating rates or deciding whether or not to apply N in-crop.

Source: Agriculture & Agri-Food Canada.

Chambers used to measure NH_3 emissions from surface applied N fertiliser.