Nitrogen fertilizer and urease inhibitor effects on canola emergence and yield in a one-pass seeding and fertilizing system

Canola uses large amounts of crop nutrients, including N. Nitrogen deficiencies limit canola yield, so N fertilization is essential to maximize canola production. When no-till systems are used, in-soil banding via injection prevents volatilization losses and immobilization in surface residues, if placed below the crop residue. Banding can reduce volatilization losses when soil has a high sorptive capacity because the soil cover reduces the risk of ammonia loss. Banding N fertilizer can slow the conversion of ammonium to nitrate, reducing the risk of denitrification and leaching losses. Weed competition can be reduced when N fertilizer is banded beneath the soil surface instead of broadcasting fertilizer.

In-soil banding of N is widely adopted on the Canadian prairies, with fertilizer commonly applied during the seeding operation. Seeding and fertilizing in a single operation reduces time, fuel, and labor costs and can help to decrease seedbed disturbance and retain soil moisture. Equipment costs are lower if the seed and fertilizer can be placed in a single band, using only one opener, but this can lead to seeding damage at high N rates.

Fertilizer toxicity to seedlings

Canola is sensitive to seedling damage. The rates of N required to optimize crop yield are usually too high to be safely placed with the seed. Separating the fertilizer from the seed, by placing it in a separate band from the seed row, reduces risk of seedling damage and increases the amount of N that can safely be applied near the seed row at the time of seeding. Nitrogen and P fertilizers are commonly placed together in a single band, and placement of P near the seed row is important to ensure that the plant can access the P early in the season. Some seeders can side-band both N and P fertilizer near the seed to allow early access of the roots to the fertilizer while reducing the risk of seedling damage.

Because canola is sensitive to fertilizer damage, a recommended separation considered safe varies from about an inch to the side and an inch below the seed row to 2 to 2.8 inches to the side and below the seed row, depending on the province. Most of the seeders being used commercially target a separation of an inch to the side and an inch below, meeting the Saskatchewan provincial recommendations, but none of the side-banding seeders that are currently widely available on the northern Great Plains target a separation that meets the provincial recommendations from Manitoba. Effective separation is likely to vary with factors such as ground speed, fan speed, equipment wear, field topography, fertilizer volume, and soil conditions, and may be less than targeted.

Urea ammonium nitrate (UAN), a liquid blend of urea and ammonium nitrate, and urea are both common forms of N fertilizer. The urea molecule is not directly damaging to seedlings, but when urea is applied to the soil, it rapidly hydrolyzes to ammonium ($\text{NH}_4^+$) in a reaction catalyzed by the enzyme urease. The more rapidly the urea hydrolyzes, the higher the concentration of $\text{NH}_4^+$ and $\text{NH}_3$ present in the soil solution, which increases the risk of damage. Ammonium is in equilibrium with $\text{NH}_3$, so seedling damage can occur both through a “salt effect,” where increased osmotic potential of the soil solution desiccates the plant, and through direct ammonium toxicity. In contrast, nitrate only causes damage through the salt effect. Therefore, toxicity to cereal seedlings is believed to increase in the order of ammonium nitrate $<$ UAN $<$ urea. For canola, ammonium nitrate is considered as toxic to seedlings as urea, but there is not much information comparing the relative toxicity of urea and UAN when used on canola.

Urea toxicity can be reduced in many crops by applying the urease inhibitor NBPT to the fertilizer granule or the UAN solution. The urease inhibitor slows the conversion of urea to ammonium, allowing more time for rainfall to occur to dilute the fertilizer and for the intact urea molecule to move away from the seed row, thus reducing the concentration of $\text{NH}_4^+$ and $\text{NH}_3$ in contact with the seedling. Since NBPT delays rather than eliminates urea hydrolysis, its effectiveness on reducing seedling damage depends on the diffusion characteristics of urea in the soil and on urease activity as well as the moisture level of the soil.

Experimental objective, methods

In the July–August 2010 issue of Agronomy Journal, researchers reported on a study in which they evaluated the effects of increasing rates of side-banded UAN and urea, with and without NBPT, on seeding emergence, biomass production, and seed yield of canola, with varying amounts of weed competition depending on the presence or...
absence of herbicide application, on sites with different soil textures.

The experiment was a split plot with whole plots arranged in a randomized complete block design, with four replications. Fertilizer treatments were the main plots, and herbicide treatments were the subplots. Statistical analysis was conducted with contrast analysis using Proc Mixed. Contrast analysis was used to determine the effects of the fertilizer rates, sources, and use of urease inhibitor. Differences or regression factors were considered significant at \( p < 0.05 \). Linear, quadratic, and cubic contrasts were assessed for each fertilizer source. Regression equations were calculated using Excel only if the linear or quadratic contrasts determined using Proc Mixed were statistically significant. The correlation between stand density and seed chlorophyll concentration was determined using Proc Corr, and regression equations were calculated only if the correlation was statistically significant.

Analyses were conducted separately by site and year because seedling damage is a sporadic occurrence that is strongly affected by soil characteristics and environmental conditions occurring immediately after seedling. Responses to fertilizers differed substantially with year and location, so assessment by site and year is a more meaningful evaluation of the effect than combining the data across sites and/or years. In no case was there a significant interaction between herbicide application and any treatment, so data were combined over herbicide application treatments.

**Stand density**

Stand counts were taken before herbicide application, so herbicide treatment had no effect on stand density. Stand density at two weeks after seeding was consistently decreased by application of side-banded urea or UAN on the clay loam soil, indicating that the fertilizer caused seedling damage, reducing germination and crop emergence. On fine sandy loam soil, stand density was reduced by urea or UAN only in 2001. Seedling damage from fertilizer applications is expected to be greater on lighter- than heavier-textured soils. In 1999 and 2000, between 1 and 2 cm of rain fell between seeding and crop emergence, while in 2001, less than 1 cm rainfall occurred in this period. The rainfall that occurred in 1999 and 2000 may have been sufficient to move the fertilizer away from the seed row in the fine sandy loam soil but may have been too little to be effective in the clay loam soil, due to the higher moisture-holding capacity of the clay loam compared with the fine sandy loam soil. Alternately, diffusion of the ammonia away from the seed row may have been more restricted on the clay loam soil than on the fine sandy loam soil, increasing ammonia toxicity.

Average seedling survival rate is 50%, but can vary from 25 to 75%, so optimal seeding rate will vary considerably depending on field conditions and seedling vigor. The stand density in the absence of fertilizer application in this study ranged from 30 to 58 plants per foot, indicating that the seeding rate was close to optimal. In spite of the significant level of seedling toxicity resulting from fertilizer application in the absence of a urease inhibitor, stand density remained within the broad range considered acceptable. Due to high seed costs of hybrid canola, there is a trend toward reducing seeding rates at the low range of, or even below, recommended levels even though higher seeding rates may be economically beneficial. Use of low seeding rates would increase the risk of lower-than-acceptable stands if seedling damage were to occur.

**Crop biomass yield at flowering**

Crop biomass yield at flowering was significantly increased by herbicide application on the fine sandy loam in 1999. In 2001, however, weed population was exceedingly high, and the plots without herbicide application could not be harvested. Herbicide application had a large effect, although it was not statistically evaluated. At the other site, biomass yield was generally numerically higher with herbicide application, but the effects were not statistically significant. Glyphosate efficacy was not reduced at lower N rates as has been seen in previous studies probably because the recommended glyphosate rate used in the current study was high enough to allow control even at the lower N rate. There was no interaction between herbicide application and treatment in any site year, so data were combined over herbicide treatments for analysis of fertilizer effects.

The canola in this study may have been able to recover from seedling damage because stand density was acceptable even where significant seedling damage occurred and growing conditions were not extreme. Seed prices for canola have increased substantially with the introduction of genetically modified and hybrid canola types. Many producers have responded to the higher seed costs by reducing their seeding rate to near or below the lower values of the recommended seeding range to decrease input costs. Reduced seeding rates and adverse growing conditions would increase the risk of inadequate stand density and reduced yield.

**Seed yield**

Seed yield was higher with than without herbicide application in four of the six site-years, with the increase ranging from 7 to 18% (data not presented). On the fine sandy loam in 2001, weed populations without herbicide applications were so high that the crop could not be harvested, so herbicide application had a major influence although it was not determined statistically. Herbicide application failed to increase seed yield only on the clay loam soil in 1999. There was no interaction between herbicide application and treatment in any site-year, so data were combined over herbicide treatments for analysis of fertilizer effects. Seed yield increased with N application in five of the six site-years, although the magnitude and pattern of N response varied with N source and environment.
Conclusions

Seedling damage occurred in canola with increasing rates of urea or UAN fertilizer applied as a side-band with target placement of about an inch to the side and an inch below the seed row at the time of seeding. Decrease in stand density with UAN was similar to that resulting from urea application. The urease inhibitor NBPT was effective at reducing seedling damage in canola from both urea and UAN fertilizer in all site-years years of the study.

Dry matter yield at flowering was not generally affected by seedling damage, but NBPT increased canola seed yield at high rates of N application in three of six site-years and decreased seed yield in one site-year. The reason for the decreased seed yield was not apparent.

The reduced stand density did not consistently result in decreased biomass yield or seed yield because canola has a great ability to compensate for reduced stand by increased branching. However, seeding damage and reduced stand density led to delayed maturity and increased chlorophyll content in four of six site-years.

This study was conducted using the full recommended rate of seeding and resulted in an adequate crop stand even where significant seedling damage occurred. Where seeding rates are used that are at the low end of, or below, the recommended range, reductions in stand density could have a greater effect on seed yield, maturity, and chlorophyll concentration than the authors noted in this study. Therefore, caution should be used to ensure that seed and fertilizer separation is adequate and safe rates of N application are not exceeded near the seed row. Use of NBPT can reduce the risk of seedling damage and increase the amount of urea or UAN that can safely be side-banded in a one-pass seeding and fertilizing operation.