DR. MARTIN KUECKE

Fluids Prosper In German Agriculture

Impressive experimental results are reported for potatoes, vegetables, cereals, and maize.

SUMMARY

The major fluid fertilizers used in Germany for injection are urea ammonium nitrate solution (UAN), urea ammonium solution, and ammonium sulfate solution. Good experimental results have been reported for potatoes and vegetables, as well as for cereals and maize. Sugar beet yields and quality after fluid injection are usually comparable to those after conventional surface application. Experimental datum for grassland is still lacking. Only a few contractors offer fertilizer injection services in Germany, but the interest of farmers, the scientific community, and the public is increasing as the environmental advantages become apparent.

In the USA and Canada, injection of liquid fertilizers has been used dating back more than 30 years and injection equipment is well developed. Four advantages generally recognized via the injection of fluids are: 1) achieving efficient use of nutrients from plant emergence to maturity, 2) preventing or reducing any harmful effects on the environment, 3) avoiding fertilizer-induced salt injury to plants, and 4) providing a convenient and economical operation for farmers and /or custom fertilizer applicators.

While research in the USA and Canada focuses mainly on higher fertilization efficiency by minimizing nutrient losses, the basic idea of the cropping studies carried out at our experimental farm at the Federal Agricultural Research Centre in Braunschweig, Germany, is to use a system called "controlled uptake long-term ammonium nutrition" or CULTAN. This can be achieved by placing N solution containing either ammonium or N forms that are transferred to ammonium (urea). The soil at the injection spot or in the fertilizer band, termed a "depot," is saturated with the fertilizer solution and the ammonium concentration is toxic for plant roots and soil micro-organisms. Due to this toxicity, the ammonium is slowly nitrified to nitrate and remains fairly stable in the hotspots due to the absorption of the ammonium ions by the soil. Part of the crops' roots creates a dense network of fine roots in the diffusion zone around the ammonium hotspots, and the crops can take up N from this diffusion zone as ammonium before it is nitrified.

Most growth experiments show highest biomass production and yield formation in systems where plants are supplied with half of ammonium and half nitrate. As almost all N fertilizer is usually completely transformed to nitrate by soil microorganisms after surface application and during passage through the soil to the plant root, this situation can hardly be achieved under field conditions with common fertilization strategies based on surface application. Under open field conditions, injection of ammonium and urea solutions opens the possibility to shift N nutrition of the crops toward the physiologically ideal ammonium/nitrate ratio.

Agronomical aspects

Winter rye. With conventional spraying of UAN + ammonium thiosulfate at 134 lbs/A of N (150 kg N/ha), yield of winter rye on a sandy loam was 7,300 lbs/A (8.2 tonnes/ha) as shown in Figure 1. A single injection of the same amount of UAN resulted in a 6 percent yield increase, and even a UAN injection of 112 lbs/A of N (125 kg N/ha) gave a higher yield than 134 lbs/A of N (150 kg N/ha) conventionally applied. As a result of the higher stem stability, lodging in the injection plots was about half of that in the conventionally fertilized plots, and N-use efficiency was doubled after UAN injection in this experiment.

Winter wheat. In another experiment on a silt loam soil, injection of UAN to winter wheat was compared with three conventional split surface fertilizations with solid urea (Figure 2). Two amounts of 94 and 134 lbs/A of N (105 and 150 kg N/ha) were chosen when the trial was established, but injection of the lower rate failed due to technical problems. On the other hand, a lack of N was recorded in May in the surrounding field and the farmer decided to apply an additional 45 lbs/A of N (50 kg N/ha). Injection of UAN at 134 lbs/A of N (150 kg N/ha) resulted in a 26 percent yield increase compared to the conventional surface fertilization. This yield was almost the same as that harvested in the surrounding field receiving the additional 45 lbs/A of N (50 kg N/ha). Grain quality (%N and protein) was slightly better than after conventional fertilization.

Such clear yield increases were not recorded in all experiments and locations in the following years, due to technical problems, summer drought, and floods. Winter wheat yields were recorded over six years in a water protection area in southern Germany, where UAN injection was used as an instrument to decrease the nitrate content in the ground water by minimizing nitrate leaching from arable land. After injection fertilization over the six-year span, a yield increase of 9 bu/A (0.6 tonnes/ha) was recorded. Protein content over five

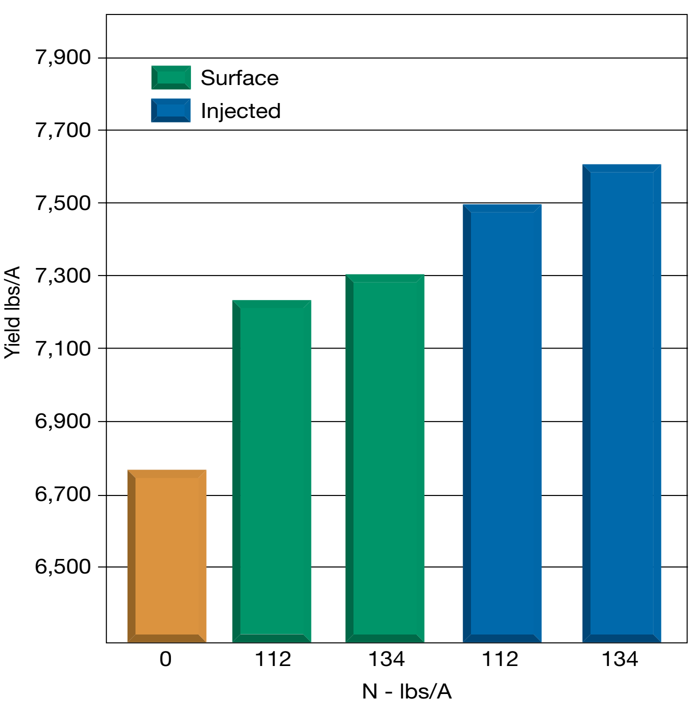

Figure 1. Yield and grain quality of winter rye after surface spraying and injecting UAN plus thiosulfate, Lindau, Germany, 2001.

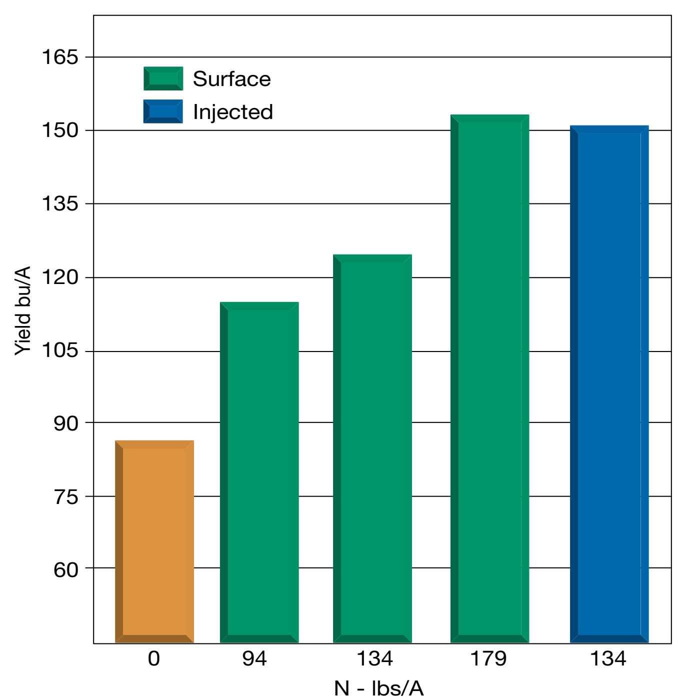

Figure 2. Yield and grain quality of winter wheat after surface application of solid urea and injecting UAN, Ohrum, Germany, 2001.

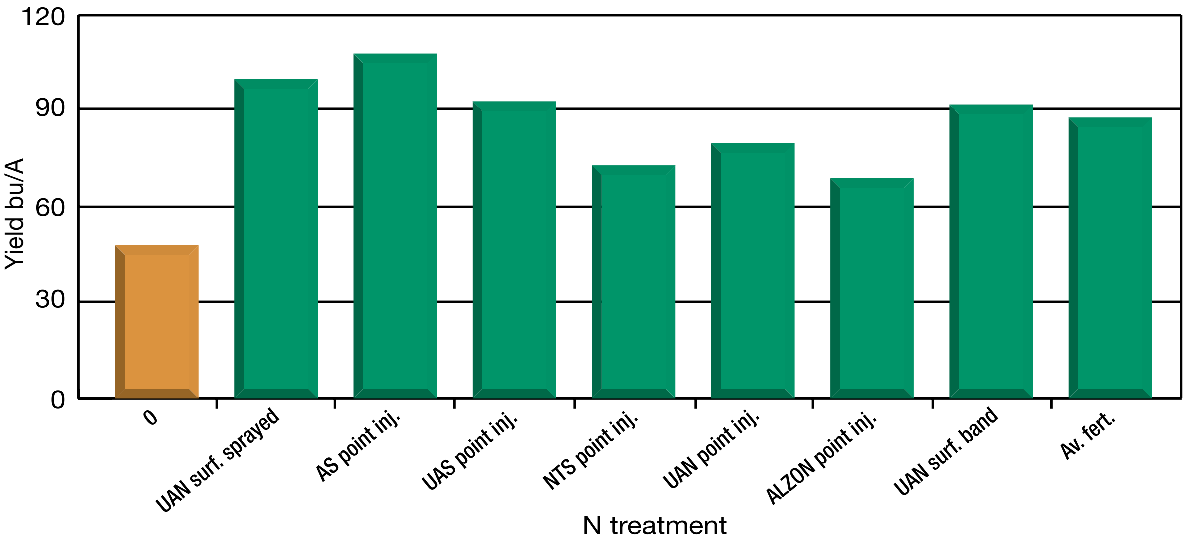

Figure 3. Yield effect of placement of different liquid N fertilizers on summer barley, Braunschweig, Germany, 2002.

years averaged 0.8% higher after UAN injection. In all trial fields, the amount of N application was equal.

Summer barley. There are several N fluids available for farmers. In a field experiment with summer barley, different fluids have been point injected (80 lbs/A of N or 90 kg N/ha). Compared to the conventional spraying of UAN (Figure 3), all injected fluids containing urea showed a yield decrease compared to the UAN sprayed treatment, while injection of ammonium sulfate solution showed a slightly higher yield. Similar results led to recommendations that urea-containing fluids are less suitable for injection fertilization in cereals, while urea seems not to be harmful for dicotyledons.

Other crops. For sugar beets, similar yield and quality have been found in 2-year experiments on two different sites. Good experiences have been reported for vegetable yields and quality after fluid injection. Depending on the vegetable species, yields are higher or similar after fluid injection compared to common fertilizer surface applications. With regard to quality, vegetables regularly show a lower nitrate content compared to conventionally fertilized plants. Experimental data for grassland are still lacking, but a long-term field experiment to determine yield and quality response of permanent grassland to UAN injection began in the spring of 2006. Injection studies with UAN on cool-season forage grasses in the USA have indicated superior performance compared to identical surface broadcast applications.

Ecological aspects

In field studies, German scientists have reported 42 percent lower nitrate leaching in plots fertilized with fluid injection, compared to the conventionally fertilized plots (data not shown)

The same procedure was used to measure nitrate leaching below open field plots with intensive vegetable cultivation, where N fertilization is commonly higher than approximately 225 lbs/A of N (250 kg N/ha). Injected UAN and surface-applied calcium ammonium nitrate were compared, both methods of placement with the same amount of N. Averaging three winter and two summer periods, researchers found that nitrate leaching decreased by 32 percent in N injection.

Conclusion

Experimental data available for German cropping conditions are encouraging, as most experiences show that fluid injection fertilization results in similar or higher yield response (depending on the crop) compared to conventional surface application. Injection of N solutions especially shows less environmental impact with regard to nitrate leaching and ammonia volatilization.

These results and positive experiences of farmers using fluid injection have increased interest of governmental and environmental authorities as well as farmers' advisory organizations. Positive agronomic experimental results that continue to build interest in fluid injection in Germany are owed principally to 1) favorable experiences of farmers who have used this fertilization strategy, and 2) an increasing amount of data that demonstrate its positive environmental potentials.

Dr. Kuecke is research scientist, Institute of Crop and Grassland Science, Braunschweig, Germany.