Making do with less

Since the 1980s the input of mineral nitrogen has been reduced by 50 percent in Danish agriculture. There has been much focus on optimising nitrogen utilization in Danish agriculture with regard to mineral nitrogen and animal manure. The Danish Agricultural Advisory Service conducts trials to test fertilizer types and strategies. The latest results with regard to nitrogen response, nitrogen types, manganese and other micronutrients will be presented.

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Use of nitrogen in Danish agriculture

■ The input of mineral nitrogen has been reduced significantly since the middle of the 1990s (Figure 1). At the same time, the amount of nitrogen in animal manure has decreased in spite of unaltered milk production and a doubling of pig production. This is because in the same period the excretion of nitrogen per kg produced milk and the excretion of nitrogen in animal manure per kg produced pig meat has been reduced 35 to 40 percent. The decrease of nitrogen in mineral fertiliser is caused by a better utilization of nitrogen in animal manure and implementation of a nitrogen quota 10 percent lower than the level in 1998, where the quota was based on economically optimal nitrogen rates.

The output of nitrogen in agricultural products (meat, milk, egg and plant products for export or human consumption) has been nearly constant. That means that the net nitrogen balance for agriculture has been reduced by 40 percent.

The consequences of nitrogen restriction for crop production have not been a significantly lower yield. However, yields have not increased according to the usual yield trend of about 0.1 ton per ha per year in winter wheat, which has been observed for a very long period prior to the 1990s. In other European countries without nitrogen restrictions the yield increase overtime also seems to be reduced. So restricted nitrogen quotas might not be the only explanation. Another consequence of restricted nitrogen quota is a decrease in the grain protein content.

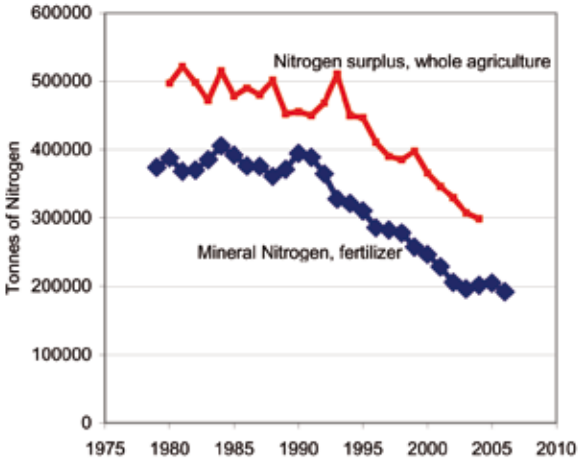

Figure 1. Nitrogen surplus (Danish agriculture as a whole) and use of mineral nitrogen from 1980 to 2006.

Highlights from fertilizer trials at the Danish Agricultural Advisory Service 2006

Nitrogen prognosis and nitrogen response in trials in 2006

The yearly prognosis for the nitrogen demand in 2006 based on model calculations and measurements of mineral nitrogen in 150 fields in the SQUARE GRID NET for nitrate investigations in Denmark in February 2006 compared with measurements from 1995-2005 showed a demand for nitrogen which was 15-20 kg nitrogen lower than normal. According to legislation, Danish farmers

must adjust their use of nitrogen according to the prognosis. 16 trials in winter wheat and 17 trials in spring barley in 2006 with increasing amounts of nitrogen showed an economical nitrogen rate which was 20 kg and 27 kg lower than the preceding five years in winter wheat and in spring barley. Calculations of economically optimal nitrogen rates in winter wheat show that the protein value has significant influence of optimal nitrogen rates.

Nitrogen types

Most of the nitrogen used in mineral fertilizer in Denmark is based on a mix of ammonium nitrate and ammonium sulphate to get a right NS-ratio in the fertilizer. About 95 percent is used in solid fertilizer and the rest in liquid fertilizer, which is mainly based on nitrogen in an amide form. In 2006 DAAS tested three different nitrogen types. Five trials were conducted in winter wheat with the fertilizer type *Sulfammo NS 23-18*. It contains a compound named NPRO, which is derived from seaweed and is claimed to improve nitrogen utilization.

In the trials there was no observed difference in the yield, protein or the calculated nitrogen utilization between the Sulfammo fertilizer and the standard NS-fertilizer. In one trial an extra treatment was added with application of Sulfammo NS 23-18 only at the first application. In this treatment there seemed to be a better utilization of the tested fertilizer.

In three trials in spring barley on fields with coarse sand there was a better nitrogen uptake in two of the three trials when using nitrogen in *ENTEC-fertilizer* with nitrification inhibitors compared with a standard NS-fertilizer. For the three trials there were no statistically significant differences in yield or nitrogen utilization.

In five trials in winter wheat, a liquid nitrogen fertilizer containing nitrogen based on urea and urea derivates was tested. In the trials no significant differences in yield or protein content were found between the tested nitrogen type and nitrogen given in solid fertilizer. The reason might be that the protein levels in the trials were high and the utilization of nitrogen in solid fertilizer was higher than normal.

Manganese

Especially in winter barley and also in winter wheat manganese deficiency can be a serious problem. If there is manganese deficiency in autumn, growth will not start in the spring and there is no active plant material to take up foliar manganese applications. This means that the crop will die and must be re-established by a spring-sown crop. Manganese deficiency is most pronounced in fields with a high content of organic matter and a high pH. Especially in the northern part of Jutland there are areas with severe manganese deficiency, and the problem is so serious that many farmers have stopped growing winter barley.

In 2006, trials to test different varieties of winter barley for susceptibility of manganese deficiency were carried out. Trials since 2002 have revealed significant differences in susceptibility between varieties. Normally, the variety Carola has been found to be tolerant for deficiency. But in 2006 this variety showed a high response to application of manganese sulphate compared with other varieties. It seems that even though there is a high difference between varieties in a single year, the ranking of varieties differs very much from year to year. This means that it is difficult to use this knowledge to recommend varieties infields where manganese deficiency is normally a problem.

In 2006, different autumn-applied manganese formulations have been tested in two trials in winter barley. No significant differences were found in the effect per gram of manganese between the standard manganese sulphate formulation and the tested Microplan Mangan where manganese is formulated with amino acids. The trials showed a significantly poorer performance of Mantrac Optiflo compared with the standard manganese sulphate.

In two trials the effect of different foot-placed fertilizers on manganese deficiency in winter barley in fields with very severe manganese deficiency were tested. The aim was to examine if acidification by nitrification of ammonium to nitrate and if oxidation of thiosulphate to sulphate could give a better manganese availability of soil manganese. In order to test if the effect of ammonium is a nitrogen effect in general due to improved root development, the effect of ammonium was compared with the effect of calcium nitrate. In order to test if the effect of ammonium thiosulphate was from ammonium or thiosulphate, it was compared with the effect of potassium thiosulphate. In the trials, crops given foot-placed 30 kg nitrogen from ammonium sulphate performed very well. Manganese deficiency was significantly lower and yield was higher than even two times foliar application of manganese sulphate in the autumn. Crops given foot-placed calcium nitrate resulted in more man-

ganese deficiency than untreated crops. Crops given thiosulphate performed much worse than those given ammonium sulphate.

Other micronutrients

The need for application of different micronutrients in agricultural crops has been discussed at length in Denmark. It has been claimed that the general recommendations are insufficient. Together with four fertilizer companies, DAAS has conducted a three year project to map micronutrient requirements in fields using EM 38, yield metre and soil and plant analysis.

In 2004 16 fields were selected. All fields were mapped using EM 38. From these maps positions for 6-15 corresponding soil and plant analyses were pointed out and sampled in 2004. In 2004, investigations were made of the effect of micronutrients by spraying out a micronutrient mix in some tramlines. The yields in treated and untreated stripes were measured using electronic yield maps.

In 2005 and 2006, in spots in the field where the analyses showed a risk of micronutrient deficiency, eight plot trials with application of different micronutrients and micronutrients mixes were placed. In most of the investigations in stripes and in none of the micronutrient plot trials, no significant effect of micronutrients was measured. All trials were conducted in winter wheat or spring barley. The following micronutrients were tested: manganese, copper, zinc and boronas well as Epso Combitop, Nutrimix and a specially made mixture of micronutrients for the trials.

Environmental questions

Over a period of nine years, DAAS has compared nitrogen leaching from mineral nitrogen, nitrogen in pig slurry, deep litter from pigs and the combination of solid manure of urine from pigs. All plots with animal manure were supplied with mineral nitrogen to the nitrogen standard for the crop and with standard utilization of animal manure. The results showed nearly the same leaching from plots using mineral fertilizer and pig slurry. Leaching from plots using deep litter or solid manure in the autumn showed a significantly higher leaching. However, only a minor part of the nitrogen surplus when using solid manure or deep litter was found as increased leaching. Much of the nitrogen goes to the soil nitrogen pool.

It is quite easy to reduce nitrogen leaching in crop rotation with spring crops by using effective catch crops in the autumn. However, the net profit, especially for pig farms, is higher when growing winter cereals or winter oil seed rape because the yields are 20 percent higher than in spring-sown crops.

The possibility of growing a catch crop of yellow mustard between two winter wheat crops and establishing winter wheat very early in a mix with yellow mustard has been tested in two trials. Establishing winter wheat in August together with yellow mustard was very effective in reducing mineral nitrogen in November and the ensuing potential leaching, but the winter wheat nearly died and the winter wheat yield was very low. Yellow mustard as a catch crop established after the harvest of winter wheat and ploughed in before establishing the next winter wheat about 20 September reduced mineral nitrogen content in autumn by 25 percent. The same result was found by establishing winter wheat in the middle of August. ■