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COST OF THE DIFFERENT OPTIONS AVAILABLE TO THE FARMERS: CURRENT SITUATION AND PROSPECTS

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Introduction

Enhancement of fertilizer use efficiency has to focus on the processes that occur after the fertilizer has been applied on to the soil until the nutrients are taken up by the crop. Any mineral nitrogen source for example applied to aerated arable soils is likely to be oxidized to nitrate and as a consequence the crop will absorb most of its nitrogen as nitrate, regardless of the source of the nitrogen.

Nutrients applied to the soil are exposed to complex chemical interactions and to a competition between soil microorganism and plant roots. Biological processes like denitrification and immobilization reduce the availability of the nutrients for the crop. In addition chemical and physical processes like precipitation and fixation or leaching and volatilization reduce the availability of the nutrients for the crop. An "ideal fertilizer" protects the nutrients against the described processes and keeps the nutrients available for the crop. The characteristics of such an ideal fertilizer are described according to Shoji and Gandeza (1992) cited in the publication of Trenkel (1).

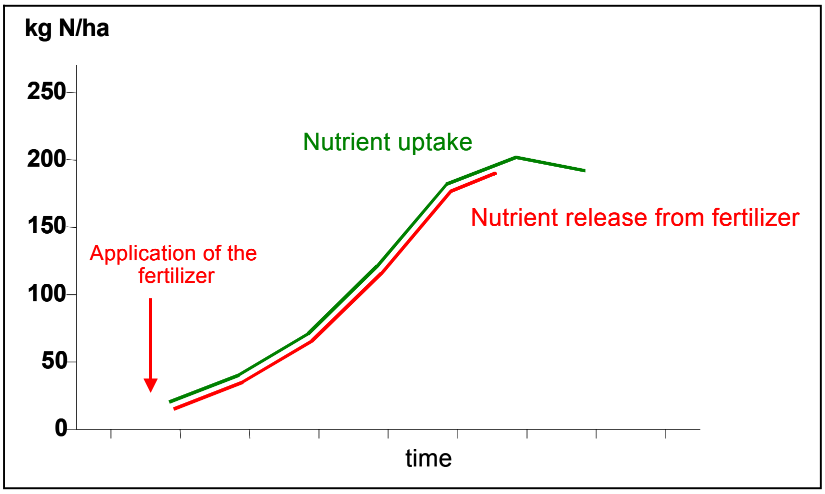
The ideal fertilizer should have at least the following characteristics:

- It only needs one single application throughout the entire growing season to supply the necessary amount of nutrients for optimum plant growth
- It has a high maximum percentage recovery in order to achieve a higher return to the production input, and
- It has minimum detrimental effects on soil, water and atmospheric environments

According to the definition the ideal fertilizer shall enable a single application strategy. The processes that reduce the availability of the nutrients for the crop however are getting more important the longer the time span is between fertilizer application and nutrient uptake by the crop. Technology to enhance the fertilizer use efficiency is therefore necessary to support the goal of a single application strategy.

The concept to develop fertilizers that are more convenient to use and that at the same time provide higher nutrient use efficiency is intriguing and still subject to a large number of ongoing research projects. Figure 1 gives a schematic description of the nutrient release pattern of ideal fertilizers.

Figure 1: The ideal fertilizer: the nutrient release is synchronized with the nutrient demand of the crop



A Patent search for example with the keywords slow or controlled release fertiliser, or urease and nitrification inhibitors, revealed 1404 patents for the period from 1963 to 1999. The majority of patents are on coated fertilizers and on slow release products with urea-formaldehyde and other urea condensate products. The technologies for the fertilizer products in focus include four main groups; a) Polymer coated fertilisers, b) Slow release fertilizers, c) Nitrification inhibitors and d) Urease inhibitors

Current status of enhanced efficiency fertilizers

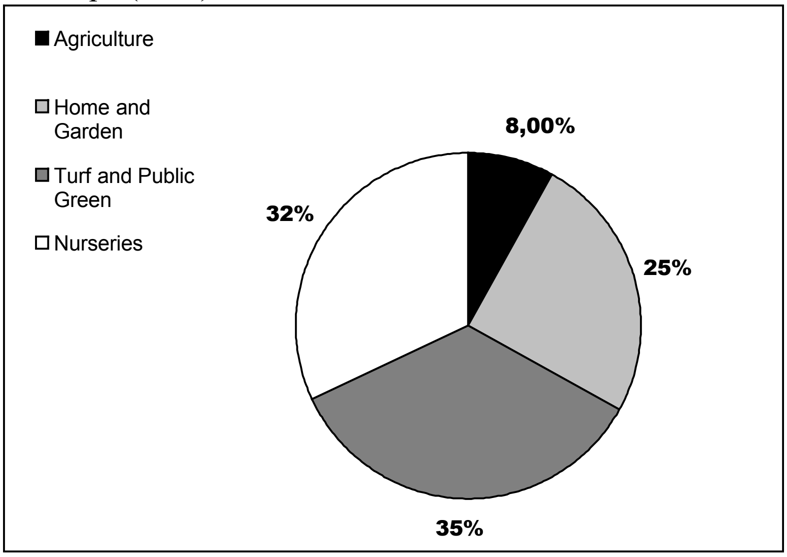
Global nutrient consumption in 1998/99 was about 130 million t of nutrients (N,P,K), which corresponds to approximately 403 million ton of fertilizer products. The consumption of slow and controlled release fertiliser in comparison was about 595,000 t Product in 1998 (2). Slow and controlled release fertilizers represent only 0.15% of the global mineral fertiliser market.

The main markets for the controlled and slow release fertilisers in 1998 are US (437,000 t), Western Europe (97,000 t.) and Japan (61,000 t). The majority of controlled and slow release products are used in non-agricultural markets. Figure 2 shows as an example the use of slow and controlled release products in Europe. Only 8% of the products were applied in agriculture. Home and garden, turf and public green and professional horticulture are the main market segments.

The main reason for the low market share of the slow and controlled release fertilizer is their price. Compared to standard fertilizer all so called enhanced efficiency fertilizers are more expensive for growers than standard soluble products. The prices of enhanced efficiency fertilizers are between 30 to 60 % higher in the case of the inhibitors and 4 to 10 times higher for slow release or polymer-coated products. These prices make the products often too expensive for most agricultural crops except for some high value crops.

In order to be used to any larger extent they have to provide a benefit for the grower pays for their additional cost. Any price increment for such products has to be compensated by additional benefits and benchmarked against the cost of alternatives.

Figure 2: Market segments of controlled and slow release products in Europe (1998)



The objective of using nitrification inhibitors is to keep nitrogen longer in the ammonium form, in order to control leaching of nitrate from the nitrogen fertilizer applied and thereby increase the efficiency of the nitrogen applied. In addition they shall prevent denitrification of nitrate. Fertilisers with nitrification inhibitors are therefore referred to as stabilised fertilisers. In contrast to controlled release fertilisers, nitrification inhibitors are used almost exclusively on agricultural crops. Even if the economy of their use is much more favourable to farmers compared to controlled release fertilisers, their application has so far been mainly to vegetables with a shallow root system and under the special climatic condition of leaching losses of fertilizer nitrogen. Urease inhibitors delay the conversion rate of Urea into ammonium. If the conversion rate is slow, ammonia volatilisation is reduced. Urease inhibitors are so far only used to any extent in the Unites States.

The fertilizer products and technologies that are discussed as enhanced efficiency fertilizers are not new to farmers and the fertilizer market. They have been developed during the last decades and are commercially available since many years. It can therefore be assumed that the enhanced efficiency fertilizers that are available in the market and their market share in the various market segments reflect the economic balance between the cost of the fertilizers and their benefits in the related market segments.

Prospects for Enhanced Efficiency Fertilizers

Any consideration about the prospects of enhanced efficiency fertilizers in the future need to examine the alternatives for the growers. The use of enhanced efficiency products will only increase beyond the current market segments if they provide a more economic and environmental sound solution than any alternative. In principle two main concepts are possible to improve fertilizers use efficiency. One concept is to use different fertilizers, like the enhanced efficiency products, the other concept are to use standard soluble fertilizers in a better way. The options can be described as enhanced efficiency fertilizer versus enhanced efficiency fertilization. Table 1 shows the different options to improve the nutrient use efficiency from fertilizers. It compares a strategy with a primary focus on improved fertilizer products with a strategy with a primary focus on the fertilizer management with standard fertilizers.

Table 1: Main strategies to improve nutrient use efficiency

Enhanced efficiency fertilizers (Product strategy)	**Enhanced efficiency fertilization** (Management strategy)
Primary focus product features ▪ coated fertilizers ▪ slow release fertilizers ▪ nitrification inhibitors ▪ urease inhibitors	Product features ▪ fast acting, water soluble fertilizers
Nutrient management ▪ reduced number of applications ▪ yield expectation determines N rate	**Primary focus** nutrient management ▪ split N application ▪ N rate based on plant analysis ▪ variable N rate (time & space, precision farming)

A primary objective of the "product strategy" is to reduce the number of fertiliser applications, resulting in convenience and cost savings in labour and energy. This objective describes the targets for the enhanced efficiency fertilizers. To reduce nutrient losses that occur during the long time span between nutrient application and uptake by the plant to reduce any problem of toxicity, that may be, caused by the high application rate in a single application strategy. In order to minimise nutrient losses and any risk of toxicity associated with soluble fertilizers, the "management strategy" accepts to use split application of fertilizers wherever possible. Table 2 shows the advantages and disadvantages of both strategies.

Table 2: Advantages and disadvantages of both strategies.

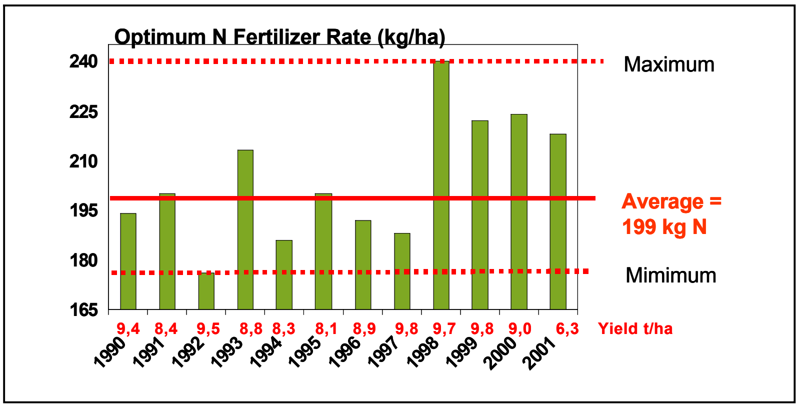
Enhanced efficiency fertilizers (Product strategy)	**Enhanced efficiency fertilization** (Management strategy)
Advantages ▪ convenience for the farmer ▪ cost saving in fertilizer application	**Advantages** ▪ possibility to adjust the fertilizer rate during the growing season ▪ crop management ▪ lower cost of fertilizer
Disadvantages ▪ higher cost of fertilizer ▪ yield expectation is uncertain = N rate may be incorrect	**Disadvantages** ▪ data acquisition for split application ▪ cost of the split application

In order to reduce the number of fertilizer applications to one single application the farmer need to decide about the correct fertilizer rate at the beginning of the growing season. This is a major challenge because the difficulty with nitrogen fertilizer application is the fact that the nitrogen demand for any given field and crop changes from season to season. This is mostly caused by the annual variability of climatic conditions.

In principle the nitrogen fertilizer demand depends on the nitrogen demand of the crop minus the nitrogen supply from the soil. Both are dependent on the climatic conditions during the growing season. The nitrogen demand of the crop can be estimated by the yield expectation. Climatic variations like the precipitation however, may cause a significant deviation of the observed crop growth from the expected. The same is valid for the mineralization of nitrogen from the soil organic matter.

The actual N supply from the soil in a specific growth period may be quite different from the average. As a consequence the same yield can be obtained at different sites with different nitrogen fertilizer rates. Even at a given site the nitrogen fertilizer requirement changes from season to season. This is confirmed by the data from the long-term trial in Rothamsted, where at the same site the same crop rotation is grown each year (Figure 3). During the period from 1990 to 2001, the optimum N fertilizer rate to winter wheat varied between 176 kg N/ha in 1992 and 240 kg N/ha in 1998, while the average was 199 kg N/ha.

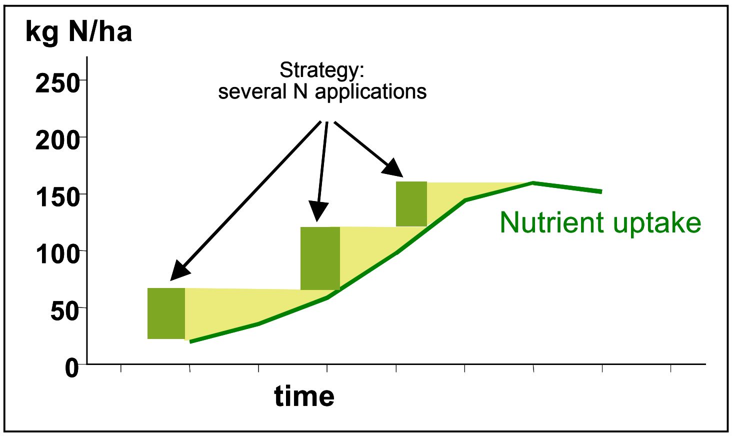
Figure 3: Annual changes in the optimum N fertilizer rate at the same site with the same crop and pre-crop
(Crop: Winter wheat (long-term trial, Rothamsted, UK)



It is therefore not an easy task to determine the required nitrogen fertilizer rate in advance at the beginning of the growing season. Any fertilizer concept with a reduced number of applications has to manage that risk. Any over-application of nitrogen because of an overestimation of the expected yield will reduce the nitrogen use efficiency even if the application has been made with the controlled or slow release products.

The alternative is a split application of nitrogen fertilizers (figure 4). It reduces the time span between nutrient application and nutrient uptake by the crop and it delays the decision about the total N fertilizer rate to later growth stages. It may be considered as a controlled management of fertilizers because the farmer manages the release of the nutrients according to the demand of the crop.

Figure 4: Enhanced efficiency fertilization concept:
Fertilizer application in several N dressings



To split the fertilizer application into several dressing enables the farmer to react on the specific climatic conditions during the vegetation period and to adjust the fertilizer rate accordingly. The objective to apply the right amount of nutrients is therefore much easier to achieve with split application than with one single fertilizer application. Field trials are done to compare the various concepts described above.

Figure 5: Yield of winter wheat at different N fertilizer strategies

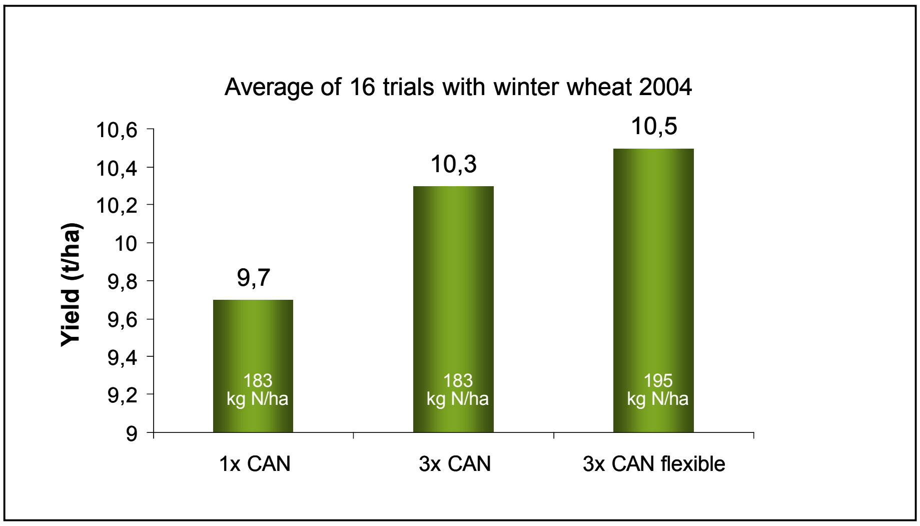


Figure 5 illustrates the impact of different fertilizer strategies. As an example it shows the average yield data of 16 trials with winter wheat to compare different fertilizer strategies. With one single application of the standard soluble fertilizer **C**alcium **A**mmonium **N**itrate (**CAN**) a yield of 9.7 t was obtained at nitrogen rate of 183 kg/ha. Split application of the same amount of nitrogen gave a yield of 10.3 t/ha.

The yield difference of 0.6 t/ha between both treatments indicates the potential improvement that can be expected if an enhanced efficiency fertilizer would have been used instead of CAN. At wheat price of 140 USD the yield increase of 0.6 t/ha has a value of 84 USD. Under the assumption that a farmer may be willing to share this additional value 50/50 with a fertilizer producer an enhanced efficiency fertilizer at an N rate of 183 kg/ha could be in principle 42 USD more expensive. The cost for an application of mineral fertilizer with a tractor and a spreader are at about 10 USD per ha, thus the total additional cost for the split application is only 20 USD per ha. Therefore in crop segments where a mechanized fertilizer application is possible, the alternative cost of the split application cost may set a frame for the prices of enhanced efficiency fertilizers.

The data of the flexible treatment in figure 5 show the result of a flexible fertilizer strategy based on split application. In this treatment the decision about the total amount of N fertilizer applied was taken during the growth period and based on the nutritional status of the crop. Crop analysis recommended the application of 195 kg N/ha instead of 183 kg N/ha and the yield was increased to 10.5 ton/ha instead of 10.3 ton/ha. The nitrogen rate of 183 kg/ha in the treatment with one and with three applications has proven to be too low. It has been the best estimate at the beginning of the cropping season and was kept stable during the season in order to compare one single application with a split application.

Compared to the fixed fertilizer rates just divided in three applications (treatment 2) the flexible application concept has the additional cost to acquire the necessary information on how much fertilizer should be top-dressed and the cost for each fertilizer application. Methods of crop or canopy analysis as well as computer models have proven to be suitable tools to support that decision. They are available for farmers at low variable cost. A reasonable estimate for these costs may be about 5 to 10 USD, which will come on top of the application cost of about 20 USD/ha.

These data show that a flexible fertilizer strategy is more suitable to address the nutrient requirements of the crop during the growing season. The alternative cost of such a strategy as a benchmark to enhanced efficiency products is about 25 to 30 USD.

Conclusion

Enhanced efficiency fertilizers products provide the economic solution for crop segments in which they are used toady. For many other crop segments the split application of standard soluble fertilizers is a viable alternative to increase the nutrient use efficiency. The cost for the split application will therefore set the frame for the additional price the farmer may be prepared to pay for enhanced efficiency fertilizers.

Summary

Enhanced efficiency fertilizer products are not new. They exist in the market since decades and their use has grown over time. Their total market share however is still quite low, because of the fact that they are much more expensive than conventional fertilizers. Only high value crop segments are able to cover the additional cost for that type of products. The current main markets are therefore professional horticulture, turf and public green and home and garden.

The future perspective of the Enhanced Efficiency fertilizes depend on wether they will grow into other segments. This depends on the future cost of the products and the cost of alternatives to enhance the nutrient use efficiency. An important alternative to improve the fertilizer use efficiency is a split application of soluble fertilizers (enhanced efficiency fertilization).

In many crop segments both approaches result in very similar fertilizer use efficiencies. A single fertilizer application strategy is faced with the challenge to decide on the right fertilizer rate at the beginning of the growing season. Split application provides the possibility to adjust the nutrient supply during the growing season. In mechanised agriculture the cost of fertilizer spreading are quite low which make a split application concept very competitive.

References:

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