Harvesting Energy with Fertilizers

Agriculture produces energy and captures atmospheric CO$_2$. Fertilizers greatly increase this effect.
Looking for advanced technological solutions that optimize the use of existing energy sources.

Making the use of renewable energy sources a high priority.

Finding energy sources which do not accelerate the greenhouse gas problem, and can even contribute to fixing or binding some CO₂.

Agriculture converts solar energy into biomass, which in turn provides energy for human beings and animals:

Energy is a central issue in agriculture. The very reason for agriculture’s existence is to supply energy to mankind. It does this by making use of solar power to convert energy into biomass, which in turn supplies energy to human beings and animals in the form of food and feed.
Energy consumption for different economic sectors in West Europe:

- 85% of total energy is consumed by industry, traffic, private households and public services.
- Food production accounts for 15% of this total energy consumption.
- Only 5% is used in agriculture, and this includes the energy used to produce mineral fertilizers.

Energy consumption in European agriculture:

Of all the energy used to produce wheat, approximately 50% is needed to produce, transport and apply nitrogen fertilizers.

Energy consumption in the nitrogen fertilizer chain:

In this chain, most of the energy is required to produce mineral fertilizers, and it is therefore in this area that technologies have been developed to ensure that fertilizer manufacturing processes are as efficient as possible.

N, P and K, the three primary nutrients of plants:

N (nitrogen) is an important component of proteins, and as such is an essential nutrient for plants.

P (phosphorus), component of nucleic acids and lipids, is also key to energy transfers in plants.

K (potassium) has an important role in plant metabolism: photosynthesis, activation of enzymes, osmoregulation, etc.

Production: 40
Transport: 1
Spreading: 3

- values in Giga Joule (GJ) / tonne of N

* including energy used for the extraction and transport of fossil fuels to the N fertilizer factory (average value for all N fertilizers).
** transport of N fertilizer over a distance of 400 km by ship and truck (1 GJ = 25 litres oil)
Technical improvements in mineral nitrogen fertilizer production:

Energy efficiency in N fertilizer production has been significantly improved since the beginning of the 20th century. Modern fertilizer factories are close to the theoretical minimum of energy consumption when producing ammonia, which is the first step in the production of N fertilizer.

Evolution of ammonia production efficiency

Efficient energy use is also a central issue on farms:

Modern application techniques can help to reduce the amount of energy used by adapting the quantity of fertilizer and the number of applications to the crop’s needs. Grain yield increases as more mineral nitrogen is applied. However, there is an economic optimum of N fertilizer rate.

Economic optimum of nitrogen fertilizer rate

In these trials the optimum N fertilizer application rate is about 170 kg N/ha, resulting in a yield of 8.2 tonnes per hectare. At this N rate the farmer’s profit per hectare is the highest. This economic optimum is also known to have the best energy used / energy captured ratio.
The use of nitrogen fertilizer benefits the environment because it helps to fix extra CO₂:

- When using 170 kg N fertilizer on a hectare of land, wheat yields are approximately 8.2 tonnes compared with 4.7 tonnes without N fertilizer.
- These 8.2 tonnes equate to 126 GJ* of solar energy captured in the form of biomass when nitrogen is applied, compared with only 71 GJ without N fertilizer.
- The extra 55 GJ captured when using N fertilizers are more than 6 times the 8 GJ used to produce, transport and spread the same fertilizers.

CO₂ fixed on 1 ha wheat

| Biomass (tonne/ha) | CO₂ captured in extra biomass due to fertilizer use | CO₂ captured in basic biomass production without fertilizer use | CO₂ emissions* :
|--------------------|-----------------------------------------------|----------------------------------------------------------|
| without N fertilizer | 15 | 15 | on field activities etc.
| with fertilizer 170 kg N/ha | +11 | 17.4 | N fertilizer production, transport & spreading.

* including N₂O emissions: 1 kg N₂O = 310 kg CO₂

The CO₂ binding is permanent when part of the crop is ploughed in, increasing the soil organic content.

* GJ = Giga Joule
In conclusion

- Energy balance in crop production is extremely positive.
- Crop production has a positive effect on greenhouse gas levels.

Mineral Fertilizers are essential for Sustainable Agriculture, which feeds the current world population without compromising the ability of future generations to meet their needs.