The carbon footprint of fertilizers

Knowledge grows

Ⓐ FERTILIZER PRODUCTION

When operating with 'Best Available Technique' (BAT) ammonia and nitric acid plants, the total carbon footprint of AN is 3.6 kg CO_2-eqv per kg N.

Ammonia production

Binding nitrogen from the air requires energy. Natural gas is the most efficient energy source. Yara plants are among the best performers in terms of energy efficiency worldwide.

- European average energy consumption: 35.2 GJ per ton ammonia
- EU BAT energy consumption: 31.8 GJ per ton ammonia (= 2.2 kg CO_2 per kg N in AN)

Nitric acid production

Nitric acid is used for making AN-based fertilizers. Its production releases N_2O. Catalytic cleansing developed by Yara reduces N_2O emissions below BAT level.

- N_2O emission without cleansing: 7.5 kg N_2O per ton nitric acid
- EU BAT emission with cleansing: 1.85 kg N_2O per ton nitric acid (= 1.3 kg CO_2-eqv per kg N in AN)

Solidification

AN solutions made from ammonia and nitric acid are granulated or prilled to form high-quality solid fertilizer. Solidification needs energy.

- European average energy consumption: 0.5 GJ per ton of product (= 0.1 kg CO_2 per kg N in AN)

MITIGATION POTENTIAL:

- Improve the energy efficiency of ammonia production and other production systems
- Install and further optimize catalytic cleansing of N_2O

Ⓑ TRANSPORTATION

Ammonium nitrate is transported by ship, barge, road or rail.

- European average: 0.1 kg CO_2 per kg N

MITIGATION POTENTIAL:

- Optimize logistics chain from production sites to farmers

Ⓒ FERTILIZER USE

Nitrogen, whether from organic or inorganic sources, is subject to natural microbial conversion in the soil. During this process N_2O can be lost to the air. In addition, CO_2 is also released by liming and farming machinery.

- Average footprint for AN: 5.6 kg CO_2-eqv per kg N

MITIGATION POTENTIAL:

- Assure balanced nutrition
- Tailor N-application according to actual crop needs
- Use placement fertilization when appropriate
- Just-in-time application to ensure rapid uptake
- Use of precision farming tools (N-Sensor, N-Tester, online applications)
- Maintain good soil structure (draining, avoid packing)
- Select appropriate fertilizer (AN or CAN based rather than ammonium or urea)
- Efficient manure management

Ⓓ BIOMASS PRODUCTION

Plants capture large amounts of CO2 during growth. Optimum fertilization can increase biomass production, and thus CO2 uptake, by a factor of 4-5 compared to fields that remain long-term unfertilized. For example, at a yield of 8 t / ha achieved with 170 kg N / ha, the grain fixes 12 800 kg / ha of CO_2. This corresponds to 75 kg of CO_2 fixed per kg of N applied.

- Example footprint: -75 kg CO_2-eqv per kg N

MITIGATION POTENTIAL:

- Ensure optimal fertilization to increase biomass production and CO_2 uptake per ha.
- Avoid land-use change at one place to compensate for reduced efficiency at another place
- Preserve and improve soil carbon stocks by increased inputs of organic material to the soil (e.g. residues) and conservation tillage techniques
- Catch and cover vegetation in between actual crops in order to reduce N leaching losses and to produce additional CO_2-fixing biomass
- Restore degraded agricultural land

Ⓔ BIOMASS CONSUMPTION

Most of the biomass produced is consumed as food or feed. CO_2 fixation is therefore only short term and cannot be considered a saving on a global scale. The balance is different for bio-energy since it avoids the burning of fossil fuels. For example, using biomass instead of mineral oil for heating purposes reduces the CO_2 emission by as much as 70-80%.

MITIGATION POTENTIAL:

- Optimize efficiency of bio-energy production
- Increase productivity in food and feed production, allowing more acreage for bio-energy production

Ⓕ FOREST AND WETLANDS

Forests and wetlands store 2-8 times more CO_2 than croplands. Land use change, mainly due to burning of tropical forests, is a large source of CO_2 emissions, accounting for 20% of manmade CO_2 emissions. Preserving tropical and boreal forests is the most important contribution to mitigate climate change.

MITIGATION POTENTIAL:

- Protect tropical forests and wetlands
- Reforestation, restoration of wetlands
- Forest fertilization to increase long-term carbon capture
- Avoid further land-use change by increasing productivity on existing agricultural land

Yara Carbon Life Cycle Assessment of fertilizers determines greenhouse gas (GHG) emissions and absorptions throughout every stage of the 'life' of a fertilizer. Production, transportation and use of fertilizers contribute to emissions of GHG, notably carbon dioxide (CO_2) and nitrous oxide (N_2O). At the same time, fertilizers enhance agricultural productivity and stimulate CO_2 uptake by the crop. Fertilizers increase yield and reduce the necessity to cultivate new land, thus avoiding GHG emissions from land use change.

The illustration describes the life cycle of ammonium nitrate, the most common source of nitrogen in European agriculture. It can be found in commercial products such as AN, CAN, NPK, NP, NK etc. All figures are expressed in kg CO_2 or kg CO_2 equivalents (kg CO_2-eqv) per kg of nitrogen applied. 1 kg of N_2O corresponds to 296 kg CO_2-eqv.