PROSPECTS FOR COAL IN AGRICULTURE

The global agriculture industry faces powerful economic, climatic, and political challenges that are driving higher food prices and fuelling demand for fertiliser to maintain yields. The decline in soil health, increasing erosion and sodicity (the presence of a high proportion of sodium ions) pose a serious threat to global food security with famine already occurring in Africa.

Agricultural products form a large $200 billion global market led by nitrogen-based chemicals. The Asia-Pacific region dominates with 60% of demand and overall sales are expected to increase by 3%/y to 2027 (Pulidindi and Prakash, 2021).

The production of essential cereal crops is decreasing due to a combination of factors: climatic effects, declining soil fertility, political turmoil in major exporter countries, a fall in biodiversity and pollinators, and high energy prices. Bioenergy crops may become a competitor for agricultural land and fertiliser; and there may be competing uses for ammonia (NH_3) in electricity generation, rather than fertiliser production (Zhu, 2022).

As nitrogen is an essential nutrient for plants, the production of ammonia, fertiliser's core chemical, has tripled over the last 50 years and demand continues to rise. Ammonia is mainly obtained from natural gas with cost directly affected by gas pricing, but now there is an alternate coal gasification route which is gaining market share in China. The coal to ammonia process contributes almost half of China's fertiliser production and is set to increase. The process is more carbon intensive than methane to ammonia but has technical advantages which will lower the cost of carbon capture.

The use of fertiliser is rising, but the ability of plants to use that nitrogen has declined leading to more nitrogenous pollution; less than half of the nitrogen applied can be utilised by plants. Release of ammonia and nitrous oxide into the atmosphere from farming causes significant pollution: ammonia contributes to particulate respiratory hazards; and run-off in heavy rain leads to river contamination and algal blooms. Nitrous oxide itself is a powerful greenhouse gas and an important component of agriculture's contribution to climate change.

Carbon is an essential soil component, present in soil as humic acid. At only 3–6% of soil content it is essential to retain water and support the bacteria and fungi which are responsible for the fixation of essential nutrients in plants such as nitrogen, phosphorus and potassium (NPK), the key constituents of fertilisers. Global carbon soil condition has declined generally from 'good' 30 years ago to between 'very poor' and 'fair' in 2021, according to a satellite survey. The use of traditional carbon sources such as manure and peat may decline for various reasons.

A product that boosts soil carbon content, resists water loss and buffers sodicity is urgently needed. Coal, especially low rank immature coals which contain organic carbon, can be used to restore soil with minimal impact to the environment, as coal is formed from the coalification of plants forming a resource of humic acid. Adding sufficient coal-sourced carbon to raise the soil carbon content above 2% can transform a poor soil into a fertile growing medium. In addition, raising the humic content promotes more efficient

use of nitrogen and phosphate reducing the environmental impact of fertiliser application. Improved nitrogen efficiency means that less need be applied and consequently less pollution is released.

The mineral Leonardite has been applied to amend soil for over 100 years. It is formed by oxidation of shallow lignite deposits. For immature coal deposits, the process can be accelerated using oxidising agents such as air/ammonia, hydrogen peroxide and ozone. Humic products are normally obtained by alkaline extraction from lignite and subbituminous coal, but there are also microbial methods that release humic acid with gas as a by-product. There is growing evidence of the beneficial effects of coal-derived humic substances on soil that include the proliferation of microorganisms, enhanced soil cohesion, more efficient nitrogen fixation, resistance to water loss and enhanced carbon sequestration. These attributes are increasingly important as the agricultural sector responds to climate change and the environmental impacts of chemical fertiliser.

The demand for agricultural products is directly linked to population growth, and the global population is set to exceed eight billion in November 2022. Fertiliser represents the most significant operating cost to farmers and, as prices are directly linked to natural gas, NPK fertiliser has become increasingly unaffordable during 2022. The cost crisis may worsen as competition grows for ammonia from the technologies being developed to reduce CO_2 emissions such as hydrogen and ammonia firing, and the use of biofuels, which will require fertiliser. The current (2022) market for humic products is approximately 0.5 billion $/y and is set to increase at 10%/y in Asia over the next decade. Declining soil fertility and increased competition for fertilisers, with a need to reduce nitrogen and phosphate pollution, means there could be a significant role for coal-derived humates.

Research supporting the use of humate products is strengthening but there are caveats. Where the soil carbon content exceeds 3% adding more humates has limited benefit; it is more a product for impoverished soils. The impact on soil microorganisms is key to enhanced nitrogen fixation, but their recovery takes time to develop, generally more than one season. A significant effect is that applying humates reduces demand for nitrogen products, thereby reducing farmers' costs, waste, and pollution. A product that improves soil health, improves soil water retention, needs less added nutrients, and reduces pollution must be attractive. The opportunity for the coal industry is primarily, but not exclusively, for low rank coal. A significant alternative use for coal is timely, and this agricultural application offers clear environmental benefits and a means to support food production into the future.

Each executive summary is based on a detailed study which is available separately from: www.sustainable-carbon.org. This is a summary of the report: Prospects for coal in agriculture by Dr Ian Reid, ICSC/325, ISBN 978-92-9029-648-59, 78 pp, September 2022.