USING MORE NITROGEN FROM THE AIR FOR PLANT GROWTH

By

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Nitrogen is essential for all life, both plant and animal. Before the green revolution nitrogen for agriculture was obtained from recycled waste. But with increasing population and crop production in early 20th century, the need for new sources of nitrogen fertilizer became clear.

The element nitrogen is not in short supply, as nitrogen gas (N_2) constitutes 80 per cent of the atmospheric air around us. But no animal or higher plant, by itself is able to use this atmospheric nitrogen as a source for protein production. The simple reason for this is that these organisms do not possess a mechanism to break the extremely strong bond between the nitrogen atoms and convert nitrogen gas into fixed nitrogen (nitrate, amonia or amino acids). This process of converting atmospheric N_2 into fixed nitrogen compounds is referred to as nitrogen fixation.

In early the 1900s, the German Scientists Haber and Bosh discovered a way to convert N_2 into amonia by use of a metal catalyst. Later this finding was developed on an industrial scale and this discovery remains the main source of nitrogenous fertilizer for today's intensive agriculture. This reaction requires a considerable amount of fossil fuel such as oil and natural gas. When petroleum products were freely available and relatively cheap, fertilizer costs remained low. In the last few years, however, fossil fuel costs have risen dramatically, with greater increases predicted for the future and now we are aware that their supply is not unlimited. So as long as the production of nitrogenous fertilizers depends on fossil fuels, the rising costs and limited supplies will affect the worldwide price of food. The increasing cost of nitrogenous fertilizer, which is essential for continuing productivity of agricultural crops, opened the door to the worldwide enthusiasm for biological nitrogen fixation.

Fortunately there is a group of organisms, bacteria and blue-green alage, which are capable of taking up atmospheric nitrogen and fixing it in a form available to plants. These organisms are collectively known as diazotrophs and they possess an unique enzyme called nitrogenase through which they can convert N_2 in the air to fixed form.

These diazotrophs are a priceless gift to mankind. Globally, they fix around 140 million metric tonnes of N_2 per year, and this does not cost us anything at all. In contrast, artificial fertilizer manufacturers produce only 45 - 55 million tonnes of nitrogen per annum at a very high cost.

These nitrogen fixing organisms could be simply classified into two major groups as free living organisms and symbiotic nitrogen fixers, considering their nature of living. The most important group of these is the symbiotic nitrogen fixers. In these associations the host plant provides a home for the diazotroph and energy to fix or gather nitrogen from the air. In return the plant receives fixed nitrogen from the fixing organism. The classical example of this is the bacteria (rhizobia) associated with the root nodules of legumes.

Legumes include such plants as soybean, bean, mungbean, lentil, groundnut, dambala and cowpea etc. and the family leguminoseae plays a significant role in many agricultural systems. Most tropical countries including Sri Lanka have used leguminous pulse crops for centuries to supply some or all of their protein requirements for human and animal consumption. The need to protect the soil from the effects of erosion after heavy rainfall and to assist in maintaining fertility in plantation crops led to technique of intercropping leguminous cover crops. The practice of shifting cultivation traditional in our country, also depends upon some fertility contribution from the leguminous component. Legumes are also used in pastures sown for grazing animals. This is a very important combination in restration the grass clover mix in pastures.

Leguminous plants gather and use nitrogen from the air by working symbiotically with a special bacterium (rhizobia) in nodules on their roots. This relationship is fairly specific. The plant and the bacterium have their own ways of recognising each other among all the other plant roots and micro-organisms living in the soil. Once the bacteria recognise the host, they gain entry through the root hairs. Here the bacteria enlarge, multiply, develop nodules (knots) and set up small nitrogen fixing factories on the legume roots. In these factories leguminous plants produce 80 million tons of fixed nitrogen annually. The amount of nitrogen fixed by some important legume-rhizobium associations are shown in Table 1..

Table 1 – Estimated amounts of nitrogen fixed by legume crops

Plants	Nitrogen fixed KgN/ha/yr.
Ipil Ipil	74 - 584
Pigeon pea	168 - 280
Cowpea	73 - 354
Mung bean	63 - 342
Soybean	60 - 168
Lentil	88 - 114
Groundnut	72 - 124
Chickpea	103

Another symbiotic nitrogen fixing system is represented by blue green algae and ferns. Here nodules are not formed and blue green algae are found living in the cavities of the leaf bases of azolla, a water fern. Under favourable conditions 30 kg of N/ha can be fixed by this symbiosis in two weeks.

Even though the international community has taken note of this symbiosis only very recently, it has been utilized for centuries in Southern China and Vietnam as a source of nitrogen for flooded rice. As the fixed nitrogen is found inside the fern this should be incorporated into the soil and allowed to decay before the nitrogen becomes available for the growth of rice.

The second group of diazotrophs are non-symbiotic and free living. Some examples are: the blue green algae, *Anabaena* and *Nostoc;* the aerobic bacteria, *Azotobacter* and *Spirillum;* the anaerobic bacterium *Clostridium;* facultative anaerobes that grow equally well under aerobic and anaerobic conditions *i.e.* with and without oxygen like *Bacillus* and *Enterobacter* and the photosynthetic bacteria, *Chlorobium* and *Rhodospirillum.*

The current energy crisis is responsible for the high cost of nitrogenous fertilizers. This poses serious and continuing problems for agricultural production in developing countries like Sri Lanka, creating a serious drain on limited supplies of foreign exchange. These problems are likely to become more critical in future with increasing populations.

On the other hand poor utilization of nitrogen fertilizers applied to the crops can also create environmental inbalances and other pollution problems. It has been estimated that only 30 - 50% of the inorganic nitrogen fertilizers applied is used by the plants. The rest is lost by denitrification, volatilization or leaching of nitrate into the ground water. The contamination of drinking water with nitrate results in significant health hazards in industrialized areas.

The excessive fertilizer use is also known to alter the chemical composition of the foodstuffs. There are also various reports of nitrate toxicity due to its accumulation in the foodstuffs. Another important disadvantage of heavy doses of nitrogen fertilizer is that of the destruction of useful free living and symbiotic microorganisms in the soil.

For these reasons, use of fixed nitrogen from air will have to be greatly expanded to meet the demand for food from increasing populations.