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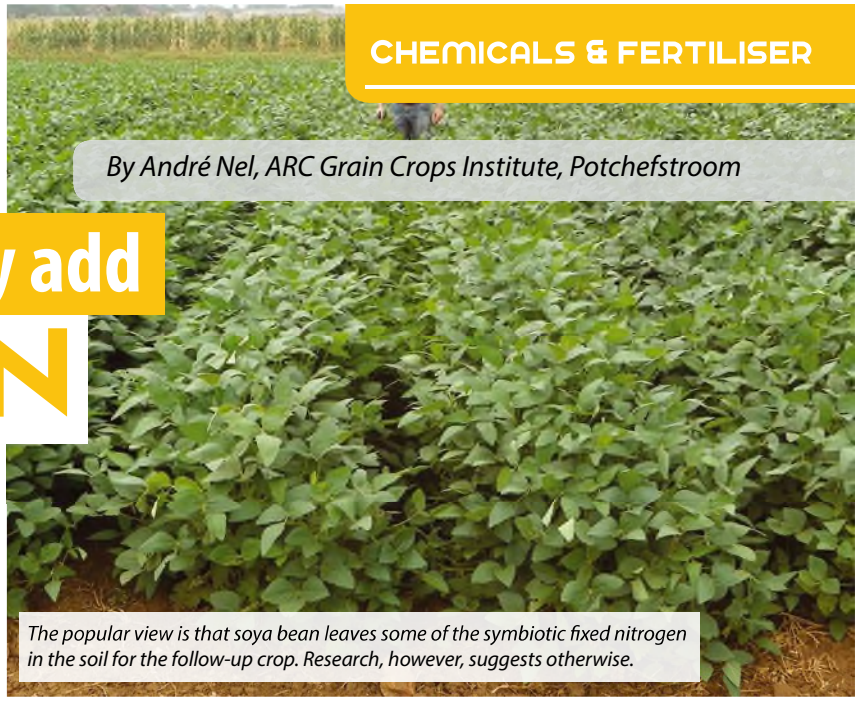
Does soya bean really add NITROGEN to the soil?



The popular view is that soya bean leaves some of the symbiotic fixed nitrogen in the soil for the follow-up crop. Research, however, suggests otherwise.

The statement is often made that soya bean adds nitrogen to the soil through its symbiotic nitrogen-fixing ability with *Rhizobium* bacteria. Farmers observe it as vigorous growth of maize following a soya bean crop and then ascribed it to the additional nitrogen.

Some research confirmed that a person needs to apply an amount of nitrogen to maize following maize, to match the yield of maize following soya bean without any addition of nitrogen. This conclusion is, however, wrong for most cases as some research has shown that soya bean is nitrogen-neutral.

The soil, after the soya bean crop, is left with about the same amount of nitrogen it initially had. What most likely happens, is an improvement in the efficiency of nitrogen uptake by the following maize crop from the soil.

Nitrogen fixing

Leguminous crops, of which soya bean is a member, have the unique ability to supplement the soil nitrogen supply through a symbiotic nitrogen fixing process with *Rhizobium* bacteria. The bacteria penetrate hair roots on young growing roots and form the well-known root nodules.

Symbiosis is a beneficial cohabitation between organisms. In the case of *Rhizobium* and soya beans, the bacteria live on the energy supplied by the photosynthetic process of the plant. The bacteria, in turn, fix nearly inert atmospheric nitrogen (N_2) into compounds useful to the soya bean plant.

To take advantage of this symbiotic process, nitrogen fertilisation of soya beans is not recommended, except on sandy soil where the nitrogen supply is usually low. Small amounts of nitrogen fertiliser are therefore recommended on such soils for enhanced growth of young plants. Inoculation of the seed or soil with a specific *Rhizobium* species, *Bradyrhizobium japonicum,* associated with soya bean, is very important as it does not occur naturally in South African soils.

Maize yield improvement

The yield of maize following soya bean on a particular field is often noticeably better than that of maize following maize. Our own research, stretching over several years and localities, showed that the maize yield improvement is about 13% on sandy textured soils.

The soya bean rotated maize usually shows no nitrogen deficiency symptoms, while it often appears in mono-cultured maize during the reproductive part of the growing season. The popular interpretation is that some of the symbiotic fixed nitrogen is still available for uptake by the soya bean following a maize crop.

Closer investigation has, however, showed that this is unlikely. Roughly the same amount of nitrogen that is fixed by soya bean is removed by the grain. Increases in the soil's residual nitrogen after soya bean are usually too small to explain maize yield improvements. Some results even showed that soya bean can decrease the amount of residual nitrogen in the soil.

The yield of mono-cultured maize is often lower than that of maize preceded by a soya bean crop, no matter the amount of fertiliser nitrogen applied. This indicates that something else aside from nitrogen is causing the yield increase of soya bean rotated maize.

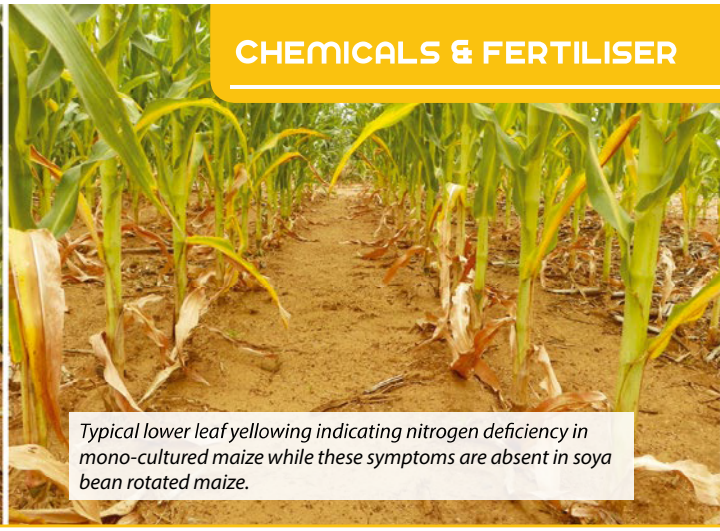
Improved efficiency

Several possible explanations, some with supporting evidence, have been presented. Among them are the carry-over of soil moisture from the soya bean to the follow-up maize crop, an improvement of the soil's physical properties, a decrease or increase in growth suppressing or promoting substances respectively, and a decrease in disease pressure.

Decreases in maize root diseases probably also play a role in our environment. According to pathologists, root rot with varying intensity and extent can be found on nearly all maize plants annually. Root rot, which usually go unnoticed, damage and kill parts of the root system, especially during the reproductive phase. The root system is consequently restricted and the uptake of moisture and nutritional elements such as nitrogen is limited, eventually affecting the growth and yield.

Trials at Viljoenskroon showed that the root system of maize following soya bean measured after pollination was 16% larger than that of mono-cultured maize. This value agrees well with the yield increase found for soya bean rotated maize.

Generally, maize takes up only about 50% of applied nitrogen fertiliser. This efficiency of nitrogen uptake can, however, vary between 20 and 80%, depending on



Typical lower leaf yellowing indicating nitrogen deficiency in mono-cultured maize while these symptoms are absent in soya bean rotated maize.

circumstances. The enhanced performance of maize following soya beans is most probably the result of an increase in the efficiency of nitrogen uptake, through a larger and probably healthier and longer living root system rather than a larger nitrogen supply in the soil.

Nitrogen replacement value

In addition to the maize yield improvement, the nitrogen fertiliser application rate on maize following soya bean can be lowered, therefore improving the net return even further. The question is, with how much?

The answer is explained by *Figure 1*, where the yield response of maize grown in rotation with soya bean and in mono-culture is compared from trial work done on sandy soil near Viljoenskroon. Note that the term "nitrogen replacement value" of soya bean is used rather than the more popular "nitrogen credit" due to the crop's nitrogen neutrality.

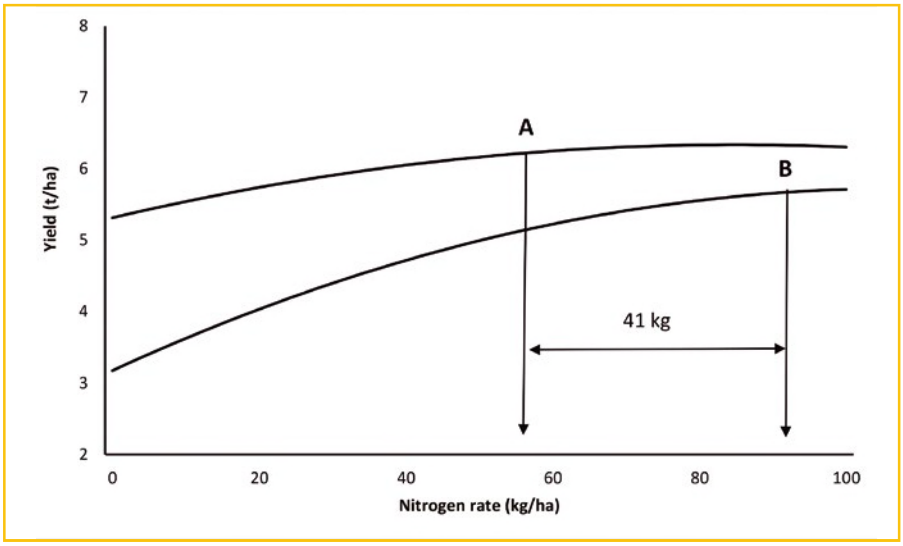
The yield response of maize in crop rotation with soya beans (upper curve) is different from that of mono-culture maize (lower curve) as shown in the figure. Points A and B represent yield at the economically optimum nitrogen fertiliser rate for maize in rotation and in mono-culture, respectively.

The yields at these points are 6,53t/ha for the soya bean rotated maize and 5,9t/ha for the mono-cultured maize, while the corresponding optimum nitrogen application rates are 54 and 95kg/ha respectively.

The nitrogen replacement value of soya beans in this case is 95 minus 54, which equals 41kg/ha. This value agrees with that found in the USA but is not applicable everywhere, as it can be influenced by various factors.

Indications exist, for example, that soil with a higher clay or organic material content will have a lower nitrogen replacement value than sandy soil with a low organic material content, such as those on which the trial was done. Some evidence also indicates that the nitrogen replacement value will be smaller where no-till is practiced in comparison with conventional tillage.

Figure 1: The yield response curves of soya bean rotated and mono-cultured maize with points A and B indicating their respective optimum nitrogen application rates.



No relationship

Contrary to what was previously thought, the nitrogen replacement values have no relationship with the yield of soya beans. Consequently, replacement values cannot be estimated from the yield of soya beans.

With the limited information currently available, it seems relatively safe to reduce the nitrogen fertilisation rate of mono-cultured maize on sandy soil, with 20 to 30kg/ha for maize following a soya bean crop.

Maize can thus benefit in two ways from the preceding soya bean crop. Firstly, by the yield enhancement which is often present and secondly from the saving on nitrogen fertiliser. To take advantage of these benefits, soya bean should be followed by a non-leguminous crop such as maize rather than other dicotyledonous crops such as sunflower, with which it has several diseases in common.

Results suggest, against the popular impression, that soya bean does not add nitrogen to the soil but rather improves the nutrient uptake efficiency of follow-up crops such as maize. Due to this improved efficiency, the application rate of nitrogen fertiliser on the following maize crop can be significantly reduced.

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