

Kick-starting legumes

Ken Giller

Leguminous plants must rate among the most bountiful and perfect gifts of nature. Legumes provide a large number of products, and at the same time they enhance soil fertility. The products range from beans and pulses that are the principal source of protein for the majority of the world's poor, to vegetable oil, animal fodder, poles and fuel wood. Legumes are also capable of improving soil fertility through their ability to fix nitrogen from the air making use of rhizobia bacteria in their root nodules.

Legumes add nitrogen to the soil mainly through falling leaf litter, and to a lesser extent by decaying roots and root nodules below-ground, and thus they have great potential for restoring degraded soils. The organic matter produced by legumes is generally rich in nitrogen and of good quality, meaning that it decomposes quickly and is a good source of nitrogen for other plants. The legumes best for enhancing soil fertility are those specifically grown for that purpose, namely the herbaceous green manure legumes and fast-growing legume trees. Herbaceous green manure legumes are often referred to as cover crops, as they provide a dense soil cover that can prevent soil erosion and suppresses weeds. In the case of food and fodder legumes, much of the nitrogen fixed is removed from the land with the produce.

Getting legumes going

Although legumes have a high potential to rehabilitate degraded soils, they also need good conditions to grow. Degraded soils are, by definition, inhospitable environments for plants, including legumes. Therefore, some soil improvements may be needed before the benefits from nitrogen fixation can be realised. Maximal rates of nitrogen fixation are mainly achieved under very good conditions: with irrigation under cloudless skies, and with abundant supply of other nutrients than nitrogen.

Phosphorus

When trying to establish legumes, the most common problem is shortage of phosphorus. In highly acid soils liming or adding animal manure can raise the pH and increase the availability of phosphorus. In most soils, however, the only option is adding phosphorus. Adding plant residues or animal manures will help provide some phosphorus, but mineral fertilisers are by far the most effective means. When sowing grain legumes or green manures, adding small amounts of phosphorus (20 to 30 kg per hectare) will usually be enough.

All over the uplands of South-East Asia, the invasion of *Imperata cylindrica* is a huge land degradation problem. These grasslands, covering millions of hectares of land, are man-made savannas as *Imperata* mono-cultures do not occur naturally. *Imperata* poses major difficulties for restoring the land for productive agriculture, as it is very difficult to get rid of. One option to deal with this problem is planting velvet beans. Velvet bean (*Mucuna* spp.) is a universal green manure in the tropics which can adapt easily to many different conditions. After slashing back the grass, velvet beans should be sown with abundant phosphorus so that a cover will develop rapidly and suppress aggressive weeds. One highly successful approach is to add one ton of rock phosphate per hectare, but this is only possible with external investment. Reclamation of these grasslands can also be achieved by sowing other crops such as groundnuts, but these require considerably more labour. A

similar approach has been used in Western Kenya, where either phosphate fertiliser or rock phosphate have been used to establish 'improved' fallows of fast-growing trees and shrubs such as *Sesbania*, *Tephrosia* and *Crotalaria* species.

Despite the many claims as to the usefulness of phosphate rocks, one should be aware that the vast majority of rock phosphates cannot be applied directly to the soil. The way rock phosphates can be used will depend partly on their chemical composition. As most rock phosphate sources have been researched extensively, information should be available about the usefulness of different rock sources.

Other nutrients

Other nutrient shortages may also limit the establishment and growth of legumes. Depleted soils commonly lack potassium and sulphur. Shortages of calcium and magnesium are often associated with soil acidity, which is a widespread problem in



Disappointed farmers and researchers discussing the failure to establish sunn hemp (*Crotalaria juncea*). Photo: Ken Giller

the tropics. The toxicity of aluminium can be overcome with small amounts of lime. For example in the Mekong delta, drainage of land previously flooded with brackish water led to the formation of 'acid-sulphate' soils, where extreme acidity prevented growing legumes such as soyabean (*Glycine max*). A very elegant and simple method of dealing with this problem is using mulches of rice straw and small amounts of ash to create a favourable environment in the planting holes. This allows rhizobia bacteria inoculated with the seed to form nodules and fix nitrogen from the air. The results were spectacular, with yields increasing ten-fold from 0.3 to 3 ton per hectare.

Tailoring and targeting technologies

The extensive literature on the rehabilitation of degraded soils by using legumes, suggests the existence of 'off-the-shelf' methods with universal acceptability. However, such research has often been done under favourable conditions and with the assumption that 'We have shown that it works so now farmers will use it!' Despite more than a century of research on green manures in the tropics, examples of smallholder farmers using such methods to regenerate their soils are remarkably rare. Extensive reviews of past experiences indicate that rapid uptake by farmers occurs only when green manures have other advantages, beyond simply improving soil fertility. Cover crops and green manures appear to spread rapidly among farmers only when they bring additional benefits such as the suppression of aggressive weeds. This



Researchers standing in a field with Mucuna. In the background a 2 m high stand of sunn hemp. Photo: Ken Giller

suggests that simply improving soil fertility does not justify the investment of labour and land in green manures. Farmers appear to be more interested in legumes that provide food or fodder as well as improve soil fertility, such as cowpea (*Vigna unguiculata*) and soyabean. These 'multi-purpose legumes' have the advantage of providing some immediate benefit in the form of products with direct economic value while also helping to improve soil fertility for subsequent crops.

In many smallholder farming systems, soil fertility may vary considerably within individual farms even on the same soil types. This generally results from concentrating available animal manure, compost and other organic inputs to fields close to the homestead. Few, if any, inputs are added to soils that are further away. Farmers understand and manage this variability: they have insufficient manure to effectively fertilise all of their land and choose to concentrate resources where they can be reasonably sure of good crop yields. A major challenge remains to experiment together with farmers to explore ways that they can release some of the manure to use as a means of kick-starting the growth of nitrogen fixing legumes in their degraded outfields, and so to bring this land back into productive agriculture.

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Bioremediation: decontaminating polluted soils

Peter Doelman

Healthy, fertile soil supports plant growth and crop production. One look at the quality of surface vegetation is usually enough to get a rough impression of soil health. Plants establish their roots in the top layer of the soil. Closer study of this layer shows that every gram of earth contains over one billion organisms of over 10,000 different species. These little creatures are known as microorganisms. They are soil-friendly, beneficial microbes that eat organic material and excrete minerals such as nitrates and phosphates in a continuous re-cycling process that has a direct effect on plant quality and productivity.

Microbes are responsible for 90% of biological recycling. Amongst the things they need to do their work are oxygen, water and the right soil temperature. All natural organic compounds in the soil can be recycled providing the soil has sufficient microbe-carrying capacity to encourage biodegradation.

Creating healthy soil with an active soil life ensures that geo-physical processes continue undisturbed and also that it is capable to deal with human interventions that could lead to long-term degradation. One aspect of degradation that is receiving increasing attention is the way in which soil contamination can be reversed by supporting the activity of soil organisms.

There are thousands of elements that can contaminate soil. However, only organic contaminants can be broken down by microorganisms. For this process to be effective, however, the soil must have some degree of natural fertility. If this is not the case contaminated land must be "farmed" back to health so that the microorganisms can begin their work of biodegradation.



A closer look into the soil shows the presence of millions of beneficial friendly microbes. Illustration: Loek de Moll, 2003

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