Managing organic resources for soil amendment

Ken Giller, Michael Misiko and Pablo Tittonell

Soil fertility management is a key issue for sustaining agricultural production in the tropics. Organic resources are important for short-term nutrient availability, as well as for longer-term maintenance of soil organic matter. For smallholder farmers, organic materials are an important source of nutrients, and necessary to manage soil fertility. However, the amount of organic material available on-farm is often limited in supply, and differs widely in quality. This is why the little that is available needs to be used as efficiently as possible.

Did you ever wonder why some leaves of plants just seem to vanish as soon as they fall to the ground? Or why you can still find remains of maize stalks a year after they were turned into the soil? There are many different types of organic matter and to use these effectively as soil amendments it is important to understand how to manage them for nutrient supply or soil cover. The "quality" of organic resources determines their effectiveness for different uses; quality indicators are the carbon-to-nitrogen ratio, the lignin and tannin (polyphenol) contents. Through working together with smallholder farmers in Africa some tools have been developed that can be used in joint-learning research. Here we describe our experiences and important lessons learned.

Creating decision trees

The importance of the "quality" of plant residues in governing rates of decomposition and effects on soil fertility has long been recognised. A decision tree was developed to guide the use of organic resources based on our understanding of the critical concentrations of nitrogen, lignin and tannins (see Figure 1). This simple diagram summarises knowledge of the relationships between the chemical quality of plant leaves and litter and their rates of decomposition and nitrogen release. Scientists may feel

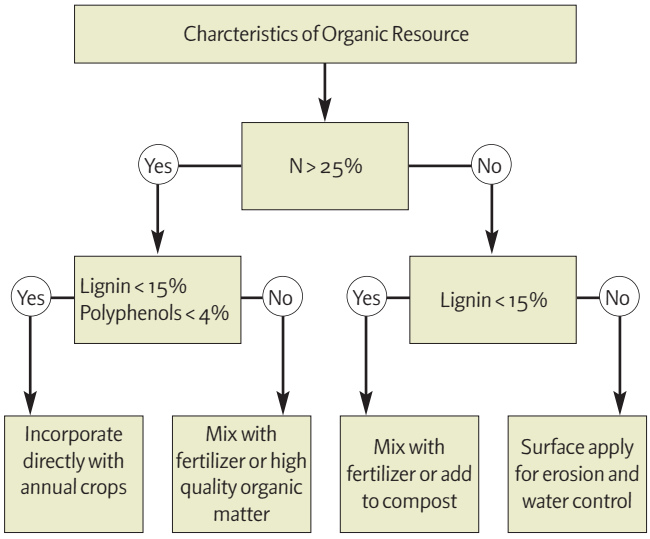

Figure 1. A decision tree to assist management of organic resources in agriculture (from Palm et al., 2001).

Photo: Michael Misiko

Lucy Aojata, a local farmer in Chakol, western Kenya, explains local understanding of quality of organic resources before farmers and researchers started a joint experiment.

the need for a laboratory to analyse the quality of the residues, but simple characteristics can be used instead of some chemical tests. Nitrogen concentrations of leaves and litters can be estimated simply on the basis of their colour. If a leaf can be crushed to a powder when dry this indicates it contains little lignin as leaves rich in lignin are stiffer and more fibrous. Farmers in Zimbabwe, when asked which multi-purpose legume tree species they would value as a fodder for their cattle, simply tasted them and readily identified those rich in reactive polyphenols. This "tongue test" is due to the bitter, astringent taste caused by the polyphenols binding with salivary proteins, and clearly separates out species with strong protein-binding capacity.

Such simple field tests made it possible to create a decision tree that can be used as a tool to discuss litter/fodder quality directly with farmers in participatory research. This tool can also be explained in pictures (Figure 2). Farmer field schools in western Kenya have been experimenting with different qualities of organic residues for soil amendment and growing maize, vegetables and other crops. They planted experiments comparing maize production when organic residues were applied to the soil that belonged to the four classes identified in the decision tree. This certainly led to an increase in understanding of the principles of resource quality and decomposition. For instance, farmers picked fresh green leaves of hedgerow plants little by little and incorporated them into compost heaps to speed up decay and get hotter. A hot compost "cooks" faster. After the experiments, participating farmers also knew that hot composts comprising resources that break down easily took shorter periods to "cook well".

Nitrogen-rich organic residues were in very short supply for these farmers. The most popular use of nitrogen-rich organic materials was with tomatoes and cabbage that fetch a good price at the market. The major problems identified with using organic residues as soil amendments were the extra work involved, and the lack of sufficient quantities, particularly of the types of organic material suitable for immediate application. There were also competing uses for residues poor in nitrogen such as maize stover: one farmer proposed "Give me a cow, I will feed it and

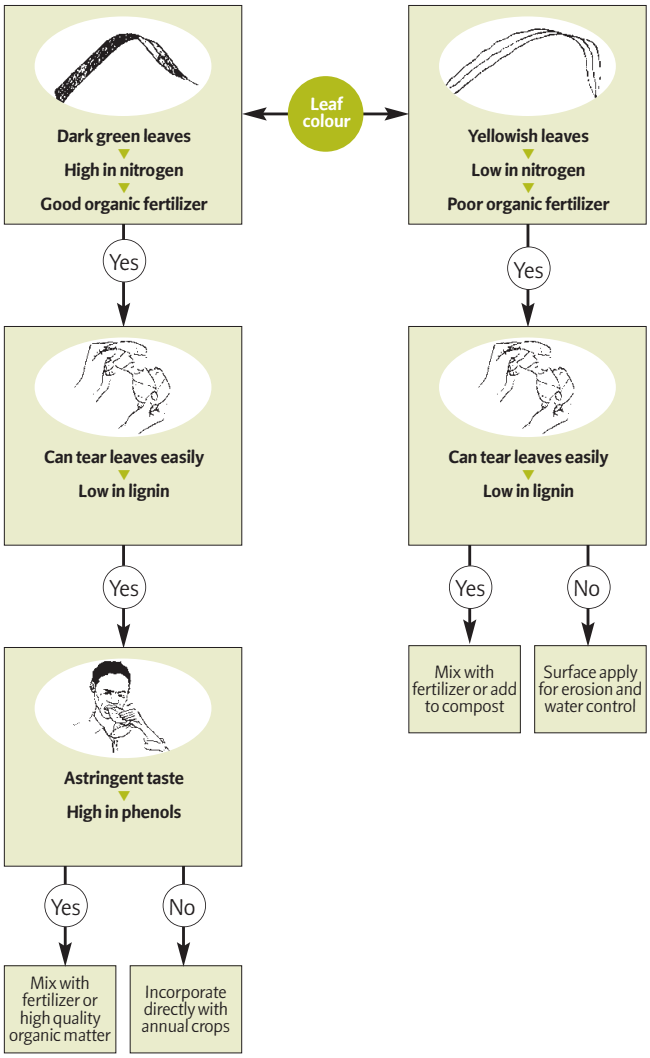

Figure 2. A pictorial translation of the decision tree (IIRR, 1998).

use its manure to do soil fertility management!" Maize stover was used as fuel for cooking, particularly by poorer households. Farmers with sufficient quantities of poor-quality organic materials used them for bedding for cattle and thus eventually adding to the manure heap, or for mulch to assist in soil conservation. The farmers also observed that more succulent and fibrous leaves or material such as sisal and plants belonging to the genus *Euphorbia* decayed slowly and were hard to crush. They were also difficult to compost and therefore of little use for nutrient management. From their experiments, the farmers concluded that it was useful to know how to manage their organic residues alongside the mineral fertilizers that are in short supply and difficult to get hold of. As farmers learnt new skills and gained better perspectives on research knowledge, they increasingly changed their old practices such as burning stover.

Understanding the concepts

Microorganisms, bacteria and fungi are responsible for breaking down all types of organic residues to release the nitrogen they contain –the process of "nitrogen mineralisation"– and make it available in a mineral form that can be absorbed by plants. When micro-organisms break down organic material that provides a lot of energy, as sugars or other carbon compounds that are rapidly broken down, then they need more nitrogen to grow than is released from the organic material itself. To satisfy their hunger for nitrogen the micro-organisms absorb this extra nitrogen from the soil, in a process known as "nitrogen immobilization". We often talk of the carbon-to-nitrogen ratio as being an important indicator of whether a plant residue will make a good organic manure. When the organic materials are rich in nitrogen (when the C-to-N ratio is less than 25) there is "net nitrogen mineralisation". Conversely, when the rates of nitrogen immobilisation are faster than nitrogen mineralisation (when the C-to-N ratio is greater than about 25), there is "net nitrogen immobilisation".

Some other aspects of the "quality" of organic residues are also important. Woody twigs and branches and older leaves break down more slowly than young green leaves. This is partly due to the wider C-to-N ratio, but the rate of breakdown is also strongly influenced by the greater proportion of lignin in woody materials. Another aspect of organic residue quality is the presence of secondary compounds in the leaves, such as tannins. These are complex molecules that slow down or prevent decomposition and release of the mineral nitrogen by binding to nitrogen-rich proteins when the leaves are cut.

Earthworms, termites and other soil animals help to break down plant material, but the role of the earthworms is to render the residues into small pieces. The micro-organisms are able to attack plant residues more easily if they are first broken into smaller pieces, so decomposition is faster when the plant residues are broken up. Plant residues that are woody are harder to break up into smaller pieces and decompose more slowly because of this. The focus is on nitrogen as few plant materials contain enough of the other major nutrients, phosphorus and potassium, to be important sources of these nutrients for crop production.

Test the principles behind the decision trees yourself

Many farmers are now trying out these ideas, and experimenting. When you grow maize plants, you could try it too – add some green manure biomass (rich in nitrogen) in some plots and add maize or wheat straw in some other plots. As a check, sow some plots with maize but do not add any extra organic matter here. You could also include a plot with some mineral fertilizer added for comparison. The plants growing in plots to which straw is added will be clearly more yellow and less vigorous than if they are fed with the green leaves.

Decomposition and nitrogen release are determined by the quality of organic matter which regulates their susceptibility to attack by microbes. This explains why some leaves just vanish when they fall to the ground while maize stalks can remain in the field a year after they were turned into the soil. Farmers can use these concepts to make decisions as to the best ways to manage organic resources for fodder, for nutrient supply, for composting or for mulch. ■

Ken Giller. Professor, Plant Production Systems. Department of Plant Sciences, Wageningen University. P.O. Box 430, 6700 AK Wageningen, The Netherlands.
E-mail: ken.giller@wur.nl

Michael Misiko and **Pablo Tittonell.** Tropical Soil Biology and Fertility Institute (TSBF-CIAT). P.O. Box 30677, Gigiri, Nairobi, Kenya.
E-mails: michael.misiko@wur.nl ; pablo.tittonell@wur.nl

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