When There Is No Soil Test... Helping Extension Workers Assess Soil Fertility in the Tropical Uplands

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Alternative approaches are needed to assess soil fertility in many areas of the world where on-farm soil testing and the supporting correlation and calibration information required for precise fertilizer recommendations are not available. The approach described in this article is an on-going process of developing, implementing, and modifying tools and methods for farmers and extensionists in Indonesia's uplands. This straightforward and strictly participatory method aims for general guidelines in simple soil fertility assessment and fertilizer management applicable in the tropical uplands of Southeast Asia.

While precision agriculture is gaining prominence in some developed countries, most upland farmers in Indonesia have no access to common soil testing because they lack the financial resources to pay for simple soil tests or facilities are not locally available. Likewise, soil test correlations and calibration information are not usually available for upland soils and crops. Yet, fertilizer consumption is increasing in Indonesia and farmers need advice on fertilizer use and soil fertility management.

A low cost Pehameter (Hellige) provides a quick pH test in the field.

The lack of accurate soil test data and fertilizer recommendations reflects the local-specific information vacuum that extension workers face when advising farmers in the uplands of Indonesia and other developing countries. Agricultural extension and the supporting technical information base have historically focused on wetland rice areas, but increasing demand has been placed on intensifying agricultural production on the rainfed uplands.

An approach is being developed by the Area Development for the Rehabilitation of Critical Land and the Protection of Natural Resources and Environment (ProRLK) in West Sumatra to provide extension workers with the information and skills required to advise farmers on proper soil fertility management for the rainfed uplands.

The Approach

The approach involves two major steps.

1. A general soil fertility assessment of an area is carried out through a participatory soil survey.
2. Tools and methods are developed to help extension workers make specific farm-level diagnoses and to provide farmers with recommendations which are then tested in farmers' fields.

In this approach, the five elements of the environmental education learning process ... *awareness*, *knowledge*, *attitudes*, *skills*, and *participation* ... are applied. Table 1 shows how these steps correspond with soil fertility assessment at different scales (e.g. from a large region, possibly several villages, down to farm-specific soil fertility assessment).

Table 1. The tools and methods used to move from general to specific soil fertility assessment and the corresponding learning process elements experienced by extension workers.

Learning process element	Geographical focus	Tool/method
Awareness	Several villages	Participatory soil survey
Knowledge and attitudes	↓	Dissemination of results (e.g., soil handbook, workshops, etc.)
Skills	↓	Training on diagnosis and recommendation (using indicator plants, nutrient deficiency symptoms, etc.)
Participation	Single farm	Participatory technology development

Awareness - *Participatory Soil Survey*

The participatory soil survey involves extension workers, farmers, and scientists as they share their individual expertise to identify the potentials and limitations of agriculturally important soils. Extension workers are included in the process to increase their awareness of the properties of local soils, which will eventually help them to assist farmers in their soil fertility management. The major steps involved in the approach are shown in Table 2.

Table 2. The major steps involved in the participatory soil survey.

1. Scientists review secondary soil data.
2. Farmers, assisted by extension workers and scientists, sketch simple land use and soil maps. Farmers identify soils by color, texture, presence of indicator plants.
3. Based on the information from steps 1 and 2, farmers and scientists select representative sites to dig soil pits.
4. Scientists, in the presence of extension workers, farmers, and village officials, characterize the soil pit profiles and obtain soil samples for basic chemical and physical analyses.
5. Scientists process the results.
6. Feedback through discussion in the village and visits to soil pits.

Although additional soil fertility information (particularly where pronounced soil spatial variability exists) can be gathered by means of auger-hole sampling, the soil pit is an important vehicle for increasing awareness among participants. Besides having a good look at the subsoil (e.g., clayey and deep, shallow and stony), participants can easily recall the location of a soil pit and the soil's characteristics, which is less likely to occur for auger-hole sampling. The entire process of characterizing a soil profile in the field stimulates ample discussion about the soil among the participants.

Knowledge and Attitudes - *Dissemination of Results*

It is critical to follow-up the awareness and expectations created by the participatory soil survey. Workshops and technical and extension publications are used to share the soil survey results with farmers. Crop suitability and general soil fertility assessment of the surveyed soils

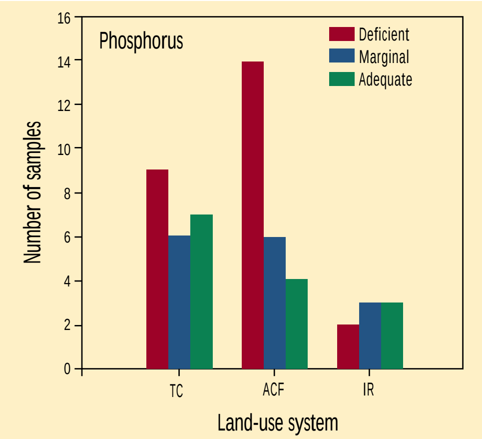

Figure 1. Number of soil samples containing deficient, marginal, and adequate P (Olsen) in tree crops (TC), annual crops with fallows (ACF), and irrigated rice (IR) land-use systems in West Sumatra.

are presented to local planning officials and extension staff in half-day workshops. Additionally, the soil surveys are published in detailed technical reports and provided to relevant agencies and organizations.

An extension handbook provides extension workers with basic soil fertility information from the participatory soil survey. The handbook also includes relevant chemical data of the topsoil, maps with profile locations, and photos of representative profiles. As mentioned earlier, precise correlation and calibration data are not available in Indonesia, so general guidelines are used in order to convey important messages to extension workers.

Figure 1 and Figure 2 show examples of data from West Sumatra. Soil available phosphorus (P) was deficient in 40 percent of the samples taken from fields planted to tree crops and 60 percent of the samples taken from fields planted to annual crops (Figure 1). In contrast, potassium (K) was only deficient in 20 percent of the tree crop fields and 5 percent of the annual crop fields (Figure 2). In tree crop and annual cropping systems, P deficiency must be corrected before there will be any response to K.

In addition to soil fertility data interpretation, a simple five step process helps extension workers to improve on-farm soil fertility management practices, without having to rely on precise soil data (Table 3). A basic principle of this approach is that extension workers should first try to improve the management of the fertilizer that the farmer is already willing to purchase, and only then focus on trying to determine the correct fertilizer dose.

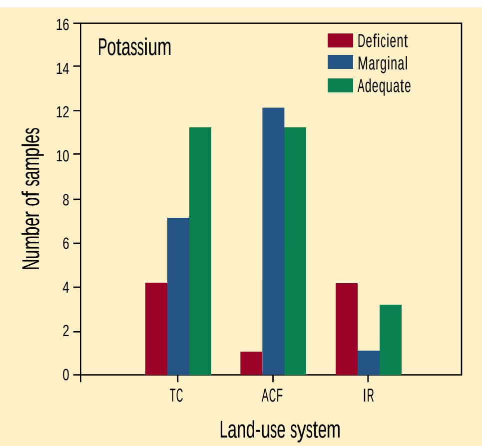

Figure 2. Number of samples containing deficient, marginal, and adequate exchangeable K in tree crops (TC), annual crops with fallows (ACF) and irrigated rice (IR) land-use systems in West Sumatra.

Skills - *Training on Diagnosis and Recommendation*

Simple tools and methods help train extension workers on how to diagnose and provide recommendations to farmers based on the results of the participatory soil survey. Geographical regions and related potential soil fertility problems are identified during the participatory soil survey. However, extension workers need to be shown how to determine whether or not these conditions exist on a particular farm.

Extension staff should be trained to identify and interpret nutrient deficiency symptoms. For example, when an extension worker enters an upland area in West Sumatra, one of the first observations in the field is to look for indicator plants that suggest P deficiency. The presence of large amounts of weed species such as *Imperata cylindrica* (cogon grass or alang-alang), *Melastoma malabathricum* (Straits rhododendron) and *Dicranopteris linearis* (tropical bracken) may indicate an acid, low P soil. Among annual crops, maize is an especially useful indicator of various nutrient deficiency symptoms, particularly of P (e.g., purpling of leaves and stem bases).

A simple worksheet can help the extension worker analyze the field cropping history with the farmer, in particular crop yields and the management of crop residues, soil amendments and fertilizers. Nutrient removal/replacement graphs provide estimates of the amounts of nutrients removed from the field under different management practices. While the total uptake of nitrogen (N) and K by a maize crop is similar, the amount of N contained in the grain is

Table 3. Five suggested steps for extension workers to help improve farmers' soil fertility management.
1. Improve the timing of fertilization.
2. Improve fertilizer application methods.
3. Improve the balance of fertilization.
4. Improve organic material management.
5. Optimize fertilizer use.

With its distinctive red flowers, Straits rhododendron is a good indicator of acid soil.

twice the amount in the stover. However, the amount of K contained in the stover is four times the amount in the grain. These two tools can be used to develop simple nutrient budgets to identify possible nutrient imbalances on the farm.

If crop yields are relatively low for the area, the amount of P fertilizer used was small, indicator weeds species are present, and P deficiency is found in maize leaves, the extension worker starts to build a case for P limitations to crop production. He/she may then recommend that the farmer increase the amount of P fertilizer applied or even propose P recapitalization of the farmer's soil. The source of P used should be related to soil pH test, using a Pehameter (after Hellige) soil pH kit. Rock phosphate is only recommended when pH is less than 5.5.

In areas where aluminum (Al) toxicity is identified as a probable limiting factor, the extension worker would have to learn the relative Al tolerance of various crops (e.g., cassava is more tolerant than soybean). If an Al-sensitive crop is being grown, a simple pH test kit can be used to estimate the approximate lime requirement. A broad relationship between soil pH and Al saturation was found for the soil pits tested in the West Sumatra survey. It may be useful for the calculation of lime requirements based on soil pH. Chemists have used pH indicators for centuries with a high degree of precision and it may be possible to estimate the amount of lime required to reduce Al saturation to the required level by measuring the pH of soil-water solutions to which different amounts of lime have been added. The advantage is that the tests can be carried out in the field using the pH kit and some plastic containers.

Field meetings allow an exchange of information among farmers and extension workers.

Participation - *Participatory Technology Development*

While farmers and extension workers participate in the process from the beginning, the last and most important phase puts focus on how the extension workers could test their tentative recommendations with the farmer. Although the process also requires skill training, this step is seen more as a working relationship put to practice. The extension worker must be taught how to work with a farmer to test, monitor and evaluate the new recommendations against the current farmer practice. BCI

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