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# TROPSOILS

# SOIL MANAGEMENT CRSP
# HUMID TROPICS

# INDONESIA
# TROPSOILS PROJECT

*University of Hawaii at Manoa*
*Center for Soils and Agroclimate Research, Bogor*

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*Summary of Accomplishments*

*North Carolina State University*
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## Summary of Accomplishments

The Indonesia TropSoils project was established in 1983 in the Sitiung Region of West Sumatra. Extreme soil acidity and infertility, uneven terrain excessive leaching, and droughtiness are the main agronomic obstacle to profitable farming in this area. Since its inception, collaborative research between Indonesian and U.S. scientists have resulted in the following accomplishments.

A. Liming to Correct Soil Acidity

1. Efficiency: The first increment of applied lime is very effective in neutralizing acidity and the effectiveness decreases with increasing application. The cost-effectiveness of lime application is highest at low rates.

2. Prediction: An equation to predict lime requirements for various soils and degree of acidity has been selected for Indonesian soils. The use of this equation reduces the amount of lime to achieve desired results to about 1/3 of the traditionally recommended amount.

3. Maintenance: Lime has a long residual effect in the soils of Sitiung. This is likely to be true for all similar soils in Indonesia and the humid tropics. The high initial cost of lime application may be amortized over several years. The amount of lime needed to maintain favorable soil conditions is low owing to its slow leaching in these soils.

4. Crop tolerance: Crops differ in their tolerance to soil acidity and aluminum toxicity. The tolerance of crops to soil acidity, expressed in percent aluminum saturation is as follows:

| Crop | Tolerance level in % Aluminum saturation | |
|---|---|---|
| Mungbean | | |
| Soybean | 0 | lower |
| Maize | 15 | tolerance |
| Peanut | 30 | |
| Rice | 40 | |
| Cassava | 60 | higher |
| | 80 | tolerance |

These findings clearly indicate why resource-poor farmers prefer to grow cassava, rice and peanut rather than mungbean or soybean.

6. Incubation: Unlike soils in dryer zones, lime reacts very quickly in the warm, moist soils of Indonesia's acid uplands. This means that crops can be planted a few days after lime is applied.

7. Lime movement: Leaching of lime is minimal. This is a desirable feature of the soil as leaching losses are minimized. On the other hand, some movement of lime into subsoil is desired. It is anticipated that the productivity of acid upland soils will continue to increase over many years as lime and phosphorus slowly move into deeper layers.

B. Phosphorus

1. These soils have remarkably low phosphorus requirement given the high degree of weathering and iron content. Rates of 10 to 20 kg P/ha are adequate to sustain a crop. Theses amounts are one-fourth of the rate normally recommended for similar soils.

2. The method of P fertilization is not critical for fertilizer use efficiency, but broadcast application has the lowest labor requirements.

C. Potassium

1. The soils are highly impoverished of potassium and crops respond to potassium application.

2. Owing to low negative charge on soil particles, positively charged potassium leaches rapidly from the root zone. This means that farmers must apply the fertilizer in small increments over the crop cycle.

3. The severity of the rice blast disease is reduced with potassium fertilizer application.

D. Sulfur

In spite of widespread claims that these soils are sulfur deficient, no response to sulfur has been observed in Sitiung. It is expected that with continued removal of nutrients from the soil, these soils will become sulfur deficient in 10 years, particularly if farmers use high purity, low sulfur fertilizers.

E. Magnesium

Strong visual response has been observed in maize and soybean but not in rice or peanut. It is expected that magnesium will become increasingly deficient in the future. This problem can be avoided by using lime with high magnesium content.

F. Soil Variability

1. A geostatistical method to predict soil properties at unsampled locations has been developed. This method enables extension agents to make more accurate soil management recommendations based on better soil information.

2. The above method has been used to map the distribution of soils in Sitiung area on the basis of their acidity, lime requirement and fertilizer needs. It can be applied anywhere in the world.

3. A user's guide for using this procedure has been prepared for distribution worldwide.

G. Organic Matter Management

1. There is no response to lime in newly-cleared soils despite high soil acidity. This is due to detoxification of aluminum by organic matter.

2. Green manure can substitute for lime when lime is not available. Five tons of green manure is equivalent to one ton of lime.

3. *Paraserianthes falcataria, Caliandra calothyrsus* and *Gliricidia sepium* have performed poorly owing to soil fertility. They suffer from the same deficiencies as the food crops after 3-4 years of pruning. With small additions of lime, phosphorus and potassium, they are excellent for controlling soil erosion and serve as sources for fuelwood, fodder and green manure.

H. Tillage

1. Soil compaction is not a problem in Sitiung except in areas cleared by tree-dozers.

2. Tillage problems are minimized because these soils have outstanding physical properties.

I. Soil Water

1. Rainfall rapidly infiltrates into the open structure of the soils so that runoff is low for rainfall amounts and intensities measured in Sitiung.

2. Water retention capacity of the soils is high, but the soil is droughty .

3. The large reservoir of water in the subsoil is not accessible to acid sensitive plants because roots are damaged by toxic aluminum.

4. Deep (15-20 cm) incorporation of lime results in marked yield increase from more efficient use of water and nutrients.

J. Soil Conservation

1. Mulching, grass strips, bench and bund terraces, and slot mulching have all been effective in reducing runoff and erosion.

2. Soil conservation measures reduce downstream siltation of dams and preserves the benefit of liming and fertilizer application.

3. Infertile subsoil exposed by erosion is difficult and expensive to reclaim.

K. Socioeconomics

1. Women are heavily involved in agriculture and farm level decision making.

2. Food consumption surveys are useful in identifying dietary preferences, thereby enabling researchers to focus on locally preferred crops.

3. Time allocation studies showed large investments in time for harvesting forage for animals indicating a need for more research on feed and forage. This information was used to introduce CIAT forage grasses and legumes to Sitiung and Indonesia.

4. Tree crops are highly prized and are an integral part of the farming system, and indigenous knowledge far exceeds <u>researcher</u> knowledge in this and other aspects of home gardening.

5. The perception of soils by farmers and researchers differ greatly and farmer adoption of soil management practices depends heavily on farmer

perceptions of the connection between soil, soil manipulation and benefits to the farmer.

6. Tropsoils' social scientists have made agronomic research more efficient by serving as "cultural brokers" between farmers and researchers and by helping to identify research priorities.

L. Expert Systems, Decision Support Systems and Geographic Information Systems

1. An expert system that captures project accomplishments and organizes the results in a user-oriented way has been developed for distribution to the extension services and government planners.

2. An expert system serves as the institutional memory of the errors and successes of research and helps others avoid redoing and rediscovering what has already been done and is already known.

3. The expert system produced by the TropSoils scientists performs better and faster than human experts because the computer has a larger memory for details and data than humans.

4. The expert system presently incorporates a partial budget analysis that considers the cost of lime, transportation to the farmer's home and their field, and the cost of spreading the lime. The value of the potential increase in crop yield due to lime is estimated and the various costs are then subtracted from the increased value of the crop.

5. The expert system can determine whether use of lime for a particular crop, soil, type of lime, depth of incorporation and particle size of the lime is profitable to the farmer.

6. The expert system is able to explain its recommendation, and give reasons why another strategy may be more or less profitable.

7. A geographic information system shows that transportation costs and easy access to markets are major factors governing resource allocation and decision making on the farm.

M. Training

The TropSoils project has provided long and short term training to students and other professional staff. The following are individuals representing several

institutions who have benefited from TropSoils training and research opportunities.

Indonesian Institutions

M. Soekardi, Center for Soil and Agroclimate Research, Bogor
Karim Makarim, Food Crops Research, Bogor
Fahmuddin Agus, Center for Soil and Agroclimate Research, Bogor
Subagio H., Center for Soil and Agroclimate Research, Bogor
Eko Legowo, AAETE, Malang
Djohan Aliusius, Andalas University, Padang
Bujang Rusman, Padjajaran University, Bandung
Kasli, Padjajaran University, Bandung
Istiqlal Amien, Center for Soil and Agroclimate Research, Bogor
Diah Setyorini, Center for Soil and Agroclimate Research, Bogor
Arsil Saleh, Center for Soil and Agroclimate Research, Bogor

United States Institutions

Dan Gill, North Carolina State University
Carl Evensen, University of Hawaii
Stephanie Kan, University of Florida
Jan Shultz, University of Hawaii
James Hansen, University of Hawaii
Phoebe Kilham, University of Hawaii
Thomas Dierolf, University of Hawaii

Collaborating Institutions

Ellen Veger, Amsterdam University, Netherlands
Bruce Trangmar, DSIR, New Zealand
Ruey-Shyang Huang, National Taiwan University, Taiwan

N. Lessons Learned

1. In any research project, it is useful to preserve what is learned in portable, user-friendly, decision aids so that what is learned can be combined with what was known to enable users to (1) apply knowledge to solve problems and (2) avoid redoing what has already been done and is already known.

2. In the impoverished lands of Sumatra, Kalimantan, Sulawesi and Irian Jaya, agronomic, economic and ecological factors equally constrain sustainable development and therefore must be treated in an integrated manner.

3. One bottleneck to development is the communication gap between the research agencies that uncover contraints to development and the government planners who need the information to formulate policies. This gap must be bridged in any U.S.-Indonesian effort.

4. A new research agenda based on human ecology and systems thinking is needed in Indonesia.