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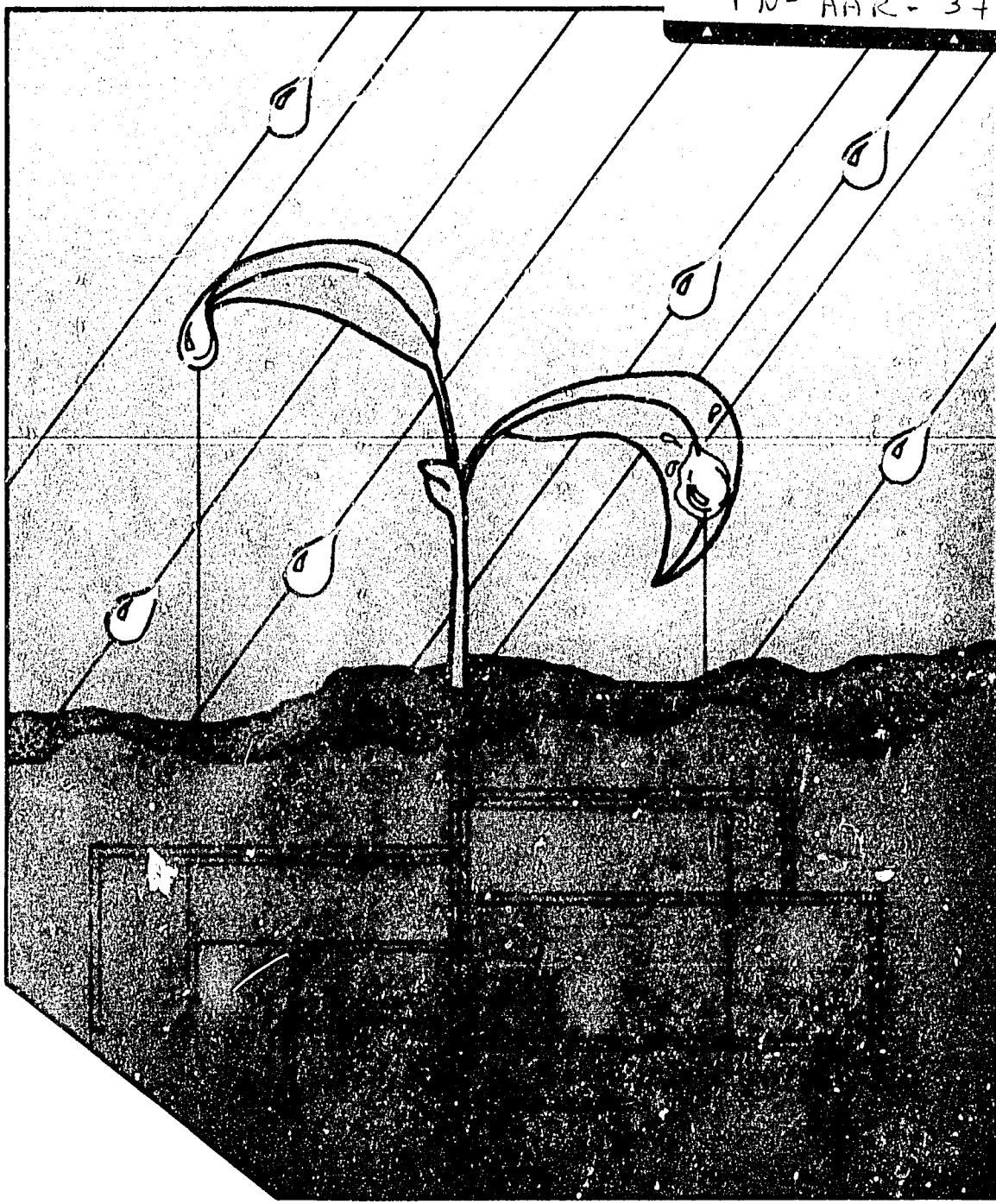
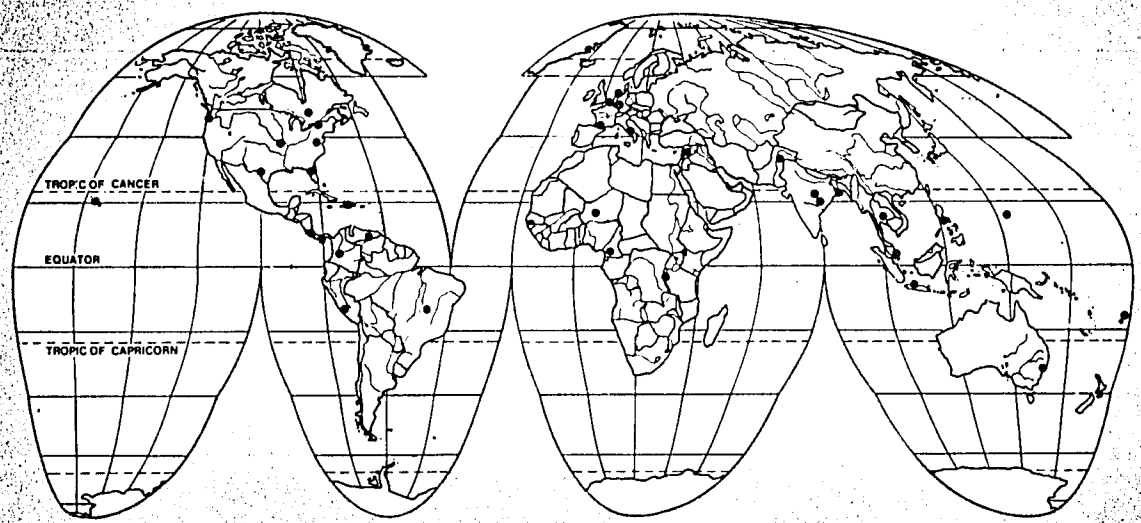


International Benchmark Sites Network for Agrotechnology Transfer

A SYSTEMS ANALYSIS AND CROP SIMULATION PROJECT

Network of Cooperators



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Purpose

IBSNAT is a collaborative endeavor to consolidate national and international agricultural research centers into a prototype network for the purpose of developing, validating, and utilizing a scientific method for the effective transfer of agrotechnology among and within countries in the tropics and subtropics.

The primary objective of IBSNAT is to develop a method for the transfer of agroproduction technology that combines elements of transfer by analogy with systems analysis and computer simulation techniques and that will

- accelerate the flow of agrotechnology from its site of origin to new locations,
- maximize the successes and minimize the failures in the transfer of agricultural technology in the tropics and subtropics, and
- assess the long-term effects of agricultural practices on the soil resource.

IBSNAT involves many agricultural research institutions throughout the world. The University of Hawaii, under a contract from the U.S. Agency for International Development, serves as the coordinating entity and headquarters of IBSNAT. Also involved in the management of the project are the USDA Agricultural Research Service and the University of Puerto Rico.

Maize is a common crop to both temperate and tropical regions of the world. Differences in production levels are related to genetics and management of soil and environmental constraints. Similar statements can be made for wheat, rice, and sorghum, the other cereal crops included in IBSNAT.

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Why IBSNAT?

Large quantities of agricultural technology have been and are being developed by the national and international agricultural research centers in the tropics and subtropics. But this technology becomes useful only when it is effectively conveyed to the ultimate user—the farmer—with a minimum of error and time lag.

THE Benchmark Soils Project of the universities of Hawaii and Puerto Rico has shown that the U.S. system of soil classification, *Soil Taxonomy**, can be used to define agroenvironments in which crops and agricultural systems respond and perform in a common and predictable ways. Thus, *Soil Taxonomy* can be employed to determine where particular sets of agricultural technology will perform similarly. Researchers then are capable of predicting the performance of new agroproduction technologies at locations where they have not yet been tested.

This transfer by analogy is most useful in the "horizontal transfer" of technology among research centers. However, the process of agrotechnology transfer is not complete without "vertical transfer," or the diffusion of technology to farmer fields. Since each farmer and his farm is unique, vertical transfer requires the matching of technology to the specific combination of the agroenvironmental conditions of the farm and the cultural and resource characteristics of the farmer. Historically, farmers and extension agronomists have used their judgment and experience to decide whether the agricultural technology developed by traditional experimental methods on research stations should be implemented in a particular field. This is a practical application of agrotechnology transfer by analogy. Yet, since transfer is often attempted among sites with quite different soils and climate, what results frequently is failure.

IS it possible, then, to improve our predictions of the applicability of new agricultural technology in agroenvironments where it has never been tested? Specialization would suggest that would be possible if the experience and judgment of many experts could be tapped whenever a decision is needed. Just as several opinions from specialists in different medical areas are often sought in the treatment of disease, the opinions of soil scientists, agronomists, plant breeders, pathologists, economists, and social scientists could be pooled to predict whether a new package of agricultural technology will succeed or fail in a particular situation. And so, how can we bring existing experience to bear on routine problems?

RECENT advances in artificial intelligence and data management allow computers to synthesize large amounts of medical data and assist the physician in disease diagnosis. Likewise, recent advances in the simulation of agricultural processes make it possible to synthesize climate, soil, crop, and management data in new and useful ways. By using agricultural simulation models, scientists can quickly, easily, and cheaply predict the effects of different packages of agricultural technology on both crop production and the soil resource, and can estimate soil water content, soil erosion, nutrient availability, and crop growth on a daily basis throughout the year. Even the effects of planting dates and the time, amounts, and types of fertilizer application on crop growth, nutrient leaching, runoff, and erosion can be estimated. They can predict the effects of soil characteristics on water and nutrient movement, erosion, plant nutrition, fertilizer requirements, and crop growth. Thus, agricultural simulation models can be used to predict many of the consequences of agricultural technology transferred to a new location. These

*Soil Survey Staff, Soil Conservation Service, U.S. Dep. Agr. 1975. Soil taxonomy: a basic system of soil classification for making and interpreting soil surveys. Agr. Handbook 436. U.S. Gov. Printing Off., Washington, D.C.

models are extremely versatile and can be used to predict the effects of changing only one component, e.g. fertilizer rate, of the system or of changing the entire package of management practices, e.g. improved cultivar + additional fertilizer + irrigation.

Like any statistical model, however, simulation models can be used only with confidence within the range of conditions for which they have been developed and tested. To date, most agricultural simulation models have been developed for temperate environments. They now must be tested, modified, and validated using data from experiments conducted over a wide range of tropical and subtropical conditions.

- Establish a prototype network of collaborating national, regional, and international agricultural research centers whose stations represent the dominant agroecological zones and major kinds of soils of the tropics and subtropics. These centers will serve as both sources and recipients of agrotechnology;
- Characterize the sites of the network with respect to land, soil, and climate;
- Identify the minimum set of soil, crop, weather, and management data needed to use, validate, and improve existing agricultural simulation models for the lower latitudes. The crops to be studied include four cereals (maize, rice, sorghum, wheat), three grain legumes (beans, groundnuts, soybeans) and three root crops (aroids, cassava, potato);
- Establish a computerized data management system to store soil, climate, cultivar, and management data to facilitate model development and testing;
- Collect data from previous experiments and conduct experiments at the collaborators' sites to generate the comprehensive soil-crop-weather-management data base required to validate and/or modify agricultural models to accurately simulate crop production combined with ongoing experimentation at the collaborators' sites;
- Use the collected data sets to improve and validate existing models of agricultural processes at IBSNAT sites;
- Train collaborators in the use and application of simulation models;
- Hold periodic meetings to enable the collaborators to report on progress and discuss future work;
- Design a prototype telecommunication system for the transnational exchange of data, models, and other information.

Expected results

IBSNAT will develop a comprehensive and integrated agricultural management model consisting of simulation models and the associated soil, weather, crop, and management data bases that can be used to address a variety of questions about land management, such as:

- What are the short-term effects of introducing improved cultivars with and without increasing fertilizer?
- What are the fertilizer and irrigation requirements of a certain crop grown in a particular soil at a specific location?
- How can planting dates, crops, and cultivars be manipulated to maximize yields under double cropping for a particular soil and climate?
- What are the long-term effects on soil fertility, soil erosion, and fertilizer requirements of introducing minimum tillage at a particular location?
- What are the long-term effects of two management strategies on soil erosion and crop production at a particular location?
- Can fertilizer N efficiency be improved at a given location by splitting N applications?
- How much additional lime will be required if a high-yielding but acid-intolerant genotype is introduced?
- Will the yield improvement due to liming and deep tillage offset the cost of deep incorporation of lime?

Soybeans are one of three pulse crops included in IBSNAT. Groundnuts or peanuts and beans (Phaseolus var.) are the other two. Collectively, these three crops are grown in areas representative of a range of soils and climatic environments.

Questions and answers about IBSNAT

What will be my role in IBSNAT if I join and what are the benefits?
IBSNAT is not a technical assistance program. Rather, it is an international team effort in which many institutions have joined forces to collaboratively work toward a common goal. You will contribute a small part to this effort, but you will be the beneficiary of both the pooled research results generated in the worldwide network and all other project findings and products. You also will receive the computer software developed by IBSNAT and you will be trained to use this software for agrotechnology transfer in your country. IBSNAT and SMSS will assist you in the detailed characterization of your experiment sites. Further, IBSNAT will sponsor your participation in the annual meeting of collaborators should you lack institutional funds.

Could you describe the computer software that will be provided by IBSNAT?
The computer software will consist of simulation models of agricultural processes (weather, hydrology, erosion, nutrient transformation, crop growth, etc.) developed by specialists associated with IBSNAT. These models will be compatible with the weather, soil, crop, and management data furnished by IBSNAT collaborators, and these data will be used to validate and improve the models.

The software also will include computerized weather generator models that can provide long sequences of simulated weather data; computerized soils files that include chemical, physical, mineralogical, and taxonomic data for the soils of the IBSNAT network; computerized machinery files that estimate the effects of various tillage equipment on soil roughness, mixing, etc.;

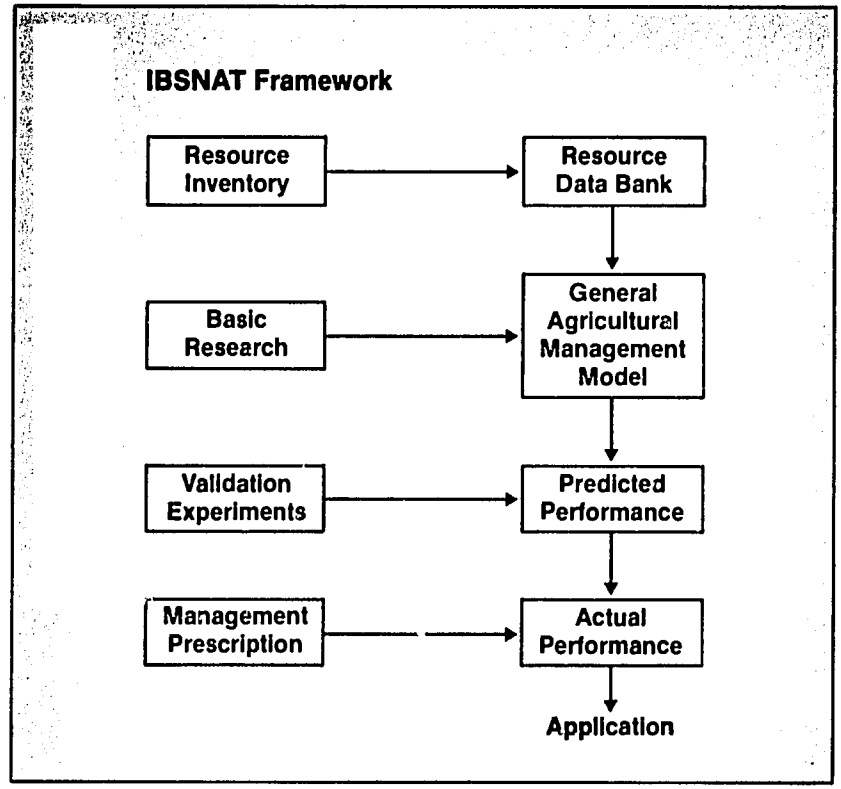
Taro is an aroid grown in lowland and upland areas of the tropics. Along with cassava and potatoes, these three root crops have extremely different physiological and nutritional requirements. Site characteristics must be matched with these requirements for optimum growth and development.

and computerized crop data from all IBSNAT experiments.

The entire package of computer software is in some way analogous to statistical software packages that are available from various sources. The software is a user-oriented tool that can be utilized in many ways to facilitate decision-making.

How is *Soil Taxonomy* used in the models?

In simulating the agriculturally important processes that occur in the soil, we have to consider the nature of the dynamic soil forming processes that operate in the solum. Because these processes are reflected in the taxa of *Soil Taxonomy*, we can and must relate our simulations to soil classes. This approach is based on the realization that the numerical value of an individual soil parameter is meaningful only in relation to other soil properties and that the effect of a given parameter varies with the taxonomic class of the soil. These relationships will be inferred from the carefully characterized soils of the IBSNAT sites and from many other benchmark soils collected and analyzed by SMSS. As the Benchmark Soils Project has shown, these relationships can be applied by analogy to taxonomically similar soils and thus will be used in the simulation models.



We don't use *Soil Taxonomy*. Are we at a disadvantage?

No. Should you become a collaborator and select your experiment sites, SMSS and IBSNAT will assist you in site characterization and in performing complete physical, chemical, and mineralogical analyses for your benchmark soils.

SMSS also is conducting training courses on *Soil Taxonomy*, and if you so request, a course can be held in your country or region.

Can we work on crops other than those you have currently selected?

Certainly. There are probably others in the network interested in the same crops and if there is sufficient interest IBSNAT will try to develop simulation models. Your collaboration in this effort is crucial

as you will have to take the prime responsibility to produce the data base for model development and conduct the necessary experiments to test and validate the model.

How do I go about developing a national network and what help can I get from IBSNAT?

IBSNAT is a prototype of an international network that acts as a link between national and regional networks. Therefore, we encourage you to develop a national network of benchmark sites, in which we will be happy to provide assistance.

What are the lines of communication?

IBSNAT headquarters at the University of Hawaii will develop a mechanism to keep collaborators and others informed about all relevant events and developments. It also will establish a communication system with and among collaborators to allow the free exchange of data and ideas, and provide periodic reports and newsletters. In addition, IBSNAT plans to organize training programs so that the networking method is easily understood by and mutually beneficial to various countries.

FOR more information contact your country USAID mission or write to:

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