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TROPICAL SOIL BIOLOGY AND FERTILITY
A Handbook of Methods
Second Edition

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CAB INTERNATIONAL

Chapter 2 SITE DESCRIPTION

2.1 CLIMATE

2.1.1 Climatic characterisation of site locality

To characterise the climate of a site, long-term data (>10 years and preferably, >20 years) are required, for at least monthly mean values of precipitation and temperature (maximum, minimum). Wherever possible information on soil temperatures, relative humidity (maximum, minimum), sunshine, wind (speed and direction) and evaporation should complement the "Minimum Dataset". These climatic data should be obtained from the nearest (or climatically most similar) weather station with an indication of the duration of record for each parameter and along with the particulars of the station such as name, latitude, longitude, altitude. Further information on the distance of the study site from that meteorological station, the relative altitudes, the aspects and topographical positions must be provided to enable an assessment of eventual climatic differences.

2.1.2 Meteorological observations

The site of a meteorological station should be representative of the natural conditions in the study area. It should:

1 be fairly level and free from obstructions;
2 have a short grass cover or natural cover common to the area (not be concrete, asphalt or rock);
3 not be closer to any obstruction (trees, buildings) than eight times that obstruction's height;
4 not be near areas with cold drainage, flooding or frequent sprinkling;
5 be easily accessible;
6 be fenced to exclude animals.

The daily observation times should be the same as used in the respective national meteorological service. If only one daily observation can be carried out it should be the morning observation. Minimum requirements for TSBF studies include:

Precipitation

Rainfall measurements should be made with standard gauges (WMO, 1983, Section 7) and the readings made to the nearest 0.2 mm. The orifice of the gauge must be horizontal and high enough to avoid splash from the ground, but low enough to prevent major wind influence. To assure comparability, standards as used by the national meteorological service should be followed. (Preference should be given to gauge types with at least 200 cm^2 receptive area.)

Air temperature

To obtain reliable air temperature data thermometers (dry bulb, maximum, minimum) or other probes used in connection with recording devices must be screened from direct radiation but yet be exposed to free air movement. Standard wooden or plastic screens, available for this purpose, are usually installed at a height of 1.2 - 2.0 m above the ground; the actual height chosen at a particular project site should coincide with the one used by the national meteorological service. The thermometers have to be calibrated and should have a graduation which allows a reading accuracy of 0.2°C.

Soil temperature

Standard soil thermometers should be positioned to measure the soil temperature at 0.10 m depth. The thermometers have to be calibrated and should have a graduation which allows a reading accuracy of 0.2°C.

Air humidity

Relative air humidity, defined as the ratio in percent of the actual water vapour pressure in the atmosphere to the one which can be held at a given temperature (saturation vapour pressure), can be directly measured with hygrometers or hygrographs. Absolute values of the vapour pressure (measured in hectopascals) are determined with psychrometers which consist of two thermometers; one is measuring the air temperature (dry bulb) while the other is covered by a wick kept moist with distilled, deionised water to depress the (wet) bulb temperature. The wet bulb wick must be kept clean and checked frequently for rot. The temperature difference between the dry and wet bulbs allows the calculation of the vapour pressure. As ventilation affects results considerably, models with forced ventilation (Assmann type) are strongly recommended. For recording purposes the Assmann psychrometer can be supplemented by a hygrograph.

Minimum air temperature near the soil

In high altitude areas which are liable to frost it is recommended to measure the minimum temperature near the ground. This is measured with a regular minimum thermometer exposed on a small shaded support 5 cm above the ground.

Sunshine

Solar radiation is the basic meteorological parameter for all heat and energy balance assessments. If no direct measurements of the solar radiation are made, the duration of bright sunshine allows for estimates of the energy available for physical and biological processes. The standard instrument to measure the duration of sunshine is the Campbell-Stokes recorder, where the focused radiation from the sun burns a trace in a chart. Sunshine duration is expressed in hours per day. As the sunshine patterns usually do not change over short distances, data from nearby meteorological stations may be used.

Wind

Wind data are essential for estimations of evapo(trans)piration. The basic instrument for measuring the wind speed is the cup anemometer; when equipped with a counting device it allows measurement of distances of wind run over time, and thus the mean wind speed over given time intervals can be derived. Data on wind speed should be complemented by information on the wind direction which can be observed with a wind vane.

In agricultural meteorology the standard height for wind measurements is 2 m above the ground but as topography and the surface cover influence the wind field to a large extent, observation sites have to be chosen very carefully.

Evaporation

To measure potential (maximum) evaporation directly, pans or open water tanks are exposed to the environmental conditions. The most commonly used evaporation pan is the Class A pan which has a diameter of 120.6 cm and a height of 25.4 cm. It is installed on a wooden grid approximately 13 cm above ground level, with a wire mesh protecting it from animals. The water level is controlled with a graduated hook gauge, set on a still well, or with a fixed point to which the pan is refilled with a calibrated container each time a measurement is made. The amount of water loss, analogous to rainfall, is expressed as the equivalent depth (in mm) of water evaporated.

Theoretical approaches, based on the surface energy budget, use measured data of sunshine duration, temperature, air humidity and wind run to estimate the maximum water loss from an open water surface, or from a surface covered with green grass well supplied with water (reference crop evaporation).

Recent research has shown that correlated data from shaded Piche evaporimeters provide good substitution for the aerodynamic term in formulas used for evaporation estimates. They would replace humidity and wind estimates.

Reference

WMO No. 8 (1983) *Guide to Meteorological Instruments and Methods of Observation.* Fifth Edition. World Meteorological Organisation.

2.2 SOIL CHARACTERISTICS

Data are needed at two levels:

1 Information necessary to ensure that the study site is representative of the region

This should be based on available regional soil maps coupled with reconnaissance survey if necessary.

2 Detailed information

Detailed information at a scale of 1:5000 or larger, is required for the actual site. The soils should be classified at the Family level of USDA Soil Taxonomy (Soil Survey Staff, 1987), and at least two (usually more depending upon the area) representative soil profile descriptions should be given (Breimer *et al.*, 1986) plus standard analyses (as listed in Table 1.2) of samples from 0-20 cm.

The soil parameters requiring measurement for TSBF can also be used to apply the Fertility Capability Soil Classification System (Sanchez *et al.*, 1982). This will help in the interpretation of soil constraints in terms of soil biological processes. Soil analytical methods are given in Chapters 6 and 7.

References

Breimer, R.F., van Kekem, A.J. and van Reuler, H. (1986) Guidelines for Soil Survey and Land Evaluation in Ecological Research. *MAB Technical Notes* **17**, UNESCO, Paris.

Sanchez, P.A., Couto, W. and Buol, S.W. (1982) The Fertility Capability Soil Classification System - Interpretation, Applicability and modification. *Geoderma* **27**, 283-309.

Soil Survey Staff (1987) *Keys to Soil Taxonomy* revised edition. Soil Conservation Service, Washington DC.

2.3 LAND MANAGEMENT

2.3.1 Land use

It is relatively rare to find sites on which the natural vegetation and soils have not been disturbed, to a greater or lesser degree, by land use. A description of the nature and intensity of such use is therefore an essential basis for the study of soil/vegetation dynamics and should be based on a classification plus a verbal description. The classification enables sites of similar nature to be related. The description enables account to be taken of the wide diversity of possible uses.

In the context of TSBF studies, it is particularly important to record the inputs and outputs to and from the ecosystem by the agency of man and domestic animals.

Area, site, present and past use

Land use is the use of land by man (including animals under control of man) for productive and/or service purposes. In the present context "use" should be interpreted widely, to include both land improvements (e.g. irrigation, drainage, terracing) and land degradation (e.g. forest clearance, salinisation). The spectrum of land use extends from the considerable disturbance of conditions through arable use at one end, to "undisturbed natural vegetation" as a limiting case at the other. Two distinctions are made: that between land use of the area and of the site; and that between present and past use.

The land use of the area refers to the surroundings within which the experimental site lies. Land within a circle of 5 km radius around the site may be given as a guideline. It will usually be necessary to describe the use in proportional terms, giving approximate percentages, e.g. "30% arable (mainly cereals and legumes), 20% pasture and 50% natural woodland, used for grazing and collection of fuel wood and domestic timber". The land use of the area does not directly concern the dynamics of the site, but provides a setting, enabling it to be recognised as broadly similar to that in other countries. For example, "former shifting cultivation, now changed by population pressure into semi-permanent arable use" indicates a situation of widespread applicability.

The site refers to use on the actual site of the experimental work. Land use will normally be the same over the whole site. Present land use is the use during the immediately preceding year. It will frequently include differences in use as between wet and dry seasons, e.g. "maize for 4-5 months commencing in the wet season, natural fallow with limited cattle grazing for the rest of the year". Land clearance, cultivation (hand hoeing, animal or tractor-powered ploughing, etc.), sowing/planting and harvesting methods should be recorded with date. The full description of farming systems is a substantial task and the subject of a wide range of publications (e.g. Simmonds, 1985).

Past land use refers to the trends of use in recent years. For the area as a whole, this provides a further element of contextual setting. For the site, the intention is to cover whatever period may have appreciably affected the present condition of the soils and vegetation. A 10-20 year span should be included as a minimum, with brief reference to earlier land use history where appropriate, e.g. "Forest clearance in this area is thought to have taken place about 50-60 years ago; for the past 10 years, the site has been under semi-natural pasture, intensively grazed by cattle, sheep and goats".

Classification (after Young, 1985):

1 Annual crops
Arable use for annual, or quasi-annual, crops. Include cassava, hill rice, vegetables if on a field scale; exclude swamp rice, gardens.

2 Swamp rice
If irrigated, list also as irrigation.

3 Tree and shrub crops
Perennial crops, excluding field perennials.

4 Field perennials
Sugar cane, sisal, pineapple, bananas.

5 Gardens
Intensive production, of vegetables and/or fruit, on small plots.

6 Irrigation
Include rice if water brought to fields, but not if retention of rainfall only; include irrigated pasture, forest.

7 Natural pasture
Livestock production from natural pasture, including nomadic grazing, ranching.

8 Improved pasture
Livestock production from substantially improved or sown pasture.

9 Forestry: natural forest
For timber and/or other products.
10 Forest plantations
For timber and/or other products.
11 Agroforestry
Trees interacting with crops and/or pastures/livestock.
12 Wildlife conservation
Flora and fauna, intentional use for this purpose.
13 Water catchments
Intentional use for this purpose.
14 Engineering use
Any form of construction.
15 Unused
Natural vegetation, with no significant use.

Format

The following format for land-use classification is suggested:

Area Present use:
Classes (with approximate percentages):
Description:
Past use:
Description:

Site Present use:
Class:
Description:

Management: (e.g. methods of vegetation clearance, sowing/planting, weeding, pruning, harvesting)
Inputs: (types, quantities, composition, timing and manner of application)
Organic material:
Inorganic material:
Water (irrigation):
Outputs: (harvest etc.; types, quantities, composition)
Past use:
Description:
Inputs and outputs: (general account, approximate quantities where possible)

References

Simmonds, N.W. (1985) *Farming systems research: A review.* World Bank Technical Paper No. 43. World Bank, Washington DC.

Young, A. (1985) *An environmental database for agroforestry.* ICRAF Working Paper 5 (revised edition), ICRAF, Nairobi, Kenya.

2.3.2 Fire

The required data are the date, completeness and intensity of the burn. Completeness is a visual estimate, or the difference between a before and after fire sample, of the percentage of the litter, herbaceous and woody standing crops consumed by the fire, and thus estimates of carbon loss. Intensity is a measure of the rate of energy release by the fire related to nitrogen and phosphorus losses. It can be calculated from the fuel load (F, kg/m^2), the energy content of the fuel (E, kJ/g: for most biomass this can be assumed to be 20 kJ/g), and the rate of spread (V):

$$V \text{ (m/s)} = A / (w \times t)$$

$$\text{Intensity (kJ/m/s)} = F \times E \times V$$

where

A = area of plot (m^2)
w = width of flame front (m)
t = time to burn plot (s).

Alternatively, intensity can be estimated from the following rough guide (Trollope, 1984):

Category	Intensity (kJ/m/s)	Description
Warm	> 500	Flames < 1 m, easily approachable
Hot	500-1000	Flames 1-1.5 m, approachable
Very hot	1000-2000	Flames 1.5-3 m, difficult to approach
Extremely hot	>2000	Flames > 3 m, uncontrollable

In keeping with the peak-trough philosophy of vegetation monitoring, herbaceous biomass (fuel load) should be assessed before burning.

Reference

Trollope, W.S.W. (1984) Fire Behaviour. In: Booyessen, P. de v. and Tainton, N.M. (eds.) *Ecological Effects of Fire in South African Ecosystems. Ecological Studies* **48** Springer-Verlag, Berlin.

2.3.3 Socioeconomic components

The TSBF programme recognises the need to focus local research programmes on local land use practices. The overall objective of TSBF is to determine management options for improving tropical soil fertility through the manipulation of biological processes. Within the range of more specific TSBF objectives, there is a need to choose those that have local applicability.

There are different approaches and levels of investigation required in a program of research on soil fertility. Basic research, or strategic research, on soil biological fertility provides the information needed for target research and extension programs assisting farmers in coping with fertility constraints such as low productivity due to soil erosion. The application of the principles learned from strategic research to the local soil fertility problems as defined by the target population requires an understanding of the socioeconomic context of the farming systems in which they operate.

There are many techniques used to gather socioeconomic data. One of these is participant observation. Participant observation allows the researcher to gather an in-depth knowledge of the indigenous farmers' practices and beliefs. It can be quite time consuming and is better suited to smaller populations. A second technique is the use of questionnaires which are standardized, structured and suited to quantifying socioeconomic data of generally large populations (for example, see Moran in TSBF Handbook of Methods, first edition). A standardised questionnaire cannot respond to unanticipated site-specific problems (Beebe, 1985) and the analysis can be quite time consuming. A third technique is in-depth interviews which are used to gather data using clearly specified criteria generally aimed at a better understanding of specific problems or processes. This technique uses a flexible data collection/processing procedure, generally focuses on smaller populations (L. Llambi, Caracas, Venezuela, 1988, personal communication), and can be adjusted to time constraints and site-specific problems. TSBF researchers used a structured questionnaire, proposed in the 1986 TSBF Yurimaguas Workshop by Moran (1986). They concluded that structured questionnaires were not expedient in performing multidisciplinary land use surveys. It was proposed that in-depth interview techniques such as Rapid Rural Appraisals which pay attention to context be used as effective procedures for recognizing constraints and opportunities for land users.

Rapid Rural Appraisals were designed to use observation and in-depth interviews to gather data on agricultural systems in developing countries. Rapid Rural Appraisal (RRA) is an interdisciplinary, iterative approach used to gain insight into land use practices. Small teams of researchers representing different disciplines such as social science and soil science work together using techniques such as in-depth interviews, based on key indicators, and direct observation to gain insight into management practices. It is a highly iterative approach which allows the reformulation of hypotheses based on new information (Grandstaff *et al.*, 1987). The real value of techniques such as RRA are the use of indigenous technical knowledge (ITK) such as the farmers' knowledge of plants, soils, and the local ecosystem to reformulate these hypotheses. The relevance and validity of these rapid techniques are evaluated in the short term through repeated iterations of the RRA process and in the long term by the effectiveness of actions based on knowledge and perceptions generated by the RRA.

Organisations such as ICRAF (Raintree, 1987) and IBSRAM (1988) are successfully using techniques such as RRAs to assess soil management techniques and other agroecosystem concerns in developing countries.