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FERTILITY CAPABILITY CLASSIFICATION SYSTEM AND ITS UTILIZATION

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ABSTRACT

The incompatibility between the requirements of soil scientists, viz. permanent soil characters found essentially in the subsoil, and those of the agronomists, viz. fertility parameters found in the topsoil, are explained. The dilemma is between the type of information given by the soil scientist which is often not directly relevant to immediate practical issues and the agronomist's hope of finding a universal soil test, which is unrealistic if not related to other soil properties.

Most of the data needed by the agronomist could be found from a soil map. However, essential properties such as surface texture or pH are not specifically expressed in soil classifications. Soil fertility parameters are mostly found in the topsoil and have been listed to form the Fertility Capability Classification (FCC) system. Using and testing the FCC in the last ten years has proved a rewarding exercise. It has made if possible to group together soils which are homogeneous enough in these properties to allow soil management decisions to be taken. The interactive computer software programs now available for personal computers should greatly facilitate its use in the future.

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In like fashion, the upper few centimeters are excluded from soil taxonomic consideration, again with a few notable exceptions such as categories that utilize various epipedons for class criteria. The family category of Soil Taxonomy specifically avoids the surface layer in most soils by defining a control section from 25 cm to 100 cm.

It is really not very useful to argue about whether or not more attention needs to be paid to the subsoil by the agronomist. In several regression studies of variables affecting row crop yields, the properties of the topsoil are always more significant to crop growth than subsoil properties. It can be argued that only satisfactory subsoil properties are incorporated in the selection of suitable sites. The folly of prolonging the argument is that the agronomist has almost no technology to change most soil properties below plow depth or subsoiling depths of perhaps 50 cm. Although soil scientists are fond of pointing out the completely controlling influence that shallow bedrock, fragipans, duripans, etc. have on land use, we have to remember that these choices of land use have already been made before the working agronomist gets involved. In fact much of the disregard given soil survey information stems from the fact that within any local area most of the soils that are intensively used for a crop are similar in many respects, and those soils not responding to conventional management are not used for cultivation.

SOIL PROPERTIES - AGRONOMIC OPERATIONS

No attempt will be made to create a definitive list of management practices and of how the presence, absence, or degree of a given soil property influences the agronomic operations. However, there are a few categories of problems that I think we can address. One potential area is that of fine-tuning soil test interpretations. All soil test procedures attempt to extract an arbitrary fraction of several elements from a soil sample and then predict how much fertilizer will be needed for 60 to 120 days, or longer. There are many situations where this works very well; but the real problems result when interpretations are made in soil material which is not like the soil where the calibration was developed. The impulse of the agronomist has been to look for a universal extractant,

them almost everything they wanted to know from what we would expect in a map unit description. I could not do this from a taxonomic placement, regardless of the classification system, primarily because of the question that emerged to be number one among the agronomists. Simply, they wanted to know: What is the surface texture? As one individual put it, "I first give the soil a kick to see what the texture is." I concluded I did not have to be too precise about texture if it could be done with a kick, but I had better lead off a soil description by giving a surface texture if I am to get an agronomist's attention.

After rather unanimous agreement on surface texture, the background of the individuals made for a rather diverse list of concerns. Certainly pH was high on the list, as was subsoil texture, soil test levels, past cultural practices, and rainfall and temperature. It became apparent that what agronomists wanted to know about soils was far less than the soil surveyor had to have to classify a soil. Many of the analytical methods preferred were not the same. The units of expression were different, and there was a host of reasons why they did not relate to the various soil survey reports.

Most of these apparent problems faded, however, when the agronomists were asked to put "quantitative criteria" on their categories of "high P-fixing soils", "rapidly leached soils", "wet soils", etc. It was obvious that they had almost no creditable way of communicating with each other. Consequently, they did not communicate well, and I think evidence of this lack of communication is reflected in verbal and published statements to the effect that "this is the practice to use in state X, while in state Y or county Z another practice is to be preferred." It seems agronomists can usually agree on the political boundaries on a map, but that does not appear to be a scientifically satisfying way to communicate cause and effect of soil management techniques.

What followed was a series of appoximations to express the concerns of agronomists in a formal fashion and with quantitative class limits. As we all now know, essentially all soil properties form a continuous solid series and any class limit is going to fit better in one part of the world than in another. Thus the limits used in FCC have been arrived at either because they can be conveniently borrowed from Soil Taxonomy or

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e = (low cation exchange capacity): applies only to plow layer or surface 20 cm, whichever is shallower: CEC 4 meq./100 g soil by bases + KCl-extractable Al (effective CEC), or CEC 7 meq./100 g soil by cations at pH 7, or CEC 10 meq./100 g soil by cations + Al + H at pH 8.2;

a = (aluminum-toxicity): 60% Al-saturation of the effective CEC within 50 cm of the soil surface, or 67% acidity saturation of CEC by cations at pH 7 within 50 cm of the soil surface, or 86% acidity saturation of CEC by cations at pH 8.2 within 50 cm of the soil surface, or pH 5.0 in 1:1 H2O within 50 cm, except in organic soils where pH must be less than 4.7;

h = (acid): 10-60% Al-saturation of the effective CEC within 50 cm of soil surface, or pH in 1:1 H2O between 5.0 and 6.0;

i = (high P-fixation by iron): % free Fe2O3/% clay 0.15 and more than 35% clay, or hues of 7.5 YR or redder and granular structure. This modifier is used only in clay (C) types; it applies only to plow-layer or surface 20 cm of soil surface, whichever is shallower;

x = (X-ray amorphous): more than 1.4% oxalate extractable Al or a pH 10.6 in 1N NaF in the top 20 cm;

v = (Vertisol): very sticky plastic clay: 35% clay and 50% of 2:1 expanding clays, or severe topsoil shrinking and swelling;

k = (low K reserves): 10% weatherable minerals in silt and sand fraction within 50 cm of the soil surface, or exchangeable K 0.20 meq./100 g, or K 2% of bases, if bases 10 meq./100 g;

b = (basic reaction): free CaCO3 within 50 cm of soil surface (effervescence with HCl), or pH 7.3;

s = (salinity): 4 mmhos/cm of electrical conductivity of saturated extract at 25°C within 1 m of the soil surface;

n = (natric): 15% Na-saturation of CEC within 50 cm of the soil surface;

c = (cat clay): pH in 1:1 H2O is 3.5 after drying and jarosite mottles with hues of 2.5 Y or yellower and chromas 6 or more are present within 60 cm of the soil surface; (only used in Cg and Cg' substrata);

= (gravel): a prime (') denotes 15-35% gravel or coarser (2 mm) particles by volume to any type or substrata type texture (example: S'L = gravelly, sand over loamy; SL' = sandy over gravelly loam); two prime marks (") denote more than 35% gravel or coarser particles (2 mm) by volume in any type or substrata type (example: LC" = loamy over clayey skeletal; L'C" = gravelly loam over clayey skeletal);

% = (slope): where it is desirable to show slope with the FCC, the slope range percentage can be placed in parentheses after the last condition modifier (example: Sb (1-6%) = uniformly sandy soil, calcareous in reaction, 1-6% slope).

suggested for upland agriculture (Table 2) and paddy rice cultivation (Table 3). However, in an operational setting local editing and modification by local agronomists are highly desirable.

Table 2. FCC sample interpretation. (Sanchez *et al.*, 1982)

S: high rate of infiltration, low water-holding capacity.
L: medium infiltration rate, good water-holding capacity.
C: low infiltration rates, good water-holding capacity, potential high runoff if sloping, difficult to till; when i modifier is present, these (Ci) soils are easy to till, have high infiltration rates and low water-holding capacity.
O: artificial drainage is needed and subsidence will occur; possible micronutrient deficiencies; high herbicide rates usually required.
SC, LC, LR, SR: susceptible to severe soil degradation from erosion exposing undesirable subsoil; high priority should be given to erosion control.

Interpretation of modifiers:

When only one modifier is included in FCC unit,the following limitations or management requirements apply to the soil. Interpretations may differ when two or more modifiers are present simultaneously or when textural types are different.

g': too wet for upland use unless expensive protection is provided.
g: denitrification frequently occurs in anaerobic subsoil; tillage operations and certain crops may be adversely affected by excess rain unless drainage is improved by tilling or other drainage procedures; good soil moisture regime for rice production.
d: moisture is limiting during the dry season unless soil is irrigated; planting date should take into account the flush of N at onset of rains, germination problems are often experienced if first rains are sporadic.
e: low ability to retain nutrients against leaching, mainly K, Ca and Mg; heavy applications of these nutrients and of N fertilizers should be split; potential danger of overliming.
a: plants sensitive to Al-toxicity will be affected unless lime is applied; extraction of soil water below depth of lime incorporation will be restricted; lime requirements are high unless an e modifier is also indicated; this modifier is desirable for rapid dissolution of phosphate rocks

CEC, low ability to supply K; availability of K should be monitored and K-fertilizers may be required frequently for plants requiring high levels of K.

Lgth: good waterholding capacity, medium infiltration capacity;limitations in drainage so that tillage operations and some crops may be adversely affected unless drainage is improved by tilling or other procedures; strong to medium acid soil; liming required for some crops; excellent soil for flooded rice, as acidity will be eliminated by flooding.

LCaegk: erosion or other removal of surface soil will expose undesirable clay-textured subsoil; drainage limited so that tillage operations and some crops may be adversely affected unless drainage is improved by tilling or other procedures; low ability to retain nutrients for plants, mainly K, Ca, Mg; heavy application of these nutrients and N fertilizer should be split; plants sensitive to Al-toxicity will be affected unless lime is deeply incorporated; however, deep liming practices are difficult because of clay-textured substrata; low ability to supply K; availability of K should be monitored and K fertilizers may be required frequently for plants requiring high levels of K.

L: excellent soil with no major fertility constraints; N deficiency likely with intensive use.

Table 3. Sample interpretations of FCC condition modifiers for rice cultivation in aquic soil moisture regime. (Sanchez and Buol, 1985).

Modifier	Limitations or management requirements
g	= Defines wetland soils. Preferred moisture regime for rice cultivation.
g'	= Prolonged submergence causes Zn deficiency.
d	= Topsoil moisture limited during dry season unless irrigated. Generally only one rain-fed rice crop can be grown a year. Irrigated rice during the dry season has higher yield potential and responds to higher N rates.
k	= Low inherent fertility because of low reserves of weatherable minerals. Management levels higher than in soils without this modifier. Potential K deficiency depending on base contents of irrigation water.
e	= Low ECEC reflects less gradual N release, more exacting N management. Identifies degraded paddy soils with SLa or LCa and low organic matter

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recent three-volume publication of "Land in Tropical America" by Cochrane *et al.*, 1985. All of the FAO world soil map units in Africa have been converted to FCC units in preparation for compiling interpretive maps of Africa. FCC groupings have been tested as guides for N fertilization of lowland rice (Lin, 1984) and P and K fertilization of lowland rice (Lin, 1985) in Taiwan. FCC has been used to evaluate the extent of soil constraints (Sanchez and Cochrane, 1980; Trangmar *et al.*, 1984) and as a basis for evaluating future fertilizer manufacturing requirements (T. Kaddar, 1981, personal communications). Several studies have used FCC to group soils in smaller regions as the basis for further technology transfer and research (Oliveira, 1978; Avilan *et al.*, 1979; Avilan *et al.*, 1978; Avilan *et al.*, 1977; Brito *et al.*, 1979; Paredes Arce, 1986).

Not all users found that their needs were fully satisfied by FCC; however, only slight modifications were suggested. Concepts of what a technical classification system should and can do certainly vary from scientist to scientist. In my opinion, there is a tendency to expect too much in the way of interpretations from almost every classification system. In the case of FCC, I do not expect that it will serve well as a predictor of yield. The criteria are not selected with this in mind. What is hoped for are groups of soils that are homogeneous enough in properties that soil management decisions are the same in kind, if not totally in quantity, within groups and different between groups. While rigorous testing of response to management inputs is appropriate, the ultimate test appears to be in an evaluation of the use of the system in the delivery of soil management information to the user. In almost every country the delivery of advice to farmers follows a path of researcher - extension specialist - farmer. Often soil science is but one of several disciplines an extension specialist is expected to communicate to the farmer. If FCC groups permit clearer and more precise information to be transmitted while requiring a less sophisticated comprehension of soils terminology, often not relevant to the area, the more inclined the extension specialist is to get the job done properly.

LIN, C.F. 1985. Fertility Capability Classification (FCC) as a Guide to PK-Fertilization of Lowland Rice. FFTC Book Series No. 29. Soil Taxonomy - Review and Use in the Asian and Pacific Region.

KADDAR, T. 1981. Personal communications. International Fertilizer Development Center, Muscle Shoals, Alabama.

OLIVEIRA, J.B. 1978. Classificacao de solos da quadricula de Campinas. Institutuo Agronomico de Campinas. Bol. Tec. 59.

PAREDES ARCE, P.G. 1986. Le systeme de classification des sols par capacité de fertilité. Faculté des Sciences Agronomiques, Gembloux, Belgium.

SANCHEZ, P.A., and COCHRANE, T.T. 1980. Soil constraints to major farming systems of tropical America. Pages 107-139 in: Soil-Related Constraints to Food Production in the Tropics, ed. M. Drosdoff et al. Los Banos, Philippines: IRRI.

SANCHEZ, P.A., COUTO, W. and BUOL, S.W. 1982. The fertility capability soil classification system: interpretation applicability and modification. Geoderma 27:283-309.

SANCHEZ, P.A. and BUOL, S.W. 1985. Agronomic Taxonomy for wetland soils. Pages 207-227 in: Wetland Soils: Characterization, Classification and Utilization. Proceedings of the International Rice Research Institute Workshop, 26 March-5 April 1984. Los Banos, Philippines.

SOIL SURVEY STAFF. 1975. Soil Taxonomy. U.S. Department of Agriculture. Handbook No. 435. Washington, D.C: U.S. Government Printing Office.

TRANGMAR, B.B., YOST, R.S., SUDJADI, M., SOEKARDI, M., and UEHARA, G. 1984. Regional Variation of Selected Topsoil Properties in Sitiung, West Sumatra, Indonesia. Research Series No. 026. Collection of Tropical Agriculture and Human Resources, University of Hawaii.